Journal of Experimental Psychology: General
2004, Vol. 133, No. 1, 3–22

0096-3445/04/$12.00 DOI: 10.1037/0096-3445.133.1.3

Trauma Films, Information Processing, and Intrusive Memory Development

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Three experiments indexed the effect of various concurrent tasks, while watching a traumatic film, on intrusive memory development. Hypotheses were based on the dual-representation theory of posttraumatic stress disorder (C. R. Brewin, T. Dalgleish, & S. Joseph, 1996). Nonclinical participants viewed a trauma film under various encoding conditions and recorded any spontaneous intrusive memories of the film over the following week in a diary. Changes in state dissociation, heart rate, and mood were also measured. As predicted, performing a visuospatial pattern tapping task at encoding significantly reduced the frequency of later intrusions, whereas a verbal distraction task increased them. Intrusive memories were largely unrelated to recall and recognition measures. Increases in dissociation and decreases in heart rate during the film were also associated with later intrusions.

A hallmark symptom of posttraumatic stress disorder (PTSD) is repeated intrusive imagery of the traumatic event that is described as exceptionally vivid and rich in sensory detail (Brewin, 1998, 2003; Brewin & Holmes, 2003). PTSD is a distressing and disabling psychological response to a traumatic event. In this context, a traumatic event is defined as one involving actual or threatened death, serious injury, or threat to the physical integrity of self or others (*Diagnostic and Statistical Manual of Mental Disorders,* 4th ed. [*DSM–IV*]; American Psychiatric Association, 1994). The three core elements of PTSD are reexperiencing of the trauma (e.g., as intrusive images), avoiding reminders of the trauma, and experiencing physiological hyperarousal. Very little is known about why some people develop more unwanted images of a trauma than others or why people develop images of particular moments. Our hypothesis was that cognitive processes, such as those that occur during encoding of the traumatic experience (i.e., *peritraumatically*), are crucial in understanding intrusive memories. As it is difficult to conduct research at the time of real trauma, analog experimental methods, for example using a trauma film, provide a useful tool.

In this article we report a series of experimental studies in which nonclinical participants viewed a trauma film under several different encoding conditions to investigate the development of intrusive memories. The research was based on the dual-representation theory of PTSD (Brewin, 2001, 2003; Brewin, Dalgleish, & Joseph, 1996), which proposes that traumas are encoded both in the form of verbal or narrative memories and as lower level, image-based memories.

Several cognitive theorists have also distinguished verbal from nonverbal memory information. Paivio's (1971) dual-coding theory proposed that there are two independent yet connected systems for imagery and verbal coding. The multiple-entry, modular memory system (Johnson, 1983; Johnson & Multhaup, 1992) may be considered a modern development and distinguishes between two perceptual and two reflective memory systems. The latter are thought to develop later in childhood and exercise a degree of control over the former. The different systems can be activated independently, by either situational or self-reflective processes. Several models of autobiographical memory distinguish between memory for perceptual and memory for conceptual or narrative information (Brown & Kulik, 1977; Conway & Pleydell-Pearce, 2000; Pillemer, 1998; Pillemer & White, 1989). In the context of generalized anxiety disorder, Borkovec has argued that verbal worry is used to suppress unwanted emotional imagery (e.g., Borkovec & Inz, 1990). Although PTSD has provided a springboard for the current research, our analog trauma studies and intrusive memories may have more general relevance that extends beyond responses to traumatic events.

Our main focus was to investigate the influence of concurrent tasks during the encoding of analog trauma, on intrusive memory development. Tasks including visuospatial tapping, verbal distraction, or verbal enhancement are discussed. The clinical literature also alerted us to the potential importance of peritraumatic dissociation. The American Psychiatric Association (1994) defined

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We are grateful for the support of Camden and Islington Mental Health and Social Care Trust. Teresa Peck and Andy Haswell at Royal Holloway, University of London gave helpful advice and technical support. We are very grateful for assistance from Anna Saunders, Anoushka Khan, Kate Seviour, Karla Bailey, and Tanja DasGupta and to Warren Mansell and Andrew Mathews for their helpful comments on drafts of this article. Emily A. Holmes thanks the British Association for Behavioural and Cognitive Psychotherapies for their annual BABCP Research Award in supporting this work. We are grateful to Anke Ehlers for her loan of the video.

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dissociation as “a disruption of the usually integrated functions of consciousness, identity or perception of the environment” (p. 477). Despite the notorious difficulties in satisfactorily defining dissociation, prospective clinical research has indicated that dissociative responses at the time of the trauma (e.g., feeling that the experience is not happening in reality, time changing, out-of-body experiences) are predictive of PTSD (e.g., Engelhard, van den Hout, Kindt, Arntz, & Schouten, 2003; Murray, Ehlers, & Mayou, 2002; Ozer, Best, Lipsey, & Weiss, 2003; Shalev, Peri, Canetti, & Schreiber, 1996). It has been suggested that this is because dissociative mental processes somehow disrupt the encoding of traumatic information (Ehlers & Clark, 2000; Foa & Hearst-Ikeda, 1996; van der Kolk, van der Hart, & Marmar, 1996). Despite the evidence implicating dissociation in PTSD, the precise definition of the concept remains elusive.

The stressful film paradigm creates an analog situation in which response to trauma can be studied in the laboratory (e.g., Lazarus, Opton, Nomikos, & Rankin, 1965). A number of studies have used this method to study the development of various kinds of intrusion in the days after exposure to the film, as assessed using the diary method (Butler, Wells, & Dewick, 1995; Davies & Clark, 1998). Of most relevance for our purposes are studies that have attempted to manipulate individuals’ encoding conditions while they watch the film. In an innovative study by Murray (1997), participants were asked to try to dissociate while watching a film involving a series of automobile accidents. They were given guidelines to help them do this, although there was no opportunity to practice dissociating or to select individuals who were able to respond in this way. Compared with controls, participants instructed to dissociate did not experience more intrusive memories involving the film in the following week. However, participants higher in trait dissociation experienced more intrusive memories regardless of their experimental condition.

On the basis of Murray’s (1997) idea, Brewin and Saunders (2001) tested the hypothesis that the separation between normally integrated mental processes that is characteristic of dissociation could be modeled by dividing participants’ attention and having them carry out a secondary task while they watched the trauma film. The task they selected was to tap a series of varying patterns on a concealed keyboard (Moar’s, 1978, visuospatial tapping task). Brewin and Saunders predicted that this would reduce the amount of attention given to the film, impair explicit memory, and increase subsequent involuntary intrusions of images from the film. Unexpectedly, the divided attention condition led to a significant decrease in intrusions over the following 2 weeks compared with a no-task control condition, despite there being no difference in explicit memory for the film.

Following Holmes (2000), we argue that Brewin and Saunders’s (2001) results may be explained in terms of the dual-representation theory of PTSD (Brewin, Dalgleish, & Joseph, 1996). This theory applies a multiple-memory-systems idea to PTSD, whereby trauma memories are processed in two systems and create two separate representations. Dual-representation theory holds that during a traumatic event, information receiving a relatively high level of conscious processing is laid down in a form that can later be deliberately retrieved, in the verbally accessible memory (VAM) system. The VAM system corresponds to ordinary autobiographical memory and forms the basis of subsequent verbal accounts of the trauma. Information that does not receive sufficient attention to be stored in VAM is encoded in the situationally accessible memory (SAM) system. The SAM system primarily stores sensory information, especially visuospatial information, in the form of images. Information in this system can be accessed automatically by exposure to relevant cues and may be spontaneously reexperienced in the form of detailed visual images, affective responses, and emotion-laden flashbacks corresponding to moments of intense arousal during the trauma. Unlike most theories of emotional memory based in experimental research, which examine effects on standard measures of recall and recognition (e.g., Cahill, 1997), this approach explicitly addresses the mechanisms underlying the intrusive images that are so prominent in PTSD.

Brewin (2001) proposed a neuropsychological basis for dual-representation theory and argued that a detailed VAM representation of the trauma is necessary to block the automatic, unwanted retrieval of SAM representations and their accompanying images. VAM, unlike SAM, representations are thought to contain rich contextual information, such as temporal context. It would therefore be difficult to discriminate SAM-based images of past events from current events. Paying repeated attention to spontaneous images can lead to the development of VAM representations, which do provide a basis for discriminating whether a current situation is threatening. Behavioral data suggest that inhibitory pathways (connecting the prefrontal cortex to the amygdala) could allow emotions to be regulated by higher cognitive processes such as reasoning and labeling (Hariri, Bookheimer, & Mazziotta, 2000). Applying these findings to dual-representation theory leads to the suggestion that hippocampally processed VAM representations may be able to inhibit lower level SAM representations.

A second line of research that may support dual-representation theory indicates that having to verbalize the appearance of a previously seen object or picture may make it harder to distinguish it from similar objects or pictures in a recognition test (Schooler & Engstler-Schooler, 1990; Schooler, Fiore, & Brandimonte, 1997). More generally, in some tasks requiring knowledge that is hard to put into words, having participants verbalize information may interfere with their ability to use their perceptual memory of the event, an effect called *verbal overshadowing.* One explanation is that the verbal description leads to a new and only partially accurate memory that interferes with people’s ability to access the original visual image, at least under some circumstances (Schooler & Engstler-Schooler, 1990). Similarly, detailed VAM representations may compete successfully for retrieval with SAM representations, reducing the likelihood of vivid visual images intruding spontaneously into consciousness. However, it has also been shown that the verbal overshadowing effect can occur for nonstudied items (Westerman & Larsen, 1997). Further, the magnitude of the effect does not appear related to the quality of verbalizations, and an alternative explanation to “interference” may be that verbal processing can induce a processing shift that impairs nonverbal operations (Schooler, 2002).

We predict that tasks that primarily disrupt VAM encoding during a trauma will lead to increased intrusions, whereas hindering input to the SAM system will decrease intrusions. We assume that the dissociative symptoms and altered consciousness that have predicted an increased risk for PTSD in the clinical studies may have entailed a selective interference with encoding into the VAM system. As a consequence, detailed VAM representations would have been unavailable to block the occurrence of unwanted intru-

sions, and intrusive trauma memories would be more frequent. In contrast, Brewin and Saunders's (2001) results are explicable if it is assumed that the visuospatial tapping task selectively interfered with encoding into the system supporting intrusive imagery (the SAM system). More generally, within a dual-task framework, we predict that tasks that directly compete for verbal resources or otherwise restrict verbal encoding by placing competing demands on consciousness (e.g., through dissociation) should have opposite effects on intrusion development to tasks that compete for visuospatial resources (e.g., pattern tapping).

Indirect support for the above account of Brewin and Saunders's (2001) results is available from two lines of inquiry. First, Andrade, Kavanagh, and Baddeley (1997) investigated the impact of a concurrent visuospatial tapping task (similar to the one used in this study) on the creation of emotional visual images. Nonclinical participants asked to form images of neutral and negative pictures rated them as less vivid and less distressing when they were carrying out this concurrent task, compared with a nonvisuospatial control condition. Similar results have been obtained by van den Hout, Muris, Salemink, and Kindt (2001) and Kavanagh, Freese, Andrade, and May (2001). Second, Hellawell and Brewin (2002) had patients with PTSD write a detailed narrative about their trauma. During the narrative, participants were stopped and asked to perform a verbal or visuospatial task. This happened both while they were reporting the content of ordinary autobiographical memories of the trauma (theoretically supported by the VAM system) and while they were reporting intrusions, that is, spontaneously occurring vivid images of the trauma (supported by the SAM system). As predicted, performance on the visuospatial task (but not on the verbal task) was hindered during periods when patients had intrusive images, suggesting that this type of memory was dependent on visuospatial resources.

Together, the theory and empirical findings suggest that selective interference with the VAM and SAM systems in individuals watching a trauma film should have opposite effects on the subsequent development of intrusive memories (i.e., increased vs. decreased intrusions, respectively). Our predictions are tested in three experiments. The first experiment compares the effects of a dissociation task with visuospatial tapping, predicting that they will have opposite effects on memory intrusion. The second experiment tests the prediction that varying the degree of visuospatial load, through simple tapping, practiced complex tapping, and unpracticed complex tapping, will progressively lead to greater reductions in intrusive images. The third experiment provides a test of the hypothesis that interfering with encoding into the VAM system (using a concurrent verbal counting task) will increase intrusive memory development. This experiment also uses a noncompeting verbal condition predicted to have the opposite effect on intrusions.

Experiment 1

In the first experiment we aimed to assess the influence of both a visuospatial task and a dissociation manipulation task during a trauma film on subsequent intrusive memory development. The concurrent visuospatial task involved continuous tapping of a five-key complex pattern on a keyboard concealed from view, as in Brewin and Saunders (2001). We modified the task to use one pattern, rather than changing patterns during the film, thereby avoiding the interruptions incurred by Brewin and Saunders when the pattern was changed, as the control condition was uninterrupted. A review of methods of inducing concurrent dissociation (Leonard, Telch, & Harrington, 1999) suggested that prolonged staring at a small dot was an effective technique that could be pursued during film viewing. To ensure that participants were able to comply with the task, an initial screening phase was devised to eliminate those who were unable to dissociate in this context. The success of the manipulation was assessed using a self-report measure of state dissociation. During real trauma, dissociation is typically considered to be a spontaneous rather than a deliberate processing strategy, and we expected similar spontaneous responses to the trauma film. We therefore investigated the possibility that changes in state dissociation would be related to memory development independent of experimental condition. Given the results reported by Murray (1997), we also measured trait dissociation to see whether any effects of state dissociation on memory development could be better explained in terms of stable individual differences.

Increased physical hyperarousal to trauma cues is characteristic of PTSD (Orr, Lasko, Shalev, & Pitman, 1995; Pitman et al., 1990). However, there is a considerable degree of individual variation, and recent research has indicated that dissociation in the context of challenge or trauma may be accompanied by a relative suppression in heart rate (Griffin, Resick, & Mechanic, 1997; Leonard, Telch, & Owen, 2000). Nijenhuis, Vanderlinden, and Spinhoven (1998) argued that the physiology of dissociation reflects a "freeze and surrender" reaction and is distinct from hyperarousal, which reflects a fight or flight reaction. Further, attentional orienting to aversive stimuli has been associated with heart rate bradycardia (Lang, Bradley, & Cuthbert, 1997). These findings suggest that a general decrease in heart rate while watching a trauma film may predict more subsequent intrusions, because low heart rate could reflect maximum attentional intensity, dissociation, or both. More specifically, if heart rate reduction reflects moments of maximum disruption to peritraumatic encoding, the specific parts of a trauma film that later intrude as images should be those when heart rate was lowest.

During the trauma film viewing, there were three experimental conditions: a visuospatial tapping condition, a dissociation condition, and a no-task control condition. The main outcome variable was the number of intrusive memories of the film recorded in a diary, which may be considered an analog of reexperiencing symptoms in PTSD. Additional measures assessed possible competing explanations for any differences between conditions: An attention rating and recall test were designed to measure global distraction effects; mood ratings assessed the emotional impact of each task condition and also allowed the aversiveness of the film to be confirmed. Intrusion phenomenology was assessed to check comparability with intrusions in PTSD. Finally, descriptions of individual intrusions were obtained so that they could be matched with sequences in the film and so that peritraumatic heart rate during these sequences could be calculated.

We predicted, first, that report of intrusions would be less frequent, relative to a no-task control condition, when participants were required to carry out a concurrent visuospatial tapping task (cf. Brewin & Saunders, 2001). Second, we predicted that involuntary intrusive memories in the week following a trauma film would be more frequent, relative to controls, when participants

watching the film were given dissociation instructions and required to stare at a small dot superimposed on the screen. Third, we predicted that across all experimental conditions, individuals who responded to the film with greater increases in spontaneous state dissociation would later experience more frequent intrusions, regardless of levels of trait dissociation. Fourth, we predicted that across all experimental conditions, individuals who responded to the film with reduced heart rate would later report having more intrusions. Finally, we predicted that heart rate would be lower during film sequences that corresponded to the content of a participant's subsequent intrusive memories than during the remaining film sequences. To check on the external validity of the task, we asked participants to describe their spontaneous memories of the trauma film. These were compared with intrusive memory characteristics in PTSD (e.g., Ehlers & Steil, 1995; Ehlers et al., 2002; Holmes, Grey, & Young, in press).

Method

Participants initially went through a screen for their ability to dissociate using a dot-staring task. Those who passed the screen continued to an experimental phase in which they were assigned to watch a trauma film under one of three concurrent task conditions. Measures were collected pre- and postfilm. Participants recorded their intrusions of the film in a diary for 1 week and then returned for a follow-up session.

Participants

Forty-eight female and 24 male unpaid student volunteers completed the screening phase. Recruitment took place through advertisements on the university campus. Because of ethical considerations, the recruitment material provided information about the traumatic nature of the film, specifically that it contained graphic scenes of the aftermath of road traffic accidents that might be remembered involuntarily after the experiment. The 54 participants (75%) that passed the screen continued to the main experiment. Three participants failed to complete the follow-up and were excluded from subsequent analyses; thus results are reported for 17 participants per condition. The age range was from 18 to 31 ($M = 20.2$ years, $SD = 2.2$). As part of informed consent for the experiment, all participants confirmed to the experimenter in writing that they had not previously received any treatment for a mental health problem (in the form of medication or psychological therapy).

Trauma Film

A 12.5-min trauma video of real-life footage (compiled by Steil, 1996) was projected on a 125- × 90-cm screen using an audiovisual LCD projector (Sharpvision XV-710P; Sharp Electronics Corporation, Mahwah, NJ). It consisted of five scenes of horrific content, namely, live footage from the aftermath of road traffic accidents, including emergency service personnel working to extract trapped victims, injured victims screaming, dead bodies being moved, and body parts among car wreckage. Between scenes, a brief commentary provided context to each accident and the people involved.

With respect to the ethical issues of showing a film with traumatic content, we note that previous studies using the same trauma film (Brewin & Saunders, 2001; Murray, 1997), as well as those using other trauma films (e.g., Davies & Clark, 1998), found that no participants reported ongoing distress subsequent to the end of the experiment. Further, although transiently distressing, the film content is similar to that witnessed by television viewers watching programs such as news coverage of road traffic accidents, or programs about the police or ambulance service work. Participants were informed in the recruitment material and at the experiment prior to viewing the video that the film contained graphic scenes of the aftermath of road traffic accidents. They were also informed that they could terminate the experiment at any point. All participants were encouraged to contact the experimenter before the follow-up session if they felt distressed; they were also given the experimenter's details to retain after the experiment. Further, clinical psychologists with experience of managing distress conducted the experiments.

Screening Task

Participants were asked by the experimenter to identify and describe an occasion when they had dissociated. All participants could do this. The experimenter defined dissociation as follows:

> Dissociation involves a range of experiences which have in common that things feel different from usual, as if one's mental processes are not integrated at the time. Dissociation is a spectrum ranging from everyday daydreaming to out-of-body experiences. It can occur during positive events, such as graduation day, as well as negative events, such as trauma. Examples of dissociation include spacing out, day dreaming and drifting off, feeling unreal or not quite there, feeling numb and cut off, and when you feel you can see yourself.

Participants were told that they would shortly be required to dissociate and that the psychological state to aim for was similar to that in their example. They then stared for 10 min at a 1-cm diameter dot fixed to the center of a 125- × 90-cm projection screen at a distance of 290 cm. During this time, the experimenter sat behind the participant, out of his or her field of view. The lab was quiet and the lights were dimmed. Participants were instructed not to speak or fidget during this period but to focus on the dot. No participant interrupted the screen by speaking, although some shifted posture. All appeared to continually stare at the dot.

Experimental Tasks During the Trauma Film

Visuospatial tapping task. Participants were shown the square box with a 5 × 5 matrix of buttons, each identified with an individual letter (from *A* to *Y*), in rows running from left to right (Brewin & Saunders, 2001; Moar, 1978). They were told that during the video they would be required to tap a specified sequence of five keys continuously, on a keyboard concealed from view. Further, they were told that the computer was wired up to record the number of correct sequences, the time it took to complete a sequence, and any errors. They were given 1 min to practice tapping the sequence *JYPVA* (an irregular pattern) using their dominant hand. Only at this stage were they able to look at the keyboard, and visual feedback was given of the characters tapped on the visual display unit (VDU). The keyboard was then concealed from view. Immediately prior to the film starting, instructions on the VDU reminded participants of the sequence to tap.

Dissociation task. Participants practiced dissociating for 2 min immediately before the film by staring at the dot used in the screening phase, which remained on the screen when the film started. They were instructed to make an effort to continue dissociating as they had done during the screening task previously and to not slip into their normal "TV watching habit."

Measures

State dissociation. The 19 subject-rated items from the Clinician Administered Dissociative States Scale (Bremner et al., 1998) are referred to here as the Dissociative State Subscale (DSS). Symptom areas assessed include depersonalization, derealization, and amnesia (American Psychiatric Association, 1994), and the measure was developed to assess alterations in levels of state dissociation in a clinical population. Items are rated on a 5-point scale anchored with 0 (*not at all*) and 4 (*extremely*). Sample

items include “Do you feel as if you are looking at things from outside of your body?” and “Do things appear to be moving in slow motion?” The 19 subjective DSS items have satisfactory reliability (Cronbach’s $\alpha = .94$), whereas the 8 observer-rated items do not (Bremner et al., 1998) and so were excluded. Bremner et al. reported mean full-scale scores of 1.5 ($SD = 2.5$) for healthy controls and 18.9 ($SD = 18.3$) for patients with PTSD, thereby supporting the validity of the measure.

Trait dissociation. The 38-item Trait Dissociation Questionnaire (TDQ; Murray, 1997; Murray et al., 2002) was based on *DSM–IV* (American Psychiatric Association, 1994) criteria for dissociative disorders and dissociative symptoms in PTSD. Items are rated on a 6-point scale anchored with 0 (*never*) and 5 (*always*). The measure has an alpha coefficient of .93 ($n = 211$), has a retest reliability of .86 ($n = 83$) over 2 months, and predicts PTSD following road traffic accidents (Murray et al., 2002).

Intrusions. Participants were asked to use a tabular diary to record any intrusions of the film during the 7 days following the film (cf. Brewin & Saunders, 2001; Butler et al., 1995; Davies & Clark, 1998; Murray, 1997). They noted each intrusion’s content (“What was the intrusion of?”) and rated the distress associated with it on an 11-point scale anchored with 0 (*not at all distressing*) and 10 (*extremely distressing*). They rated whether their intrusion was an image, a thought, or a combination. Clear verbal and written instructions were given about the nature of unwanted intrusions and how to keep the diary. As in assessing reexperiencing symptoms in PTSD, intrusions were defined as “spontaneously occurring” (not deliberate) memories of the film. Participants were asked to carry the diary with them and to record each intrusion they experienced each day. They were also asked to set aside a regular time each day to check whether they had completed their diary and to indicate if they had no intrusions. The total number of intrusions was calculated from the diary entries by the experimenter. At follow-up, a diary compliance rating was made. Following Davies and Clark (1998), participants were instructed, “Please rate how true the following statement is: I have often been unable (or have forgotten) to record my intrusive images in the diary.” Their response was anchored with 0 (*not at all true*) and 10 (*extremely true of me*). At follow-up, participants were also asked to describe their “most significant intrusion” from their diary in their own words. Open-ended questions were asked about people and objects in the image and about what was happening. This description was used to locate the corresponding film sequence to a given intrusion. Participants were asked whether this intrusion appeared like a snapshot or a film snippet, whether it was a whole scene or a detail, and whether something “bad” was happening in it.

Mood and distress. Participants rated their distress associated with viewing the film after it had ended. They also rated their level of depression, anger, happiness, and anxiety both pre- and postfilm (Davies & Clark, 1998). Eleven-point scales were used, with anchors of 0 (*not at all*) and 10 (*extremely*).

Attention and memory. Participants were instructed, “Please indicate how much attention you paid to the film you have just seen,” using a rating scale anchored with 0 (*none at all*) and 10 (*total attention*). A 21-item cued recall test assessed memory of the five scenes in the film, based on Brewin and Saunders (2001). Sample items include “What color was the car that was seen on fire at the beginning of the first scene?” and “How many people were put into coffins in scene four?”

Heart rate. Heart rate was recorded using a blood-flow optical sensor attached to a participant’s ear lobe (Pulsmeter XR210; Bosch & Sohn, Jungingen, Germany). Interbeat intervals were recorded online to the nearest millisecond. Heart rate was measured continuously throughout the phases of the experiment (Griffin et al., 1997). Mean heart rate was calculated offline for the 6-min resting baseline, the 10-min dot-staring screening task, and the 12.5-min video. The mean change in heart rate between baseline and film was calculated. The timing of the video and heart rate monitor were synchronized by computer. Sequences in the film corresponding to intrusion descriptions (see above; e.g., “body thrown into coffin”) were identified to the nearest second. Mean heart rate during such sequences for each participant was calculated.

Procedure

All participants received information about the experiment and gave their written informed consent to taking part.

Screening phase. Participants were seated alone in the laboratory. After 3 min for the apparatus to stabilize, a 6-min heart rate resting baseline was recorded. The experimenter reentered, and the first DSS (baseline) was administered. After the dissociation-screening task, participants completed the DSS for the second time (postscreen). Participants were then asked to dispel any feelings of dissociation by going outdoors for a 5-min break. Participants were blind to the consequence that they would be deselected if they did not pass the screen.

Experimental phase. Participants who scored above a cutoff of 17 on the second administration of the DSS, indicating an ability to dissociate (J. D. Bremner, personal communication, May 15, 2000) completed the DSS for the third time (prefilm) and the TDQ, and then watched the trauma film. They were randomly assigned to one of the three experimental conditions: (a) the no-task (control) condition, in which participants were told that while watching the video they did not have to make any special effort to dissociate and to behave as they would normally when watching a film; (b) the dissociation condition; or (c) the visuospatial tapping condition. Immediately prior to the film starting, instructions on the VDU reminded participants of their task. When the film ended, the DSS was administered for the fourth time, and participants rated the amount of attention they had paid to the film, and their mood, as above. They were then instructed in the use of the 7-day diary. Participants were reminded to contact the experimenter if they felt concerned or distressed about the study.

Follow-up session. The follow-up session was conducted at 1 week. Participants completed the diary compliance rating and the cued recall test, and described their most significant intrusion. The experimenter debriefed participants. In our clinical opinion, no participant displayed a significant level of distress at the follow-up session. Although no participant did contact the experimenters subsequently, a procedure was in place should any participant make contact.

Results

The data were examined for potential univariate outliers using box plots for each variable. Four scores were more than 3 standard deviations from the mean and were changed to one unit larger (if the score was below the mean) or smaller (if above the mean) than the next most extreme score in the distribution (Tabachnick & Fidell, 1996). One participant’s heart rate data and attention ratings postfilm were missing owing to technical error. An alpha level of .05 was used for all statistical tests. Homogeneity of variance was assessed for independent-sample *t* tests using Levene’s statistic. When this was significant, we report the *t* statistic for which homogeneity of variance was not assumed.

Dissociation Screening Phase

In the dissociation screening phase, subjective report of state dissociation increased after the dot-staring task. Participants as a whole reported significantly higher DSS scores postscreen ($M = 27.22$, $SD = 13.85$) than at baseline ($M = 5.49$, $SD = 5.77$), $t(69) = 14.32$, $p < .001$, $d = 3.77$. The 51 participants who passed the screen and thus continued to the experimental phase scored higher than the 18 who failed on the baseline DSS ($M = 6.51$, $SD = 6.23$ vs. $M = 2.61$, $SD = 2.66$), $t(62.39) = 3.64$, $p = .001$,

$d = 0.70$, as well as on the postscreen DSS ($M = 32.51$, $SD = 12.13$ vs. $M = 12.22$, $SD = 3.46$), $t(65.46) = 10.77$, $p < .001$, $d = 0.19$. Participants who passed the screen also had higher trait dissociation (TDQ) scores than those who failed ($M = 65.37$, $SD = 20.28$ vs. $M = 44.78$, $SD = 17.70$), $t(67) = 3.82$, $p < .001$, $d = 1.05$.

Randomization and Manipulation Checks for the Main Experimental Phase

Randomization checks. In the experimental phase, there were no significant differences between the three groups in age, TDQ, baseline DSS, or prefilm DSS ($F < 1$ in all cases). Nor was there a significant difference between groups in postscreening DSS, $F(2, 48) = 1.34$, $MSE = 145.25$, $p = .27$, or heart rate baseline, $F(2, 48) = 1.47$, $MSE = 134.54$, $p = .24$. There was no difference in gender between conditions, $\chi^2(2, N = 51) = 0.17$, $p = .92$.

Task compliance. Participants in the visuospatial tapping condition tapped rapidly and accurately throughout the film. The mean total number of key presses during the film was approximately 70 per minute, and an accurate five-key sequence order was tapped on 82.3% of occasions (see Table 1). Participants in the three conditions rated that they were equally compliant completing their diary, $F(2, 48) = 1.49$, $MSE = 2.89$, $p = .24$ (see Table 1). The overall mean diary compliance rating was 2.52 ($SD = 1.72$), suggesting participants believed that they had recorded most of their intrusions.

Changes in state dissociation. As shown in Table 1, participants in the dissociation condition reported larger increases in state dissociation (DSS) between baseline and postfilm than those in the other two conditions. Using a 2 (time: baseline vs. postfilm) × 3 (condition) mixed analysis of variance (ANOVA), we found significant main effects of time, $F(1, 48) = 54.83$, $MSE = 91.92$, $p < .001$, $\eta^2 = .53$, and condition, $F(2, 48) = 3.96$, $MSE = 149.11$, $p = .03$, $\eta^2 = .14$, and a significant interaction, $F(2, 48) = 4.52$, $MSE = 91.92$, $p = .02$, $\eta^2 = .16$. Examination of the interaction using one-way ANOVA revealed no significant differences between conditions at baseline, $F(2, 48) = 0.25$, $p = .78$. As predicted there was a significant difference between conditions on the postfilm DSS, $F(2, 48) = 4.84$, $MSE = 206.15$, $p = .01$, $\eta^2 = .17$. DSS scores were significantly higher in the dissociation condition than in both the control condition, $t(48) = 2.19$, $p = .03$, $d = 0.90$, and the visuospatial tapping condition, $t(48) = 3.01$, $p < .01$, $d = 0.96$. The visuospatial tapping and control conditions did not differ, $t(48) = 0.82$, $p = .42$.

Effects of Experimental Condition

Intrusions over 1 week. Overall, the mean number of intrusions recorded by participants was 4.24 ($SD = 3.82$), and the range was 0 to 14 intrusions. As shown in Table 1, there was a significant difference in the total number of intrusions between conditions, $F(2, 48) = 4.02$, $MSE = 13.05$, $p = .02$, $\eta^2 = .14$. As predicted, participants in the visuospatial tapping condition reported significantly fewer intrusions than participants in the control condition, $t(48) = 2.18$, $p = .04$, $d = 0.63$. Participants in the visuospatial tapping condition also reported fewer intrusions than those in the dissociation condition, $t(48) = 2.66$, $p = .01$, $d = 1.03$. There was no significant difference in the number of intrusions reported

Table 1
Task Manipulation and Outcome Measures From Experiment 1 for Each Experimental Condition

	Condition					
	No-task control		Dissociation		Visuospatial tapping	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
Tapping						
Total key presses					807.19	254.35
No. of correct sequences					132.88	56.99
Diary compliance rating	2.76	1.75	2.85	1.92	1.94	1.30
Total no. of intrusions in 1 week	4.94	4.29	5.53	3.48	2.23	2.92
Depression						
Prefilm	3.94	2.38	3.23	2.19	2.76	2.86
Postfilm	5.47	2.46	5.06	2.51	4.41	2.81
Anger						
Prefilm	0.47	0.80	0.76	0.90	0.59	1.00
Postfilm	3.53	3.34	3.12	2.93	2.24	2.80
Happiness						
Prefilm	5.53	1.37	6.29	1.16	5.47	1.77
Postfilm	3.06	1.43	3.65	1.62	3.71	1.72
Anxiety						
Prefilm	3.76	2.73	4.82	1.59	4.12	2.75
Postfilm	4.35	2.21	5.06	2.77	4.65	2.45
Distress during film	5.11	2.59	5.41	3.02	4.19	2.01
Attention paid to film	8.41	1.37	6.24	2.44	7.13	2.50
Recall measure	8.06	2.83	7.50	2.65	8.32	1.98
Change in state dissociation between baseline and after the film	12.29	10.48	21.76	18.62	8.12	9.75

between the dissociation and control conditions, $t(48) = 0.48$, $p = .64$.

Mood and distress ratings. Viewing the film resulted in a deterioration of mood ratings (see Table 1). Using 2 × 3 mixed ANOVAs, we found significant main effects prefilm to postfilm for depressed mood, $F(1, 48) = 32.91$, $MSE = 2.15$, $p < .001$, $\eta^2 = .41$; anger, $F(1, 48) = 35.98$, $MSE = 3.92$, $p < .001$, $\eta^2 = .43$; and happiness, $F(1, 48) = 87.54$, $MSE = 1.53$, $p < .001$, $\eta^2 = .65$; but not anxiety, $F(1, 48) = 1.25$, $MSE = 4.14$, $p = .27$. There were no significant effects of experimental condition on any mood ratings ($F < 1$) except for happiness, $F(2, 48) = 1.25$, $MSE = 3.14$, $p = .30$. There were no significant interaction effects on any mood ratings: For depression and anxiety, $F < 1$; happiness, $F(2, 48) = 1.21$, $MSE = 1.53$, $p = .31$; anger, $F(2, 48) = 1.08$, $MSE = 3.92$, $p = .35$. Viewing the film was rated as equally distressing across conditions, $F(2, 47) = 1.00$, $MSE = 6.69$, $p = .38$ ($M = 4.92$, $SD = 2.59$; see Table 1).

Attention and memory for the film. As shown in Table 1, a significant difference was found between conditions in ratings of attention paid to the film, $F(2, 47) = 4.37$, $MSE = 4.66$, $p = .02$, $\eta^2 = .16$. The attention rating in the dissociation condition was significantly lower than in the control condition, $t(25.21) = 3.21$, $p < .01$, $d = 1.58$, but did not differ from the visuospatial tapping condition, $t(30.76) = 1.03$, $p = .31$. The control and visuospatial tapping conditions did not differ significantly from each other, $t(22.98) = 1.82$, $p = .08$, although there was a trend for there to be more attention paid in the control condition.

At follow-up, cued recall memory for the film was tested. Initial analyses suggested that there were no memory differences across conditions. However, subsequent observation suggested that the memory measure may be insensitive.[1] We calculated the percentage of correct responses across all participants for individual cued recall items. Percentage correct ranged from 2% to 83%, with five items being markedly skewed (percentage correct < 15% or > 85%). The analyses reported refer to the measure after the invariant items were removed. The modal recall score was 7.5 ($M = 7.96$, $SD = 2.48$), indicating that approximately 47% of items were answered correctly. No difference was found for the recall measure between the three conditions, $F(2, 48) = 0.48$, $p = .62$. The recall measure was unrelated to frequency of intrusive memories in any of the experimental conditions, largest $r(15) = -.24$, $p = .35$. Further, when all conditions were combined, the correlation between the cued recall measure and intrusion frequency was not significant, $r(49) = -.06$, $p = .67$. The pattern of results was the same when the invariant items in the cued recall measure were included.

State and Trait Dissociation Across All Conditions

Changes in state dissociation could also occur naturally in response to the film regardless of participants' experimental condition. The results reported above indicated that in all conditions, state dissociation increased from baseline to postfilm (see Table 1). To assess whether increases in self-reported state dissociation had a general effect on intrusions, we computed a correlation between the change in state dissociation (DSS) and reported number of intrusions. This was significant, $r(49) = .36$, $p = .01$.

To examine whether changes in state dissociation still contributed to intrusion development if experimental condition and trait dissociation ability were also considered, a hierarchical regression was used. The first block consisted of two dummy variables representing participants' experimental condition as well as TDQ (trait dissociation) scores. The second block consisted of DSS score change (state dissociation), measured from baseline to postfilm. The dependent variable was the total number of intrusions reported. The first block of variables did not reach significance, $F(3, 47) = 2.67$, $p = .06$, R^2 change = .15. The measure of state dissociation explained significant variance, $F(1, 46) = 4.76$, $p = .04$, R^2 change = .079. In the final model, state dissociation change, but not trait dissociation, made a significant contribution (DSS change: $\beta = .32$, $p = .04$; TDQ: $\beta = -.13$, $p = .35$). The results indicate that increases in peritraumatic state dissociation may be related to intrusion development over and above attempts to manipulate dissociation experimentally.

Heart Rate Change and Intrusive Memories

Heart rate was examined in two ways. First, we compared the overall change in the mean heart rate during the baseline period to the mean heart rate while watching the film. Second, we examined heart rate during sequences of the film that participants later identified as intrusions. Because heart rate was potentially influenced in the visuospatial condition by the motor activity of tapping, these analyses were restricted to participants in the control and dissociation conditions.

Overall change in heart rate. As predicted, the number of intrusions and change in heart rate were significantly negatively correlated, $r(32) = -.34$, $p = .01$. That is, greater reductions in heart rate during the film relative to baseline were associated with an increased number of intrusions. The mean heart rate during the baseline and then during the film was 81.94 ($SD = 12.51$) and 77.70 ($SD = 10.99$), respectively. The mean drop in heart rate from prefilm to postfilm was 4.24 ($SD = 7.12$) beats per minute.

Heart rate during intrusive memory sequences. This analysis was carried out with the subset of 30 participants who reported at least one intrusion over the following week. The contents of each participant's intrusion descriptions from the follow-up questionnaire were matched to the related sequences in the film, blind to the corresponding heart rate data. There was sufficient information to carry out this match for 100% of participants' self-defined "most significant intrusions" and a further 64% of additional intrusions noted in the diaries. The mean duration of the film sequences corresponding to intrusions, hereafter referred to as *intrusion sequences,* was 38.92 s ($SD = 41.28$).

Participants' mean heart rate recorded during their own intrusion sequences ($M = 76.71$, $SD = 10.77$) was compared with their mean heart rate during the remainder of the film that did not figure in their intrusions ($M = 78.33$, $SD = 11.26$). Heart rate during intrusion sequences was on average 1.61 beats per minute lower ($SD = 2.49$) than during nonintrusion sequences, a significant difference, $t(29) = 3.55$, $p = .001$, $d = 0.14$. Repeating the heart rate analysis on each person's most significant intrusion alone yielded similar results, on average 1.79 beats per minute lower ($SD = 2.52$) than baseline, $t(29) = 3.90$, $p = .001$, $d = 0.16$.

[1] These observations were made following helpful suggestions from anonymous reviewers.

Nature of intrusions. Participants with intrusions reported a mean of 1.95 ($SD = 1.20$) different intrusions that they had spontaneously recalled, with a range of 1 to 5 different intrusions. There was no difference between conditions in mean ratings of intrusion distress ($M = 3.4$, $SD = 2.3$), $F(2, 40) = 0.15$, $p = .86$. The intrusion descriptions indicated that 56% of intrusions involved death of a person in the film, for example, a body in a coffin. A further 37% described serious injury, such as someone screaming in agony. Only three intrusion descriptions did not mention death or serious injury, for example, the "man who got away without dying." Most participants (88%) reported that something "bad" was happening in their intrusion. Most intrusions (86%) were reported as taking the form of images rather than verbal thoughts. Whereas 56% of participants described their most significant intrusion as like a snapshot, 44% rated it as like a film sequence. The intrusions appeared to be a whole scene for 34% of participants and as a detail for the remaining 66%.

Discussion

A major finding from this experiment was that participants who engaged in a visuospatial tapping task during the trauma film reported experiencing fewer intrusive memories of the film in the subsequent week than those who had no such task. This replicates the effect found by Brewin and Saunders (2001), using improved methodology. The reduction in intrusions was not accounted for by the task protecting against negative mood or distress caused by the film (cf. Davies & Clark, 1998). Nor does it seem likely that the effect of the visuospatial task was simply due to distraction in terms of attention self-report. Participants in the visuospatial tapping condition did not report paying less attention to the film than controls, whereas those in the dissociation condition did give lower ratings of attention but did not report fewer intrusions. However, lower ratings of attention in the dissociation condition may reflect specific demand characteristics. Further, albeit weak, evidence against a distraction account is provided by the absence of a difference between conditions on the cued recall measure concerning events in the film. It is therefore plausible that the effect of the tapping task in reducing intrusions was due to its visuospatial nature.

The second major finding in Experiment 1 concerns the impact of dissociation during the film. The dissociation task manipulation was unsuccessful. However, we found that spontaneous increases in state dissociation after viewing the film, regardless of experimental condition, were associated with report of an increased number of intrusions. Further, this effect was not explained by individual differences in trait dissociation. This finding is of interest as it is consistent with a number of clinical studies of peritraumatic dissociation (cf. Ozer et al., 2003). Our experiment used a truly prospective design to examine the impact of dissociation at encoding. In contrast, clinical studies on which the hypothesis was based inevitably had to ask about dissociative responses that had occurred days or weeks earlier. The dissociation task condition may have failed to lead to an increased number of intrusions (see also Murray, 1997) because spontaneously occurring dissociation differs in some way from attempts to manipulate dissociation.

The third noteworthy result from Experiment 1 concerns heart rate and intrusions. These indicate, first, that a relative suppression in heart rate during the film (compared with baseline) was associated with report of an increased number of intrusions. Second, we used a novel methodology whereby we matched participants' descriptions of their intrusions, such as "a baby being carried by a fireman," to the corresponding sequence in the trauma film. Coordinated timing allowed us to determine a given participant's heart rate during the matched sequence when they had originally watched the film. Intriguingly, we found that heart rate during the intrusion sequences was suppressed compared with film sequences that did not intrude for a given participant.

The nature of the intrusions that participants reported indicated a high proportion of images, often of specific details, and that they took the form of snapshots as well as film sequences. They tended to be of the worst moments in the film, such as "a body being flung into a coffin" (cf. Grey, Holmes, & Brewin, 2001). This suggests that they may be similar to intrusions described by patients with PTSD (Ehlers & Steil, 1995). The number of different types of intrusion of the film is similar to that reported after real trauma (Ehlers et al., 2002; Holmes, Creswell, & O'Connor, 2004). These findings support the external validity of the analog film paradigm.

Experiment 2

In Experiment 1 we found that a visuospatial tapping task reduced the intrusions reported after a trauma film. Previous research has indicated that tapping a predetermined spatial array selectively impairs visuospatial processing, as can other tasks, such as visual noise or the presentation of irrelevant pictures (Logie, 1986; Quinn & McConnell, 1996). Baddeley and Andrade (2000) found that imagery vividness was selectively reduced with concurrent visuospatial tasks such as novel visual patterns as well as pattern tapping. Visuospatial processing, imagery, and emotion have been linked in recent studies such as that of Andrade et al. (1997), who found that the vividness and emotionality of imagined personal recollections were reduced by pattern tapping, as well as by a visuospatial eye movement task (see also Kavanagh et al., 2001; van den Hout et al., 2001). It is therefore likely that the pattern tapping task used in Experiment 1 competed for visuospatial resources while participants encoded the film.

This experiment was designed to provide a more precise test of the hypothesis that the development of intrusive memories is blocked by a concurrent visuospatial task because such a task uses up resources within the image-based SAM system that are also used for the encoding of trauma images. If such a resource competition model is correct, systematically altering levels of visuospatial demand at encoding should be related in a linear fashion to the number of subsequent intrusive memories. In practice it is difficult to devise tasks that vary only in visuospatial demand, because such demands are almost invariably dependent on general attentional resources (Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001). However, it is possible to vary the combination of visuospatial and general attentional demands.

In this experiment, overall levels of visuospatial and general attentional demand were manipulated by altering the nature of the tapping task during the film. In a control condition participants had no concurrent task. The first level of demand involved repeatedly tapping a single key on a concealed keyboard. The second level of demand involved tapping the same pattern as in Experiment 1 (*JYPVA*), but only after this sequence had been overpracticed. We

hypothesized that overpractice would reduce the combination of general attentional and particularly visuospatial resources required for the task. The third level of demand involved tapping same pattern but with minimal previous practice (exactly as in Experiment 1). Our prediction was that across the four conditions, the frequency of subsequent intrusive memories would increase in a linear fashion.

We predicted replication of the finding that a concurrent visuospatial task would lead to a reduction in reported intrusions, in a sample not screened for dissociative ability. We sought to replicate other key findings of Experiment 1—specifically, that spontaneous increases in state dissociation across conditions would be associated with report of an increased frequency of intrusive memories and that heart rate suppression during the film would be associated with intrusions. The dissociation manipulation condition was not included in the replication. Additional measures of trait dissociation and explicit memory for the film were used to enhance generalizability of the results. The diary measure of intrusions relies on introspective report, and if participants had discerned the aims of the experiment, this may have influenced their recording of intrusions (Baddeley & Andrade, 2000). We therefore asked participants to rate their predictions of the impact of each condition on intrusions, to consider possible demand effects.

Method

Participants watching the trauma film were randomly assigned to one of four concurrent task conditions. Measures were collected pre- and postfilm. Participants recorded their intrusive memories of the film in a diary for 1 week and then returned for a follow-up session. Similar ethical procedures were followed as in Experiment 1.

Participants

Thirty-nine female and 41 male student volunteers took part and were paid a small fee. Recruitment took place through advertisements on the university campus. The mean age was 24.0 (SD = 6.4 years). As in Experiment 1, all participants confirmed that they had not received treatment for a mental health problem.

Materials

The film was the same as that used in Experiment 1. It was displayed on a 41- × 56-cm television monitor (CI-29H40, 29-in. [73.66-cm] color stereo TV; LG Electronics Inc., Englewood Cliffs, NJ) viewed at 130 cm.

Experimental Tasks During the Trauma Film

The experimenter gave the instructions, described below, to participants. In the control condition there was no task, and participants were asked to watch the film as usual. Prior to the film, in all conditions, instructions on the VDU reminded participants of their task.

Single key tapping task. Participants were asked to tap one key on the square box continuously throughout the film. They were told that the computer would record their performance. The keyboard was concealed from view, as in Experiment 1.

Overpracticed visuospatial tapping task. Participants were given similar instructions to the visuospatial tapping condition used in Experiment 1, except that they practiced the task for 6 min with an emphasis on achieving full accuracy.

Visuospatial tapping task. This task was the same as in Experiment 1.

Measures

The measures were identical to those used in Experiment 1, with the exception that memory for the film was assessed more comprehensively with a 15-item cued recall task as well as a 20-item recognition task. Examples of recognition items are “Scene 1: A policeman stands watching the wreckage whilst making notes on clipboard [yes/no]” and “Scene 5: A distraught teenager is led away from the scene by a member of the public [yes/no].”

In addition to the TDQ, the Dissociative Experiences Scale was included. The 28-item Dissociative Experiences Scale (DES–II; Carlson & Putnam, 1993) is the most widely used measure of trait dissociation. Participants circle a number indicating the percentage of time they have a given experience in their daily life, from 0% (*never*) to 100% (*always*). The DES–II has been shown to have high internal consistency, with a Cronbach’s alpha of .95 (Frischholz et al., 1990). Carlson and Putnam (1993) reported test–retest reliability ranging from .84 to .96 in different studies.

All participants were asked at follow-up what effect they predicted each of the three concurrent tasks would have on intrusions of the kind recorded in their diaries, in comparison to watching the film with no task. They responded on a 21-point scale anchored with −10 (*would extremely reduce intrusions*) and 10 (*would extremely increase intrusions*).

Procedure

Experimental phase. Participants were randomly assigned to one of the four task conditions: (a) no task (control), (b) single key tapping, (c) overpracticed visuospatial tapping, or (d) minimally practiced visuospatial tapping. The measures were taken prefilm and postfilm, as in Experiment 1. In addition, the DES–II was completed prefilm.

Follow-up session. The follow-up session was conducted at 1 week, as in Experiment 1. No participant was judged to have significant levels of distress at follow-up, and none contacted the experimenter after the experiment ended.

Results

The data were examined for potential univariate outliers using box plots for each variable, both across all cases and within groups for analyses with grouped data. Eight scores were more than 3 standard deviations from the mean and thus were changed to one unit larger or smaller than the next most extreme score in the distribution, as appropriate. Three cases were identified as multivariate outliers. One could be adjusted univariately (on the total number of intrusions). The remaining two cases were deleted from multivariate analyses (Tabachnick & Fidell, 1996). Missing data were identified for tapping task performance for 3 participants. In addition, for 2 participants measures of distress and attention paid to the film as well as heart rate during the film were missing. This was due to technical error in terminating the computer program. An alpha level of .05 was used for all statistical tests unless otherwise reported.

Randomization and Manipulation Checks

Randomization check. There were no significant differences between the four conditions on age, trait dissociation (using the DES–II), or prefilm state dissociation (DSS); in all cases, $F < 1$. Nor were there significant differences for trait dissociation (TDQ), $F(3, 76) = 1.82$, $MSE = 427.85$, $p = .15$, or heart rate baseline, $F(3, 76) = 1.32$, $MSE = 109.19$, $p = .27$. There was no difference in gender between conditions, $\chi^2(3, N = 80) = 1.75$, $p = .63$.

Task compliance. Participants in the three tapping task conditions tapped at a similar rate throughout the film, $F(2, 54) = 3.07$, $MSE = 139{,}630.21$, $p = .06$ (see Table 2), although there was a trend for the total number of key presses to be greater in the single key tap as opposed to pattern tapping conditions. The mean total number of key presses was 943.4 ($SD = 387.2$), which is approximately 75 per minute. Confirming the success of overpractice, participants in the overpracticed condition tapped more accurately than those in the minimally practiced condition, $F(1, 37) = 4.26$, $MSE = 3{,}503.36$, $p = .046$, $\eta^2 = .10$ (see Table 2). Participants across conditions rated that they were similarly compliant in filling in their intrusions diary, $F(3, 76) = 2.19$, $p = .10$. The overall mean rating for diary compliance was 2.01 ($SD = 1.36$), indicating that participants believed they had recorded most of their intrusions (see Table 2).

Effects of Experimental Condition

Intrusions of the film over 1 week. Overall, the mean total number of intrusions reported in 1 week was 4.78 ($SD = 5.53$), and the range was 0 to 26 intrusions. To check whether the visuospatial tapping result of Experiment 1 was replicated as predicted, we used one-tailed tests to test this directional hypothesis. As shown in Table 2, more intrusions were reported after the control condition than after the minimally practiced visuospatial tapping condition, $t(76) = 1.97$, $p = .03$ (one-tailed), $d = 0.40$. The overpracticed visuospatial tapping condition was also associated with fewer intrusions than the control condition, $t(76) = 1.71$, $p = .046$ (one-tailed), $d = 0.35$. The data showed the predicted linear trend for the total number of intrusions, $F(1, 76) = 4.82$, $MSE = 29.86$, $p = .03$, $\eta^2 = .06$, with the number of intrusions decreasing systematically with greater levels of task demand.

Demand characteristics. Participants were asked to rate how much they thought performing each of the tapping tasks during the film would impact on having intrusions, compared with no task. Overall, mean ratings of task impact were close to 0 (*no impact*) and similar for each task: tapping a single key ($M = 0.16$, $SD = 3.68$), tapping a practiced pattern ($M = -2.60$, $SD = 4.63$), and tapping a minimally practiced pattern ($M = -0.76$, $SD = 4.13$). Ratings showed no significant difference between conditions ($F < 1$) except when rating the impact of tapping a single key, $F(3, 75) = 1.12$, $MSE = 45.13$, $p = .35$.

We also examined participants' impact predictions within conditions with respect to actual intrusion frequency. With respect to the key replication result, mean prediction ratings within the control and minimally practiced conditions of the impact of the minimally practiced task on intrusions were similar, $M = -0.42$ ($SD = 3.58$) and $M = -0.15$ ($SD = 4.16$), respectively. Further, predictions within the other two task conditions were not consistent with the trend in actual intrusions (see Table 2).

Mood and distress ratings. Viewing the film resulted in a deterioration of mood ratings. Using a 2 × 3 mixed ANOVA, we found significant main effects prefilm to postfilm for depressed

Table 2
Task Manipulation and Outcome Measures From Experiment 2 for Each Experimental Condition

Measure	No-task control *M*	No-task control *SD*	Single tapping *M*	Single tapping *SD*	Overpracticed tapping *M*	Overpracticed tapping *SD*	Minimally practiced tapping *M*	Minimally practiced tapping *SD*
Tapping								
Total key presses			1,119.17	514.40	895.14	248.04	827.68	322.56
No. of correct sequences					164.65	45.26	125.53	70.97
Diary compliance	2.10	1.34	1.50	0.89	2.56	1.61	1.88	1.38
Total no. of intrusions	6.65	8.36	5.50	5.11	3.70	3.28	3.25	3.55
Depression								
Prefilm	3.45	2.70	2.60	2.41	2.15	1.73	2.30	2.29
Postfilm	3.50	2.37	3.55	2.70	2.45	1.73	3.15	1.92
Anger								
Prefilm	0.45	1.00	0.75	1.33	0.65	1.27	1.20	1.79
Postfilm	2.05	2.78	2.10	2.17	1.05	1.67	1.45	1.50
Happiness								
Prefilm	5.85	1.90	5.75	1.77	5.00	1.86	5.40	1.27
Postfilm	3.65	2.41	3.50	2.39	3.00	2.22	4.10	1.92
Anxiety								
Prefilm	3.10	1.55	4.20	2.21	3.70	2.03	3.50	2.70
Postfilm	3.75	2.12	3.65	2.21	2.60	2.04	3.50	2.16
Distress during film	4.30	2.29	4.89	2.73	3.68	1.89	3.35	2.06
Attention paid to film	7.86	2.90	8.47	1.68	8.11	1.73	7.54	2.47
Recall measure	7.10	2.79	7.58	2.28	6.88	2.19	6.52	2.38
Recognition measure	11.85	2.78	10.50	2.24	9.35	2.46	10.10	2.79
Change in state dissociation prefilm to postfilm	5.90	6.91	1.95	5.58	3.42	8.08	1.45	5.43
Predicted task impact within condition			−0.40	3.96	−3.26	4.63	−0.15	4.16

mood, $F(1, 76) = 5.19$, $MSE = 2.23$, $p = .03$, $\eta^2 = .06$; anger, $F(1, 76) = 21.06$, $MSE = 1.54$, $p < .001$, $\eta^2 = .22$; and happiness, $F(1, 76) = 100.47$, $MSE = 1.49$, $p < .001$, $\eta^2 = .57$. There was no significant main effect of anxiety, $F(1, 76) = 1.25$, $MSE = 2.01$, $p = .27$. There were no significant effects of experimental condition for any mood in all cases ($F < 1$) except depressed mood, $F(1, 76) = 1.25$, $MSE = 8.04$, $p = .30$. However, there was an interaction between condition and mood for both anger, $F(3, 76) = 2.90$, $MSE = 1.54$, $p = .04$, $\eta^2 = .11$, and depression, $F(3, 76) = 2.80$, $MSE = 2.23$, $p = .046$, $\eta^2 = .10$ (see Table 2). There was no interaction effect for anxiety ($F < 1$) or happiness, $F(3, 76) = 1.29$, $MSE = 1.49$, $p = .29$, $\eta^2 = .05$. Further examination of the simple effects showed that these were not significant.

Participants also rated how distressing they found watching the film. Viewing the film was rated as equally distressing across conditions, $F(3, 77) = 1.77$, $MSE = 5.12$, $p = .16$ ($M = 4.05$, $SD = 2.30$).

Attention and memory for the film. There was no significant difference between conditions on attention ratings for the film ($M = 8.26$, $SD = 1.53$), $F(3, 74) = 0.36$, $p = .78$ (see Table 2). At follow-up, participants completed measures of recall and recognition (see Table 2). As in Experiment 1, because of concerns about sensitivity, we calculated the percentage of correct responses for each item. For cued recall, percentage correct ranged from 7% to 70%, with only one item being markedly invariant (percentage correct < 15% or > 85%). For recognition, percentage correct ranged from 25% to 91%, with four items falling outside the limits. These five items were therefore removed in reported analyses to maximize sensitivity. On the recall and recognition measures, the modal scores were 9 and 8, respectively, indicating that on average, 56% and 57% of questions were answered correctly. The mean scores on each measure were 7.02 ($SD = 2.40$) and 10.45 ($SD = 2.69$), respectively. No difference was found between the four conditions on the cued recall measure, $F(3, 76) = 0.66$, $MSE = 5.86$, $p = .58$. However, there was a significant difference between tasks on the recognition measure, $F(3, 76) = 3.31$, $MSE = 6.63$, $p = .024$, $\eta^2 = .12$. Further examination indicated that recognition scores in the control condition were significantly better than both the minimally practiced, $t(76) = 2.15$, $p = .035$, $d = 0.63$, and the overpracticed tapping conditions, $t(76) = 3.07$, $p = .003$, $d = 0.90$. There were no significant differences between other conditions (highest $t = 1.41$). Prior to the removal of invariant items, there were no differences between conditions.

Correlations between the explicit memory measures and number of intrusive memories were examined both within each condition and across all conditions combined and were largely nonsignificant. One significant correlation was found between cued recall and intrusions in the overpracticed group, $r(18) = -.63$, $p = .003$, indicating that better recall was associated with fewer intrusions. It remained significant when correcting for the number of comparisons ($n = 8$; corrected α required $= .0063$). There was a trend toward significance between cued recall and intrusions in the control condition, $r(18) = .40$, $p = .08$, although any association was in the opposite direction. Other comparisons were nonsignificant (highest $r = .21$ for recognition in the single key tap condition). There was also no significant correlation for either revised memory measure across all conditions combined: cued recall, $r(76) = .01$, $p = .93$, and recognition, $r(76) = -.08$, $p = .47$. These correlations remained nonsignificant when the invariant items were included.

State and Trait Dissociation Across All Conditions

State dissociation. Spontaneous changes in state dissociation from prefilm to postfilm were examined with a 2 (time: prefilm vs. postfilm) × 4 (condition) mixed ANOVA. There was a significant main effect of time, $F(1, 76) = 18.31$, $MSE = 19.90$, $p < .001$, $\eta^2 = .19$. There was no main effect of experimental condition, $F(3, 76) = 1.95$, $MSE = 86.94$, $p = .13$, and no significant interaction, $F(3, 76) = 1.58$, $MSE = 19.90$, $p = .20$. Mean DSS score increased from 5.28 ($SD = 6.68$) prefilm to 8.30 ($SD = 8.11$) postfilm (see Table 2). To assess whether increases in state dissociation were related to subsequent intrusive memories across all groups, we computed a correlation. This showed a significant effect in the predicted direction, $r(73) = .25$, $p = .03$.

Trait dissociation. A hierarchical regression was used to examine the role played by trait dissociation in conjunction with state dissociation change in the development of intrusions. The first block consisted of three dummy variables representing participants' experimental condition, as well as TDQ (trait dissociation) scores. The second block consisted of DSS (state dissociation) score change. For the total number of intrusions the first block had a significant effect, $F(4, 71) = 3.09$, $MSE = 17.54$, $p = .02$, R^2 change $= .14$. On the second step, the change in state dissociation still explained significant extra variance, $F(1, 70) = 8.01$, $MSE = 15.96$, $p = .01$, R^2 change $= .087$. In the final model, both state and trait dissociation made significant contributions to predicting total intrusions (TDQ: $\beta = .32$, $p = .004$; DSS change: $\beta = .31$, $p = .006$). The analyses were repeated with the alternative measure of trait dissociation (DES–II) instead of the TDQ. This showed that the first block no longer had a significant effect, $F(4, 71) = 2.03$, $MSE = 18.48$, $p = .10$, R^2 change $= .103$. On the second step, change in state dissociation again had a significant effect, $F(1, 70) = 8.29$, $p = .01$, R^2 change $= .095$.

Heart Rate Change and Intrusive Memories

As in Experiment 1, heart rate during the film was examined in two ways: relative to baseline and in intrusion sequences. Because heart rate was potentially confounded by the motor activity of tapping, analyses were restricted to participants in the control condition.

Overall change in heart rate. Seeking to replicate the effects of Experiment 1, we had predicted that decreases in heart rate during the film (compared with baseline) would be associated with more frequent intrusions. The correlation between number of intrusions and change in heart rate was significant, $r(18) = -.41$, $p = .04$ (one-tailed). Comparable to the previous experiment, the mean drop in heart rate from prefilm to postfilm was 3.07 ($SD = 3.09$) beats per minute. Mean heart rate was 74.24 ($SD = 9.08$) during baseline and 71.17 ($SD = 7.60$) during the film.

Heart rate during intrusive memory sequences. We also predicted, following Experiment 1, that there would be a reduction in heart rate during sequences of the film that later intruded compared with the rest of the film. This analysis was carried out with the 16 participants who reported at least one intrusion. There was sufficient information to match intrusion sequences for 88% of partic-

ipants' most significant intrusions and a further 63% of additional intrusions in the diaries. Mean heart rate during the nonintruding part of the film was 70.44 (SD = 7.77) beats per minute and 68.67 (SD = 8.14) during a participant's intrusion sequences. The mean reduction in heart rate of 1.91 beats per minute (SD = 3.08) was significant, $t(14) = 2.24$, $p = .01$ (one-tailed), $d = 0.25$.

Discussion

Experiment 2 replicated the results of Experiment 1, showing that the visuospatial tapping task carried out while encoding a trauma film appeared to protect against the subsequent development of intrusive memories compared with a no-task condition. The hypothesis that the task competes for resources in the same memory system as that responsible for intrusive visual images was supported: There was a linear relationship between increased levels of visuospatial and general attentional demands at encoding and reductions in reported intrusive memories. Even when the complex tapping task was successfully overpracticed, there was a significant reduction in reported intrusions relative to the control condition. This supports the importance of the visuospatial element of the task, as overpractice should reduce general attentional demands while largely preserving the visuospatial aspect of the task.

As in Experiment 1, we did not find support for various competing explanations of these effects. There was no difference between conditions in the negative impact of the film on self-report of mood or distress, or in ratings of attention paid to the film. Further, participants' own predictions of how each task might influence intrusion development were not in line with the actual reported intrusions. This indicates it was unlikely that demand characteristics could account for the intrusion results.

We found that recognition memory scores were better in the control condition than in either pattern tapping condition. Recognition measures are widely regarded as more sensitive than recall measures, and this finding gives some indication that pattern tapping may have interfered with encoding, as would be expected (cf. Moscovitch, 1994). However, explicit memory scores were not reliably associated with intrusion frequency.

Experiment 2 also replicated Experiment 1 in showing that increases in state dissociation while watching the film (independent of experimental condition) were associated with report of increased intrusion frequency. Both state and trait dissociation made separate contributions to this effect. The influence of trait dissociation was, however, restricted to one of the measures, the TDQ (and not the DES–II). The trait dissociation findings appear less robust than the state dissociation findings, supporting clinical research that dissociative states at the time of the trauma may be better predictors of PTSD (e.g., Ozer et al., 2003) than more general dissociative responses (Brewin, Andrews, Rose, & Kirk, 1999). We also replicated the novel effect found in Experiment 1 that within the control condition (uncontaminated by the potential confound of motor activity), relative heart rate suppression overall during the film was associated with an increase in intrusions. Experiment 2 also replicated the finding that those specific sequences in the film that were to later intrude for a given participant were associated with lower heart rate than periods of the film that did not later intrude.

It remains possible that any concurrent task, rather than a specifically visuospatial one, is sufficient to disrupt encoding in such a way as to make the occurrence of later intrusive memories less likely. Dual-representation theory (Brewin, 2001, 2003; Brewin, Dalgleish, & Joseph, 1996) in fact makes the specific prediction that concurrent verbal interference tasks should have the opposite effect and increase intrusive memories. This is because verbally accessible memories of a traumatic event, unlike the image-based memories of the situationally accessible memory system, include information about the context of the event (e.g., that it happened at a specific time and in a specific place). According to the theory, intrusive images are more likely to be triggered when there is little contextual information in memory to distinguish retrieval cues in the current environment from similar features of the traumatic event. Therefore, tasks that compete for resources involved in verbal encoding will lead to less contextual information being encoded and will increase (rather than decrease) the likelihood of intrusions.

Experiment 3

Experiment 3 tested the prediction that a concurrent task that competed for verbal processing resources would increase the number of subsequent intrusions of a trauma film. The task selected was counting backward in threes (Hellawell & Brewin, 2002; Peterson & Peterson, 1959; Vallar & Baddeley, 1982). Counting backward in threes is thought to selectively impair verbal processing as carried out by the articulatory loop of working memory (but not to impair the other slave subsystem, that is, the visuospatial scratchpad; Baddeley, 1990) and to affect rehearsal within short-term verbal memory. Counting backward in threes is thought to make greater general processing demands than articulatory suppression tasks such as repeating a single word (Vallar & Baddeley, 1982). This verbal distraction task was contrasted with a task expected to enhance (rather than interfere with) verbal encoding of the film; participants were required to describe aloud details of the film scenes while watching it. The verbal enhancement condition was expected to lead to more detailed verbal representations, including greater contextual detail, and hence should have been associated with fewer intrusive memories. Both conditions were contrasted with a no-task control. Potential demand characteristics were assessed using prediction ratings of task impact. In Experiment 3 we also sought to replicate the findings regarding dissociation and heart rate found in Experiments 1 and 2.

Method

Participants watched the trauma film under one of three concurrent task conditions: verbal distraction, verbal enhancement, or a no-task control condition. As before, participants recorded their intrusions of the film in a diary for 1 week and then returned for a follow-up session. Previous ethical procedures were followed.

Participants

Thirty-three female and 27 male student volunteers took part and were paid a small fee. Recruitment took place through advertisements on the university campus. The mean age was 26.5 (SD = 8.6 years). No participant had received treatment for a mental health problem.

Materials

The trauma film was the same as that used in Experiments 1 and 2. It was displayed on the same TV monitor as in Experiment 2.

Experimental Tasks During the Trauma Film

Verbal interference task. Participants were asked to count backward in threes from 958 throughout the film without stopping. Participants' verbalizations were audiotaped. Task compliance was assessed from accuracy in backward counting per 10 s and from the length of pausing in the counting task.

Verbal enhancement task. Participants were asked to continuously verbalize "what went through their mind" as they watched the film, including what they could see and hear, their thoughts and feelings about the film, and any memories the film evoked. Participants' verbalizations were audiotaped. Task compliance was assessed from the length of pausing in the verbalization task and by rating the type of verbalizations made as either describing the contents of the film or making statements about its meaning.

Measures

The measures were identical to those used in Experiment 2. For the demand measure, participants in the verbal interference and verbal enhancement conditions were asked at follow-up what effect they predicted their concurrent task had had on intrusions, compared with watching the film with no task, using the same rating scale as in Experiment 2.

Procedure

Experimental phase. Participants were randomly assigned to one of the three task conditions: (a) no-task (control) condition, (b) verbal interference task, or (c) verbal enhancement task. Measures were taken prefilm and postfilm as in Experiments 1 and 2.

Follow-up session. The follow-up session was conducted at 1 week as in Experiments 1 and 2. No participant was judged by the experimenter to show significant distress at follow-up, and none contacted the experimenter after the experiment ended.

Results

The data were examined for potential univariate outliers using box plots for each variable, both across all cases and within groups for analyses with grouped data. Four scores were more than 3 standard deviations from the mean and thus were changed to one unit larger or smaller than the next most extreme score in the distribution, as appropriate. Three cases were identified as multivariate outliers, of which one could be adjusted and two were deleted from multivariate analyses. Due to technical error, missing data were identified for the distress and attention paid to the film for 2 participants. One participant's diary compliance score was missing. Data were missing for 3 participants' recognition measures and 4 participants' recall measures because of faulty data storage. An alpha level of .05 was used for all statistical tests unless otherwise reported. Homogeneity of variance was assessed for independent-sample t tests using Levene's statistic.

Randomization and Manipulation Checks

Randomization check. There were no significant differences between the three experimental groups on trait dissociation (as assessed by the DES), prefilm state dissociation (DSS), or heart rate baseline ($F < 1$ in all cases). There was also no significant difference for age, $F(2, 57) = 3.07$, $MSE = 70.05$, $p = .054$, or trait dissociation (TDQ), $F(2, 57) = 1.59$, $MSE = 519.95$, $p = .21$. There was no difference in gender between conditions, $\chi^2(2, N = 60) = 0.40$, $p = .82$.

Task compliance. To assess task compliance, we audiotaped participants' speech during both verbal task conditions. Unfortunately for 4 participants (2 in each condition), their speech was not decipherable above the noise of the video. Data are presented for the remaining 36 participants. In the verbal interference condition, the mean number of errors was 6.94 ($SD = 9.77$), indicating a high level of task performance. In the verbal enhancement condition, participants spent 62% of the time describing physical features of the film, 20% describing the meaning and implications of the film, and 18% pausing for more than 2 s. There were significantly more pauses in the verbal enhancement condition than in the verbal interference condition, $F(1, 34) = 9.71$, $MSE = 75.10$, $p = .004$, $\eta^2 = .22$, and these pauses were of longer duration, $F(1, 34) = 5.12$, $MSE = 8.05$, $p = .03$, $\eta^2 = .13$.

The overall mean rating for diary compliance was 2.02 ($SD = 1.61$), indicating that most intrusions were recorded (see Table 3). There was no significant difference between conditions on rated diary compliance, $F(2, 56) = 1.64$, $MSE = 2.55$, $p = .20$.

Effects of Experimental Condition

Intrusions of the film over 1 week. Overall, the mean total number of intrusions reported in 1 week was 5.97 ($SD = 7.14$), and the range was 0 to 36 intrusions. As shown in Table 3, there was a significant difference in the number of intrusions between experimental conditions, $F(2, 57) = 5.11$, $MSE = 44.77$, $p = .01$, $\eta^2 = .15$. As predicted, participants in the verbal interference condition reported significantly more intrusions than those in the control condition, $t(23.4) = 2.66$, $p = .01$, $d = 1.18$. There was a nonsignificant trend between the verbal enhancement condition and the control condition, $t(37.88) = 1.81$, $p = .08$, in the opposite direction to that predicted. There was a nonsignificant trend between the verbal interference condition and the verbal enhancement condition, $t(22.96) = 1.87$, $p = .08$, $d = 0.59$, in which, as predicted, there were more reported intrusions after verbal distraction than after verbal enhancement.

Demand characteristics. Participants in the verbal interference condition rated the impact of the concurrent task as likely to reduce rather than increase intrusions ($M = -3.79$, $SD = 5.26$). In contrast, participants in the verbal enhancement condition rated the impact of the concurrent task as likely to increase intrusions ($M = 2.21$, $SD = 5.26$); see Table 3 for ease of comparison with actual intrusion frequency.

Mood and distress ratings. Viewing the film resulted in a deterioration of mood ratings (see Table 3). Using a 2×3 mixed ANOVA we found significant main effects prefilm to postfilm for depressed mood, $F(1, 57) = 20.27$, $MSE = 1.74$, $p < .001$, $\eta^2 = .26$, and happiness, $F(1, 57) = 82.66$, $MSE = 1.45$, $p < .001$, $\eta^2 = .59$. There was a trend for an increase in anger, $F(1, 57) = 3.62$, $MSE = 2.21$, $p = .062$, $\eta^2 = .60$, and no main effect of anxiety, $F(1, 57) = 0.55$, $p = .46$. There were no significant effects of experimental condition for any mood ($F < 1$) except for anxiety, $F(2, 57) = 1.07$, $MSE = 7.99$, $p = .35$. There were no significant interactions between condition and mood: For interactions be-

Table 3
Task Manipulation and Outcome Measures From Experiment 3 for Each Experimental Condition

Measure	No-task control *M*	No-task control *SD*	Verbal interference *M*	Verbal interference *SD*	Verbal enhancement *M*	Verbal enhancement *SD*
Diary compliance	1.50	1.05	2.37	1.92	2.20	1.70
Total no. of intrusions	3.10	3.60	9.70	10.47	5.10	3.40
Depression						
Prefilm	1.65	2.13	1.70	2.22	2.10	2.33
Postfilm	2.60	2.39	3.40	2.66	2.70	1.94
Anger						
Prefilm	0.20	0.41	0.85	1.63	1.25	2.22
Postfilm	1.10	2.45	1.30	2.08	1.45	2.28
Happiness						
Prefilm	5.40	2.04	5.85	1.73	5.35	1.63
Postfilm	3.15	2.43	3.85	2.43	3.60	1.27
Anxiety						
Prefilm	2.75	2.10	3.10	2.26	3.05	2.23
Postfilm	2.50	2.14	4.00	2.12	3.05	2.81
Distress during film	4.50	3.03	4.80	2.38	4.45	1.88
Attention paid to film	8.94	1.59	7.50	1.28	9.20	0.95
Recall measure	7.44	1.95	7.63	2.11	8.16	2.32
Recognition measure	9.63	2.73	9.05	2.70	10.58	2.41
Change in state dissociation prefilm to postfilm	4.90	7.87	6.30	7.44	4.25	6.27
Predicted task impact within condition			−3.79	5.26	2.21	5.26

tween condition and both anger and happiness, $F < 1$; for the interaction with depressed mood, $F(2, 57) = 1.82$, $MSE = 1.74$, $p = .17$; for the interaction with anxiety, $F(2, 57) = 1.44$, $MSE = 0.55$, $p = .25$.

Participants also rated how distressing they found watching the film (see Table 3). Viewing the film was rated as equally distressing across conditions ($M = 4.59$, $SD = 2.41$), $F(2, 55) = 0.12$, $p = .89$.

Attention and memory for the film. There was a significant group difference in the amount of attention participants rated they paid to the film, $F(2, 55) = 10.04$, $MSE = 1.66$, $p = .004$, $\eta^2 = .27$ (see Table 3). The overall mean rating was 8.53 ($SD = 1.48$). Further examination showed that participants reported paying significantly less attention to the film during the verbal interference condition than during both the control, $t(55) = 3.45$, $p = .001$, $d = 0.91$, and verbal enhancement conditions, $t(55) = 4.18$, $p < .001$, $d = 1.51$. The verbal enhancement and control conditions did not differ, $t(55) = 0.61$, $p = .54$.

At follow-up, participants completed recall and recognition measures for the film (see Table 3). Examination of these measures, as in Experiments 1 and 2, revealed several invariant items. On the cued recall measure, percentage correct ranged from 13% to 84%, with one item being markedly skewed. On the recognition measure, percentage correct ranged from 23% to 94%, with five items being markedly skewed. These six items were removed in the subsequent analysis. On the cued recall and recognition measures, the modal scores were 8 and 11, respectively, indicating that approximately 57% and 73% of questions were answered correctly. Mean scores on each measure were 7.75 ($SD = 2.11$) and 9.75 ($SD = 2.65$), respectively (see Table 3). No difference was found between the three conditions on the cued recall measure, $F(2, 53) = 0.56$, $p = .57$, or the recognition measure, $F(2, 54) = 1.65$, $MSE = 6.85$, $p = .20$. The recall results are the same as those found before removal of the invariant item. However, for the recognition measure before removal of the invariant items, there was a significant difference between conditions, $F(2, 54) = 4.41$, $MSE = 6.10$, $p = .017$, $\eta^2 = .14$. Recognition scores were higher in the verbal enhancement than in both the control, $t(54) = 2.04$, $p = .047$, $d = 0.62$, and verbal interference conditions, $t(54) = 2.89$, $p = .006$, $d = 0.41$. There was no significant difference between the control and verbal interference conditions, $t(54) = 0.85$, $p = .40$. However, although better recognition memory would be expected after verbal enhancement, these results should be considered cautiously given that any effect disappeared when insensitive items were removed.

Correlations between the two explicit memory measures with the number of intrusive memories were examined. Neither were related to the frequency of intrusive memories in any experimental condition (largest $r[15] = .38$, $p = .13$, for recall in the verbal interference condition). There were no significant correlations between either explicit memory score with intrusions across all conditions combined: recognition, $r(53) = .08$, $p = .56$, and cued recall, $r(52) = .04$, $p = .80$. The pattern of results is the same when the invariant items are included.

State Dissociation Across All Conditions

Spontaneous changes in state dissociation scores from prefilm to postfilm were examined. Using a 2 (time: prefilm vs. postfilm) × 3 (condition) mixed ANOVA, there was a significant main effect

of time, $F(1, 57) = 31.30$, $MSE = 24.29$, $p < .001$, $\eta^2 = .35$. There was no main effect of experimental condition, $F(2, 57) = 0.48$, $p = .62$, and no significant interaction, $F(2, 57) = 0.30$, $p = .74$. The mean DSS score increased from 3.31 ($SD = 4.10$) prefilm to 8.35 ($SD = 9.46$) postfilm (see Table 3). To assess whether increases in state dissociation had the predicted general effect on intrusions, we computed a correlation across all conditions combined. This correlation was not significant, $r(58) = .10$, $p = .23$ (one-tailed), indicating a failure to replicate the equivalent finding in Experiments 1 and 2.

Heart Rate Change and Intrusive Memories

Because heart rate may have been influenced by speech motor activity in the two verbal conditions, analyses were conducted in the control condition alone. This strategy follows the conservative approach taken in Experiments 1 and 2, where heart rate data from tapping conditions, which also involved motor activity, were not analyzed. Heart rate was examined in two ways, as in Experiments 1 and 2.

Overall change in heart rate. A correlation was computed between the number of intrusions and change in average heart rate from baseline to during the film. A nonsignificant association was found in the direction opposite to that predicted, $r(18) = .38$, where $p = .10$ (two-tailed), whereas according to the prediction made, $p = .90$ (one-tailed). Comparable to the previous experiment, the mean drop in heart rate from prefilm to postfilm was 2.87 ($SD = 4.66$) beats per minute. The mean heart rate was 73.21 ($SD = 11.33$) during baseline and 70.34 ($SD = 11.11$) during the film.

Heart rate during intrusive memory sequences. As in Experiments 1 and 2 we investigated heart rate during moments in the film that each participant later reported experiencing as intrusions. This analysis was carried out with the 13 participants in the control condition who reported at least one intrusion. There was sufficient information to match film sequences with intrusions for 70% of participants' most significant intrusions and a further 63% of additional intrusions. Mean heart rate during the nonintruding part of the film was 73.31 ($SD = 11.06$) beats per minute and that during a participant's intrusion sequences was 68.96 ($SD = 12.54$). The mean reduction in heart rate of 4.35 beats per minute ($SD = 9.25$) exceeded that in Experiments 1 and 2, but the predicted difference fell slightly short of significance, owing possibly to the small sample size, $t(10) = 1.56$, $p = .075$ (one-tailed), $d = 0.40$.

Discussion

The major finding of Experiment 3 was that the verbal interference task led to a significant increase in reported intrusions of the trauma film compared with a no-task control condition. This did not appear to be due to demand characteristics, as participants expected the task to have the opposite effect. These results support our prediction that a task that competes for resources with the system supporting verbal memories (the VAM system) will lead to an increased number of intrusions as reported in a diary. These data are important because they point to the specific content of the competing tasks as being critical rather than some more general process such as distraction. This is consistent with finding no difference between the verbal interference and control condition on either explicit memory measure, though it is possible these were too insensitive, despite the removal of invariant items.

The results of Experiment 3 did not show that the verbal enhancement condition led to the predicted reduction in the number of intrusions. There may be several reasons for this. First, compliance was not perfect. Participants in this condition paused for significantly longer than those in the verbal interference condition. The enhancement task thus may not have been robust or well practiced enough to succeed in creating verbal representations adequate to suppress later intrusions at all time points. Second, the verbalizations indicated that participants were predominantly describing the physical features rather than the meaning of events associated with the film. A narrative richer in meaning might be associated with greater suppression of intrusions.

Experiment 3 failed to replicate the findings of Experiments 1 and 2 concerning state dissociation. It may be that these findings do not indicate a robust effect. Alternatively, it is possible that the verbal tasks and dissociative responses affect the encoding of trauma information via the same mechanism, obscuring any effect of dissociation on intrusions.

With respect to heart rate, the expected association between an overall drop in heart rate and later intrusions was not found, and it is difficult to speculate further given the small sample size. However, there was some indication that heart rate during specific film sequences that would later intrude was again lower than during the rest of the film, with the magnitude of decrease consistent with Experiments 1 and 2.

General Discussion

This series of experiments has produced patterns of findings that shed light on the mechanisms underlying spontaneous intrusive memories of traumatic material. Our data clearly establish that processes at encoding are indeed critical in influencing the likelihood of later reported intrusions, presumably because they affect the representations that individuals form of the event. Whereas a competing visuospatial task during a trauma film appeared to significantly reduce later intrusions of it, a competing verbal task appeared to increase intrusions. Spontaneous increases in state dissociation and overall drops in heart rate while watching the film were associated with later intrusions in two out of three studies, and these relationships did not depend on participants' experimental condition. The importance of events at encoding is further underscored by the finding that heart rate was lower at the time individuals were watching sections of the trauma film that later returned as spontaneous intrusions than during the rest of the film.

To our knowledge this is the first time traditional measures of explicit memory and measures of spontaneous intrusive memories for the same material have been collected in the same study. At the level of the experimental group, our manipulations had strong effects on reported intrusions. In contrast, there was rarely an effect on recall or recognition, although it is possible that the measures were insufficiently sensitive. At an individual level, recall and recognition measures appeared unrelated to the number of intrusive memories reported in participants' diaries. This suggests that studies of spontaneous intrusive memories are likely to yield different insights into memory. Theories developed to explain patterns of recall and recognition may be insufficient to explain intrusions.

Most existing theoretical accounts of emotional memory or posttraumatic stress disorder might struggle to explain the results we have reported. As previously mentioned, one possible account of the finding that visuospatial tasks reduced subsequent intrusions as reported in a diary is that such tasks are distracting and lead to a general impairment in encoding that reduces the amount of material in memory available to be triggered by retrieval cues. There is little support for this account in the current data, as a different distracting task (verbal distraction) led to a significant increase (rather than decrease) in intrusions. Given the well-documented effects of emotional arousal on enhancing explicit memory (e.g., Cahill, 1997), it might also be suggested that the visuospatial tasks led to a reduction in levels of arousal. However, our manipulations produced changes in intrusions without reliably affecting mood ratings, recall, or recognition. It is possible that all of these measures were insensitive. If so, it would be necessary to assume the visuospatial task (associated with fewer intrusions) reduced arousal whereas the verbal distraction task (associated with more intrusions) had the opposite effect on arousal, which seems unlikely.

Dual-representation theory (Brewin, 2001; Brewin, Dalgleish, & Joseph, 1996) provided a basis for the predictions that have driven this series of experiments. The theory has similarities to other general and clinical theoretical frameworks proposing that there are different memory systems, broadly visual and verbal, as discussed previously. It was hypothesized that a visuospatial tapping task would specifically impoverish SAM representations and result in poorer encoding of some perceptual details, making the representations less likely to be accessed by reminders, and thus less likely to intrude during the following week. Experiments 1 and 2 together provided support for the idea that the complex pattern tapping task competed for limited resources within a mechanism responsible for encoding visuospatial features. From dual-representation theory we also hypothesized that competition for resources used to encode material into the VAM system, by a concurrent verbally loaded task, would specifically impoverish VAM representations and reduce their ability to suppress subsequent intrusive images. This would lead to more frequent intrusions. Although this prediction was supported, the studies have not shed light on the specific mechanism whereby impoverishing VAM representations might have this effect. One possibility is that there may have been reduced retrieval competition from VAM memories when trauma reminders were subsequently encountered.

Several other authors have also addressed the relationship between memory and PTSD (Conway & Pleydell-Pearce, 2000; Ehlers & Clark, 2000; Foa & Hearst-Ikeda, 1996). They have proposed that disturbed encoding, brought about for example, by a dissociative state at the time of the trauma, is likely to produce more fragmented representations and more frequent intrusive memories. Conway and Pleydell-Pearce (2000) suggested that trauma memories in which perceptual details were poorly integrated into the overall representation would be more vulnerable to being accessed by a match between those details and corresponding retrieval cues encountered after the trauma. Research relating the direct, unintentional retrieval of sensory–perceptual–affective episodic memory to goals of the working self (Conway, 2001) has clear relevance to the study of intrusive memories in the context of trauma.

Our data provide partial support for these theories and are also consistent with several cross-sectional and longitudinal clinical studies that have found an association between the occurrence of dissociative responses at the time of the trauma and an increased risk for PTSD (Ozer et al., 2003). Unlike dual-representation theory, most of the above theories do not, however, appear to predict that some other forms of disturbed encoding might decrease rather than increase the probability of later intrusive images of a trauma. Our data imply that a single explanation for the effects of competing tasks, in terms of distraction, disturbed encoding, and so on, is unlikely to account for intrusive memory development.

Another theory that at first glance might appear consistent with our effect of the verbal task in increasing intrusions is found in Wegner’s work on the ironic effects of mental control (Wegner, 1994). In short, the deliberate suppression of material can be associated with a later “rebound” of intrusions of that material. This effect is exacerbated under conditions of concurrent cognitive load. However, this theory does not appear to account for the reduction of intrusions following the visuospatial task. Our results appear more consistent with the dual-representation theory of PTSD and with other theories proposing parallel memory systems that could be differentially affected by our interventions.

In their recent clinically oriented, cognitive model of PTSD, Ehlers and Clark (2000) suggested that processes at encoding might affect intrusive memory development. Citing the distinction between “data-driven” and “conceptual” processing made by Roediger and McDermott (1993), they proposed that processing information in a predominantly data-driven manner was likely to increase intrusive memories of a trauma. Data processed more conceptually were less likely to intrude. Our findings may therefore be consistent with this model, if the assumption is made that a competing visuospatial task selectively disrupts data-driven processing whereas counting backward in threes selectively disrupts conceptual processing.

One of our most novel findings was that reductions in heart rate during the film not only predicted the occurrence of intrusions between individuals but, even more strikingly, were associated with the scenes that specific individuals later reported having experienced as intrusions. A full theoretical account of why intrusions may be associated with decreased heart rate (bradycardia) remains to be developed. One possibility is that reductions in heart rate and blood pressure are an adaptive dissociative response designed to aid freezing and to conserve resources in the face of overwhelming threat (Nijenhuis et al., 1998). Bradycardia has been observed in another anxiety disorder, blood phobia. Within a stressful film paradigm, reductions in heart rate have been linked to a similar conservation–withdrawal response in such individuals faced with injury or blood loss (Steptoe & Wardle, 1988). Although many of the scenes in our trauma film did contain blood and injury, the blood phobia explanation would not account for all of the sequences that were likely to intrude (e.g., a fireman carrying a baby).

The orienting response to any novel or meaningful stimulus is also characterized by a brief, transient bradycardia. Unlike neutral or positive pictures, aversive pictures (including corpses, as in our film) have been found to lead to sustained (i.e., lasting several seconds) rather than merely transient bradycardias (Lang et al., 1997). The more arousing aversive pictures were judged to be, the greater were the bradycardias, a finding that contrasts with the

traditional defense reaction of heart rate acceleration thought to occur to extremely aversive nonpicture stimuli (Campbell, Wood, & McBride, 1997). *Aversively motivated attending* may allow stimuli to be processed in more detail. Interestingly, Lang et al. (1997) argued that this reaction to aversive slide stimuli resembles the “fear bradycardia” widely observed in animals who freeze in response to threat, and that it may be evolutionarily advantageous to be immobile but primed to respond, particularly when immediate escape is not possible. This suggestion is similar to that of the dissociation theorists. From the perspective of dual-representation theory, it is plausible that bradycardia is a response associated with enhanced input into the SAM system and reduced input into the VAM system. Brief episodes of bradycardia may correspond to clinical descriptions of “hot spots” in the trauma narrative of a patient with PTSD, moments that are particularly likely to figure as intrusive memories and that are associated with intense emotions (Grey et al., 2001; Grey, Young, & Holmes, 2002; Holmes et al., in press).

Witnessing a trauma film is a situation where an active defense reaction is not appropriate and the participant cannot “escape” without terminating the experiment. The participant may therefore be more likely to respond with heart rate deceleration rather than acceleration. Thus, our results could be due to dissociative processing, attending to stimuli (orienting), or possibly both. Clinical observations suggest that some types of dissociative process involve orienting. For example, when patients with PTSD report feeling “unreal,” they may describe having had heightened visual and auditory perception. Their attentional focus appears typically not on their own bodies but, for example, on a detail in a room during a rape or on the sky while trapped in car wreckage. Intensely focusing on such external stimuli (analogous to our dot-staring task) may lead to feelings of derealization or depersonalization as attention is taken away from internal physical sensations or emotions that are normally involved in creating an ongoing sense of self. Such external sensory engagement may also be at the expense of the resources available for more verbal or conceptual processing (Brewin, Dalgleish, & Joseph, 1996; Ehlers & Clark, 2000), leading to a greater probability of subsequent intrusions.

An account of intrusion development in which attention was a mediating factor would also suggest that intrusions could arise from “attention grabbing” or novel experiences that were highly positive, not just traumatic. Further research is required on attentional deployment during film material and intrusion development, using films of both positive and traumatic nature. Our current measure of attention was limited to self-report, and more sophisticated measures should be used.

Our series of experiments has a number of limitations. Although the film was unpleasant and dealt with real-life incidents, its impact must have been considerably lessened by being viewed remotely within a controlled context. Although this limitation is inherent in analog studies, pioneers of the trauma film paradigm have used it to advance clinical theory (Horowitz, 1969; Lazarus et al., 1965). The film used does fulfill *DSM–IV* (American Psychiatric Association, 1994) diagnostic criterion A1 for a traumatic event, in that participants witnessed actual death and suffering. It was rated as stressful and led to negative mood changes, and the intrusions were reported as unwanted and distressing. The nature of the intrusions, such as the high proportion of images and the presence of both snapshots, sometimes involving specific details, and film sequences, is similar to those intrusions described in actual PTSD (Ehlers & Steil, 1995). The number of types of images was similar to that reported after real trauma. These data suggest some ecological validity of the paradigm. Indeed, such considerations mean care is required in terms of ensuring the experiments are conducted with appropriate ethical consideration. Further, recent research has shown that children in London exposed to television film coverage of the traumatic events in the United States of September 11, 2001, experienced intrusive visual imagery of this trauma viewed indirectly. Intrusions were associated with levels of PTSD-type symptoms (Holmes, Creswell, & O’Connor, 2004). However, these arguments clearly do not definitively demonstrate the generalizability of research on analog trauma to real trauma. Convergent evidence from a variety of methodologies would be optimal.

Another possible limitation in our experiments was the use of diaries to assess the main dependent variable (intrusions). Intrusion diaries have been regularly used in clinical psychology research attempting to explore this phenomenon (e.g., Brewin & Saunders, 2001; Butler, Wells, & Dewick, 1995; Davies & Clark, 1998). Diary methodology is not easy to evaluate according to standard psychometric theory, as there are no external criteria of validity and standard measures of reliability are inappropriate. We believe nevertheless that diaries offer a potentially more accurate method of assessment than overall ratings of intrusion frequency administered at follow-up. This judgment was supported by the compliance data and by the consistent pattern of theoretically predicted results that suggested that the measure had adequate construct validity. One potential drawback of using diaries is that self-report of experiencing intrusions may be liable to demand effects (Baddeley & Andrade, 2000); however, Experiments 2 and 3 indicated that these were not in evidence in our study.

It would be valuable to supplement the current experiments with similar studies using alternative emotional film material. This should be both trauma related and non–trauma related, particularly because there are several reports of the existence of positive intrusive memories (Berntsen, 1996, 2001; Brewin, Christodoulides, & Hutchinson, 1996). For example, in Berntsen’s (1996) diary study of healthy college students, the emotional valence of involuntary memories was more likely to be positive than negative. Neither dual-representation theory nor the results presented here imply that our findings are necessarily unique to traumatic material. The wider study of emotional memory would be considerably enhanced by investigating whether highly positive material recruits similar mechanisms as does highly negative material. As discussed above, it would be interesting to explore the potential mediating role of attention (orienting) to novel stimuli in intrusion development.

Further experiments should also attempt to implement the dual tasks theoretically predicted to interfere with encoding into the SAM and VAM systems within the same study, rather than within separate studies. For example, the baseline rate of intrusions in the control condition varies across the three experiments presented here. This variation may be partially attributable to our screening for dissociative ability in Experiment 1. Although we were able to replicate the effect of the visuospatial task in Experiment 2, the visuospatial tapping task and the verbal task should be compared against a control condition within the same experiment. Ideally

such an experiment should also investigate extremely positive as well as traumatic material. However, it may prove a challenge to identify material that is perceived as highly positive across participants to compare with a trauma film. Future experiments could also refine measures of explicit memory and use further physiological indices. Finally, interpretation of the results in terms of verbal and visuospatial processes also requires follow-up studies that replicate the pattern of findings using alternative tasks.

PTSD provided a springboard for the current experiments. However, the relevance of our experimental findings may not be limited to trauma. Intrusion development may occur in other domains, including after positive experiences. Intrusive image development may be relevant to several other psychological disorders, for example, in the context of worry (generalized anxiety disorder, Borkovec & Inz, 1990; insomnia, Nelson & Harvey, 2002), and images may intrude of various types of threat (social phobia, Hackmann, Clark, & McManus, 2000; agoraphobia, Day, Holmes, & Hackmann, in press).

This series of experiments supports clinical claims concerning the centrality of encoding processes in predicting intrusive memories and some specific predictions made by the dual-representation theory of PTSD. We found that both experimental manipulations and individual differences in mental and physiological responses while watching a trauma film were related to the development of later intrusive visual images. Importantly, the results suggest that despite the significant gap between analog and real trauma, it may be possible to model some peritraumatic processes in the laboratory. The data point to the need for theories of emotional memory to address intrusive memory phenomena as well as standard measures of explicit memory such as recall and recognition. How different competing tasks may interact with individual components of the memory system should also be considered. Likely to be of clinical relevance is the confirmation that performing a concurrent visuospatial task is able to hinder the development of intrusions following exposure to trauma stimuli. Further work is needed to locate more precisely the aspect of the task responsible for this effect, which may prove to be valuable in both preventing and controlling unwanted intrusive symptoms.

References

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Andrade, J., Kavanagh, D., & Baddeley, A. (1997). Eye-movements and visual imagery: A working memory approach to the treatment of post-traumatic stress disorder. *British Journal of Clinical Psychology, 36,* 209–223.

Baddeley, A. (1990). *Human memory: Theory and practice.* Hove, England: Erlbaum.

Baddeley, A. D., & Andrade, J. (2000). Working memory and the vividness of imagery. *Journal of Experimental Psychology: General, 129,* 126–145.

Berntsen, D. (1996). Involuntary autobiographical memories. *Applied Cognitive Psychology, 10,* 435–454.

Berntsen, D. (2001). Involuntary memories of emotional events: Do memories of traumas and extremely happy events differ? *Applied Cognitive Psychology, 15,* S135–S158.

Borkovec, T. D., & Inz, J. (1990). The nature of worry in generalized anxiety disorder: A predominance of thought activity. *Behaviour Research and Therapy, 28,* 153–158.

Bremner, J. D., Krystal, J. H., Putnam, F. W., Southwick, S. M., Marmar, C., Charney, D. S., & Mazure, C. M. (1998). Measurement of dissociative states with the clinician-administered dissociative states scale (CADSS). *Journal of Traumatic Stress, 11,* 125–136.

Brewin, C. R. (1998). Intrusive autobiographical memories in depression and posttraumatic stress disorder. *Applied Cognitive Psychology, 12,* 359–370.

Brewin, C. R. (2001). A cognitive neuroscience account of posttraumatic stress disorder and its treatment. *Behaviour Research and Therapy, 39,* 373–393.

Brewin, C. R. (2003). *Post-traumatic stress disorder: Malady or myth?* New Haven, CT: Yale University Press.

Brewin, C. R., Andrews, B., Rose, S., & Kirk, M. (1999). Acute stress disorder and posttraumatic stress disorder in victims of violent crime. *American Journal of Psychiatry, 156,* 360–366.

Brewin, C. R., Christodoulides, J., & Hutchinson, G. (1996). Intrusive thoughts and intrusive memories in a nonclinical sample. *Cognition and Emotion, 10,* 107–112.

Brewin, C. R., Dalgleish, T., & Joseph, S. (1996). A dual representation theory of posttraumatic stress disorder. *Psychological Review, 103,* 670–686.

Brewin, C. R., & Holmes, E. A. (2003). Psychological theories of posttraumatic stress disorder. *Clinical Psychology Review, 23,* 339–376.

Brewin, C. R., & Saunders, J. (2001). The effect of dissociation at encoding on intrusive memories for a stressful film. *British Journal of Medical Psychology, 74,* 467–472.

Brown, R., & Kulik, J. (1977). Flashbulb memories. *Cognition, 5,* 73–99.

Butler, G., Wells, A., & Dewick, H. (1995). Differential effects of worry and imagery after exposure to a stressful stimulus: A pilot study. *Behavioural and Cognitive Psychotherapy, 23,* 45–56.

Cahill, L. (1997). The neurobiology of emotionally influenced memory: Implications for understanding traumatic memory. In R. Yehuda & A. C. McFarlane (Eds.), *Annals of the New York Academy of Sciences: Vol. 821. Psychobiology of posttraumatic stress disorder* (pp. 238–246). New York: New York Academy of Sciences.

Campbell, B. A., Wood, G., & McBride, T. (1997). Origins of orienting and defensive responses: An evolutionary perspective. In P. J. Lang, R. F. Simons, & M. T. Balaban (Eds.), *Attention and orienting: Sensory and motivational processes* (pp. 41–68). Mahwah, NJ: Erlbaum.

Carlson, E. B., & Putnam, F. W. (1993). An update on the Dissociative Experiences Scale. *Dissociation, 6,* 16–27.

Conway, M. A. (2001). Sensory-perceptual episodic memory and its context: Autobiographical memory. *Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences, 356,* 1375–1384.

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review, 107,* 261–288.

Davies, M., & Clark, D. (1998). Predictors of analogue post-traumatic intrusive cognitions. *Behavioural and Cognitive Psychotherapy, 26,* 303–314.

Day, S. J., Holmes, E. A., & Hackmann, A. (in press). The occurrence of imagery and its link with early memories in agoraphobia. *Memory.*

Ehlers, A., & Clark, D. M. (2000). A cognitive model of posttraumatic stress disorder. *Behaviour Research and Therapy, 38,* 319–345.

Ehlers, A., Hackmann, A., Steil, R., Clohessy, S., Wenninger, K., & Winter, H. (2002). The nature of intrusive memories after trauma: The warning signal hypothesis. *Behaviour Research and Therapy, 40,* 995–1002.

Ehlers, A., & Steil, R. (1995). Maintenance of intrusive memories in posttraumatic stress disorder: A cognitive approach. *Behavioural and Cognitive Psychotherapy, 23,* 217–249.

Engelhard, I. M., van den Hout, M. A., Kindt, M., Arntz, A., & Schouten, E. (2003). Peritraumatic dissociation and posttraumatic stress after pregnancy loss: A prospective study. *Behaviour Research and Therapy, 41,* 67–78.

Foa, E. B., & Hearst-Ikeda, D. (1996). Emotional dissociation in response to trauma: An information processing approach. In L. K. Michelson & W. J. Ray (Eds.), *Handbook of dissociation: Theoretical, empirical, and clinical perspectives* (pp. 207–224). New York: Plenum Press.

Frischholz, E. J., Braun, B. G., Sachs, R. G., Hopkins, L., Shaeffer, D. M., Lewis, J., et al. (1990). The Dissociative Experiences Scale: Further replication and validation. *Dissociation, 3*, 151–153.

Grey, N., Holmes, E., & Brewin, C. R. (2001). Peritraumatic emotional “hotspots” in traumatic memory: A case series of patients with posttraumatic stress disorder. *Behavioural and Cognitive Psychotherapy, 29,* 367–372.

Grey, N., Young, K., & Holmes, E. (2002). Cognitive restructuring within reliving: A treatment for peritraumatic emotional “hotspots” in posttraumatic stress disorder. *Behavioural and Cognitive Psychotherapy, 30,* 37–56.

Griffin, M. G., Resick, P., & Mechanic, M. (1997). Objective assessment of peritraumatic dissociation: Psychophysiological indicators. *American Journal of Psychiatry, 154,* 1081–1088.

Hackmann, A., Clark, D. M., & McManus, F. (2000). Recurrent images and early memories in social phobia. *Behaviour Research and Therapy, 38,* 601–610.

Hariri, A. R., Bookheimer, S. Y., & Mazziotta, J. C. (2000). Modulating emotional responses: Effects of a neocortical network on the limbic system. *Neuroreport, 11,* 43–48.

Hellawell, S., & Brewin, C. R. (2002). A comparison of flashbacks and ordinary autobiographical memories of trauma: Cognitive resources and behavioural observations. *Behavior Research and Therapy, 40,* 1139–1152.

Holmes, E. A. (2000). *Peritraumatic processing and the development of intrusions.* Unpublished doctoral dissertation, Royal Holloway, University of London, London, United Kingdom.

Holmes, E. A., Creswell, C., & O’Connor, T. G. (2004). *Imagery and post-traumatic stress type symptoms in London school children following 11th September 2001.* Manuscript submitted for publication.

Holmes, E. A., Grey, N., & Young, K. (in press). Intrusive images and “hotspots” of trauma memories in posttraumatic stress disorder: An exploratory investigation of emotions and cognitive themes. *Journal of Behavior Therapy and Experimental Psychiatry.*

Horowitz, M. (1969). Psychic trauma: Return of images after a stress film. *Archives of General Psychiatry, 20,* 552–559.

Johnson, M. K. (1983). A multiple-entry, modular memory system. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 17, pp. 81–123). New York: Academic Press.

Johnson, M. K., & Multhaup, K. S. (1992). Emotion and MEM. In S. Å. Christianson (Ed.), *Handbook of emotion and memory* (pp. 33–66). Hillsdale, NJ: Erlbaum.

Kavanagh, D. J., Freese, S., Andrade, J., & May, J. (2001). Effects of visuospatial tasks on desensitization to emotive memories. *British Journal of Clinical Psychology, 40,* 267–280.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). Motivated attention: Affect, activation, and action. In P. J. Lang, R. F. Simons, & M. T. Balaban (Eds.), *Attention and orienting: Sensory and motivational processes* (pp. 97–135). Mahwah, NJ: Erlbaum.

Lazarus, R. S., Opton, E. M., Nomikos, M. S., & Rankin, N. O. (1965). The principle of short-circuiting of threat: Further evidence. *Journal of Personality, 33,* 622–635.

Leonard, K. N., Telch, M. J., & Harrington, P. J. (1999). Dissociation in the laboratory: A comparison of strategies. *Behaviour Research and Therapy, 37,* 49–61.

Leonard, K. N., Telch, M. J., & Owen, K. K. (2000). Fear response to dissociation challenge. *Anxiety, Stress, and Coping, 13,* 355–369.

Logie, R. H. (1986). Visuo-spatial processing in working memory. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 38*(A), 229–247.

Miyake, A., Friedman, N. P., Rettinger, D. A., Shah, P., & Hegarty, M. (2001). How are visuospatial working memory, executive functioning, and spatial abilities related? A latent-variable analysis. *Journal of Experimental Psychology: General, 130,* 621–640.

Moar, I. (1978). *Mental triangulation and the nature of internal representations of space.* Unpublished doctoral thesis, University of Cambridge, Cambridge, United Kingdom.

Moscovitch, M. (1994). Cognitive resources and dual-task interference effects at retrieval in normal people: The role of the frontal lobes and medial temporal cortex. *Neuropsychology, 8,* 524–534.

Murray, J. (1997). *The role of dissociation in the development and maintenance of post-traumatic stress disorder.* Unpublished doctoral dissertation, Oxford University, Oxford, England.

Murray, J., Ehlers, A., & Mayou, R. (2002). Dissociation and posttraumatic stress disorder: Two prospective studies of road traffic accident survivors. *British Journal of Psychiatry, 180,* 363–368.

Nelson, J., & Harvey, A. (2002). The differential functions of imagery and verbal thought in insomnia. *Journal of Abnormal Psychology, 111,* 665–669.

Nijenhuis, E. R. S., Vanderlinden, J., & Spinhoven, P. (1998). Animal defensive reactions as a model for trauma-induced dissociative reactions. *Journal of Traumatic Stress, 11,* 243–260.

Orr, S. P., Lasko, N. B., Shalev, A. Y., & Pitman, R. K. (1995). Physiologic responses to loud tones in Vietnam veterans with posttraumatic stress disorder. *Journal of Abnormal Psychology, 104,* 75–82.

Ozer, E. J., Best, S. R., Lipsey, T. L., & Weiss, D. S. (2003). Predictors of posttraumatic stress disorder and symptoms in adults: A meta-analysis. *Psychological Bulletin, 129,* 52–73.

Paivio, A. (1971). *Imagery and verbal processes.* New York: Holt, Rinehart & Winston.

Peterson, L. R., & Peterson, M. J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology, 58,* 193–198.

Pillemer, D. B. (1998). *Momentous events, vivid memories.* Cambridge, MA: Harvard University Press.

Pillemer, D. B., & White, S. H. (1989). Childhood events recalled by children and adults. In H. W. Reese (Ed.), *Advances in child development and behavior* (Vol. 21, pp. 297–340). Orlando, FL: Academic Press.

Pitman, R. K., Orr, S. P., Forgue, D. F., Altman, B., de Jong, J. B., & Hert, L. R. (1990). Psychophysiologic responses to combat imagery of Vietnam veterans with posttraumatic stress disorder versus other anxiety disorders. *Journal of Abnormal Psychology, 99,* 49–54.

Quinn, G., & McConnell, J. (1996). Irrelevant pictures in visual working memory. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 49*(A), 200–215.

Roediger, H. L., & McDermott, K. B. (1993). Implicit memory in normal human subjects. In H. Spinnler & F. Boller (Eds.), *Handbook of neuropsychology* (Vol. 8, pp. 63–131). Amsterdam: Elsevier.

Schooler, J. W. (2002). Verbalization produces a transfer inappropriate processing shift. *Applied Cognitive Psychology, 16,* 989–997.

Schooler, J. W., & Engstler-Schooler, T. Y. (1990). Verbal overshadowing of visual memories: Some things are better left unsaid. *Cognitive Psychology, 22,* 36–71.

Schooler, J. W., Fiore, S. M., & Brandimonte, M. A. (1997). At a loss from words: Verbal overshadowing of perceptual memories. In D. L. Medin (Ed.), *The psychology of learning and motivation* (Vol. 37, pp. 291–339). New York: Academic Press.

Shalev, A. T., Peri, T., Canetti, L., & Schreiber, S. (1996). Predictors of PTSD in injured trauma survivors: A prospective study. *American Journal of Psychiatry, 153,* 219–225.

Steil, R. I. (1996). *Posttraumatische Intrusionen nach Verkehrsunfällen*

[Posttraumatic intrusions after road traffic accidents]. Frankfurt, Germany: Peter Lang.

Steptoe, A., & Wardle, J. (1988). Emotional fainting and the psychophysiological response to blood and injury: Autonomic mechanisms and coping strategies. *Psychosomatic Medicine, 50,* 402–417.

Tabachnick, B. G., & Fidell, L. S. (1996). *Using multivariate statistics* (3rd ed.). New York: HarperCollins.

Vallar, G., & Baddeley, A. D. (1982). Short-term forgetting and the articulatory loop. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 34*(A), 53–60.

van den Hout, M., Muris, P., Salemink, E., & Kindt, M. (2001). Autobiographical memories become less vivid and emotional after eye movements. *British Journal of Clinical Psychology, 40,* 121–130.

van der Kolk, B. A., van der Hart, O., & Marmar, C. S. (1996). Dissociation and information processing in posttraumatic stress disorder. In B. A. van der Kolk, A. C. McFarlane, & L. Weisaeth (Eds.), *Traumatic stress* (pp. 303–327). New York: Guilford Press.

Wegner, D. M. (1994). Ironic processes of mental control. *Psychological Review, 101,* 34–52.

Westerman, D. L., & Larsen, J. D. (1997). Verbal overshadowing effect: Evidence for a general shift in processing. *American Journal of Psychology, 110,* 417–428.

Received September 18, 2002
Revision received July 31, 2003
Accepted August 19, 2003 ■