EFFECTS OF VISUOSPATIAL AND VERBAL PROCESSING ON TRAUMATIC INTRUSIONS

By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Posttraumatic Stress Disorder (PTSD) is currently classified as an anxiety disorder andis characterized by three main symptom clusters:re-experiencing an extremelytraumatic event, increased arousal, and avoidance of stimuli associated with the trauma (DSM-IV-TR; American Psychiatric Association, 2000).Re-experiencing symptoms generally include recurrent and intrusive recollections and dreams of the event, intense negative psychological or physiological responses to trauma cues, and flashbacks (Ehlers, Hackmann, & Michael, 2004).Avoidance symptoms include efforts to avoid thoughts and feelings associated with the traumatic event,activities, places or people that are reminders of the traumatic event, difficulty remembering important parts of the traumatic event,and decreased capacity to experience certain feelings (Foa, Riggs, &Gershuny, 1995). Symptoms of hyperarousal generally includesleep difficulties, irritability or outbursts of anger, difficulty with concentration, and feeling constantly on guard and being easily startled (Woodward, Murburg, &Bliwise, 2000).

Flashbacks in PTSD

Among the three main symptom clusters, re-experiencing is the most frequently endorsed PTSD symptom (Durham, McCammon, & Allison, 1985). Re-experiencing symptoms also occur immediately after a trauma (Eberly, Harkness, &Engdahl, 1991), which may lead to the development of other symptom clusters, including avoidance and hyperarousal. For example, the intense emotions and physical reactions associated with re-experiencing may take the form of hyperarousal that reinforces avoidance of trauma reminders(Steil& Ehlers, 2000).A wide range of situational cues can easily trigger re-experiencingand subsequent avoidance can significantly interfere with normal functioning (Ehlers, 2010). Re-experiencing symptoms can also be difficult to treat given that they are often fixed and difficult to modify even with corrective information (Michael, Ehlers, Halligan, & Clark, 2005).

The term 'flashbacks' is often used to refer tothe sensory-based intrusions that are characteristic of re-experiencing symptoms in PTSD.Sensory-based intrusions in PTSD can take different forms, including visual images as the most common, followed by sounds, smells, tastes or bodily sensations(Ehlers, Hackmann, Steil, Clohessy, Wenninger, & Winter, 2002). Flashbackshave been defined as a dissociative re-living of the traumatic situation as if the traumatic event were recurring (Axmacher, Do Lam, Kessler, & Fell, 2010; Falsetti, Monnier, Davis, &Resnick, 2002). Flashbackshave great perceptual detail (e.g., sensory and movement information), and are accompanied by primary emotions of fear, helplessness, and horror that were experienced during the trauma itself (Hellawell&Brewin, 2002a). However, flashbacks generallylackcontextual information and their contents are experienced as isolated and disconnected from the present.As a consequence, flashbacks appear disjointed from other relevant autobiographical information (Ehlers et al., 2004).

Although flashbacks represent a significant component of re-experiencing, they only capture lifelike perceptual features. PTSD patients also report intrusive thoughts (Ehlers et al., 2002).Intrusive thoughts are lexical cognitions that fall into three categories:

thoughts about threat and danger; negative thoughts about the self; and thoughts about the meaning of the event (De Silva & Marks, 1999). The content of intrusive thoughts consists of not only a recollection of the trauma event itself, but also rumination and evaluative thoughts about the trauma, such as attributions and appraisals, which alwaysfocus on experiences surrounding the traumatic event and trauma sequelae(Hackmann, Ehlers, Speckens, & Clark, 2004).Compared to flashbacks or sensory-based intrusions, intrusive thoughts are less commonly reported (Ehlers et al., 2002) and have not been studied as much. Previous PTSD research often investigateda certain form of intrusions, either flashbacks or intrusive thoughts. In order to provide a broader understanding of re-experiencing, the present study directly examined both sensory-based intrusions and intrusive thoughts. Below, the term "intrusions" is used to describe both of them.

Memory Systems and Trauma-Related Memory

A better understanding of intrusions may be facilitated by consideration of the research on memory retrieval. Broadly speaking, memorymay be retrieved via two processes: generative retrieval and direct retrieval. Generative retrieval is a top-down process through which the desired memory is intentionally retrieved. In contrast, direct retrieval refers to the retrieval of a specific memory when event-specific knowledge is activated by cues in the environment (Sumner, 2012). Similarly, trauma-related memory can be accessed via two processes. Intrusions can be retrieved involuntarily in an uncontrolled and unintended manner in response to situational cues, whileintentional recall of trauma can be retrieved voluntarily and intentionally in a controlled and goal-directed manner(Ehlers & Clark, 2000).

Several theorists have argued that voluntary access to the trauma memory is impaired, whereas involuntary access is enhanced in PTSD (Ehlers & Clark, 2000; Laposa& Rector, 2012).This idea is consistent with the common observation that patients with PTSD report a high frequency of involuntarily triggered intrusions in a vivid and emotional way (Berntsen, Willert, & Rubin, 2003). In contrast, several studies have found that PTSD patients have deficits in intentional memory recall, including fragmentation and poor organization, missing details, and difficulty in reproducing the exact temporal order of events (Amir, Stafford, Freshman &Foa, 1998; McNally, Litz, Prassas, Shin, & Weathers, 1994; Moore &Zoellner, 2007). In one study, McNally, Lasko, Macklin, and Pitman (1995) found that individuals with PTSD were less specific than those without PTSD in their recall when asked to generate a memory in response to a cue word. One reason for this deficit is that resource-consuming processes such as intrusions and avoidance may interfere with effortful retrieval of specific memories (Williams, 1996). Given that a portion of working memory is allocatedto intrusions and avoidance, limited executive resourcesmay lead to less coherent, more repetitive, and more disorganizedintentional recall of trauma(Brewin, 2007;Jones, Harvey, &Brewin, 2007).

Models of PTSD have attempted to explain the apparent discrepancy between difficulties in intentional memory recall and easily triggered re-experiencing of the traumatic event (Moore &Zoellner, 2007;Williams, 2006). One view is that voluntary versus involuntary remembering may reflect the operations of two distinct memory systems or fundamentally different processes (e.g., Brewin, Dalgleish, & Joseph, 1996; Ehlers & Clark, 2000). One prominent theory, the dual representation theory (DRT; Brewin et al., 1996),suggests that there are two types of memory representations of trauma (Brewin, 1989). One representation isthe situationally accessible memory (SAM system), which may be accessed automatically in situations similar to the traumatic event. The other representation,the verbally accessible memory (VAM system), is the person's conscious experience of trauma that can be deliberately retrieved.The DRTpositsthat sensory, physiological, and motor aspects of the trauma, includingspontaneous intrusions that are dissociated from context,are represented in the SAM system; whereas autobiographical memoriesthat can be verbally communicated and deliberately recalled are represented in the VAM system. Although the two memory systems operate in parallel, they may manifest independently of each other (Brewin, 2003). For example, trauma may diminish neural activity in anatomical structures serving conscious processing and enhance activity in structures serving nonconscious perceptual and memory processes (Jacobs &Nadel, 1985). Therefore, trauma may facilitate the development of sensory-based intrusions throughthe SAM system, and less trauma-related memoriescan be integrated into overall autobiographical memory through the VAM system. The two memory systems may also have some implications for the treatment of PTSD. For example,focusing and maintaining attention on the content of the sensory-based intrusionspresent in the SAM system, rather than avoiding them, may allow for the assignment of a spatial and temporal context to these intrusions that can be re-encoded into the VAM system.

Although the underlying tenets of the DRT model of PTSD remain largely untested, it represents an initial attempt to understand the mechanisms through which voluntary and involuntary trauma memories are developed. Some studies have been conducted to investigate how the two memory systems – SAM and VAM - operate during traumaby employing a dual task paradigm (Bourne, Frasquilho, Roth, &Holmes, 2010; Hellawell&Brewin, 2002a). The dual task paradigm examines the extent to which performance on a basic primary task of interests is impaired when it is performed simultaneously with a second task, compared to a situation when the primary task is performed alone. Reductions in performance on the primary task reflect the extent to which the two tasks are in competition for the same underlying cognitive resources (Hellawell&Brewin, 2002b). In analogue PTSD studies, development of trauma-related memory after exposure to trauma stimuli is considered the equivalent of the primary task; whereas a cognitive task is considered a second taskcompeting for the same resources. The development of trauma-related memory would be impaired when the second task relies on the same processing resourcesused for encoding, consolidation, and/or retrieval of traumatic memories.For instance, a visuospatial task requiring processing via a perceptual memory system would compete for the resources in the SAM system. In turn, perceptual information related to trauma would be less well encoded, leading ultimately tofewer sensory-based intrusionsthan a no-task control condition (Brewin& Holmes, 2003). In contrast, it has been hypothesized that a verbal task would compete for the resources in the VAM system and thus lead to a less-detailed representation of trauma-related memory. This would result in moresensory-based intrusions relative to a no-task control condition(Brewin& Holmes, 2003).

To test these hypotheses based on the dual task paradigm, several studies have been conducted to explore whether in fact secondary visuospatial and verbal tasks affect the retrieval of trauma memories in the manner predicted by Brewin and Holmes (2003). Thoughthe DRT wasintended to understand the development of trauma-related memory in PTSD patients, intrusions do occur in the absent of PTSD in response to strong emotional events (Berntsen, 1996). Furthermore, the form of intrusions among those with and without PTSD is similar in nature(Ehlers et al., 2002; Michael et al., 2005). Accordingly, researchers have increasingly examined intrusions among healthy control subjectsas this may inform understanding of intrusions in PTSD.

In studies employing dual task paradigm, participantswatched a trauma filmand performed a visuospatial or a verbal task either during or after the film. They were then asked to report their spontaneous memories of the film content via daily diaries recorded over the following week. One study showed thatplaying the visuospatially demandingcomputer game “Tetris”after viewing a trauma film,resulted in significantly fewer sensory-based intrusionsover a one-week periodcompared to a no-task control condition.Intentional memory recall of the trauma film was, however,intact (Holmes, James, Coode-Bate, &Deeprose, 2009). A recent extension of this work found that verbal interference (counting backwards in threes) during a trauma film resulted in more sensory-based intrusionsover a one-week period compared to a no-task control condition.In contrast, and consistent with the results of Holmes et al. (2009), participants who performed a visuospatial task (tapping a spatial pattern on a keypad) during the film demonstrated reduced sensory-based intrusions (Bourne et al., 2010). A recent study by the same research group also found that engaging in a visuospatial task four hoursafter a trauma film resulted in fewer sensory-based intrusions, whereas engagement in a verbal task resulted in more sensory-based intrusions(Holmes, James, Kilford, &Deeprose, 2010).This line of research is consistent with the predictions of the DRT that visuospatial tasks attenuate the formation of sensory-based intrusions while verbal tasks have the opposite effects. In addition, these results suggest that various cognitive tasks may have an effect on the development of intrusions for up to 6 hours after trauma. Given that memories are still largely malleable and sensitive to change,the consolidation of memory could be disrupted within a 6-hour period (Walker, Brakefield, Hobson, &Stickgold, 2003). Therefore, one‘real world’ implication of this work is that engagement in visuospatial tasks withina few hours after a traumatic event may be employed to prevent the development of intrusions and subsequent PTSD.

Although the findings that visuospatial and verbal tasks have different effects on intrusions are consistent with the predictions of the DRT, there are inconsistencies in the literature.For example, one study found that a peri-traumatic verbal interference task (counting backwards in threes) performed during a trauma film led to a decrease in sensory-based intrusions of the film compared to a no-task control condition (Krans, Näring, & Becker, 2009). Another study found that both visuospatial and verbal tasks reducedsensory-based intrusions compared to a no-task control condition, but the two cognitive task conditions did not significantly differ fromeach other(Krans, Näring, Holmes,& Becker, 2009).These findings seem to support a distraction hypothesis in which any secondary task that requires processing resources can ultimately reduce intrusions (Gunter &Bodner, 2008). Consistent with this view, a recent study employing affective images as traumatic stimuli included two visuospatial and two verbal tasks varying in cognitive load and found that both visuospatial and verbal tasks that are higher in cognitive load reducedthe frequency of intrusions,but lower cognitive load tasks had noeffecton intrusions (Pearson & Sawyer, 2011).

The inconsistent findings suggest thatthe effects of cognitive tasks on trauma memories may not be modality specific.Importantly, most studies do not match the visuospatial and verbal tasks in important dimensions which may partially account for findings showing predicted differences.Although visuospatial and verbal tasks may differ with regards to the memory systems that theyrecruit, it is important that they do not differ in other aspects, such as difficulty and engagement levels, when examined in the laboratory. Matching the two tasks on such dimensions will allow for ruling out the possibility that differences in intrusions are due to differences in cognitive load rather than the functional properties of the tasks.

The DRT also predicts that intentional memory recallwould be impaired in a verbal condition because less trauma-related memory can be processed in VAM due to the competition of a verbal task. In contrast,a visuospatial task would compete for the resources in the SAM system and perceptual information of trauma would be less well encoded. Thus,there would be fewer sensory-based intrusions developed, and more trauma-related memory can be integrated into autobiographical memory (Brewin& Holmes, 2003). However, a majority of studies have observed no differences in intentional memory recall between different cognitive task conditions (Holmes et al., 2009; Holmes et al., 2010). The null findings of intentional memory recall are inconsistent with the DRT, and no appropriate interpretations have been provided in previous research (e.g., Holmes et al., 2009). One possibility is that null findings may be largely due to limitations in the assessment of intentionalmemory recall in prior studies. The measuremost widely used was a true/false questionnaireprobing about specific occurrences in the trauma film employed in a study. Each item pertained to a specific trauma film clip (e.g., Three cars were involved in the crash) but the items used may not have probed sufficient details to provide an optimally comprehensive and sensitive measure of recall. Accordingly, the current study employed multiple approaches to more comprehensivelyassessing intentional memory recall and better examining the hypotheses of the DRT.

Overview of Present Study

According to the DRT,visuospatial tasks compete for the limited resources in the SAM system, leading to perceptual information being less well encoded and resulting in fewer sensory-based intrusions; in turn, the intentional recall of trauma memory is enhanced with more intrusions transferred and integrated into overall autobiographical memory. In contrast, verbal tasks compete for the resources in the VAM system, leading to a less-detailed conscious representation of trauma memory, and resulting in more sensory-based intrusions. However, findings along these lines have been far from consistent. In addition, the DRT did not state clearly about the development of less reported intrusive thoughts. A majority of empirical research only studied sensory-based intrusions, so the effects of cognitive tasks on intrusive thoughts remain unknown. According to the DRT, the major difference between the SAM and the VAM is whether trauma related memory can be retrieved involuntarily by situational cues or intentionally in a controlled manner (Brewin et al., 1996). Similar to sensory-based intrusions, intrusive thoughts can be activated and retrieved by situational cues, so they were assumed to be affected by cognitive tasks the same way as sensory-based intrusions.

Because of the inconsistencies and lack of research on intrusive thoughts in the literature, the present investigation further examined the effects of visuospatial and verbal tasks on subsequent intrusions – sensory-based intrusions and intrusive thoughts - and intentional memory recall of trauma-relevant content. In the current study, the visuospatial and verbal tasks were matched in some essential aspects, such as engagement and difficulty, to better examine whether they have different effects on intrusions and whether the effects are due to the task modality. In the current study, the following hypotheses were examined:

After a visuospatial and a verbal task were matched in some essential aspects:

1. Engagement in a visuospatial task after viewing a trauma film would result in a reduction in intrusions over a one-week period relative to a verbal and no-task control conditions.
2. Engagement in a verbal task would result in an increase in intrusions relative to a visuospatial and no-task control conditions.
3. Engagement in a visuospatial task would lead to better intentional memory recall than a no-task control condition and a verbal condition because fewer intrusions developed, and more intrusions would be integrated into autobiographical memory.
4. Engagement in a verbal task would result in worse intentional memory recall than a no-task control condition and a visuospatial condition, given that verbal

tasks interrupt the encoding of trauma memory processed consciously and verbally.

CHAPTER II

STUDY 1

Method

Participants

Seventy-three participants (78% female) were recruited from undergraduate courses at a Southern University in exchange for research credit. The ageof the sample rangedfrom 18 to 24, with mean age 19.37 (*SD* = 1.18). The sample consisted of66% Caucasians, 14% African Americans, 3% Latinos, 11% Asians, and 6% that endorsed “other”.

Measures

The *Center for Epidemiologic Studies Depression Scale* (CES-D; Radloff, 1977) is a 20-item questionnaire ofdepressivesymptomson a Likert scale from 0 (“Rarely or none of the time”) to 3 (“Most or all of the time”). The CES-D had an alpha coefficient of .82 in the present study.

The *Anxiety Sensitivity Index-3* (ASI-3; Taylor et al., 2007) is an 18-item questionnaire that measures fear of anxiety-related symptoms based on the perceptions that these sensations have harmful consequence on three subscales: physical, social, and cognitivesubscales on a Likert scale from 0 (“Very Little”) to 4 (“Very Much”). The ASI-3 had an alpha coefficient of .87 in the present study.

The *State-Trait Anxiety Inventory- Trait Version*, Form Y (STAI-T; Spielberger, Gorsuch, &Lushene, 1983) is 20-item scale that measures the enduring or chronic experience of anxiety, on a Likert scale from 1 (“Almost Never”) to 4 (“Almost Always”). The alpha coefficient for the STAI-T was .86 in the present study.

The*Modified Version of the Differential Emotion Scale* (MDES; Gross &Levenson, 1995) is to assess the intensity of subjective emotional arousal in eight emotion categories (i.e., amused, angry, contented, disgusted, fearful, disinterested, sad, and surprised).The participants were required to give ratings on a 9-point scale, from 0 (“Did not feel the slightest bit of the emotion”) to 8 (“The most I have ever felt in my life”.)

The *Impact of Event Scale - Revised* (IES-R; Weiss &Marmar, 1997)is a 22-itemquestionnaire assessingthe subjective response to a specific traumatic event on a Likert scale from 0 (“Not at all”) to 4 (“Extremely”). The alpha coefficient for the IES-R was .90 in the present study. The instructions of IES-R were modified to fit the trauma film in the present study, so all of the symptoms participants reported were regardingthe trauma film, not their personal experiences.

The*Recognition Memory Test*is a 50-item scale developed for the present study to examine participants’ intentionalmemory recall of the trauma film in the present study. The testis comprised of 50 forced choice (yes/no) statements (25 are true and 25 are false; e.g. “The person who was hit in the street market was holding a blue umbrella.”). For each video clip, there are two to three questions assessing participantsmemory of details in the clip.

Trauma film

Participants were shown a 10 min film of graphic scenes of fatal road traffic accidents. The film consists of 20 separate scenes(Because not all the video clips have sound,the trauma film was presented without sound. Therefore, participants would not be biased towards video clips with sound or intrusions in the form of sound). The trauma film was displayed on a 17 inch flat computer screen. Participants sat approximately 40cm from the screen.

Cognitive Tasks

Visuospatial task. The*Benton judgment of line orientation test* (JLOT; Benton, Hamsher, Varney, &Spreen, 1983) is a neuropsychological test widely used to assess visuospatial processing. It requires participants to identify the orientation of pairs of lines on a multiple-choice display, which consists of 11 numbered lines, each separated by an angle of 18˚ (Figure 1). The display was presented for 2 seconds before it went off, then a pair of lines from the display was randomly selected and presented for 2 seconds. After that, the participants saw the display again and responded with the numbers associated with the two lines presented earlier. The display and pairs of lines were presented in white on a black background and in the center of a 17 inch flat computer screen under normal room illumination, approximately 40cm from participants. The response time was not a criterion, so enough pairs of lines were prepared to allow all participants to perform this task for 10 minutes.

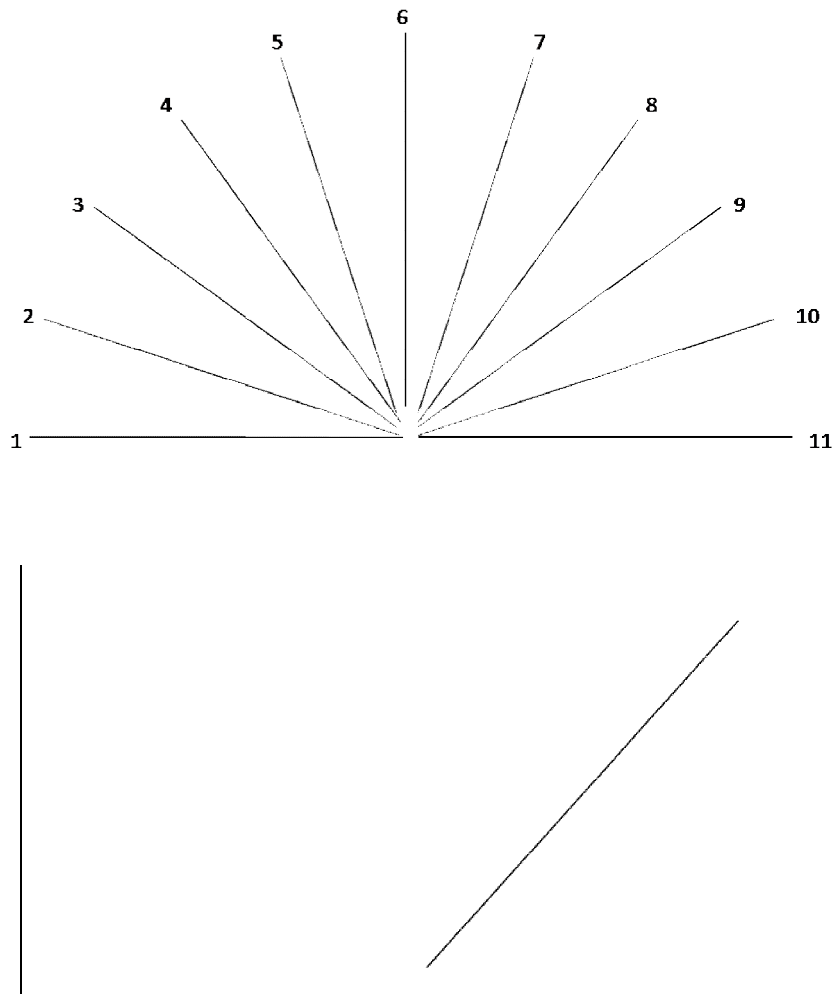


Figure 1.the Benton Judgment of Line Orientation Test - the display and a pair of lines (number 5 and number 8) from the display .

Verbal task. The Antonyms and Analogiessections of the GRE (Graduate Record Examinations) were employed. Antonyms required participants to select a word or phrase which is most opposite in meaning to the word given [e.g., DIFFUSE: (a) concentrate (b) contend (c) imply (d) pretend (e) rebel. Correct answer: (a)]. Analogies required participants to select a pair of words that best expresses a relationship similar to the pair of words given [e.g., color : spectrum: (a) tone : scale (b) sound : waves (c) verse : poem (d) dimension : space (e) cell : organism. Correct answer: (a)].Words in the verbal task were presented for 5 seconds before they went off, and then participants responded with the five options presented. Participants performed Antonyms for 5 minutes and Analogies for another 5 minutes. The words were in white on a black background and were in the center of a 17 inch flat computer screen under normal room illumination, approximately 40cm from participants.

Daily Diary

Participants kept a daily diary for 1 week, in which they recorded and rated each of their intrusionsabout the trauma film in terms of how distressing each one was on a 0-100 scale with 0 being “not at all” and 100 being “the most they could imagine feeling”. The definition of intrusionsand instructions were given on the front page of diary:

> “In the following week, recurrent and intrusive distressing recollections of the videos you watched, including images, thoughts, or perceptions, may pop into your awareness, without any conscious, premeditated attempt to search and retrieve. These memories are called intrusions. I would appreciate if you could note them down in the diary. If you have several intrusions of the same thing, please write down every individual one when it happens.”

Procedure

After giving their informed consent, participants completed the CES-D, ASI-3, STAI-T, and MDES assessing depression, anxiety sensitivity, trait anxiety, and mood. They then watched the trauma film. After watching the film, they completed the MDES againand then completed a filler task for 30 minutes that consisted of 20 minutes answeringtrivial questions, and 10 minutes of listening to music and givingratings to each music episode on how pleasant it was. The materials for the filler task were the same as those used in previous research by Holmes's research group, (Holmes et al., 2009). Give that there is often a time delay between the experience of a traumatic event and treatment in the real world, the filler task was employed to allow for time between the trauma film and the cognitive tasks. After the filler task, twenty neutral but recognizable images from the twenty film clips were presented, in order to reactivate participants' memories of the trauma film. The neutral but recognizable images were presented for two reasons: (1)The trauma film is not personally relevantand reactivating their memory may help prevent a floor effects should participants have few intrusions regarding the trauma film. (2)During the period between trauma exposure and intervention, survivors may re-experience the trauma event. Hence, presentation of images from the trauma film may be a good model for this experience.Participants were then randomized to avisuospatial condition (Benton judgment of line orientation test), a verbal condition (antonyms and analogies), or a no-task control condition (sitting quietly). They were required to performone of the two cognitive tasks or sit quietlyfor ten minutes. Participants in the visuospatial and verbal conditions also rated the tasks on how difficult and how engaging they werefrom 0 (not at all) to 9 (the most ever). After ten minutes, all participants were instructed to report initial intrusions of the trauma film over the ten minute period, in order to further help them understand the definition of intrusions and how to record their intrusions in the following week. An overview of the procedure was presented in Appendix 1.

Participants then kept a daily diary for one week, in which they recorded and described each of their intrusions. They returned the diary one week later and then completed the IES-R, theRecognition Memory Test, and provided a written description of their memories of the trauma film.

Results

Participant Characteristics

As shown in Table 1, there were no significant group differences ingender, ethnicity, or self-report measureson depression, anxiety sensitivity, and trait anxiety. However, participants in the control condition (*M* = 19.88) wereolder than those in the other two conditions[VS: *M* = 19.12, V: *M* = 19.13; $F(2, 70) = 3.48, p < .05$, partial $\eta^2 = .67$]. Although the differences were not large in magnitude, subsequent analyses included age as a covariate.

Table 1.Study 1group means (standard deviations)of measures among visuospatial, verbal, and control condition participants

	Visuospatial (*n*=25)	Verbal (*n*=24)	Control (*n*=24)	*p*
Age	19.12 (1.05)	19.13 (.99)	19.88 (1.36)	.04
Gender (%Female)	76%	88%	71%	.36
Ethnicity (%Caucasian)	72%	63%	63%	.50
CES-D	15.72 (8.18)	17.21 (7.55)	15.29 (8.53)	.69
ASI-3	13.88 (11.12)	14.46 (7.57)	13.54 (10.36)	.95

STAI-T	42.56 (8.86)	40.79 (8.28)	42.58 (8.53)	.71

Mood Manipulation Check

Ratings for eachmood on the MDES weresubjected to a 3 (condition: visuospatial, verbal, and control) X 2 (MDES:pre and post trauma film) mixed-model ANCOVA, with age as a covariate.The significant main effect of time for each mood suggestedsignificant pre to post changes on the MDES. The analyses revealedparticipants were less amused ($F(1, 70) = 179.73$, $p< .001$, partial $\eta^2 = .72$), contented ($F(1, 70) = 191.39$, $p< .001$, partial $\eta^2 = .73$), and disinterested ($F(1, 70) = 140.97$, $p< .001$, partial $\eta^2 = .67$); and more angry ($F(1, 70) = 15.24$, $p< .001$, partial $\eta^2 = .18$), disgusted ($F(1, 70) = 259.08$, $p< .001$, partial $\eta^2 = .79$), fearful ($F(1, 70) = 163.77$, $p< .001$, partial $\eta^2 = .70$), sad ($F(1, 70) = 86.62$, $p< .001$, partial $\eta^2 = .55$), and surprised($F(1, 70) = 63.34$, $p< .001$, partial $\eta^2 = .48$) after viewing the trauma film(Fig. 1). The analyses also showed significant main effect of condition on amused ($F(2, 70) = 5.94$, $p< .05$, partial $\eta^2 = .15$) and contented ($F(2, 70) = 7.51$, $p = .001$, partial $\eta^2 = .18$). Participants in the control condition were more amused and contented than those in the other two conditions before viewing the trauma film. However, these group differences were not significant after viewing the trauma film.

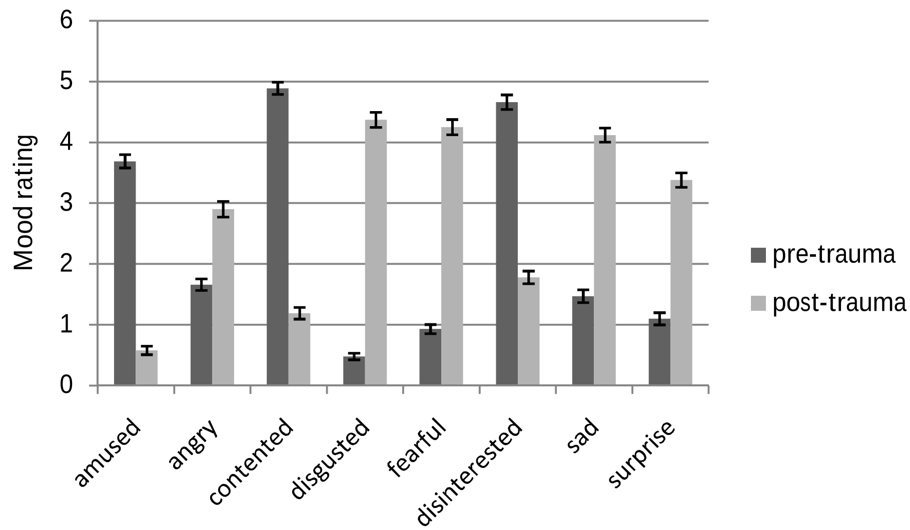


Figure 1. Effects of trauma film on mood in Study 1. Error bars represent standard errors.

Comparisons of theCognitive Tasks

As shown in Table 2, independent samples t-testrevealed no significant differences between visuospatial and verbal conditions in terms of subjects' reports about task difficulty and engagement.

Table 2. Task comparisons between visuospatial and verbal conditions in Study 1

	Visuospatial (*n*=25)*M (SD)*	Verbal (*n*=24)*M (SD)*	*t*	*df*	*p*
Difficult	5.56 (1.47)	6.06 (1.56)	-1.16	47	.25
Engaging	2.72 (2.03)	3.73 (2.47)	-1.56	47	.12

Effects of Cognitive Tasks on Intrusions

A 3 (Group) X 7 (day) univariatemixed-model ANCOVAwas employed to examine group differences in frequency of intrusions and in the pattern of decline in intrusions over the one-week period. According to Delaney and Maxwell (1981)'s recommendation for covariates in repeated measures designs, deviation of age from the grand mean across all the conditions was included as a covariate . The analyses showed no significant main effect of group ($F(2, 66) = 1.17$, $p> .05$, partial $\eta^2 = .03$) or interaction effect between group and day ($F(12, 396) = .83$, $p> .05$, partial $\eta^2 = .03$), revealing no significant group differences in intrusions and similar patterns among the three conditions.The analysis showed a significant main effect of day ($F(6, 396) = 29.93$, $p< .001$, partial $\eta^2 = .31$, and the three conditions did not differ in linear trend ($F(2, 66) = .43$, $p > .05$, partial $\eta^2 = .01$) or quadratic trend ($F(2, 66) = 2.13$, $p > .05$, partial $\eta^2 = .06$). Across the three conditions, there was alinear trend ($F(1, 66) = 64.44$, $p < .001$, partial $\eta^2 = .49$) and a quadratic trend ($F(1, 66) = 31.87$, $p < .001$, partial $\eta^2 = .33$) in the decline of intrusions, indicating the rate of decline was fast in the first few days, and then slowed down. Furthermore, ANCOVAs were conducted to examine group differences in intrusions within each day. The analyses suggested no significant group differences in intrusions in any day of the week (Day 1: $F(1, 67) = 1.92$, $p > .05$, partial $\eta^2 = .05$; Day 2: $F(1, 67) = .29$, $p > .05$, partial $\eta^2 = .01$; Day 3: $F(1, 67) = .76$, $p > .05$, partial $\eta^2 = .02$; Day 4: $F(1, 67) = .59$, $p > .05$, partial $\eta^2 = .02$; Day 5: $F(1, 67) = .70$, $p > .05$, partial $\eta^2 = .02$; Day 6: $F(1, 67) = 1.45$, $p > .05$, partial $\eta^2 = .04$; Day 7: $F(1, 66) = 1.58$, $p > .05$, partial $\eta^2 = .05$).

An ANCOVAwas also conducted to examine group differences in average distress ratings of intrusions. As shown in Table 3, no group differences emerged ($F(2, 60) = .19$, $p > .05$, partial $\eta^2 = .01$).

Table 3.Study 1group means (standard deviations)of dependent measures among visuospatial, verbal, and control condition participants

	Visuospatial	Verbal	Control	F	p	partial η^2
Intrusions	7.67 (7.25)	5.96 (6.99)	4.65 (3.68)	1.17	.32	.03
Distress Ratings	32.22 (13.77)	35.04 (25.09)	33.64 (17.97)	.19	.83	.01
IES-R	15.58 (10.95)	14.83 (12.81)	12.09 (7.91)	.38	.69	.01
Intentional Memory Recall (number of correct responses out of 50 items)	32.46 (3.58)	31.50 (3.16)	31.26 (3.24)	1.54	.22	.04
Written Memory	13.76 (7.47)	14.27 (6.83)	14.40 (9.09)	.21	.81	.01

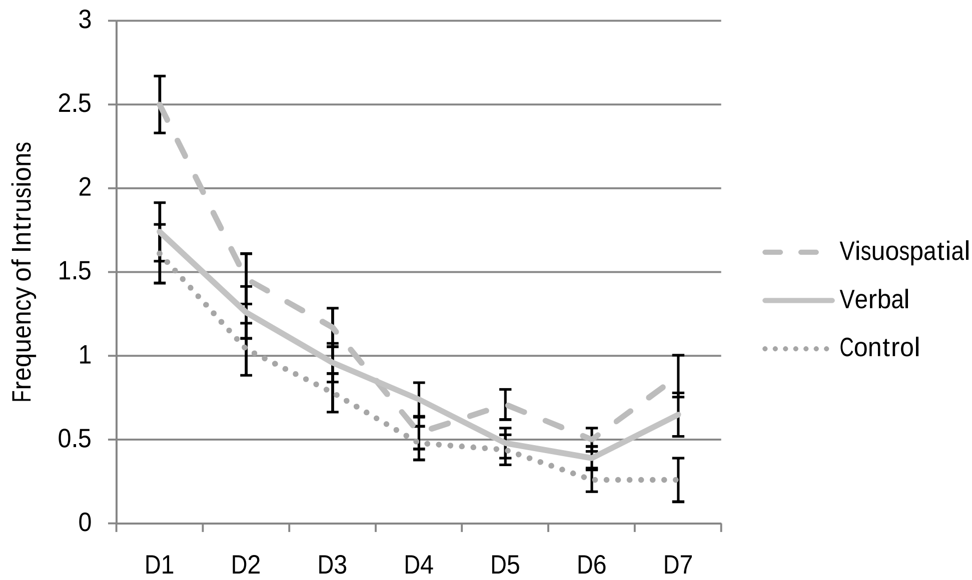


Figure 2.Rate of change in frequency of intrusions across the three conditions in Study 1. Error bars represent standard errors.

Effects of Cognitive Tasks on Analogue PTSD Symptoms

Holmes et al. (2009) found that exposure to a visuospatial task after a trauma film led to fewer reported PTSD symptoms relative to a control condition. Therefore, an ANCOVAwas conducted to assess group differences in analogue PTSD symptoms as assessed by IES-R. As shown in Table 3, no significant group differences were found ($F(2, 67) = .38$, $p > .05$, partial $\eta^2 = .01$).

Effects of Cognitive Tasks on Intentional Memory Recall

An ANCOVAwas then conducted to examine group differences in intentional memory recall on the Recognition Memory Test. Results in Table 3 showed no significant group differences ($F(2, 67) = 1.54$, $p > .05$, partial $\eta^2 = .04$). Across the three conditions, participants averaged 63.49% correct.One-sample t test showed that participants' responses were significantly above chance level ($t(70) = 17.10$, $p < .001$). Signal detection analyses revealed that the false alarm rate was .45 (a false alarm was defined as a false statement about the trauma film recognized as true) and that the false negative rate was .28 (a false negative was defined as a true statement about the trauma film was recognized as false). An analysis of covariance (ANCOVA, controlling for age) was then conducted to examine group differences in dprime (difference between hit and false alarm, indicating how sensitive participants are in deciding a true statement is true). There revealed no significant group differences ($F(2, 67) = 1.13$, $p > .05$, partial $\eta^2 = .03$). An analysis of covariance (ANCOVA, controlling for age) was also conducted to examine group differences in bias (indicating if participants are more often to respond with Yes or No), and revealed no significant group differences ($F(2, 67) = 2.31$, $p > .05$, partial $\eta^2 = .07$). Moreover, participants' written memory was rated by two coders, who were unaware of experimental conditions. The two coders followed the same guidelines and rated participants' written memories on each video clip on a 0 – 3 scale, depending on if they remembered eachvideo clip and how much detail they can provide. The possible range was 0 to 60 across the 20 video clips.The inter-rater reliability was .90 and the final ratings were determined by averaging the two coders' ratings. Examination of the ratings of written memory by ANCOVA revealed no significant group differences ($F(2, 69) = .21$, $p > .05$, partial $\eta^2 = .01$).

Correlations between Individual Differences and Dependent Variables

Given the absence ofsignificant group differences between visuospatial, verbal and control conditions on the primary dependent variables, exploratory correlations were computed to examine the associations between individual differences ondepression, trait anxiety, and anxiety sensitivity, and the dependent variables in this study, including intrusions, intentional memory recall, and PTSD symptoms.As shown in Table 4, anxiety sensitivity was more strongly correlated with PTSD symptoms and trauma-related memories than trait anxiety and depression. These associations remained largely intact after controlling for trait anxiety and depression. The associations between anxiety sensitivity and intrusions and intentional memory recall were most pronounced for the physical concerns subscale of ASI-3. Moreover, anxiety sensitivity was positively correlated with frequency of intrusions (r = .29, p< .05), but negatively correlated with intentional memory recall on the Recognition Memory Test (r = -.30, p< .05).

Table 4. Correlations (partial correlations) between individual differences and dependent variables in Study 1

	Frequency of Intrusions	Recognition Memory Test	Rating Memory	IES-R
ASI-3	.29* (.29*)	-.30* (-.25*)	-.12 (-.15)	.38** (.29*)
ASI-physical	.32** (.32**)	-.29*(-.26*)	-.14(-.18)	.29*(.19)
ASI-cognitive	.21(.20)	-.27*(-.22)	-.12(-.15)	.33**(.25*)
ASI-social	.18* (.17)	-.19(-.11)	-.05(-.04)	.30**(.23)
STAI-T	.05	-.17	.08	.12
CES-D	.07	-.17	.04	.28*

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

Discussion

Inconsistent with predictions, the present study found no significant differences betweenvisuospatial, verbal, and control conditions in frequency of intrusions, intentional memory recall, or analogue PTSD symptoms.There were two major differences between Study 1 and studies conducted by the Holmes' research group (for example: Holmes et al., 2009). One was the different visuospatial tasks: previous research employed the computer game "Tetris", while the present studyemployed the Benton Judgment of Line Orientation Test. The other difference was that previous research only counted sensory-based intrusions, whereas in the present study, both sensory-based intrusions and intrusive thoughts were included. To better understand whether only some specific visuospatial tasks have impact on intrusions and whethersensory-based intrusions are more significantly influenced by visuospatial tasks, Study 2 was conducted to investigate the effects of “Tetris” on sensory-based intrusions relative to a no-task control condition.

CHAPTER III

STUDY 2

Method

Participants

Thirty-five participants (83% female) were recruited from undergraduate courses at a Southern University in exchange for research credit. The age of the sample rangedfrom 18 to 27, with mean age 19.66 (*SD* = 1.68). The sample consisted of57% Caucasians, 23% African Americans, 11% Asians, and 9% that endorsed "other".

Measures

The *Center for Epidemiologic Studies Depression Scale* (CES-D; Radloff, 1977)from Study 1 was also used for Study 2. The alpha coefficient was.90in the current study.

The *Anxiety Sensitivity Index -3* (ASI-3; Taylor et al., 2007) from Study 1was also used for Study 2. The alpha coefficient was.92 in the current study.

The *State-Trait Anxiety Inventory- Trait Version*, Form Y (STAI-T; Spielberger et al., 1983) from Study 1 was also used for Study 2. The alpha coefficient was .94 in the present study.

The *Impact of Event Scale - Revised* (IES-R; Weiss &Marmar, 1997)from Study 1 was also used for Study 2. The alpha coefficient for the IES-R was .92 in the present study.

The*Modified Version of the Differential Emotion Scale* (MDES; Gross &Levenson, 1995),and the*Recognition Memory Test*from Study 1 were also used in Study 2.

Trauma film

The trauma film was the same as the one used in Study 1.

Visuospatial Task

The visuospatial task is a computer game "Tetris", which is a tile-matching puzzle video game requiring mental rotation of shapes. The objective of the game is to manipulate shapes by moving each one sideways and rotating it by 90 degree units, with the aim of creating a horizontal line of ten blocks without gaps. Participants were show the website http://www.freetetris.org, and performed "Tetris" in the website. Participants can choose whichever level they feel comfortable with.

Daily Diary

In addition torecording and rating all the intrusionsabout the trauma film, participants were asked to make the distinction between sensory-based intrusions and intrusive thoughts for each intrusion. Instructions were given on the front page of the diary:

> “Intrusions are recurrent and intrusive distressing recollections of the videos you just watched, including images, thoughts, or perceptions, which may pop into your awareness, without any conscious, premeditated attempt to search and retrieve. Intrusions may take the form of mental pictures called “images”, or words and phrases called “verbal thoughts.Mental images actually include any of the five senses, so you can see, feel, smell, hear, and taste in the image. Verbal thoughts are when you’re thinking using words and silently talking to yourself, like an internal running commentary or dialogue. Here is the diary for you to record your intrusions in the next week. Please write down how many times you experience intrusions each day, what the content of each intrusion is, and if they are images, verbal thoughts, or both, and please also give a rating of how distressing each intrusion is.”

Results

Participant Characteristics

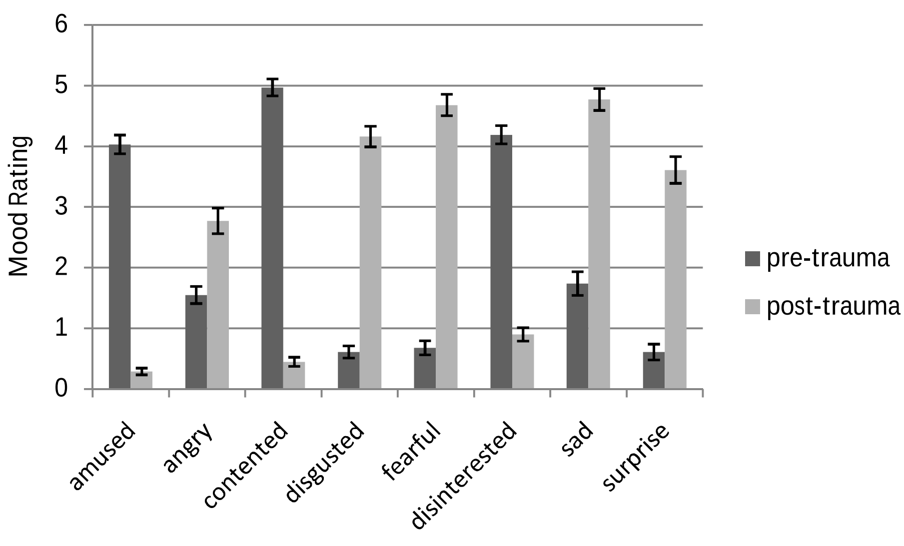
As shown in Table 5, there were no significant group differences in age,gender, ethnicity, or self-report measures before viewing the trauma film.

Table 5. Study 2group means (standard deviations)of measures among visuospatial and control condition participants

	Visuospatial (*n*=17)	Control (*n*=18)	*p*
Age	19.53 (1.23)	19.78 (2.05)	.67
Gender (%Female)	76%	89%	.33
Ethnicity (%Caucasian)	65%	50%	.47
CES-D	15.47 (10.01)	13.94 (9.57)	.65
ASI-3	17.47 (15.78)	12.28 (7.44)	.22
STAI-T	39.58 (11.52)	39.22 (10.70)	.92

Mood Manipulation Check

Ratings for eachmood on the MDES weresubjected to 2(condition: visuospatial and control) X 2 (MDES: pre and post trauma film) mixed-model ANOVA. The significant main effect of time for each mood suggested significant pre to post changes on the MDES. Follow-up analyses revealed participants were less amused ($F(1, 33) = 163.45$, $p< .001$, partial $\eta^2 = .83$), contented ($F(1, 33) = 237.38$, $p< .001$, partial $\eta^2 = .88$), and disinterested ($F(1, 33) = 150.75$, $p< .001$, partial $\eta^2 = .82$); and more angry ($F(1, 33) = 15.24$, $p< .01$, partial $\eta^2 = .24$), disgusted ($F(1, 33) = 105.95$, $p< .001$, partial $\eta^2 = .76$), fearful ($F(1, 33) = 143.88$, $p< .001$, partial $\eta^2 = .81$), sad ($F(1, 33) = 51.46$, $p< .001$, partial $\eta^2 = .61$), and surprised ($F(1, 33) = 44.33$, $p< .001$, partial $\eta^2 = .57$) after viewing the trauma film (Figure 3).



Figurer 3. Effects of trauma film on mood in Study 2. Error bars represent standard errors.

Effects of the Visuospatial Task on Sensory-Based Intrusions

A 2 (Group) X 7 (day) mixed-model ANOVA was employed to examine group differences in frequency of sensory-based intrusions and in the pattern of decline over the one-week period. There was no significant main effect of group ($F(1, 33) = .01$, $p > .05$, partial $\eta^2 < .001$) or interaction effect between group and day ($F(6, 198) = .15$, $p > .05$, partial $\eta^2 = .01$), indicating no significant group differences in sensory-based intrusions and similar decline patterns among the three conditions. The analysis showed a significant main effect of day ($F(6, 198) = 10.38$, $p < .001$, partial $\eta^2 = .24$). Across the three conditions, there was a linear trend ($F(1, 33) =28.73$, $p < .001$, partial $\eta^2 = .47$) and a quadratic trend ($F(1, 33) = 7.00$, $p < .005$, partial $\eta^2 = .18$) in the decline of sensory-based intrusions, indicating the rate of decline was fast in the first few days, and then slowed down. ANOVAs were conducted to examine group differences in sensory-based intrusions within each day. The analyses suggested no significant differences in any day of the week (Day 1: $F(1, 33) =.06$, $p > .05$, partial $\eta^2 = .002$; Day 2: $F(1, 33) =.09$, $p > .05$, partial $\eta^2 = .003$; Day 3: $F(1, 33) = .05$, $p > .05$, partial $\eta^2 = .001$; Day 4: $F(1, 33) = .08$, $p > .05$, partial $\eta^2 < .002$; Day 5: $F(1, 33) = .10$, $p > .05$, partial $\eta^2 < .003$; Day 6: $F(1, 33) = .23$, $p > .05$, partial $\eta^2 = .007$; Day 7: $F(1, 33) = .17$, $p > .05$, partial $\eta^2 = .005$).

An ANOVAwas conducted to examine group differences in average distress ratings of sensory-based intrusions. As shown in Table 5, no group differences emerged ($F(1, 29) = .34$, $p > .05$, partial $\eta^2 = .01$).

Table 5.Study 2 group means (standard deviations)of dependent measures among visuospatial and control condition participants

	Visuospatial *M (SD)*	Control *M (SD)*	*F*	*p*	partial η^2
Sensory-Based Intrusions	5.24 (4.89)	5.39 (4.18)	.01	.92	.00
Distress Ratings of Sensory-Based Intrusions	42.35 (23.15)	37.91 (18.87)	.34	.56	.01
IES-R	19.35 (13.26)	18.00 (13.42)	.09	.77	.00
Intentional Memory Recall (number of correct responses out of 50 items)	33.18 (2.98)	33.17 (2.87)	.00	.99	.00
Written Memory	15.44 (8.55)	13.11 (6.92)	.77	.39	.02

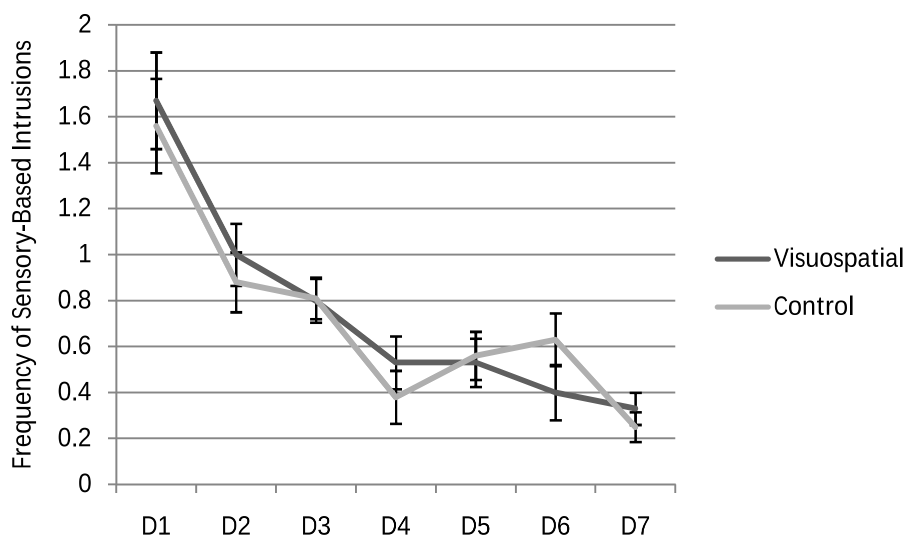


Figure 4.Rate of change in frequency of sensory-based intrusions across the two conditions in Study 2. Error bars represent standard errors.

Effects of the Visuospatial Task on Analogue PTSD Symptoms

An ANOVA was conducted to assess group differences in analogue PTSD symptoms as assessed by IES-R. As shown in Table 5, no significant group differences were found ($F(1, 33) = .09$, $p > .05$, partial $\eta^2 = .00$). There was no significant effect of visuospatial tasks on analogue PTSD symptoms compared to a control condition.

Effects of the Visuospatial Task on Intentional Memory Recall

An ANOVA was conducted to examine group differences in intentional memory recall on the Recognition Memory Test. As shown in Table 5, there were no significant group differences ($F(1, 33) = .00$, $p > .05$, partial $\eta^2 = .00$). Across the three conditions, participants performed 66.34% correct on average. One-sample t test showed that participants' responses were significantly above chance level ($t(34) = 67.00$, $p < .00$). Signal detection analyses revealed that false alarm rate was .43 (a false alarm was defined as a false statement about the trauma film recognized as true); and false negative rate was .25 (a false negative was defined as a true statement about the trauma film was recognized as false). An analysis of variance was then conducted to examine group differences in dprime. There revealed no significant group differences ($F(1, 33) = .00$, $p > .05$, partial $\eta^2 = .00$). An analysis of variance was also conducted to examine group differences in bias, and showed no significant group differences ($F(1, 33) = .51$, $p > .05$, partial $\eta^2 = .02$). In addition, participants' written memory was rated by two coders, who were unaware of experimental conditions. The inter-rater reliability was .82 and the final ratings were determined by averaging the two coders' ratings. Examination of the ratings of written memory revealed no significant group differences ($F(1, 32) = .77$, $p > .05$, partial $\eta^2 = .02$).

Correlations between Individual Differences and Dependent Variables

Given the absence of significant group differences between visuospatial and control conditions, an exploratory analysis was conducted to examine the association between individual differences in depression, trait anxiety, and anxiety sensitivity, and dependent variables of frequency of sensory-based intrusions, intentional memory recall, and analogue PTSD symptoms. As shown in Table 6, anxiety sensitivity, trait anxiety, and depression were all correlated to analogue PTSD symptoms. The associations between anxiety sensitivity and sensory-based intrusions and analogue PTSD symptoms were most pronounced for the physical concerns subscale of ASI-3. These associations of anxiety sensitivity and analogue PTSD symptoms remained largely intact after controlling for trait anxiety and depression. However,after controlling for anxiety sensitivity, the associations of trait anxiety and depression and analogue PTSD symptoms were not significant.

Table 6. Correlations (Partial Correlations) between Individual Differences and Dependent Variables in Study 2

	Frequency of sensory-based Intrusions	Recognition Memory Test	Rating Memory	IES-R
ASI-3	.26 (.16)	.09 (.02)	.33 (.33)	.53** (.39*)
ASI-physical	.37* (.33)	.20 (.16)	.32 (.31)	.54**(.43*)
ASI-cognitive	.16 (.06)	.15 (.09)	.27 (.25)	.52** (.38*)
ASI-social	.14 (-.12)	-.10 (-.21)	.27 (.24)	.33 (.13)
STAI-T	.21	.14	.12	.40*
CES-D	.13	.12	.10	.40*

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

Discussion

The results in Study 2 failed to showsignificant differences in sensory-based intrusions, intentional memory recall, and analogue PTSD symptoms between visuospatial and control conditions. Consistent with Study 1, anxiety sensitivity was more strongly correlated with analogue PTSD symptoms than trait anxiety and depression.

CHAPTER IV

GENERAL DISCUSSION

The DRTsuggested two types of memory representations of trauma – SAM system and VAM system (Brewin, 1989). Sensory, physiological, and motor aspects of the trauma, such as sensory-based intrusions are represented in the SAM system; whereas autobiographical memoriesthat can be verbally communicated and deliberately recalled are represented in the VAM system (Brewin et al., 1996).According to predictions based onthe DRT, a visuospatial task competing for resources in the VAM system shouldreduce intrusions. In contrast, a verbal task should increase intrusions because it competes for the resources in the VAM system and leads to a less-detailed representation of trauma-related memory(Brewin & Holmes, 2003).Inconsistent with these predictions, the findings of Study 1 revealed no significant differences in intrusions over a one-week period after watching a trauma film between visuospatial, verbal, and control conditions. These findings are also inconsistent with previous research supporting the predictions of the DRT by showing that engaging in a visuospatial task reduced sensory-based intrusions and engaging in a verbal task increased sensory-based intrusions compared to a no-task control condition (e.g., Holmes et al., 2010).

The inconsistent findings may be partially accounted for by differences in the visuospatial and verbal taskemployed. For example, the computer game “Tetris” (Holmes et al., 2009), tapping a spatial pattern on a concealed keypad (Bourne et al., 2010), or a trail-making task (Hellawell&Brewin, 2002a) has been the visuospatial taskemployed in previous research. Furthermore, counting backwards in threes/sevens from a three-digit number (Bourne et al., 2010) or a verbal pub quiz (Holmes et al., 2010)has been used as the verbal task. In contrast, Study 1 employed the Benton Judgment of Line Orientation Test as the visuospatial task and the Antonyms and Analogiessections of the GREas the verbal task. The lack of group differences may be due to differentcognitive loadassociated with tasks. Cognitive load theory argues that cognitive capacity in working memory is limited.If a task requires too much capacity, a secondary taskwill be hampered(Chandler &Sweller, 1991). However, if a task comparably requires less resource to process, the performance on the other task may not be significantly affected. Future research could compare cognitive tasks in the present study and those in prior research to examine whether low cognitive load of tasks contribute to the null findings.

It is also important to note that previous studies have generally failed to match visuospatial and verbal tasks on important dimensions.For example, visuospatial and verbal tasks may differ with regards to level of difficulty and engagement. Differences in intrusions may then be accounted for by differences associated withthe cognitive load of the tasks rather than the task per se. To rule out this alternative explanation, Study 1 matched the visuospatial task and the verbal task in difficulty and engagement levels. However, no significant differences were observed between these two tasks. This lack of group differences confirms thatcognitive tasks matched in difficulty and engagement exert no different effects on intrusions because they may require similar amount of cognitive resources to process. This view is inconsistent with the predictions of the DRT, but may support a distraction hypothesis(Gunter &Bodner, 2008). Differences in intrusions may be due to distraction for general working memory resources but not the nature of task.However, the distraction hypothesis still cannot interpret why there were no differences between cognitive task conditions and the control condition. It should be noted that the present study only matched cognitive tasks in respects of difficulty and engagement, future research where the cognitive loads of visuospatial and verbal tasks are systematically varied may highlight the parameters for which such tasks influence the development of intrusions.

The inconsistent findings may also be partially accounted for by how intrusions were operationalized.Sensory-based intrusions are characterized by great perceptual detail. Intrusive thoughts are characterized primarily by rumination (Ehlers et al., 2002; Hackmann et al., 2004). According to the DRT, a visuospatial task would compete for the resources in the SAM system, leading to perceptual information being less well encoded. Therefore, sensory-based intrusions, but not intrusive thoughts, would be influenced by a visuospatial task because both of them are processed on a perceptual level (Brewin& Holmes, 2003). Indeed, previous research supporting the DRT only assessed sensory-based intrusions (Holmes et al., 2009; Holmes et al., 2010). One limitation of Study 1 is that sensory-based intrusions and intrusive thoughts were not differentiated, which may account for the null findings[1].

Study 2 was designed to address some of the inconsistencies between Study 1 and previous research. Specifically, the visuospatial task Tetris that has been employed in prior research was used. Furthermore, only sensory-based intrusions were examined in Study2. Despite these changes, no significant differencein sensory-based intrusions was

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[1]The diary was subsequently coded by an experimenter that was blind to the two conditions for sensory-based intrusions and intrusive thoughts. Examination of group differences on the sensory-based intrusions revealed no significant differences ($F(2, 67) = 1.42$, $p > .01$, partial $\eta^2 = .04$).

found between participants in the visuospatial condition and those in the control condition.

The present study further examined the rate of decline in intrusions between the three conditions. One prediction consistent with the DRT is that those in the visuospatial condition may experience a faster reduction in intrusions relative to other conditions. However, no significant differences in rate of decline were found in intrusions between the three conditions in Study 1 or sensory-based intrusions between the two conditions in Study 2. The overall trend across all the three conditions in Study 1 and the two conditions in Study 2 consistently revealed a steep decline in the number of intrusions in the first few days, followed by the frequency leveling off and remaining relatively low during the last few days. Consistent with prior research (Butler, Wells, &Dewick, 1995; Trinder&Salkovskis, 1994), the decline of intrusions over the one-week period may reflect a "natural recovery" (Foa& Cahill, 2001) where high levels of symptoms are common in the aftermath of a traumatic event, but symptoms tend to subside in the posttrauma period (Brewin, 2001).

Reconciling differences between those of the present study and prior research supporting the predictions of the DRT may warrant consideration of the trauma stimuli employed. The trauma film in the present study was 20 episodes of car accidents. Prior research has used car accidents as trauma stimuli (e.g., Holmes, Brewin, &Henessy, 2004). However, such studies often include a short commentary that provides a context for these accidents. Unlike the present study, other studies have employed a variety of events, such as car accidents, people drowning, and surgery as trauma stimuli (e.g., Holmes et al., 2009). The trauma films employed in this area of research clearly differ in content, duration, and the degree to which it is based on a coherent theme versus a compilation of unconnected scenes. Although such differences in trauma stimuli may be expected to result in different distress reactions and subsequent intrusions, prior research suggests that this is not the case (Weidmann, Conradi, Gröger, Fehm, &Fydrich, 2009). Furthermore, previous research employing a variety of trauma films has shown that different cognitive tasks lead to differences in intrusions (Bourne et al., 2010; Holmes et al., 2004). Although the effects of cognitive tasks on intrusions appear to be independent of the trauma film employed, furtherinvestigation of the trauma film used in the present studyis needed to understand if the null findings can be partially accounted for by single type trauma presented or other characteristics of the film.

The present study also examined the hypothesis that intentional memory recall would be better in the visuospatial condition and worse in the verbal condition. According to the DRT, a verbal task interrupts the consciously and verbally encoding of trauma memory resulting inlesstrauma-related memory that can be intentionally retrieved. A visuospatial task, on the other hand, leads to fewer sensory-based intrusions, so more trauma-related memory can be integrated into autobiographical memory. However, the present studyfound no significant effects of cognitive tasks on intentional memory recall, a pattern of findings that is consistent withprior studies (Holmes et al., 2009; Holmes et al., 2010). A possible interpretation is that the measurement of intentional memory recall is not accurate or comprehensive enough to capture all the features of intentional memory recall of the trauma film. Although the current study included multiple assessments of intentional memory recall, other aspects including the temporal order (Ehlers et al., 2004) and fragmentation and disorganization of the trauma(Foa& Riggs, 1993) may be more sensitive to differences in cognitive tasks.

Prior research suggests that the DRT may also have implications for the treatment of PTSD. For example, Holmes et al. (2009) found that participants engaging in a visuospatial task after exposure to a trauma film reported less PTSD symptoms than those in the control condition. However, the present study found no significant differences between the three conditions in re-experiencing, avoidance, and hyperarousal symptoms as assessed by IES-R. The discrepancies regarding analogue PTSD symptoms between the present study and prior research were in accordance with findings of intrusions. Given that intrusions are one symptom of PTSD, future investigation is required to understand how different cognitive tasks interfere with the development of intrusions, and further with other PTSD symptoms.

The null findings of the present study are inconsistent with predictions derived from the DRT. A major assumption of the DRT is that SAM and VAM are two separate memory systems (Brewin et al., 1996). This assumption is consistent with a multicomponent model of working memory, which proposes two domain-specific storage subsystems for verbal and visuospatial information (Baddeley, 2000; Baddeley& Hitch, 1974). Working memory is a system for the temporary storage and processing of information (Just & Carpenter, 1992). A key aspect of working memory is its capacity limitation, usually reflected in decreasing performance in response to increase in working memory load (Callicott, et al., 1999). By employing a visuospatial or a verbal task to compete for the limited resources of working memory, the development of intrusions and intentional recall of trauma memories should be disrupted. However, the DRT may oversimplify information processing in SAM and VAM systems. It argues that processing information in the VAM system requires conscious attention, whereas processing information in the SAM system requires little attentional capacity (Brewin et al., 1996). If this is the case, a visuospatial task in a dual task paradigm should not interfere significantly with the development of intrusions in the SAM system, considering that processing information in the SAM system does not require much attentionaland working memory resources.

The DRT also fails to account for how other memory processes may influence information processing in the SAM and VAM systems. Traditional models of memory suggest that information is first held in sensory memory before it is processed in working memory (Sherry &Schacter, 1987). Working memory is limited in attentional capacity, so not all information from sensory memory can be consciously attended to and processed (Engle,Tuholski, Laughlin, & Conway, 1999). However, the DRTsimply proposes that verbal information that receives conscious attention is processed in the VAM system, whereas visuospatial information that does not require much conscious attention is processed in the SAM system(Brewin& Holmes, 2003). In fact, memory that receives conscious attention and being processed into working memory consists of both visuospatial and verbal content, so does memory that does not require much working memory capacity and is less consciously attended to. For instance, research has shown that intrusions includesensory-based intrusions and verbal thoughts (Ehlers et al., 2002; Murray, Ehlers, &Mayou, 2002). On the other hand, working memory model suggests that both visuospatial and verbal information are consciously attended to and processed to be stored in two separate systems in working memory (Baddeley, 1996). Even though there are mixed findings as to whether the two systems in working memory are independent or associated, researchers have agreed on the two domain-specific systems for information processing and storage (e.g., Alloway, Pickering, &Gathercole, 2006; Friedman & Miyake, 2000; Kane et al., 2004). Therefore, a visuospatial task does not necessarily interrupt the development of intrusions which actually consist of visuospatial and verbal information, and a verbal task does not necessarily interrupt the development of intentional recall of trauma memory which consists of information being processed in both visuospatial and verbal systems. Accordingly, examinations of the DRT have yielded mixed results when intrusions are only treated as visuospatial information being less consciously processed and intentional recall of trauma memory as verbal information being more consciously processed.

The DRT also proposes that intrusions can be re-encoded from the SAM into the VAM system if the individual pays attention to the content (Brewin& Holmes, 2003). Doing so allows the content in VAM to be deliberately retrieved and verbally communicated. However, this view is problematic because transferring information between the SAM and the VAM systems is not an automatic process, it also involves the central executive in working memory to control and manipulate information processing in the two systems. Therefore, the simplified information processing of traumatic eventsproposed by the DRTmakes it more difficult to understand the completeprocess of the development of intrusions and the way of reducing intrusions. In fact, re-experiencing the intrusive memories could help with integration of fragmentary memory into the intentional memory of the traumatic event (Jacobs&Nadel, 1998). However, people with PTSD are not able to put intrusions into context, and to access corrective information that may minimize the negative effects of intrusions (Koriat, Goldsmith &Pansky, 2000). Therefore, the difficulty PTSD patients have is in assigning a complete temporal and spatial context to intrusions and integrating fragmented and isolated intrusions into intentional recall of trauma memories(Ehlers et al., 2004). Moreover, relative to controls, PTSD patients showed reduction in both right and left hippocampal volume (Buckley, Blanchard, & Neill, 2000), which plays an important role in binding item and contextual information (Diana, Yonelinas, &Ranganath, 2007). Therefore, PTSD patients seem to lack the ability of bringing intrusions into awareness and binding intrusions and contextual information. This ability requires the central executive in working memoryto assign limited attentional resources. However, the DRT only focused on information processing within and between the SAM and VAM systems, without considering the coordination function of the higher order executive in working memory.

Another limitation of the DRT is that it proposes that perceptual information encoded and stored in the SAM system can only be retrieved by situational cues similar to those in traumatic events, and verbal information encoded and stored in the VAM system can only be retrieved intentionally as required (Brewin& Holmes, 2003). These two retrieval processes are actually in accordance with two memory retrieval strategies: generative and direct retrieval (Conway &Pleydell-Pearce, 2000). However, the distinction between the two is that generative retrieval refers to a top-down and strategic retrieval process, whereas direct retrieval is a bottom up process where specific memory can be activated by cues in the environment directly (Williams, 2004). Though there is more perceptual and sensory information involved in direct retrieval, it does not necessarily indicate that the retrieval strategy is dependent on whether the materials retrieved are verbal or visuospatial. For instance, a recent fMRI study found that generative retrieval recruited lateral prefrontal and temporal regions early on during the retrieval process to support the strategic search, whereas direct retrieval recruited many other regions at a later time point (Addis, Knapp, Roberts, &Schacter, 2012). Therefore, the critical difference between the two retrieval processesis that generative retrieval requires effortful memory search. It is highly possible to have inconsistent findings when the DRT simply regards visuospatial information as retrieved involuntarily and verbal information as retrieved intentionally.

Moreover, classic models conceptualize memory processes in three separate stages: encoding, storage and consolidation, and retrieval (Tulving, 1983). However, the DRT did not clearly describe information processing in all the three stages, and did not distinguish how traumatic memory is processed differently between the three stages. According to the DRT, the storage and consolidation stage is critical in the development of the traumatic memory. Employment of a cognitive task is intended to disrupt information processing in this stage. However, encoding success can only be estimated on the basis of retrieval performance (Blanchet et al., 2001). The effect of different cognitive tasks isonly reflected in how trauma-related memory can be retrieved later. In fact, the relationship between encoding and retrieval has not been fully investigated in memory literature. Even though some prior neuroimaging studies have indicated that brain regions that were activated during encoding are reactivated during retrieval, there are some other regions involved in only one of these stages (Kent & Lamberts, 2008). For instance, one study found that encoding and consolidation are dependent on the hippocampus, but retrieval is also mediated by the prefrontal cortex (Simons &Spiers,

2003). Therefore, the effects of cognitive task examined in retrieval stage do not only reflect how traumatic memory is disrupted in storage and consolidation stage. The number of intrusions over one-week period and intentional memory recall is also influenced by information processing in other stages, such as encoding and retrieval respectively.

Furthermore, the DRT did not consider the effects of other factors which may affect encoding and retrieval, as well as visuospatial and verbal memory differently. These confounding factors also make it difficult to understand the effects of different cognitive tasks on intrusions and intentional memory recall. For example, one study found that stress facilitated consolidation of visuospatial information (Cahill, Gorski, & Le, 2003), whereas another study showed that stress impaired retrieval of verbal information (Kuhlmann, Piel, & Wolf, 2005). Nairne (2002) suggested that the match between encoding and retrieval helps the performance on retrieval, such as the conditions where the stimuli are presented.

To sum up, the DRT oversimplified information processing in traumatic memory. The DRT regards intrusions mainly include visuospatial information that does not require much attentional capacity, whereas intentional recall of trauma memory mainly consists of verbal information that requires being consciously processed. The DRT also ignored the coordination and manipulation function of the higher order executive in working memory, but only focused on information processing in lower-order systems – SAM and VAM. Moreover, the DRT did not consider information processing in encoding, storage and consolidation, and retrieval stages and factors that may affect these stages differently, but only focused on storage and consolidation stage. These limitations of the DRT may partially explain mixed findings examining hypotheses generated from the DRT. Therefore, more research is needed to establish a more comprehensive model to better understand the development of traumatic memory, and to help reduce intrusions and other PTSD symptoms.

In the present study, exploratory analyses werealso conducted to examine the associations between various individual differences and PTSDsymptoms across conditions. Consistent with previous research (Berenz, Vujanovic, Coffey &Zvolensky, 2012; Collimore, McCabe, Carleton &Asmundson, 2008), the findings of Study 1 and Study 2 revealed positive relationships between anxiety sensitivity and PTSD symptoms, even after controlling for depression and trait anxiety.Anxiety sensitivity, the fear of physical sensations based on the perceptions that these sensations have harmful consequence (Reiss & McNally, 1985), has been implicated as a risk factor for PTSD(Olatunji&Wolitzky-Taylor, 2009). Although prior research has observed associations between anxiety sensitivity and PTSD symptom severity, especially avoidance and hyperarousal (Berenz et al., 2012; Bernsteinet al., 2005), few studies have directly examined the relationship between anxiety sensitivity and trauma-related memory. Study 1 found that the physical concerns subscale of anxiety sensitivity was positively correlated with intrusions and negatively correlated with intentional memory recall. This finding suggests that the fear of physical sensations contribute to the development of more intrusions but result in worse intentional memory recall. Study 2found a positive relation between physical concerns and sensory-based intrusions reported in Study 1, but did not replicate the negative relation between physical concerns and intentional memory recall. This overall pattern of results indicates that fear of physical sensations may predict traumatic intrusions, but its relationship with intentional memory recall requires further investigation.

Although the present findings suggest that prior evidence that engagement in visuospatial tasks reduces trauma intrusions may not be robust, various limitations should be noted. In Study 1, the visuospatial task and verbal task were matched in subjective ratings of difficulty and engagement. However, common cognitive load assessment consists of performance on a task, subjective and physiological measures (Cegarra& Chevalier, 2008).A more comprehensive assessment could be conducted to better match cognitive tasks in terms of cognitive load. Furthermore, the Recognition Memory Test was constructed to assess intentional memory recall of the specific trauma film in the present study. The psychometric properties and validity of this measurement has not been examined in a large population. Though the preliminary analyses in the present study provided initial support, indicated by high inter-rater reliability, the utility of this test requires to be explored with more comprehensive methods.

Appendix

		10 min		30 min		10 min
Individual Measures on depression, state anxiety, and anxiety sensitivity	Mood	Trauma Film	Mood	Filler Task	Neutral images presentation	Visuospatial task, verbal task, or sitting quietly

REFERENCES

Addis, D. R., Knapp, K., Roberts, R. P., &Schacter, D. L. (2012). Routes to the past: Neural substrates of direct and generative autobiographical memory retrieval. *Neuroimage, 59,* 2908-2922.

Alloway, T. P., Pickering, S. J., &Gathercole, S. E. (2006). Verbal and visuospatial short-term and working memory in children: Are they separable? *Child Development, 77*(6), 1698-1716.

American Psychiatric Association.(2000). Diagnostic and statistical manual of mental disorders (4th ed., text revision). Washington DC: Author.

Amir, N., Stafford, J., Freshman, M. S., &Foa, E. B. (1998). Relationship between trauma narratives and trauma pathology. *Journal of Traumatic Stress, 11,* 385-392.

Axmacher, N., Do Lam, A. T. A., Kessler, H., & Fell, J. (2010). Natural memory beyond the storage model: Repression, trauma, and the construction of a personal past. *Frontiers in Human Neuroscience, 4:211.*

Baddeley, A. D. (1996). Exploring the central executive.*The Quarterly Journal of Experimental Psychology A, 49, 1,* 5-28.

Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences, 4*(11), 417-423.

Baddeley, A. D., & Hitch, G. (1974).Working memory. In G. H. Bower (Ed.), *The Psychology of Learning and Motivation, 8,* 47-89. New York, NY: Academic Press.

Benton, A. L., Hamsher, K., Varney, N. R., &Spreen, O. (1983).*Contributions to neuropsychological assessment*. New York: Oxford University Press.

Berenz, E. C., Vujanovic, A. A., Coffey, S. F., &Zvolensky, M. J. (2012). Anxiety sensitivity and breath-holding duration in relation to PTSD symptom severity among trauma exposed adults. *Journal of Anxiety Disorders, 26,* 134-139.

Berntsen, D. (1996). Involuntary autobiographical memory.*Applied Cognitive Psychology, 10*(5), 435-454.

Berntsen, D. Willert, M., & Rubin, D. C. (2003). Splintered memories or vivid landmarks? Qualities and organization of traumatic memories with and without PTSD.*Applied Cognitive Psychology. 17,* 675-693.

Bernstein, A. Zvolensky, M. J., Feldner, M. T., Lewis, S. F., Fauber, A. L., Leen-Feldner, E. W., &Vujanovic, A. A. (2005). Anxiety sensitivity taxon and trauma: discriminant associations for posttraumatic stress and panic symptomatology among young adults. *Depression and Anxiety, 22,* 138-149.

Blanchet, S., Desgranges, B., Denise, P., Lechevalier, B., Eustache, F., & Faure, S. (2001). New question on the hemispheric encoding/retrieval asymmetry (HERA) model assessed by divided visual-field tachistoscopy in normal subjects. *Neuropsychologia, 39,* 502-209.

Bourne, C., Frasquilho, F., Roth, A. D., & Holmes, E. A. (2010). Is it mere distraction? Peri-traumaticverbal tasks can increase analogue flashbacks but reduce voluntary memory performance. *Journal of Behavior Therapy and Experimental Psychiatry, 41,* 316-324.

Brewin, C. R. (1989). Cognitive change processes in psychotherapy. *Psychological Review. 96,* 379-394.

Brewin, C. R. (2001). Cognitive and emotional reactions to traumatic events: Implications for short-term intervention. *Advances in Mind-Body Medicine, 17,* 160-196.

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

Brewin, C. R. (2007). Autobiographical memory for trauma: Update on four controversies. *Memory, 15,* 227-248.

Brewin, C. R., Dalgleish, T., & Joseph, S. (1996). A dual representation theory of posttraumatic stressdisorder.*Psychological Review. 103* (4),670-686.

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

Buckley, T. C., Blanchard, E. B., & Neill, W. T. (2000). Information processing and PTSD: A review of the empirical literature. *Clinical Psychology Review, 20*(8), 1041-1065.

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

Cahill, L., Gorski, L., & Le, K. (2003).Enhanced human memory consolidation with post-learning stress: Interaction with the degree of arousal at encoding.*Learning and Memory, 10,* 270-274.

Callicott, J. H., Mattay, V. S., Bertolino, A., Finn, K., Coppola, R., Frank, J. A., …Weinberger, D. R., (1999). Physiological characteristics of capacity constraints in working memory as revealed by functional MRI.*Cerebral Context, 9*(1), 20-26.

Cegarra, J., & Chevalier, A. (2008). The use of tholos software for combining measures of mental workload: Toward theoretical and methodological improvements. *Behavior Research Methods, 40*(4), 988-1000.

Chandler, P., &Sweller, J. (1991). Cognitive load theory and the format of instruction.*Cognition and Instruction, 8*(4), 293-332.

Collimore, K. C., McCabe, R. E., Carleton, R. N., Asmundson, G. J. G. (2008). Media exposure and dimensions of anxiety sensitivity: Differential associations with PTSD symptoms clusters. *Journal of Anxiety Disorders, 22,* 1021-1028.

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

Delaney, H. D. & Maxwell, S. E. (1981).On using analysis of covariance in repeated measures designs.*Multivariate Behavioral Research, 16,* 105-123.

De Silva, P., & Marks, M. (1999).Intrusive thinking in post-traumatic stress disorder. In W. Yule (Ed.), *Post-traumatic stress disorders: Concepts and therapy.* (pp. 161-175). New York: John Wiley and Sons.

Diana, R. A., Yonelinas, A. P. &Ranganath, C. (2007).Imaging recollection and familiarity in the medial temporal lobe: A three-component model.*Trends in Cognitive Sciences, 11,* 376-386.

Durham, T. W., McCammon, S. L., & Allison, E. J. (1985).The psychological impact of disaster on rescue personnel.*Annals of Emergency Medicine, 14,* 664-668.

Eberly, R. E., Harness, A. R., &Egndahl, B. E. (1991).An adaptation view of trauma response as illustrated by the prisoner of war experience.*Journal of Traumatic Stress, 4,* 363-380.

Ehlers, A. (2010). Understanding and treating unwanted trauma memories in posttraumatic stress disorder. *Journal of Psychology, 218(2),* 141-145.

Ehlers, A., & Clark, D. M. (2000).A cognitive model of posttraumatic stress disorder.*Behavior Research and Therapy, 38*(4), 319-345.

Ehlers, A., Hackmann, A., & Michael, T. (2004). Intrusive re-experiencing in post-traumatic stress disorder: Phenomenology, theory, and therapy. *Memory, 12*(4), 403-415.

Ehlers, A., Hackmann, A., Steil, R., Clohessy, S., Wenninger, K., &Winter, H. (2002). The nature of intrusive memories after trauma: The warning signal hypothesis. *Behavior Research and Therapy. 40,* 1021-1028.

Engle, R. W., Tuholski, S. W., Laughlin, J. E., & Conway, A. R. A. (1999). Working memory, short-term memory and general fluid intelligence: A latent variable approach.Journal of Experimental Psychology.*General, 128,* 309-331.

Falsetti, S. A., Monnier, J., Davis, J. L., &Resnick, H. S. (2002).Intrusive thoughts in Posttraumatic Stress Disorder.*Journal of Cognitive Psychotherapy: An International Quarterly, 16*(2), 127-143.

Foa, E. B., & Cahill, S. P. (2001).Emotional processing in psychological therapies.In N. J. Smelser& P. B. Bates (Eds.), *International encyclopedia of the social and behavioral sciences* (pp. 12363-12369). New York: Elsevier.

Foa, E. B., & Riggs, D. S. (1993). Post-traumatic stress disorder in rape victims. In J. M. Oldham, M. B. Riba, & A. Tasman, *Annual review of psychiatry* (pp, 273-303). Washington, DC: American Psychiatric Association.

Foa, E. B., Riggs, D. S., &Gershuny, B. S. (1995). Arousal, numbing, and intrusions: Symptom structure of PTSD following assault. *American Journal of Psychiatry, 152,* 116-120.

Friedman, N. P., & Miyake, A. (2000). Differential roles for visuospatial and verbal working memory in situation model construction. *Journal of Experimental Psychology: General, 129*(1), 61-83.

Gross, J. J., &Levenson, R. W. (1995). Emotion elicitation using films.*Cognition and Emotion, 9,* 87-108.

Gunter, R. W., &Bodner, G. E. (2008). How eye movements affect unpleasant memories: support for a working memory account. *Behavior Research and Therapy, 46,* 913-931.

Hackmann, A., Ehlers, A., Speckens, A., & Clark, D.M., (2004). Characteristics and content of intrusive memories in PTSD and their changes with treatment. *Journal of Traumatic Stress, 17*(3), 231-240.

Hellawell, S. J., &Brewin, C. R. (2002a). A comparison of flashbacks and ordinary autobiographical memories of trauma: Content and language. *Behavior Research and Therapy 42*, 1-12.

Hellawell, S. J., &Brewin, C. R. (2002b). A comparison of flashbacks and ordinary autobiographical memories of trauma: cognitive resources and behavioral observations. *Behavior Research and Therapy, 40,* 1143-1156.

Holmes, E. A., Brewin, C. R., & Hennessy, R. G. (2004). Trauma films, information processing, and intrusive memory development. *Journal of Experimental Psychology: General, 133*(1), 3-22.

Holmes, E. A., James, E. L., Coode-Bate, T., &Deeprose, C. (2009). Can playing the computer game "Tetris" reduce the build-up of flashbacks for trauma? A proposal from cognitive science.*PLoS ONE 4*(1):e4163.

Holmes, E. A., James, E. L., Kilford, E. J., &Deeprose, C. (2010). Key steps in developing a cognitive vaccine against traumatic flashbacks: Visuospatial tetris versus verbal pub quiz. *PLoS ONE 5*(11): e13706.

Jacobs, W. J., &Nadel, L. (1985).Stress-induced recovery of fears and phobias.*Psychological Review, 92,* 512-531.

Jacobs, W. J. &Nadel, L. (1998).Neurobiology of reconstructed memory.*Psychology, Public Policy and Law, 4,* 1110.

Jones, C., Harvey, A. G., &Brewin, C. R. (2007).The organization and content of trauma memories in survivors of road traffic accidents.*Behavior Research and Therapy, 45,* 151-162.

Just, M. A. & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review, 99*(1), 122-149.

Kane, M. J., Hambrick, D. Z., Tuholski, S. W., Wilhelm, O., Payne, T. W., & Engle, R. W. (2004). The generality of working memory capacity: A latent-variable approach to verbal and visuospatial memory span and reasoning. *Journal of Experimental Psychology: General, 133,* 189-217.

Kent, C., & Lamberts, K. (2008). The encoding-retrieval relationship: Retrieval as mental simulation. *Trends in Cognitive Sciences, 12,* 92-98.

Koriat, A., Goldsmith, M., &Pansky, A. (2000).Toward a psychology of memory accuracy.*Annual Review of Psychology, 51,* 481-537.

Krans, J., Näring, G., &Becker, E. S. (2009). Count out your intrusions: Effects of verbal encoding on intrusive memories. *Memory, 17*(8), 809-815.

Krans, J., Näring, G., Holmes, E. A., &Becker, E. S. (2009).“I see what you’re saying”: Intrusive images from listening to a traumatic verbal report. *Journal of Anxiety Disorders 24*, 134-140.

Kuhlmann, S., Piel, M., & Wolf, O. T. (2005).Impaired memory retrieval after psychosocial stress in healthy young men.*Journal of Neuroscience, 25*, 2977-2982.

Laposa, J. M., & Rector, N. A. (2012). The prediction of intrusions following an analogue traumatic event: Peritraumatic cognitive processes and anxiety-focused rumination versus rumination in response to intrusions. *Journal of Behavior Therapy and Experimental Psychiatry, 43,* 877-883.

McNally, R. J., Lasko, N. B., Macklin, M. L., & Pitman, R. K. (1995). Autobiographical memory disturbance in combat-related posttraumatic stress disorder.*Behavior Research and Therapy, 33,* 619-630.

McNally, R. J., Litz, B. T., Prassas, A., Shin, L. M., & Weathers, F. W. (1994).Emotional priming of autobiographical memory in posttraumatic stress disorder.*Cognition & Emotion, 8,* 351-367.

Michael. T., Ehlers, A., Halligan, S. L., & Clark, D. M. (2005). Unwanted memories of assault: What intrusion characteristics are associated with PTSD? *Behavior Research and Therapy, 43,* 613-628.

Moore, S. A. &Zoellner, L. A. (2007). Overgeneral autobiographical memory and traumatic events: An evaluative review. *Psychological Bulletin, 133*(3), 419-437.

Murray, J., Ehlers, A., &Mayou, R. A. (2002). Dissociation and posttraumatic stress disorder: Two prospective studies of motor vehicle accident survivors. *British Journal of Psychiatry; the Journal of Mental Science, 180,* 363-368.

Nairne, J. S. (2002). The myth of the encoding-retrieval match.*Memory, 10,* 389-395.

Olatunji, B. O. &Wolitzky-Taylor, K. B. (2009). Anxiety sensitivity and the anxiety disorders: A meta-analytic review and synthesis. *Psychological Bulletin, 135*(6), 974-999.

Pearson, D. G. & Sawyer, T. (2011).Effects of dual task interference on memory intrusions for affective for affective images.*International Journal of Cognitive Therapy, 4,* 122-133.

Radloff, L. S. (1977). The CES-D scale: A self report depression scale for research in the general population. *Applied Psychological Measurement, 1,* 385-401.

Reiss, S., & McNally, R. J. (1985). The expectancy model of fear. In S. Reiss & R. R. Bootzin (Eds.), *Theoretical issues in behavior therapy* (pp. 107-121). London, England: Academic Press.

Sherry, D. F., &Schacter, D. L. (1987).The evolution of multiple memory systems.*Psychological Review, 94,* 439-454.

Simons, J. S., &Spiers, H. J. (2003).Prefrontal and medial temporal lobe interactions in long-term memory.*Nature Reviews Neuroscience, 4,* 637-648.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory.*Palo Alto, CA: Consulting Psychologists Press, Inc.

Steil, R., & Ehlers, A. (2000). Dysfunctional meaning of posttraumatic intrusions in chronic PTSD. *Behavior Research and Therapy, 38,* 537-558.

Sumner, J. A. (2012). The mechanisms underlying overgeneral autobiographical memory: An evaluative review of evidence for the CaR-FA-X model. *Clinical Psychology Review, 32,* 34-48.

Taylor, S., Zvolensky, M. J., Cox, B. J., Deacon, B., Heimberg, R. G., Ledley, D. R., ... & Cardenas, S. J. (2007). Robust dimensions of anxiety sensitivity: Development and initial validation of the Anxiety Sensitivity Index-3. *Psychological Assessment, 19,* 176-188.

Trinder, H. & Salkovskis, P. M. (1994). Personality relevant intrusions outside the laboratory: Long term suppression increases intrusion. *Journal of Behavior Therapy and Experimental Psychiatry, 40* (1), 147-157.

Tulving, E. (1983). *Elements of Episodic Memory*. New York: Oxford University Press.

Walker, M. P., Brakefield, T., Hobson, J. A., &Stickgold, R. (2003). Dissociable stages of human memory consolidation and reconsolidation. *Nature, 425,* 616-620.

Weidmann, A. Conradi, A., Gröger, K., Fehm, L. &Fydrich, T. (2009). Using stressful films to analyze risk factors for PTSD in analogue experimental studies – which film works best? *Anxiety, Stress, & Coping, 22*(5), 549-569.

Weiss, D. &Marmar, C. (1997). The Impact of Event Scale -Revised. In J. Wilson & T. Keane (Eds), Assessing psychological trauma and PTSD. New York: Guildford.

Williams, J. M. G. (1996). Depression and the specificity of autobiographical memory. In D.C. Rubin (Ed.), *Remembering our past: Studies in autobiographical memory* (244-267). New York: Cambridge University Press.

Williams, J. M. G. (2004). Experimental cognitive psychology and clinical practice: Autobiographical memory as a paradigm case. In J. Yiend (Ed.), *Cognition, emotion and psychopathology* (pp. 251-269). Cambridge, England: Cambridge University Press.

Williams, J. M. G. (2006). Capture and rumination, functional avoidance, and executive control (CaRFAX): Three processes that underlie overgeneral memory. *Cognition and Emotion, 20,* 548-568.

Woodward, S. H., Murburg, M. M., &Bliwise, D. L. (2000). PTSD-related hyperarousal assessed during sleep. *Physiology and Behavior, 70,* 197-203.