

**Remembering and forgetting after trauma: Studies of cognition with victims of sexual  
assault**

**Ines Blix**

**Center for the Study of Human Cognition**

**Department of Psychology**

**Faculty of Social Sciences**

**University of Oslo**

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## **Amendments**

After the submission of my dissertation to the Faculty of Social Sciences June 30, 2011, a revised version of paper II has been published in *Frontiers in Psychology*, while a revised version of paper III has been accepted for publication in *Memory*.

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## General summary

The overarching goal in the present project was to investigate memory processes in trauma-exposed individuals. In three studies, processes of remembering and forgetting were examined in trauma-exposed individuals who had experienced sexual abuse and non trauma-exposed controls.

Trauma-exposed individuals experience some degree of repetitive thoughts and intrusive memories. Deficits in intentional forgetting and retrieval-induced forgetting, both thought to be underpinned by inhibition mechanisms, have been proposed to be a cause of intrusive memories in the aftermath of trauma. The studies reported in paper I and II employed a variant of Retrieval Induced Forgetting task (RIF) and the Directed Forgetting task (DF) to investigate the relationship between trauma and forgetting mechanisms. By including trauma-specific cue words, in addition to neutral, positive and threat-related cue words, it was possible to test for trauma-specific effects.

The results reported in paper I showed no differences in RIF between trauma-exposed participants and controls. However, we found a general tendency for eradicated RIF for emotional material. The finding that RIF does not work for emotional material might have different consequences for non trauma-exposed individuals as opposed to trauma-exposed individuals. For non trauma-exposed healthy individuals this tendency might be relatively harmless and perhaps be reflected in rumination over previous negative or positive experiences. In the aftermath of trauma, however, the very same tendency might have a more negative impact, because memories that repeatedly intrude into consciousness are experienced as very disturbing.

Uncomfortable intrusive memories from a traumatic experience might lead trauma victims to avoid such memories through intentional forgetting. Paradoxically, attempting to intentionally forget can have the effect that unwanted thoughts rebound with even greater persistence (Wegner, 1989). The findings in paper II showed that there was no difference between trauma-exposed and non trauma-exposed participants in correct recall of to-be-forgotten words of any valence, suggesting that the trauma-exposed participants were neither better nor worse than their non trauma-exposed peers in intentional forgetting.

In sum, the findings in paper I and II did not support a hypothesis of impaired inhibition mechanisms in trauma-exposed individuals. However, the results reported in paper



It did show that trauma-exposed individuals had a higher level of “Intrusive“ recall of to-be-forgotten trauma words when asked to recall to-be-remembered words. Moreover, this tendency was related to symptoms of intrusion reported on the IES. This might suggest problems in source monitoring of trauma-related material in trauma-exposed individuals.

Paper III investigated the relationship between trauma exposure and specificity and temporal distribution of autobiographical memories and future directed thoughts. A relationship between trauma symptoms and reduced specificity of autobiographical memories was found, but no such relationship was found for future-directed thoughts. The results reported in paper III suggest that trauma symptoms only influence the specificity of mental time travel to the past, and not to the future. No difference in temporal distribution of future directed thoughts or autobiographical memories between trauma-exposed participants and controls was found.

In summary, this thesis contributes to the understanding of processes of remembering and forgetting in trauma-exposed individuals.

### **List of papers**

- I. Blix, I., & Brennen, T. (in press). Retrieval-induced forgetting after trauma: A study with victims of sexual assault. *Cognition & Emotion*, doi: 10.1080/02699931.2011.570312
- II. Blix, I., & Brennen, T.(under review). Intentional forgetting of emotional words after trauma: A study with victims of sexual assault.<sup>1</sup>
- III. Blix, I., & Brennen, T.(under review). Mental time travel after trauma: The specificity and temporal distribution of autobiographical memories and future-directed thoughts.<sup>2</sup>

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<sup>1</sup> Revised version published in *Frontiers in Psychology*

<sup>2</sup> Revised version accepted for publication in *Memory*

## Introduction

### Trauma and post-traumatic stress

The word 'trauma' comes from Greek and means 'wound', and was first used in the beginning of the 20<sup>th</sup> century to describe mental reactions to a traumatic event (Brewin, 2003). Arousal and involuntary memories about the traumatic event and avoidance have been central in descriptions of human reactions to traumatic events in the literature (Van der Kolk, 2007). In Shakespeare's play Macbeth, classical post-trauma symptoms such as emotional overwhelming, nightmares, and disturbing recollections are described. Another example can be found in Samuel Pepys' diary where he described post-trauma reactions such as insomnia, recurrent dreams and nightmares about the traumatic event, and anxiety reactions after 'the great fire of London' in 1666 (Daly, 1983).

The understanding of trauma reactions and psychopathology in the aftermath of trauma has changed throughout history. During the World War I, traumatic stress reactions observed in soldiers were mainly explained as having physical origins (Van der Kolk, Weisaeth & Van der Hart, 2007). However, after it was evident that several of the soldiers suffering from trauma symptoms had never been exposed to gunfire, the concept '*shell shock*' was introduced in the literature by Charles Myers (1915), and trauma was recognised to have emotional origins. When World War II broke out concepts such as 'war-neurosis' and 'post-trauma syndrome' were being used by mental health professionals. Kardiner (1941) described '*post-trauma syndrome*' as characterised by intrusive recollection, hyper-vigilance, and irritability.

Parallel to the search for an understanding of trauma reactions in soldiers, scholars like Charcot, Janet, Brewer and Freud questioned the etiology of trauma in civilians. Trauma was seen in relation to hysteria, and the process of integration of trauma in memory was central in both Janet and Freud's work on trauma (Van der Kolk, 2007). Breuer and Freud (1893/1955) explained that the symptoms of hysteria were caused by memories of psychological traumas. Furthermore, they described how some individuals were tormented by unacceptable memories related to a psychological trauma in the past. These trauma memories were painful for the individual, and according to Breuer and Freud (1893/1955) defense mechanisms such as repression were used to force these memories out of consciousness.

After the Vietnam War, in 1980, Post-traumatic stress disorder (PTSD) was included as a diagnosis in DSM-III. Three groups of symptoms were defined in DSM-III; re-

experiencing symptoms, numbing symptoms, and miscellaneous symptoms including hyper-arousal symptoms, avoidance symptoms and memory and concentration impairments. The PTSD diagnosis defined a causal factor for the disorder as exposure to a “*stressor that would evoke significant symptoms of distress in almost everyone*” and was “*outside the range of normal human experience*” (APA, 1980, p.238). Thus the PTSD diagnosis was formulated to include individuals exposed to a broad variety of traumatic events. The PTSD diagnosis was heavily influenced by the work of Horowitz (1975; 1976) who proposed that trauma survivors go through alternating phases of intrusion and avoidance.

In the current DSM, DSM-IV, PTSD is classified as an anxiety disorder, and the symptoms include avoidance of reminders of the traumatic experience, avoidance of thinking about the trauma, intrusive recall of trauma-related memories, and persistent symptoms of arousal (First & Tasman, 2004). Criterion A, the definition of a traumatic event, was changed in DSM-IV to include both objective criteria for what constitutes a traumatic events and the subjective experience of the event. DSM-IV Criterion A, define a traumatic event as “*an event or events that involved actual or threatened death or serious injury, or a threat to the physical integrity of self or others*”, furthermore the criterion A (stressor) in DSM-IV also include immediate subjective reactions associated with the episode “*the person’s response involved intense fear, helplessness or horror*”. Furthermore, the DSM-III symptom “*every day memory impairments*” was replaced by “*inability to recall an important aspect of the trauma*” in DSM-III-R and this formulation was kept in DSM-IV.

Critics of the PTSD diagnosis have argued that the symptoms listed in DSM-IV should be understood as normal reactions to an abnormal event. According to Field (1999) post-trauma symptoms such as intrusive memories are normal reactions that disappear with time. However, as pointed out by Brewin (2003), even though normal reactions to traumatic events are similar to symptoms listed in DSM-IV, PTSD can be recognised by the persistence, and intensity of the symptoms and also by the fact that the symptoms do not fade with time. In line with this, DSM-IV (criterion E & F) specifies that the “*duration of the disturbance is more than one month*” and that “*the disturbance cause clinically significant distress or impairment in social, occupational or other important areas of functioning*”. Without taking a stand in the ongoing discussion about the PTSD diagnosis, it can be argued that trauma symptoms are best understood along a continuum as opposed to as a PTSD or non-PTSD dichotomy.

Understanding the relationship between trauma exposure and post-trauma symptoms, and the mechanisms underlying psychopathology in the aftermath of trauma is important, because the risk for experiencing a traumatic event sometime during life is high. A study in the U.S population reported the estimate of lifetime risk to be 82.8%; however surveys from Germany and Switzerland have reported estimates of 20-28% (Breslau, 2009). A proportion of people that experience trauma develop persistent PTSD, a review of studies from United States, Canada, Germany, the Netherlands, Switzerland, Lebanon, and Australia reported a <10% life-time prevalence of PTSD (Breslau, 2009).

### **Trauma and Memory**

That experiencing traumatic events influence memory is well established (McNally, 2003). Trauma can influence memory in a number of ways, but one particularly useful distinction is between how trauma influences memory in general and memory for the traumatic event in itself. One of the greatest controversies in modern psychology has concerned memory of the traumatic event. The fierce exchanges that took place in the 90s, often referred to as “the memory wars”, concerned how trauma is remembered (McNally, 2003). On the one hand there were clinical observations that showed that memories of trauma can be suppressed and even totally forgotten and then recovered years later (Brewin, 2003). On the other hand some researchers argued that traumatic events are rather highly memorable and more difficult to forget than other memories (e.g. Shobe & Kihlstrom, 1997; McNally, 2005).

Experiencing trauma does not only influence how we remember the traumatic episode, but also memory in general and memory for material that is related to the traumatic event in the past. Trauma has for example been reported to be associated with intrusive recall of trauma-related memories (Krans, Näring, Becker & Holmes, 2009), retrieval advantage for trauma-relevant material (e.g. Golier, Yehuda, Lupien, & Harvey, 2003; Vrana, Roodman, & Beckham, 1995), deficits in intentional forgetting (Cottencin et al., 2006), higher level of false recall (e.g. Brennen, Dybdahl, & Kapidžić, 2007; Zoellner, Foa, & Przeworski, 2000), and overgeneral retrieval of autobiographical memories (for a review see Moore & Zoellner, 2007).

Furthermore, disturbance in memory is highlighted in the DSM-IV diagnosis for PTSD, and in cognitive theories on PTSD (e.g. Brewin, Dalgleish, Joseph 1996; Ehlers &

Clark, 2000; Horowitz, 1975; Rubin et al., 2008). In a recent review, Brewin (2011) summarised the empirical literature on the relationship between PTSD and memory disturbance. He classified memory into three main aspects and concluded that PTSD is associated with alterations in capacity, content and process. Disturbance in memory capacity refers to alterations in capability to retain, retrieve and manipulate material, alterations in content refers to changes in what semantic and episodic memories individuals remember from their past, and finally disturbance of memory process are connected to encoding, storage and retrieval. In his review Brewin (2011) concluded disturbances have been reported in all three of these aspects of memory. The focus of the present thesis is the relationship between trauma exposure and PTSD symptoms and deficits in memory processes.

**Cognitive theories of PTSD.** The symptoms of PTSD can be understood from a cognitive perspective, and several models of cognitive functioning in PTSD have been proposed (e.g. Brewin, Dalgleish & Joseph 1996; Ehlers & Clark, 2000; Foa, Steketee & Rothbaum, 1989; Horowitz, 1975; Janoff-Bulman, 1992; Rubin, Berntsen & Bohni, 2008). The three theories highlighted here do not only inform us about cognition in clinical PTSD, but can also explain memory processes after trauma exposure and development of persistent trauma symptoms in the aftermath of trauma.

One of the most complete models is Ehlers & Clark's (2000) cognitive model. This model rests upon an assumption that persistent PTSD develops only if trauma is processed in such a way that it produces a sense of current threat. First, individuals who suffer from persistent PTSD are unable to see trauma as a time-limited event, and rather sees it as global and stable in that it is thought to have negative effects for the future. This first key process concerns appraisal of the traumatic event, trauma sequelae and appraisal of emotional responses. The second key process concerns a disturbance of autobiographical memory, which is particularly evident in the symptoms of unwanted intrusive thoughts and at the same time difficulties with deliberate retrieval of trauma-related memories. Ehlers & Clark (2000) explain these disturbances in memory by poor elaboration and contextualization of trauma material and at the same time strong associative memory and perceptual priming. Ehlers & Clark's (2000) model implies that the observed cognitive differences between PTSD patients, trauma survivors without PTSD, and people who have never experienced severe trauma, will be evident during processing of trauma-related material.

Brewin et al.'s (1996) dual representation theory of PTSD holds that two memory systems operate in trauma-exposed individuals; verbally accessible memories (VAM) and situationally accessible memories (SAM). VAM memories are narratives of an event that can be expressed by words, these memories are integrated with autobiographical memory, and can be voluntarily accessed and edited. SAM memories include information of a more sensory quality, these memories can only be accessed involuntarily, and are triggered by the situational context. Normally SAM memories are an integrated part of VAM memories. However, when experiencing a traumatic episode integration of SAMs into VAM can be prevented. As a result more memories of the trauma are integrated into SAM, and the lack of integration with VAMs can lead to intrusive memories because inhibition of unwanted memories depends on the VAM system. Furthermore, activation of SAM memories is thought to explain flashbacks. Normally, in the aftermath of a traumatic event flashbacks would work to transfer information from the SAM to the VAM system, however in PTSD there is a breakdown in this function possible due to avoidance mechanisms or to great difference between information in the VAM and the SAM system (Brewin, 2001). Thus, according to the dual process theory two distinct types of memories co-exist in the trauma-exposed individual and this can explain the symptoms in PTSD.

Rubin, Berntsen and Bohni (2008) proposed a memory-based model of PTSD where development of PTSD symptoms following a trauma depends on the interaction between the event and the memory processes following the event. According to the mnemonic model it is the memory of the traumatic event, not the event itself that determines reactions and symptoms. As memory is constructive, the memory of the traumatic event is changing and is retrieved in different form or versions. Furthermore, memory is influenced by an individual's current goals as well as number of individual differences such as intelligence, education, gender and personality (Rubin et al., 2008). The main argument in Rubin et al.'s (2008) model is that memory is a mediator in the relationship between trauma exposure and trauma symptoms. Rubin et al.'s (2008) model departs from the DSM-IV model in that DSM-IV does not take into consideration that the memory of the trauma changes over time.

One of the main differences between these theories is the explanation of memory processes in the aftermath of trauma. Brewin et al.'s (1996) theory, and Ehlers and Clark's (2000) theory suggest that special memory mechanisms are involved in processing memory of a traumatic event, and that these special memory mechanism can explain how post-trauma symptoms arise and develop. According to Brewin et al.'s (1996) theory, and Ehlers and

Clark's (2000) theory, intrusive memories of the traumatic event arise because these memories are not integrated with the rest of autobiographical memory. Integration in autobiographical memory is prevented by maladaptive strategies like avoidance and suppression of disturbing thoughts. According to Rubin et al.'s (2008) model, however, no special memory mechanisms are needed to explain post-trauma symptoms like intrusive memories. Rather ordinary mechanisms of memory can explain how symptoms of PTSD develop after trauma. The mnemonic model is based on a basic mechanisms view, and holds that what is known about emotion and memory in general can explain symptoms of PTSD (Berntsen, Rubin & Bohni, 2008). Furthermore, this model predicts that also memories for emotional events that fall outside the criterion A in DSM-IV can lead to PTSD symptoms.

Brewin et al.'s (1996) and Ehlers & Clark's (2000) theories predict that in trauma-exposed individuals with high levels of trauma symptoms, voluntary memory for the traumatic episode is impaired while involuntary recollection is enhanced. Rubin et al.'s (2008) theory has an arguably broader scope and is less specified than Brewin et al.'s (1996) and Ehlers & Clark's (2000) theories, and holds that normal memory functioning operates after trauma and in people with PTSD. Based on what is known about emotion and memory in general, Berntsen et al. (2008) argue that both voluntary and involuntary recall will be enhanced for trauma-related memories.

Brewin et al.'s (1996) and Ehlers & Clark's (2000) theories suggest that disturbances in memory are specifically related to the traumatic episode or material related to the traumatic episode. Also, DSM-IV describe alterations in memory that are connected to the trauma, but do not specify whether memory for emotional positive or neutral material is altered. However, whether memory deficits after trauma are best characterised a trauma-specific or general deficits are yet to be determined. Hence, a pertinent question concerns whether memory impairments in trauma-exposed individuals, and in individuals with PTSD in particular, extend beyond processing of the traumatic episode or material specifically connected to the traumatic episode.

With background in the three different theoretical perspectives on trauma and memory presented above, this thesis aims to further investigate the relationship between trauma exposure, trauma symptoms and memory processes. More specifically, the studies in the present thesis investigated both voluntary and involuntary memory of material specifically related to the traumatic episode in the past, and neutral, positive and negative material. Two of the papers in the present thesis approach this question by studying retrieval induced and



intentional forgetting of material specifically connected to the traumatic episode as well as positive, negative and neutral material. The third paper in the present thesis addresses a related question of how retrieval of positive, negative and neutral autobiographical memories and future directed thoughts are influenced by trauma exposure and post-trauma symptoms.

### **Empirical background for the present studies**

**Retrieval-induced forgetting after trauma.** The repetitive thoughts and intrusive memories that trauma-exposed people experience might be explained by deficits in inhibition mechanisms. The Retrieval-Induced Forgetting task (RIF) is used to study how repeated retrieval practice of some memories can impair retrieval of related memories (Anderson, Bjork & Bjork, 1994). In the RIF paradigm participants are asked to learn lists of categorically organised words. Subsequently, some words from some of the categories are practised in a word-stem completion task. Finally, the participants are asked to recall the words from the initial study-list. The words that are practised are best remembered. However, the more interesting point is that unpractised words from categories that were practiced are worse recalled than unpractised words from categories that were not included in the practice phase. So, retrieval practice of “banana” and “apple” makes it more difficult to remember “pear” or “orange”, but doesn’t influence how difficult it is to remember “chair” or “table”. The RIF effect is proposed to involve inhibitory cognitive control processes during retrieval practise, whose function are to facilitate retrieval of a target memory by inhibiting or suppressing competing related memories (Anderson, Bjork, & Bjork, 1994; Anderson, 2003). A line of research has proved solid evidence in support for an inhibitory mechanism account for RIF (for an overview see Anderson, 2003). However, the inhibition account for RIF has been questioned, and interference has been proposed as an alternative mechanism underlying the RIF effect (e.g. Camp, Pecher, & Schmidt, 2007). According to an interference account for RIF, forgetting can be explained by reduced effectiveness of the retrieval cue. More specifically, rehearsing some items might cause a stronger association with the category cue word, and at the same time the association between the category cue words and the unpractised item becomes weaker. A problem with an interference explanation for RIF, however, is that it cannot account for RIF in memory tests free from interference, such as RIF observed in recognition tasks (e.g. Dehli & Brennen, 2009; Hicks & Starns, 2004; Perfect, Moulin, Conway, & Perry, 2002; Potts, Law, Golding, & Groome, In Press; Veling & van

Knippenberg, 2004), or RIF in studies using independent cues (e.g. Anderson & Spellman, 1995; Aslan, Bäuml, & Pastotter, 2007; Saunders & MacLeod, 2006).

The tendency for repetitive thoughts and intrusive memories in the aftermath of trauma makes it interesting to investigate RIF in trauma-exposed individuals. On the one hand, trauma exposure is associated with problems in inhibiting intrusive memories, hence if RIF reflects an automatic inhibition mechanism as Anderson (2003) proposes, RIF might be predicted to be impaired for trauma-exposed individuals. On the other hand, if RIF is intact after trauma this might explain another disturbance of memory that has been reported after trauma exposure, that is reduced specificity of autobiographical memories (e.g. McNally, Lasko, Macklin & Pitman, 1995): If RIF is still functional, this constant rehearsal of some autobiographical memories may make it more difficult to recall the latter ones in a specific manner.

Only one study has previously studied RIF in trauma-exposed individuals. Amir, Badour and Freese (2009) investigated whether hypothesised inhibition deficits in PTSD are general or specifically related to processing of emotional material. RIF for threat-relevant, positive and neutral material was studied in participants with PTSD, trauma-exposed controls and non trauma-exposed controls. While the non trauma-exposed controls demonstrated a RIF effect for both non-threatening and threatening cues, the PTSD group and the trauma-exposed controls showed no RIF effect for any type of cue word. Amir et al. (2009) concluded that these results suggest that trauma exposure is associated with a general deficit in inhibition mechanisms, and not a specific deficit in processing of trauma-relevant material.

Intrusive memories are also characteristic for depression (e.g. Brewin, Hunter, Carroll & Tata, 1996), and intrusive memories in depression and PTSD have been found to share the same characteristics (Reynolds & Brewin, 1999). Hence, RIF studies with depressed individuals might inform us about intentional forgetting after trauma exposure. A few studies have investigated RIF in depressed participants, in one study with clinically depressed participants, weaker RIF was found for neutral material (Groome and Sterkaj, 2010). Furthermore, induced negative mood has been found to reduce RIF for neutral material in healthy participants (Bäuml & Kuhbander, 2007). However, a study with high and low dysphoric participants showed that it was no difference in RIF between the two groups. Furthermore both groups showed RIF for neutral material but no RIF for emotional negative material (Moulds & Kandris, 2006).

In summary, impaired inhibition mechanisms have been put forward as a candidate for explaining intrusive thoughts and memories in PTSD and also in depression. Amir et al.'s (2009) study suggests that trauma exposure, independent of PTSD status, is associated with impaired RIF for both threat-related and non threat-related cue words. However, as the authors themselves point out, the threatening material used in the study was general, and did not refer to a particular type of traumatic episode. Moreover, because the participants had experienced different types of traumatic events, for example natural disaster, sexual assault or life threatening illness, the threat material might not have been relevant to the kind of trauma each participant had experienced. So even if the results suggest that individuals with PTSD are susceptible to general inhibition deficits, this study cannot determine whether this tendency might be even more pronounced for trauma-specific material.

**Intentional forgetting after trauma.** The coexisting symptoms of avoidance and intrusion in trauma-exposed individuals can be explained by stronger rebound of trauma memories when attempting to suppress, forget or avoid thinking about the traumatic event. According to Brewin et al.'s (1996) and Ehlers and Clark's (2000) theories, intrusive memories of the traumatic event occur because these memories are prevented from being integrated into autobiographical memory by maladaptive strategies like avoidance and suppression of disturbing thoughts. Brewin et al.'s (1996) and Ehlers & Clark's (2000) theories suggest that this pattern is specific for processing of the traumatic episode or material associated with the traumatic episode. In line with this, a study by Shipherd and Beck (2005) reported that participants with PTSD had a stronger rebound effect than trauma-exposed controls, however this difference was only found for trauma-relevant thoughts and not for personally relevant neutral thoughts.

The Directed Forgetting task (DF) was constructed to measure intentional forgetting and has been used to study both avoidant encoding and intrusive recollection in trauma-exposed individuals. In a DF task, participants are presented with lists of words, followed by an instruction either to Remember or to Forget the presented words. There are two main versions of the DF task: In the list method DF the Remember or Forget instructions are given after presentation of each list, whereas in the item method the Forget or Remember cue is given after each word. The standard Directed Forgetting effect refers to the fact that one remember more words that one has been instructed to remember (R-words) compared to words one was instructed to forget (F-words) (Johnson, 1994).

Inhibition mechanisms have been proposed to underlie the DF-effect observed in the list method DF task. More specifically, during recall the instruction to forget starts a process that blocks access to List 1 items (e.g. Bjork, 1989). Studies that have compared recall and recognition tasks in DF have showed that the DF effect is strong and robust for recall, but absent or very weak for recognition, and this has been used as evidence for an inhibitory explanation for DF (e.g. Bjork, 1989). Although DF most often is explained by inhibition mechanisms, alternative explanations for the DF effect have been proposed. For example, Sahakyan and Kelley (2002) suggested that the DF effect can be attributed to a context change effect, more specifically the forget instruction causes an internal change in context, this new context is maintained during learning of list 2 and also during recollection, and causes reduced memory for List 1 items.

The link between DF and inhibition has made the DF-paradigm especially interesting for research with clinical populations where suppression or intrusive recall is characteristic. A few studies have used the DF task to study recall and forgetting in trauma-exposed individuals hypothesising that trauma-exposed individuals are characterised by avoidant encoding. However, Moulds and Bryant (2002; 2005) are the only item-specific DF studies that support a hypothesis about avoidant encoding after trauma. Their studies showed that participants with acute stress disorder (ASD) were significantly better at forgetting trauma words compared to a group of trauma-exposed participants without ASD. In contrast, Zoellner et al. (2003) and McNally et al. (1998) did not find any evidence for avoidant encoding in trauma-exposed participants with and without PTSD, rather they reported that trauma-exposed individuals remember trauma-related material very well.

One study investigated DF in trauma-exposed individuals from a perspective hypothesising that intrusive memories, rather than avoidance and impaired voluntary recall, characterize cognition in PTSD (Cottencin et al., 2006). More specifically, they hypothesised that PTSD participants have an impaired inhibition mechanism, and hence would have difficulties inhibiting F-words, compared to non trauma-exposed controls. Trauma-exposed participants with PTSD and a non trauma-exposed control group completed a version of the item-cued DF task comprising immediate conditional recall, where participants were asked to recall R-words, and final unconditional recall where participants were asked to recall both R-words and F-words. The results showed that in the immediate conditional recall condition the PTSD group recalled fewer R-words more F-words than controls. In the final recall task where participants were asked to recall both F- and R-words, the DF effect was reduced in the

PTSD group. The PTSD participants recalled fewer R-words, but there was no difference between groups in recall of F-words.

Since depressed and trauma-exposed share several similar symptoms, like intrusive memories (e.g. Brewin et al., 1996) studies on intentional forgetting in depressed individuals studies might inform us about intentional forgetting in trauma-exposed people. One study with clinically depressed, clinically anxious and healthy controls investigated intentional forgetting in these individuals and reported a stronger rebound of depression relevant material in clinical depression. Power et al. (2000) argued that this finding might suggest a common mechanism in depression and PTSD, involving a stronger rebound effect for aversive personal-relevant information.

In summary, the literature suggests that memory after trauma is better characterised by intrusive recollection rather than avoidant encoding and impaired recall of trauma-related memories. As discussed above, intrusive memories in the aftermath of trauma might result from an impaired ability to intentionally forget disturbing material. In line with this, Cottencin et al. (2006) found support for deficits in intentional forgetting of neutral material in participants with PTSD. However, as only neutral material was used, it cannot be determined if different patterns would emerge for emotional and trauma-specific material. Furthermore, Power et al. (2000) reported data showing stronger rebound of depression relevant material in clinical depression, and argued that the list method DF paradigm would be a good model for studying an enhanced rebound effects and intrusive memories also in PTSD. However, as far as we know no study has so far used a list method DF task to study intrusive memories in trauma-exposed participants.

**Mental time travel after trauma.** A line of research has demonstrated a link between trauma and overgeneral autobiographical memories (OGM). That is, instead of retrieving memories from specific events, trauma-exposed individuals tend to refer to more general categorical memories. For example, if asked to retrieve a memory for the word “happy”, trauma-exposed individuals would be more likely to retrieve a general memory such as “every time I did well at school”, as opposed to a specific memory, e.g. “The time I got an A on a math-test”.

A number of studies have demonstrated overgeneral retrieval in individuals exposed to a broad variety of traumatic events (e.g. Brennen et al., 2010; Dalgleish, Tchanturia, Serpell, Hems, Yiend, de Silva & Treasure, 2003; de Decker, Hermans, Raes & Eelen, 2003;

Henderson, Hargreaves, Gregory & Williams, 2002; Hermans, Van den Broeck, Belis, Raes, Pieter & Eelen, 2004; Kuyken & Brewin, 1995; Wessel, Merckelbach & Deckers, 2002; Williams & Broadbent, 1996; Williams, Williams & Ghadiali, 1998). Furthermore, overgeneral autobiographical memory (OGM) is associated with PTSD (McNally, Lasko, Macklin & Pitman, 1995; McNally, Litz, Prassas, Shin & Weather, 1994), acute stress disorder (ASD) (Harvey, Bryant & Dang, 1998), and with major depressive disorder (MDD) (Moore, Watts & Williams, 1988; Puffet, Jehin-Marchot, Timsit-Berthier & Timsit, 1991; Swales, Williams & Wood, 2001; Wessel, Meeren, Peeters, Arntz & Merckelbach, 2001; Williams & Scott, 1988).

Potentially traumatic events are often followed by traumatic stress reactions such as emotional disturbances and psychological disorders, hence it is difficult to determine whether it is exposure to potentially traumatising events per se or if it is the disturbance or disorder following trauma that affects autobiographical memory retrieval. In a review of 24 studies, Moore and Zoellner (2007) concluded that trauma per se is not likely to lead to overgeneral memory, it is rather the symptoms of psychopathology after trauma that causes OGM.

In his recent review, Brewin (2011) concluded that OGM has a predictive role in PTSD, however whether OGM has a direct causal role cannot be determined based on the current literature. As pointed out by Brewin (2011) it is not clear whether the predictive role of OGM is influenced by or can be accounted for by other factors. Several third variables have been suggested to account for the relationship between OGM and PTSD, such as rumination (Kleim, Ehlers, & Glucksman, 2007) and suppression (Schonfeld, Ehlers, Bollinghaus, & Rief, 2007). Another possible mediating variable might be disturbance in future directed thinking or future imageability. In the literature it is often noted that PTSD is associated with problems imagining the future and symptoms of future foreshortening (e.g. McNally, Lasko, Macklin & Pitman, 1995). McNally et al. (1995, p.629) suggested that “*an inability to remember the past may be related to an inability to imagine the future*”, thus in conditions where reduced specificity is found it might also be expected that future-directed thoughts have reduced specificity. However, as far as we are aware, this hypothesis has not been explored empirically. A relationship between trauma and specificity of future-directed thought might be of importance because, as suggested by Williams et al. (2007), an impaired ability to imagine specific events in the future can be related to the ability to solve problems in daily life.

As first highlighted by Tulving (1985; 2002), how we remember the past and how we imagine the future is intimately related. Tulving introduced the concept “mental time travel” and suggested that the same episodic memory system underpins how we remember the past and imagine the future. In line with this, several studies have demonstrated that there is a close relationship between memory and future-directed thinking. For example, deficits in autobiographical memory have been reported to be associated with deficits in future-directed thinking in various populations e.g. in amnesics (Hassabis, Kumaran, Vann & Maguire, 2007), people suffering from schizophrenia (D’Argembeau, Raffard & Van der Linden, 2008), and depressed patients (Williams, Ellis, Tyers, Healy, Rose & MacLeod, 1996).

In summary, symptoms of psychopathology in the aftermath of trauma are associated with an impaired ability to retrieve specific autobiographical memories. Furthermore the specificity for autobiographical memories is closely related with specificity of future directed thoughts. However, no study has investigated the influence of trauma on specificity of future directed thoughts.

### **Main research objectives**

#### **Paper I**

The main objective in this study was to investigate an automatic form of forgetting, Retrieval Induced Forgetting, in a group of sexual-assault victims and a control group. Using a recognition-cued Retrieval Induced Forgetting Task (RIF), this study examined RIF with neutral, positive, negative and trauma-specific material.

#### **Paper II**

This study investigated intentional forgetting and intrusive recall of trauma-specific versus positive, neutral and threat related material in trauma- exposed participants and controls. One aim was to investigate whether hypothesised deficits in intentional forgetting after trauma are specific to processing of trauma-specific material, or if it reflects a general tendency for all types of material. More specifically, we investigated correct recall of Remember and Forget positive, neutral, threat-related and trauma-specific words in trauma-exposed participants and controls. We also examined the relationship between trauma symptoms and depression symptoms and correct recall of Remember and Forget words

A second aim in this study was to investigate intrusive involuntary recollection of trauma-specific material versus positive, threat-related and neutral material. In order to investigate “intrusive recall”, a modified version of the list method Directed Forgetting Task was used.

### **Paper III**

The general aim of this study was to investigate specificity and temporal distribution of future directed thoughts and autobiographical memories in trauma-exposed participants and controls. More specifically an aim was to study the relationship between symptoms of traumatic stress and level of specificity for autobiographical memories. Furthermore, based on literature showing that the specificity of AM and future directed thoughts are related (D’Argembeau & Raffard, 2008; Williams et al., 1996) we investigated whether the relationship between symptoms of traumatic stress and specificity would be the same for future directed thoughts.

A second aim was to see if one can detect future foreshortening, as described in DSM-IV, in trauma-exposed participants by comparing the temporal distribution of their future directed thoughts and autobiographical memory with those of controls.

## **Methods**

### **Participants**

The trauma group consisted of 23 women, all of whom had experienced sexual assault in adulthood. The control group consisted of 23 non trauma-exposed women. The trauma group and the control group did not differ in age or years of education, however the trauma group scored higher on the clinical measures. The participants included in the study did not have any known injury or disease that could influence cognitive functions, they did not take any psychoactive drug or medication, and all participants were fluent in Norwegian.

Participants in the trauma group were recruited from the Emergency Center in Bergen, the Emergency Center in Oslo, Dixi Resource Centre, and from the Center for Crisis Psychology in Bergen. Potential participants were introduced to the project by a social worker when they were attending a follow-up meeting at Emergency Center in Oslo or Bergen. Those that expressed interest in participating in the project were given a brief project description, and if they were still interested they wrote down their contact information and signed an



informed consent form stating that they were willing to be contacted regarding participation in the project. This procedure was also followed at Dixi Resource Centre, and Center for Crisis Psychology in Bergen, though here the participants were given the information when attending a support group. The people who gave their informed consent were later contacted by mail or telephone to schedule an appointment for participation. Participants in the control group were recruited with posters at the University, on public transport and in grocery shops.

The process of recruiting trauma-exposed participants started in January 2008, and according to the progress plan we were planning to finish testing in December the same year. Our initial goal was to include 50 trauma-exposed participants and 50 controls. The first participant in the trauma-group was tested in May 2008. However, the recruiting of trauma-exposed participants turned out to be much more difficult than initially anticipated; by the end of 2008 we had only recruited 6 participants. As a result we extended the period for recruiting and data collection, and lowered our goal for number of participants. The last trauma-exposed participant, number 23, was tested in March 2010. Recruiting and testing of control participants was carried out between October 2009 and March 2010.

## **Materials**

Self-report questionnaires were administered to assess post-trauma symptoms as well as depression and anxiety symptoms in all participants. Well-known self-report questionnaires with high reported levels of test-retest reliability and high internal consistency were used.

**Posttraumatic diagnostic scale (PDS).** The posttraumatic diagnostic scale (PDS) is a standardised and validated 49 item self-report scale based on the DSM-IV diagnostic criteria for PTSD (Foa, Cashman, Jaycox, & Perry, 1997). The PDS asks the individual to identify the most disturbing traumatic experience and to assess the degree of physical threat or helplessness experienced during the episode. The PDS assesses the frequency and intensity of all symptoms listed in criteria B-D, as well as the criterion F functional impairment. The PDS has a recommended cut off score of 27 (Griffin, Uhlmansiek, Resick, & Mechanic, 2004)

**Beck Depression Inventory-II (BDI-II).** The BDI-II is used to measure current levels of depression (Beck, Steer & Brown, 1996). BDI-II is a self-administered inventory that contains 21 items. The respondents were shown statements and instructed to choose the

alternative that best described how they felt the “past two weeks, including today” on a scale from 0-3.

The BDI-II is constructed to reflect the diagnostic criteria of MDD and is seen as an indicator on prevalence and severity of depressive symptoms in accordance with the diagnostic criteria of MDD as described in DSM IV (First & Tasman, 2004). The depressive symptoms and attitudes that is measured in the BDI-II are sadness, pessimism, feelings of failure, loss of pleasure, guilty feelings, punishment feelings, self-dislike, self-criticalness, suicidal thoughts or wishes, crying, agitation, loss of interest, indecisiveness, worthlessness, loss of energy, changes in sleeping pattern, irritability, changes in appetite, concentration difficulty, tiredness or fatigue, and loss of interest in sex (Beck et al., 1996). The depression score range from 0-63, were a total score of 0-13 is minimal, 14-19 is mild, 20-28 is medium, and 29-63 is severe. Beck and colleagues (1996) reported a test-retest correlation of .93 on a sample of 26 polyclinic patients.

**Beck’s Anxiety Inventory (BAI).** Beck Anxiety Inventory (BAI) (Beck, Epstein, Brown & Steer, 1988) is a 21-item self-report inventory measuring severity of anxiety. The BAI is constructed so that each item in the inventory represents an anxiety symptom. The respondents are asked to rate in what degree they have experienced each item “the last week, including today” on a 4-point scale (0-3) ranging from not at all (0) to severely – I could barely stand it (3). The total BAI score range from 0-63. A total score of 0-7 indicate minimal level of anxiety, 8-15 mild level of anxiety, 16-25 medium level of anxiety, and a score of 26-63 indicate severe level of anxiety. Beck and colleagues (1988) reported high internal consistency ( $\alpha=.92$ ) and a test-retest correlation of .75.

**Impact of Event Scale (IES).** The Impact of Events Scale was developed to measure level of distress for adult survivors of traumatic events (Horowitz, Wilner & Alvarez, 1979). The original IES consisted of 15 items, and aimed to measure intrusion and avoidance symptoms. The IES has also been used to assess the reactions of trauma in adolescents (Sack, Seeley, Him & Clarke, 1998). The IES-R (Weiss & Marmar, 1997) is a revised version of the original IES. It is a self-report instrument and it consist of 22 items aimed to measure stress reactions commonly associated with PTSD; intrusion, avoidance and hyper-arousal. Participants are asked to rate 22 items in relation to “how distressing each difficulty has been during the past 7 days”. The items are rated on a 5 point scale ranging from 0-not at all to 4-extremely. The intrusion subscale measures the degree of memories that intrudes the

consciousness of the individuals against their wish. The avoidance subscale is used to measure the degree of which memories of trauma is consciously suppressed. The hyper-arousal scale aims to measure irritability and anger: jumpiness and exaggerated startle response: trouble concentrating: psychophysiological arousal: and hyper-vigilance (Weiss & Marmar, 1997). The total IES-R score ranges from 0-88. The internal consistency of the scale is reported to be high; one study reported the intrusion subscale to have an alpha coefficient of .91 and the avoidance subscale to have an alpha coefficient of .85 and hyper arousal .90 (Weiss & Marmar, 1997). Test-retest correlation of .57 for intrusion, avoidance .51, and hyperarousal .59 has been reported (Weiss & Marmar, 1997).

**The Dissociative Experience Scale (DES).** The DES is a self-administered scale developed by Bernstein and Putman (1986). This scale is not developed to serve as a diagnostic instrument, it is rather an instrument aimed at reflecting the general dissociative traits of a person (Cardeña & Weiner, 2004). The scale consists of 28 items, with a numerical scale from 0 to 100 in 10 point intervals, with higher scores indicating higher dissociative tendencies (Bernstein & Putman, 1986). A review of previous studies with the DES reported test-retest reliabilities ranging from .78 to .96. (for an overview see Carlson & Putnam, 1993).

**Creative Experiences Questionnaire (CEQ).** The CEQ was developed by Merckelbach, Muris, and Rassin (1999). The questionnaire includes 25 dichotomous (yes/no) items aimed at measuring experiences related to imagining, daydreaming, and intense fantasizing. The questionnaire includes statements, such as “as a child, I sometimes had the feeling of being another person” and “I often confuse fantasies with real memories”. The CEQ has shown a test-retest correlation of .95 and with regards to the internal consistency of the questionnaire, an alpha coefficient of .72 has been reported (Merckelbach, Horselenberg & Muris, 2001).

The DES and the CEQ were not reported in any of the three papers.

## **Memory tasks**

**The Retrieval Induced Forgetting Task (RIF).** The Retrieval-Induced Forgetting task (RIF) is used to study how repeated retrieval practice of particular memories impairs retrieval of related memory traces (Anderson, Bjork, & Bjork, 1994). In the RIF task participants are asked to learn lists of categorically organised words. Subsequently, some of the words from some of the categories are practiced in a word-stem completion task. Finally,

the participants are asked to recall the words from the initial study-list, and memory for three types of items were examined: retrieval practiced items (Rp+), nonpracticed competitors from the same category (Rp-), and baseline items from nonpracticed categories (Nrp).

In the study presented in paper I a recognition-cued RIF procedure was used; response time and accuracy were the dependent variables. The study-list consisted of 12 categories and 96 exemplars. The categories and associated exemplars were organised in three distinct categories for each of the following conditions: trauma-specific, negative, neutral and positive. Each of the categories in the study-list consisted of a category name, and 8 associated exemplars. On the recognition test, all of these words were presented. Additionally, 48 Extralist Unrelated words and 48 Extralist Related words were presented on the recognition test.

We used the positive and neutral lists from Dehli and Brennen's (2009) study. For the trauma-specific and negative word lists, seven psychology students were asked to generate as many trauma-specific and negative categories and associated exemplars as possible. Three other students rated all the words (trauma-specific, negative, neutral, positive) for emotional valence on a scale from -3 to 3, additionally they were asked to indicate on a scale from 0 to 3 in what degree each word were associated with rape. The frequency of each word was estimated using the Oslo Corpus of Tagged Norwegian Texts database (<http://www.tekstlab.uio.no/norsk/bokmaal/english.html>).

A one-way ANOVA with the independent variable of emotional valence showed that there were no significant difference in frequency of the words between levels of valence  $F(3,140)=.79, ns$ . A one-way ANOVA showed that there was no significant difference in word length between levels of valence  $F(3,140) = .66, ns$ . The word lists were also rated for degree of integration. Five independent raters were asked to indicate on a scale from 1-5 to what degree each of the 12 lists was coherent or integrated. The ratings showed high level of coherence for the lists in all emotional categories, neutral ( $M=4.67, SD=.29$ ), positive ( $M=4.67, SD=.14$ ), negative ( $M=4.58, SD=.08$ ), trauma-Specific ( $M=4.08, SD=.09$ ).

**The Directed Forgetting Task (DF).** In the Directed forgetting task participants are presented to lists of words with a following instruction to either remember or to forget the presented words. In the study presented in paper II two lists of words were presented to the participants. Each list consisted of 8 positive, 8 neutral, 8 threat-related, and 8 rape-related words. Across participants, the lists served an equal number of times as the Remember-list

(R) and the Forget-list (F). A modified version of the list DF was used. In this study, all participants were first asked only to recall the second list: the R-words.

The words used in the DF task were generated in a focus group, 7 students were asked to come up with as many as possible words in the four categories. For the threat-related words the students were instructed to come up with words that are associated with traumatic experiences, but not associated with rape (e.g. traffic accident, massacre, fire). Three other students were asked to evaluate the words for emotional content on a scale from -3 to 3, additionally they were asked to indicate on a scale from 0-3 to what degree each word was associated with rape. The frequency of each word was estimated using the Oslo Corpus of Tagged Norwegian Texts database (<http://www.tekstlab.uio.no/norsk/bokmaal/english.html>). A one-way ANOVA showed that there was no significant difference in frequency between levels of valence,  $F(3,76)=.41, ns$ . A one-way ANOVA showed that there was a significant difference in word length between levels of valence,  $F(3,76)=4.54, p < .01$ . Words in the neutral valence category had significantly shorter word length compared to positive words  $t(30) = 3.60, p < .001$ , compared to threat-related words  $t(30) = 2.93, p < .005$ , and compared to trauma-specific words  $t(30) = 3.46, p < .001$ .

**The Autobiographical Memory Task.** Specificity of autobiographical memories is often measured by the Autobiographical Memory Test (AMT) (Williams & Broadbent, 1986). The AMT consists of cue words, where the valences of the cue words alternates between positive, like “optimistic”, negative, like “sad”, and neutral words, like “garden”. In the study reported in paper III every cue word was embedded in a sentence, e.g. “Try to imagine an episode from the past associated with the word garden”. The cue words will be presented to the participants alternating positive, negative and neutral.

In response to each cue word, the participants were asked to recall a specific memory of a particular event that occurred within the time span of one day. The instruction was shown on the computer screen and stated: “*You will now see some sentences on the screen. The task is to describe a specific event that happened in the past to each sentence. A specific event is an episode that takes place within the time span of one day. The event that you describe can have happened either in close or distant future.*” The participants were first asked to practise on three cue words. A computer based version of the AMT was used and the answers were given in writing. Each word was present on the screen for as long as it took for the participant

to write down the memory, however if no response was started after 60 seconds, a new cue sentence would appear on the screen. Following each response to the cue sentences they participants were asked to state when the described memory happened, they were asked to write down how many days, months or years it is since the episode happened.

**The Future Cueing Task.** The future cueing task was first used by Williams and colleagues (1996) to measure the specificity of with which participants imagine their future. The participants were asked to imagine future events in response to positive, negative and neutral cue words. The instruction was shown on the computer screen and stated: *“You will now see some sentences on the screen. The task is to describe a specific event in the future to each sentence. A specific event is an episode that takes place within the time span of one day. Try to imagine an event that is likely to happen, the event that you describe can happen either in close or distant future.”* As in the AMT, the cue sentences were shown on the computer screen for as long as it took for the participant to write down a story, however if no response was started within 60 seconds a new cue sentence were presented. After each story the participants were asked to state in how many days, months or years this event would be likely to happen.

Two lists of words were used in the AMT/FCT, half of the participants were given list 1 in the AMT and list 2 in the FCT, and the other half were presented to list 2 in the AMT and list 1 in the FCT. The two word lists, was each composed by 5 positive, 5 negative and 5 neutral cue words were used. The frequency of each word was estimated using the Oslo Corpus of Tagged Norwegian Texts database (<http://www.tekstlab.uio.no/norsk/bokmaal/english.html>). The word lists were also rated for emotional content by three raters, who did not participate in the main task. The raters were asked to indicate the emotional valence for each word on a scale from -3 to 3. List 1 and 2 was matched so that it was no difference in either frequency or emotional valence.

A one-way ANOVA with the independent variable of emotional valence showed that there was no significant difference in frequency of the words between levels of valence  $F(2,27) = .98, ns$ . Mean emotional content was calculated for each level of valence, positive words ( $M = 2.50, SD = .39$ ), Negative ( $M = 2.06, SD = .38$ ), Neutral words ( $M = .20, SD = .35$ ).

## **Procedure**

The participants were tested individually in a quiet lab by the first author. Prior to testing the participants were informed about the project, about their right to at any time withdraw from the project, and they were asked to read and sign an informed consent form if willing to participate in the project.

The participants were then asked to fill out a questionnaire on background information about age, years of education, use of psychoactive medication, alcohol consumption, use of drugs, use of psychoactive medication, and time passed since traumatic episode. They were also asked if they had epilepsy, known brain injury or previous psychotic episode.

Next, the DF was administered, followed by the DES, the AMT and FCT, CEQ, RIF, PDS, IES, BDI and the BAI. All participants had a 20 minutes break after the AMT/FCT task, they also had additional short breaks between the tasks. The complete procedure included breaks lasted between 2 and 3.5 hours. The procedures for each memory task are described in detail in the manuscripts.

The only difference in procedure for the two groups concerned the IES, here the control group was asked to think back and refer to the most traumatic event they had experienced in their life.

## **Statistical analysis**

All data were analysed using The Statistical Package for the Social Sciences (SPSS) for Windows (version 16.0 and 18.0; Inc., Chicago, IL, USA). One-way between-groups analyses of variance (ANOVAs) were used to calculate group differences in continuous demographic variables and scores on questionnaires.

**Paper I.** For both reaction time and retrieval accuracy, mixed ANOVAs were carried out with Valence (positive, neutral, negative and trauma-specific) and Retrieval Practice (Rp-, Nrp) as within-subject factors and Group (trauma, controls) as between-subjects factor. Significant interactions were broken down with t-tests.

**Paper II.** A mixed ANOVA was computed to investigate the possible effect and interaction effects of Group, Instruction and Valence on the correct recall of F and R words. Similarly, a mixed ANOVA was calculated with the between subjects factor of Group (trauma, control) and the within subject factor Valence (positive, neutral, threat-related,

trauma-specific) for F-words mistakenly recalled in the Remember condition. When significant interactions were found, these were broken down with t-tests.

Pearson's correlations were performed to investigate possible relationship between mean numbers of correct recalled F and R words and scores on the IES, PDS, BDI and BAI. Also, Pearson's correlations were performed to investigate the relationship between IES scores and mistakenly recalled F-words.

**Paper III.** A mixed ANOVA was performed for specific responses with Task (Future vs. Past) and Valence (positive vs. negative vs. neutral) as within-subject factors, and Group (trauma vs. control) as between-subject factor.

Pearson's correlations were performed to investigate possible relationship between proportion of specific responses on the FCT and the AMT and scores on the IES, PDS, BDI and BAI. Also, Pearson's correlations were calculated to examine the relationship between future specificity and autobiographical memory specificity. In addition, the data was using a mediation model method following bootstrap approach suggested by Preacher & Hayes (2004). These analyses were carried out to investigate a possible mediating role of depression scores (BDI-II) and trauma scores (IES) in a suggested relationship between trauma exposure and specificity.

For temporal distribution for both the FCT and AMT responses separate one-way ANOVAs with the independent variable of group were computed to investigate possible group difference for each of the define time bins.

### **Ethical considerations**

Some of the participants in the present study had experienced severe traumatic events, and some of the materials used were specifically related to trauma. Thus, special considerations were made to secure the well-being of the participants and to minimize the risk of re-traumatisation during testing. During recruiting of participants we made sure that potential participants experienced no pressure to participate in the study. Prior to testing we put emphasis on the right to at any time withdraw for the study. Furthermore, during testing we were especially sensitive towards potential discomfort among participants, and were ready to abort the session if such was observed. After testing the participants were debriefed, and were invited to ask questions about the study and their participation. Clinical backup were



available during testing. The project was approved by the Regional Committee for Research Ethics (REK-sør) and the Norwegian Social Science Data Service (NSD).

It should be noted that none of the participants expressed particular discomfort during testing, and furthermore the testing did not trigger any observable negative reaction. Participants expressed that participation was experienced as interesting and meaningful.

## Summary of papers

### **Paper I: Retrieval-induced forgetting after trauma: A study with victims of sexual assault**

The Retrieval-Induced Forgetting (RIF) paradigm is used to study how the repeated retrieval practice of particular memories impairs the retrieval of related memory traces. A study is reported where this automatic form of forgetting is investigated in a group of sexual-assault victims and a control group. Using a recognition-cued RIF task, this study examined RIF with neutral, positive, negative and trauma-specific stimuli. Response time data showed that irrespective of previous trauma exposure, a RIF effect was observed for neutral material, but not for emotional material. No differences in RIF between the trauma group and the control group were found. The present findings suggest that the mechanisms operating in the RIF task might be resistant to emotional material, and that RIF does not operate on emotional material even when it is relevant to a trauma that participants have been through.

## **Paper II: Intentional forgetting of emotional words after trauma: A study with victims of sexual assault**

Following exposure to a trauma, people tend to experience intrusive thoughts and memories about the event. In order to investigate whether intrusive memories in the aftermath of trauma might be accounted for by an impaired ability to intentionally forget disturbing material, the present study used a Directed Forgetting (DF) task to examine intentional forgetting and intrusive recall of words in sexual assault victims and controls. By including words related to the trauma in addition to neutral, positive and threat-related stimuli it was possible to test for trauma-specific effects. No difference between the Trauma and the Control group was found for correct recall of forget or remember words. However, when recalling words from remember list, the Trauma group mistakenly recalled significantly more trauma-specific words from the forget list.

### **Paper III: Mental time travel after trauma: The specificity and temporal distribution of autobiographical memories and future-directed thoughts**

This study investigated the relationship between trauma exposure and specificity and temporal distribution of autobiographical memories and future directed thoughts. A group of sexual assault victims were compared with women without previous trauma exposure in relation to specificity of autobiographical memories, as measured by the Autobiographical Memory Task (AMT) and specificity of future directed thoughts as measured by the Future Cueing Task (FCT). The temporal distribution of future directed thoughts and autobiographical memories was studied by asking the participants to estimate when each memory reported on the AMT had occurred and when each future event reported on the FCT would occur. The results showed no difference between the trauma group and the controls in specificity of autobiographical memories nor future directed thoughts. In line with a review of Moore and Zoellner (2007), a relationship between PTSD symptoms as measured by the Impact of Event Scale (IES) and reduced specificity was found. Furthermore, we found no difference in temporal distribution of future directed thoughts or autobiographical memories between trauma-exposed participants and controls. The results provide some evidence that trauma symptoms only influence the specificity of mental time travel to the past, and not to the future.

## Discussion

### Forgetting emotional material after trauma exposure

Impaired inhibition mechanisms have been suggested to underlie intrusive thoughts and memories in trauma-exposed individuals. In paper I, an aim was to investigate automatic inhibition using a RIF task in trauma-exposed individuals and controls. In paper II one of the aims was to investigate a voluntary type of inhibition, intentional forgetting. An overarching aim in paper I and II was to investigate whether hypothesised deficits in memory processes in trauma-exposed individuals are specific to processing of trauma-related material or a more general deficit of memory.

In paper I, the results showed no differences in RIF between trauma-exposed participants and controls. Interestingly, the response time data showed that irrespective of previous trauma exposure, a RIF effect was observed for neutral material, but not for emotional material. Hence, we found no support for either a general deficit or a trauma-specific deficit in RIF in trauma-exposed people.

The results in the RIF study are in contrast to the only previous study investigating RIF in trauma-exposed individuals. Amir and colleagues reported no RIF effect in trauma-exposed individuals with and without PTSD and for both neutral and threatening cue words, the controls however showed RIF for all types of words. In the present study, no differences between groups were found. Hence, while Amir et al.'s (2009) study indicates a general inhibition deficit for trauma-exposed people, our results suggest that emotional material in general, regardless of valence and previous trauma exposure, are resistant to RIF.

There are a number of differences between the present RIF study and the study of Amir et al. (2009) that might have contributed to the different findings. First, Amir et al.'s study employed a recall task in their RIF paradigm, while the present study used a recognition cued RIF task. However, a reaction-timed cue-independent recognition-test, as used in the study presented in Paper III, has proven to be a successful approach to study RIF effects, and several studies have reported the typical RIF effect using RT as dependent variable (Perfect et al., 2002, Experiment 5; Veling & Knippenberg, 2004, Experiment 1).

Assuming that RIF reflects automatic inhibition, as suggested by Anderson (2003), the present findings suggest that automatic inhibition does not operate on emotional material, even when it is relevant for a trauma that participants have been through. The absence of RIF for emotional material is in line with the results from Moulds et al.'s (2006) study where no

RIF on accuracy rates was found for emotional words in high and low dysphoric participants, and also with Dehli & Brennen's (2009) study where no RIF on either RT or accuracy was observed for positive or negative emotional words in healthy participants. Taken together, it seems like the mechanisms operating in the RIF task might be resistant to emotional material. A general tendency for reduced forgetting of emotional material fits nicely with the well established finding that emotional material is generally better remembered than neutral material (McNally, 2003).

That emotional material is resistant to the type of automatic inhibition observed in RIF might have different consequences for non trauma-exposed healthy individuals as opposed to trauma-exposed individuals. For non trauma-exposed healthy individuals this tendency might be relatively harmless and perhaps be reflected in rumination over previous negative or positive experiences. For people who have survived trauma however, the very same tendency might have a more negative impact, because the memories that repeatedly intrude into consciousness are experienced as very disturbing by the individual. The uncomfortable consequences of intrusive memories from a traumatic experience, might lead trauma victims to avoid such memories through intentional forgetting, however this has not been studied extensively for trauma-related material.

Paper II investigated intentional forgetting and intrusive recollection of emotional material. There was no difference between the trauma-exposed and the non trauma-exposed participants for correct recall of forget words or remember words. The data gave no support to either a hypothesis about a general or a trauma-specific deficit in intentional forgetting for trauma-exposed individuals, as measured by voluntary recall of F-words on the DF task. The absence of group differences for correct recall of any word valence for both R- or F-words contrasts with previous findings (Cottencin et al., 2006). However, the modified DF-task used in this study limits the conclusions we can draw about intentional forgetting, especially due to possible influence of order.

The modification of the DF-paradigm did however allow us to study intrusive recall of F-words. The results showed the trauma-exposed participants mistakenly retrieved more trauma-specific F-words when asked to recall R-words, both relative to controls, and compared to the number of positive, neutral and threat-related F-words they mistakenly recalled. The tendency for involuntary intrusive recollection of trauma-specific words in the trauma group and simultaneous the lack of group differences in intentional forgetting or correct recall of R and F-words might be explained by a source monitoring deficit for trauma-

specific material for the trauma group. Perhaps it is more difficult for the trauma-exposed individuals to know whether a trauma-specific word originates from the remember or the forget list? Our data does not allow for any conclusions about possible mechanisms, however it might be speculated that trauma-specific material is more self-relevant and integrated for the trauma-group and that this makes it more difficult to determine the source of the items.

These results are in line with a study by Brennen, Dybdahl and Kapidžić (2007) who reported that participants with PTSD mistakenly recalled more trauma-specific critical lures in the DRM paradigm compared to trauma-exposed controls. For neutral lists however there was no difference between groups in false recall. Brennen et al.'s (2007) results can be understood as a trauma-specific source monitoring error in PTSD. The results of the present DF study can be interpreted in line with this, but suggests that such a deficit also can arise in trauma-exposed individuals without a diagnosis of PTSD.

In summary, the results from paper I and II did not provide evidence to support a hypothesis about impaired inhibition mechanisms in trauma-exposed individuals, or a hypothesis about deficits in inhibition mechanisms underlying trauma symptoms. However, the two studies used cue words, and it can be questioned to what extent processing of emotional words can inform us about inhibition of real autobiographical memories. Moreover, the use of emotional cue words will probably not evoke emotion to the same extent as autobiographical memories.

### **Mental time travel after trauma**

In paper III, a study on specificity and temporal distribution of autobiographical memories and future directed thoughts, the results showed a relationship between trauma symptoms and reduced specificity of autobiographical memories, however no such relationship was found for future directed thoughts.

The relationship between symptoms of PTSD and OGM is in line with the conclusion drawn in Moore and Zoellner's (2007) review; OGM is associated with symptoms of psychopathology and not with trauma exposure per se. Furthermore, mediation analyses confirmed this association showing that level of trauma symptoms as measured by IES act as a mediator between trauma exposure and autobiographical memory specificity. However, contrary to our hypothesis, future directed thoughts showed no relationship with either trauma exposure or symptoms of trauma exposure and specificity. This is in contrast with previous

literature showing corresponding levels of specificity of autobiographical memories and future directed thoughts (e.g. D'Argembeau & Raffard, 2008; Dickson & Bates, 2006; Williams et al., 1996, Experiment 1). Also, these findings do not provide support for McNally's (1995) suggestion that OGM underlies problems with imagining the future in PTSD. The results rather suggest that trauma symptoms only influence the specificity of mental time travel to the past, and not to the future.

Differences in results between studies can be influenced by a number of factors such as differences in concreteness of the cue words used and differences in procedure for the FCT/AMT. Furthermore, rating of data in studies using the FCT and AMT is challenging, in the present study the mean Cohen's kappa for the AMT was .77. For the FCT the mean Cohen's Kappa was .68. This also shows that rating of future directed thoughts are somewhat more difficult than rating of autobiographical memories. Future studies should ask the participants themselves to rate specificity level, and also other phenomenological characteristics of the memories that will allow for a closer examination of the relationship between trauma exposure, trauma symptoms and future and past episodic thoughts.

The results reported in paper III showed no difference in temporal distribution of future directed thoughts between trauma-exposed participants and controls. Hence, we found no support for future foreshortening in terms of an altered temporal pattern for future directed thoughts after trauma. However, few cue words were used in the present study, a higher number cue words would allow for a more nuanced analysis of the temporal pattern.

### **Cognitive control mechanisms and memory processes**

The literature on cognitive processing in PTSD has focused on two main processes: memory and cognitive control (Banich, Mackiewicz, Depue, Whitmer, Miller, & Heller, 2009). Disturbances in these two processes have been thought to underlie symptoms such as intrusive memories, fragmented memory after trauma, and hyper-vigilance. Memory processes and cognitive control processed in PTSD has mainly been considered as separate, however as suggested by Banich and colleagues in a recent review there are reasons to start to explore the relationship between these two processes (Banich et al., 2009).

Updating and monitoring of information in working memory, switching between mental sets or tasks, response selection, and inhibition of dominant responses are main aspects of executive functions that have been suggested to underlie cognitive control (Miyake et al.,



2000). Cognitive control is a relevant concept for all three studies and the associated memory processes addressed in the present thesis.

Impaired cognitive control might be a relevant third variable in the relationship between reduced specificity of autobiographical memories and post-trauma symptoms. Retrieval of specific autobiographical memories is a generative process that necessitates monitoring and executive capacity (Conway & Pleydell-Pearce, 2000). Lack of cognitive capacity might result in a truncated search for a specific memory in the autobiographical knowledge base. Furthermore, in his CaRFAX model, Williams (2006) proposed that executive control dysfunction can be underlying OGM. According to Williams (1996) model of autobiographical memory retrieval, a search for a specific memory involves inhibition of related category descriptions in memory. More specifically, failure to inhibit a category description results in a truncated search and a generic memory. According to this view, it might be hypothesised that impaired inhibition mechanism underlies OGM. Although the present study did not systematically address cognitive control mechanism, the RIF paradigm and the DF paradigm are thought to measure of two types of inhibition mechanism. Thus, it is interesting to explore the relationship between these two types of inhibition and retrieval specificity of autobiographical memories and future directed thoughts.

To investigate the relationship between RIF and specificity, correlation analyses between RT RIF size for each level of valence (positive, negative, neutral, trauma-specific) and level of specificity of the AMT and FCT, was computed. These analyses did not show any significant correlations, all  $p$ 's < .1.

To investigate the relationship between intentional forgetting and specificity, a "DF score" was computed by subtracting the number of correctly recalled R-words from number correctly recalled F-words. Next, Pearson's correlations between DF score and specificity level was computed. Also, Pearson's correlations between correctly recalled R-words and F-words and specificity level were computed. All analyses were computed both for all levels of valence on the DF and separately for each level of valence. None of the correlations turned out significant, all  $p$ 's < .1.

### **How do the present findings fit with cognitive models of PTSD?**

Overall, the results reported in paper I and II suggest, in line with Rubin et al.'s (2008) model, that normal memory mechanisms operate in trauma-exposed people. The findings

from paper I showed that RIF is eradicated for emotional material independent of previous trauma exposure. This can be interpreted in line with Rubin et al.'s (2008) model which holds that ordinary mechanisms of memory can explain symptoms of PTSD. If emotional material in general is resistant to mechanism of forgetting, as suggested by the RIF study presented here, this might have different consequences for trauma-exposed individuals compared to non trauma-exposed individuals. According to Rubin et al.'s (2008) model it is the memory of the traumatic event and not the event itself that determines trauma symptoms. In terms of this model, it can be argued that the consequences of absent RIF for emotional material might depend of the memories of the traumatic event. For trauma-exposed individuals who might have more disturbing memories associated with the traumatic event, the absence of RIF might have a more negative impact because the memories that repeatedly intrude into consciousness are experienced as very disturbing by the individual.

As pointed out by Berntsen, Rubin and Bohni (2008), emotional stress enhances both encoding of and access to a memory, thus both involuntary and voluntary memory recall will be enhanced for traumatic episodes. In line with this, the findings from paper II showed enhanced level of "intrusive recall" of trauma-specific material for the trauma-exposed participants. However, we did not find a higher level of voluntary recall of trauma-specific material. A slightly different view was proposed by Ehlers and Clark (2000) and Brewin et al. (1996), these theories predict that voluntary recall of the traumatic event are impaired and involuntary recollection is enhanced. However, paper II showed a pattern of results where involuntary recall of trauma-specific material was enhanced, but there was no evidence for impaired voluntary recall of trauma-specific material.

Brewin et al.'s (1996) and Ehlers & Clark's (2000) theories hold that disturbances in memory in the aftermath of trauma are specifically related to processing of the traumatic episode or material related to the traumatic episode. In paper I and II we found no evidence for any general deficits in RIF or intentional forgetting. However, the results from paper II showed one trauma-specific finding with the enhanced level of "intrusive recall" of trauma-specific material for the trauma-exposed participants. It should be noted that this effect can most likely be explained by other ordinary memory mechanisms. For example it can be suggested that trauma-specific material is more self-relevant to the trauma-exposed participants and also more closely integrated with each other. However, paper II cannot conclude fully on this, hence this is an empirical question to be investigated.

The results reported in paper III showed that trauma symptoms are related to reduced specificity of autobiographical memories. This suggests a general deficit in autobiographical memory, for memories that are not related to trauma. The role of reduced specificity of autobiographical memories is not specified in any of Rubin et al.'s (2008), Brewin et al.'s (1996) or Ehlers and Clark's (2000) theories. However, Ehlers and Clark (2000, p. 327) propose that the "*general organisation of their autobiographical memory knowledge base may be disturbed*" in people with PTSD who have experienced to have the view of themselves seriously threatened. The relationship between specificity of autobiographical memory and trauma symptoms is robust and has important clinical implications, and should be considered in future models of PTSD.

### **Methodological considerations**

In the present project one threat to validity lies in the recruiting of participants. The participants in the trauma-group might not be a representative sample for sexually abused individuals. The trauma-exposed participants were recruited either by healthcare personnel at emergency units or at an interest organisation for survivors of sexual abuse. It is well known that only a proportion of victims of sexual abuse seek professional help, hence the participants in the present project represent only individuals that seek help, and it cannot be ruled out that the results might have been different for trauma-exposed individuals that we did not reach through our recruiting strategy. Furthermore, we cannot rule out the possibility that the individuals that chose to participate in the project are different on factors relevant for performance on the tasks in the present study. For example, it might be suggested that the trauma-exposed individuals that have higher levels of avoidance are not included in our sample.

The control group was recruited by displaying posters in grocery shops and on public transportation. Those that chose to participate in a "project about trauma and memory" might have done so because of a particular interest, thus representativity of this sample might also be questioned. To meet this problem, participants in the two groups were matched on age, gender and years of education. Ideally, more factors such as working memory capacity and intelligence could have been included when matching participants but practical consideration prevented this. However, several questionnaires on mental health variables were included, allowing us to assess the mental health of both groups.

The procedure and events that take place during testing can also influence the results (Pedhazur & Shmelkin, 1991). In the present project, the same individuals participated in the three different cognitive tasks. In addition questionnaires were administered, and the average duration of participation was about 3 hours. Both the length of testing and the content of the tests and questionnaires can be argued to influence the results. Of particular concern is how completing the depression inventory and the trauma-inventories might affect the trauma-group. To avoid any differential influence between groups due to filling the questionnaires, the order of tests and questionnaires were carefully considered. The questionnaires measuring trauma symptoms and depression were conducted after the cognitive tasks, because answering these questions might alter the mood state especially for the trauma-exposed participants. Furthermore, the IES and the PDS contains questions and formulations that could be mixed up with the trauma-specific words in the DF and the RIF.

Relevant to all three papers is ecological validity. The concept of ecological validity refers to two related constructs: representativeness and generalisability. Representativity concerns whether the tasks used represent the phenomenon as it occurs in everyday life (Kvavilashvili & Ellis, 2004). Generalisability refers to what extent the results can explain similar processes in everyday life (Kvavilashvili & Ellis, 2004). The tasks used in paper I and II involves encoding and retrieval of word lists. It can be questioned to what extent RIF or DF of emotional stimuli can inform us about automatic inhibition, intrusive memories and intentional forgetting of real autobiographical memories. Moreover, the use of emotional cue words will probably not evoke emotion to the same extent as autobiographical memories. Hence, to get a clearer picture of RIF and DF in trauma-exposed individuals future studies should employ autobiographical material in these tasks.

A related issue is whether the cue words in the trauma-specific categories in the DF and RIF study are really associated with the traumatic episode the participants have been through. To this end, the trauma-related words were validated by asking independent student raters to evaluate to what extent each word was associated with rape. However, future studies using trauma-specific material should validate trauma words in a sample of trauma survivors, rather than in healthy student controls.

Regarding ecological validity for the study presented in paper III, it might be questioned whether a cue word task is the most appropriate method to study recall or future directed thinking in everyday life. It might be suggested that spontaneously generated past

and future thoughts might better represent mental time travel in everyday life and consequently be a more ecologically valid method to study the influence of trauma on this form of cognition.

**Statistical conclusion validity.** Statistical conclusion validity refers to the appropriate use of statistics to infer whether the presumed independent and dependent variables covary, and to the strength of which they covary (Shadish, Cook & Campbell, 2002). Incorrect conclusions about the existence of a relationship between two variables might involve concluding that two variables covary when they in fact do not (Type I error), or concluding that two variables do not covary when they in fact do (Type II error). There are several threats to statistical conclusion validity, two of which are of particular relevance to the present project; low statistical power and inaccurate effect size estimation.

Statistical power refers to “*the probability that a statistical test will reject the null hypothesis when it is false*” (Shadish, Cook & Campbell, 2002). Low statistical power can lead to incorrect conclusions about the relationship between variables. More precisely low statistical power is associated with inaccurate estimates of effect size and an increased risk of Type II error (Shadish et al., 2002). Statistical power is determined by factors such as size of experimental effects, level of errors in the experiments and statistical analysis (Shadish et al., 2002). In the present study matching of groups, control for possible confounders and high level of experimental control are factors that can be argued to contribute to higher statistical power. Several factors might compromise statistical power, and in the present studies, sampling issues are of particular relevance. With all other factors being equal, studies with bigger sample have higher statistical power. In the present project we had a relatively small sample, with 23 participants in each of the two groups, and no possibility of increasing the sample size. However, in all three papers significant effects were obtained, this suggests that despite a relatively small sample size significant effects can be detected.

In recent years there has been an increasing awareness about the importance of reporting effect size. However, inaccurate effect size estimation is presented by Shadish et al. (2002) as one threat to statistical conclusion validity. Several factors determine the accuracy of effect size estimations, for example outliers or the use of an inadequate effect size measure can compromise estimation of effect size. In the present project eta squared,  $\eta^2$ , was reported for all significant effects. Eta-squared is a simple measure of effect size and reflects “the sums of squares for the effect divided by the total sum of squares” (Tabachnick & Fidell, 2007, p.112). Thus, Eta-squared reflects the percentage of the variance in the DV’s explained

by the IVs in the particular sample. A disadvantage with eta-squared is that it is slightly upwardly biased, it generally overestimates the effect size in the population the sample is drawn from. An alternative to the eta-squared would have been to use omega-square as this analysis adjust for the overestimation. However, to decrease the possibility to commit type-II error, Eta-squared seemed to be more appropriate in the present study.

**Trauma-exposed versus PTSD.** The trauma-exposed participants in the present project were not under formal treatment, and they did not have a formal diagnosis of PTSD. Hence, one can not know whether the findings in the present study can be generalised to a clinical sample of PTSD patients. However, data on trauma symptoms were obtained through the IES and the PDS, and when following the recommended cut-off score on the PDS 11 participants were found to qualify for a PTSD diagnosis and 14 did not. Our analyses and subsequent conclusions however concerned the relationship between trauma exposure and performance on the memory tasks, and the relationship between trauma-symptom scores and performance on the memory tasks.

Most people exposed to severe trauma do not have a diagnosis of PTSD, and studying trauma-exposed individuals without a diagnosis of PTSD might give us new insight on the impact of trauma on cognitive functioning.

### **Future directions**

**Intentional forgetting.** Paper II investigated intentional forgetting and intrusive recollection of neutral, positive, threat-related and trauma-specific cue words. However, the alterations made in design in order to investigate intrusive recollection limit the conclusion we can draw about intentional forgetting per se. Hence, future studies should further investigate intentional forgetting of trauma-specific, positive, negative and neutral material in trauma-exposed people. Also, directed forgetting studies using autobiographical material should be carried out in future research. Moreover future studies should investigate intrusive recollection of trauma-specific versus non trauma related emotional material, and an aim should be to explore possible underlying mechanisms.

**Mental time travel after trauma.** Temporal distribution of autobiographical memories and future directed thoughts in trauma-exposed samples should be addressed in future studies. The present study used few cue words, future studies should use more cue

words and possibly also different strategies to elicit autobiographical memories and future directed thoughts. It would also be interesting to look at the relationship between temporal distribution and specificity in future studies.

Future research should strive to develop novel methods to study specificity and temporal distribution of autobiographical memories and future directed thoughts. Research applying different methods is also necessary to establish whether the findings are robust.

**Cognitive control.** As pointed out by Banich et al. (2009) future research should explore the relationship between memory processes and cognitive control. Hence future studies on forgetting of emotional material after trauma, and studies on autobiographical memories and future directed thoughts should aim to more systematically investigate a possible contribution of cognitive control mechanisms.

## **Implications**

The results from paper I showed that emotional material is more difficult to forget, but that this tendency is not specific for trauma-exposed people, but rather a general tendency. This finding adds to an extensive amount of literature showing that emotional material is better remembered than more neutral material. Further knowledge about forgetting of emotional material might have practical implications for understanding reactions and symptoms in the aftermath of trauma. If emotional material is more resistant to mechanisms of forgetting this will have different implications for trauma-exposed individuals.

The results from paper II showed that trauma-exposed individuals demonstrate more intrusions of trauma-specific material. This finding might be explained in terms of a source monitoring error in trauma-exposed individuals, however this remains an empirical question that should be addressed in future studies. Further knowledge about source monitoring in trauma-exposed people might be of great relevance for understanding how trauma is recalled, this in turn might be of significant relevance for legal professionals.

Legal professionals can be informed by the present results. The present research suggests that trauma-exposed individuals do not necessarily have deficits of memory. To the contrary, individuals exposed to sexual assault in the present study, are in fact as good at remembering trauma-specific information as their non-offended peers. However, higher levels of trauma symptoms are related to a limited ability to specifically recall events from their past. However, this is only related to autobiographical memory in general, and therefore not

necessarily indicating an impairment of their memory for the traumatic event. OGM has been associated with psychopathology, and clinical psychologists should be aware of the link between OGM, PTSD and depression.

### **Conclusion**

The present findings suggest that trauma-exposed individuals have no deficits in remembering trauma-specific material, rather they tend to remember this material as well as non trauma-exposed individuals. Furthermore, the results indicate that normal mechanisms of forgetting are intact in trauma-exposed individuals. More specifically, no evidence for deficits in retrieval induced or intentional forgetting for trauma-exposed individuals was found.

The findings from paper I suggest that emotional material is resistant to a mechanism of forgetting, irrespective of previous trauma exposure. The eradicated RIF effect for emotional material might have a more negative impact for people who have survived trauma, because the memories that repeatedly intrude into consciousness are experienced as very disturbing by the individual. The uncomfortable consequences of intrusive memories from a traumatic experience, might lead trauma victims attempt to intentionally forget these memories. However, the findings reported in paper II did not support neither a hypothesis about a general nor a trauma-specific deficit in intentional forgetting for trauma-exposed individuals as indicated by recall rates of F words for the two groups. However, trauma-exposed individuals did show a higher level of intrusive recall of trauma-specific material. This tendency was related to higher symptoms of intrusion as measured by the IES.

Paper III confirmed previous findings reporting an association between higher levels of trauma symptoms and reduced specificity of autobiographical memories. However, contrary to our expectations this tendency was not found for future-directed thoughts. Hence the results from this study suggest that trauma symptoms only influence the specificity of mental time travel to the past, and not to the future.



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## Papers I-III









Intentional forgetting of emotional words after trauma: A study with victims of sexual assault

Ines Blix and Tim Brennen

Center for the Study of Human Cognition, Department of Psychology, University of Oslo

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Corresponding author: Ines Blix, Department of Psychology, University of Oslo, PO Box  
1094, 0317 Oslo, Norway

Email: [ines.blix@psykologi.uio.no](mailto:ines.blix@psykologi.uio.no)

Telephone: (+47) 22 84 5204

Fax: (+47) 22 84 50 01

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**Abstract**

Following exposure to a trauma, people tend to experience intrusive thoughts and memories about the event. In order to investigate whether intrusive memories in the aftermath of trauma might be accounted for by an impaired ability to intentionally forget disturbing material, the present study used a modified Directed Forgetting (DF) task to examine intentional forgetting and intrusive recall of words in sexual assault victims and controls. By including words related to the trauma in addition to neutral, positive and threat-related stimuli it was possible to test for trauma-specific effects. No difference between the Trauma and the Control group was found for correct recall of to-be-forgotten (F) words or to-be-remembered (R) words. However, when recalling words from R- list, the Trauma group mistakenly recalled significantly more trauma-specific words from F- list. “Intrusive“ recall of F trauma words when asked to recall R-words was related to symptoms of intrusion reported on the IES.

*Keywords:* Intentional forgetting, retrieval, forgetting, rape, directed forgetting, trauma, memory, sexual assault

## Introduction

After exposure to a trauma people often report intrusive thoughts and memories about the traumatic event (McNally, 2003), and these can be extremely persistent over many years. Intrusive memories or “recurrent recollections” refer to repetitive involuntary memories about the traumatic event. Intrusive memories are experienced as highly disturbing and have the paradoxical property that the more the person tries to suppress or avoid them the more persistent they become (Wegner, 1989). The present study investigated intrusive recall and capacity to intentionally forget in a nonclinical sample of trauma-exposed individuals, and a control group.

A proportion of individuals exposed to trauma develop Post-Traumatic Stress Disorder (PTSD), in which intrusive memories and thoughts are core symptoms (DSM-IV). Several models of cognitive functioning in PTSD have been proposed (e.g. Brewin, 2001; Ehlers & Clark, 2000; Horowitz, 1975; Janoff-Bulman, 1992; Rubin & Berntsen, 2008). These theories do not only inform us about cognition in clinical PTSD, but can also explain memory processes after trauma-exposure and development of persistent trauma symptoms in the aftermath of trauma. According to Brewin’s (2001) and Ehlers and Clark’s (2000) models, intrusive memories of the traumatic event arise because these memories are not integrated with the rest of autobiographical memory. Integration in autobiographical memory is prevented by maladaptive strategies like avoidance and suppression of disturbing thoughts.

Rubin, Berntsen and Bohni (2008) proposed a memory-based model of PTSD where the development of PTSD symptoms following a trauma depends on the interaction between the event and the memory processes following the event. According to this model, no *special* memory mechanisms are needed to explain the development of trauma symptoms, or to explain intrusive memories in the aftermath of trauma. Rather what is known about emotion

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and memory in general can explain the development of trauma-symptoms (Berntsen, Rubin & Bohni, 2008).

Indeed several studies have demonstrated that involuntary memories are not a trauma-specific phenomenon; on the contrary, recurrent involuntary memories are common in everyday life. For the normal population the majority of these are positive (for an overview see Berntsen, 2009). However, in a diary study, students with PTSD symptoms recorded an equal number of positive and negative involuntary memories (Berntsen, 2001). Another diary study with PTSD participants showed that participants with a high level of PTSD symptoms recorded more negative involuntary and voluntary memories than participants with lower levels of PTSD symptoms (Rubin, Boals & Berntsen, 2008). Berntsen, Rubin and Bohni (2008) argued that emotional stress enhances both encoding of and access to a memory, thus both involuntary and voluntary memory recall will be enhanced for traumatic episodes.

One task that has been used to study encoding and retrieval in the aftermath of trauma is Directed Forgetting (DF). In a DF task, participants are presented with lists of words, and an accompanying instruction either to remember or to forget the presented words. There are two main versions of the DF task: In the list method DF the Remember or Forget instructions are given after presentation of each list, whereas in the item method the Forget or Remember cue are given after each word. The standard Directed Forgetting effect refers to the fact that one remembers more words that one has been instructed to remember (R-words) compared to words one was instructed to forget (F-words) (Johnson, 1994). This Directed Forgetting effect is thought to reflect the ability to voluntarily forget material, and is often referred to as intentional forgetting.

A few studies with trauma-exposed individuals have used the DF task to study recall and forgetting from a perspective hypothesising that trauma-exposed individuals are characterised by avoidant encoding, that is, a tendency to fail to encode upsetting material.

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McNally, Metzger, Lasko, Clancy, and Pitman (1998) used an item method DF task to study intentional forgetting of trauma-related words relative to neutral and positive words in sexually abused participant with and without PTSD, and controls. However, in contrast to a hypothesis about avoidant encoding of trauma-related material in PTSD, the results showed no difference between the groups in recall of trauma-related R-words or F-words. On the contrary, but consistent with Rubin et al.'s model (2008), the participants remembered trauma-words very well, including the words they were instructed to forget. However, the PTSD patients demonstrated lower overall recall rates for positive and negative R-words.

One possible explanation for the lack of support for avoidant encoding in PTSD, could be alternating states of dissociation (Zoellner, Sacks, & Foa, 2003). To examine this proposal Zoellner and colleagues induced dissociation prior to an item-cued DF task. Their main hypothesis was that state dissociation would eradicate the DF-effect for threat-related material in individuals with PTSD. The results revealed the opposite pattern. On the recall test, DF for threat-relevant stimuli was observed after serenity induction but not after dissociation induction. No differences between PTSD participants and controls were observed. On the recognition test, DF was observed after serenity induction for both groups. However after dissociation induction there was no DF for PTSD participants.

Moulds and Bryant (2002; 2005) tested the avoidant encoding hypothesis using an item-specific DF procedure in trauma-exposed participants with acute stress disorder (ASD). They argued that it is more probable that avoidant encoding would be observed in the weeks after a trauma, rather than in persistent PTSD. The participants with ASD recalled fewer F trauma words compared to a group of trauma-exposed participants without ASD. However, the trauma-exposed participants without ASD showed no DF effect at all for trauma words, and this makes the results more difficult to interpret.

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In summary, Moulds & Bryant's (2002; 2005) studies are the only item-specific DF studies that support a hypothesis about avoidant encoding after trauma. Furthermore, the results from Zoellner et al. (2003) and McNally et al.'s (1998) studies shows that trauma-exposed individuals remember trauma-related material very well.

Cottencin and colleagues (2006) investigated DF in trauma-exposed individuals from a perspective arguing that intrusive memories, rather than avoidance and impaired voluntary recall, more correctly characterize cognition in PTSD. They hypothesised that due to a faulty inhibition mechanism, trauma-exposed participants with PTSD would have difficulties inhibiting F-words, compared to non trauma-exposed controls. In their study, a group of trauma-exposed participants with PTSD and a non trauma-exposed control group completed a version of the item-cued DF task comprising immediate conditional recall, where participants were asked to recall R-words, and final unconditional recall where participants were asked to recall both R-words and F-words. The results revealed that in the immediate conditional recall condition the PTSD group recalled fewer R-words compared to the controls. In contrast, the PTSD group recalled more F-words. In the final conditional recall where participants were asked to recall both F and R-words, a reduced DF effect for the PTSD group was found. The PTSD participants recalled fewer R-words, but there was no difference between groups with respect to recall of F-words.

Intrusive memories are also characteristic for depression (e.g. Brewin, Hunter, Carroll & Tata, 1996), and intrusive memories in depression and PTSD have been found to share the same characteristics (Reynolds & Brewin, 1999). Hence, DF studies with depressed individuals might be informative about intentional forgetting in PTSD. Power, Dalgleish, Claudio, Tata, and Kentish (2000) studied DF in clinically depressed, clinically anxious and healthy controls using a list method DF task, where half of the participants received a Forget cue after the first list and the other half did not. The results showed that the clinically

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depressed participants in the Forget condition actually recalled more negative words than the clinically depressed participants in the Remember condition. This pattern was not found for positive words. Furthermore this pattern was not found for the clinically anxious participants or the controls. These results suggest a stronger rebound of depression-relevant material in clinical depression. Power et al. (2000) argued that this effect may also explain intrusive memories in PTSD, and suggested a common mechanism in depression and PTSD, involving a stronger rebound effect for aversive personal-relevant information.

Wessel and Merckelbach (2006) investigated DF for emotional material in healthy participants. Using a list method DF task, these researchers showed a directed forgetting effect of equivalent size for neutral and negative word lists. This study indicates that for healthy participants there is no difference in intentional forgetting of either emotional or neutral material (Wessel & Merckelbach, 2006).

In summary, the literature suggests that trauma-exposed individuals, especially those with a diagnosis of PTSD, suffer from intrusive memories about the traumatic event. Moreover, memory after trauma is better characterised by intrusive recollection rather than avoidant encoding and impaired recall of trauma-related memories. As discussed above, intrusive memories in the aftermath of trauma might result from an impaired ability to intentionally forget disturbing material. In line with this Cottencin et al. (2006) found support for deficits in intentional forgetting of neutral material in participants with PTSD. However, in Cottencin et al.'s (2006) study only neutral material was used, and so is silent as to whether different patterns would emerge for emotional and trauma-specific material. Furthermore, Power et al. (2000) reported data showing stronger rebound of depression-relevant material in clinical depression, and argued that the list method DF paradigm would be a good model for studying an enhanced rebound effect and intrusive memories also in PTSD.

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In the present study we used a modified version of the list method DF task to study intentional forgetting and intrusive memories in a nonclinical group of trauma-exposed participants and controls. The purpose of the present study was twofold. The first aim was to investigate whether hypothesised deficits in intentional forgetting after trauma are specific to processing of trauma-specific material, or if they reflect a general tendency for all types of material. On the one hand, Cottencin et al.'s (2006) study with trauma-exposed participants with PTSD suggests a general tendency of impaired intentional forgetting in trauma-exposed individuals with PTSD. On the other hand, cognitive theories of PTSD (e.g. Brewin et al., 1996; Ehlers & Clark, 2000) suggest that memory deficits in trauma exposed individuals are specific for processing of material associated with the traumatic episode. Furthermore, these theories predict impaired voluntary recall and enhanced involuntary recall for trauma-specific material in trauma-exposed individuals. Rubin et al.'s (2008) model is in agreement that involuntary recall should be enhanced, but also predicts enhanced voluntary recall of material associated with the trauma in trauma-exposed individuals.

In order to investigate intrusive recall, a modified version of the list method DF was used. In the present study, all participants were first asked only to recall the second list: the R-words. This way, any F-words that were recalled when asked to recall R-words could be considered intrusions. In line with Rubin et al.'s (2008) mnemonic model we hypothesised enhanced involuntary recall for trauma-specific material for the Trauma group. More specifically, we hypothesised that the Trauma group would mistakenly recall more trauma-specific F-words when asked to recall R-words compared to controls. Furthermore, following Power et al. (2000) we hypothesised that the Trauma group would mistakenly recall more trauma-specific F-words compared to positive, neutral and threat-words, and compared to the controls. Thus the paradigm uses R and F instructions, but is not designed to pick up the

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standard DF effect per se, although it does allow a comparison of correct recall of both F-words and R-words between groups.

In line with Rubin et al.'s (2008) model, we hypothesised that the trauma group would correctly recall more trauma-specific R-and F-words compared to controls, and compared to positive, neutral and threat-related words. We also examined the relationship between trauma symptoms and depression symptoms and correct recall of R- and F-words. The second aim in the present study was to investigate intrusive involuntary recollection of trauma-specific material versus positive, threat-related and neutral material.

### **Method**

#### **Participants**

The Trauma group consisted of 23 women, all of whom had experienced sexual assault in adulthood. The Control group consisted of 23 non trauma-exposed women. Participant characteristics are presented in table 1. The participants in the trauma group were recruited from the Emergency Center in Bergen, the Emergency Center in Oslo, Dixi Resource Centre, Oslo and from the Center for Crisis Psychology in Bergen. The participants in the control group were recruited with posters placed on public transport, at the University, and in grocery shops. The project was approved by the Regional Committee for Medical Research Ethics for South-Eastern Norway.

#### **Design**

The present study used a mixed design with Group (trauma-exposed and non trauma-exposed controls) as a between-subject factor. The within-subject factors were: Emotional Valence (Trauma-Specific, Threat-related, Neutral and Positive) and R/F (Remember, Forget). Recall accuracy was the dependent variable.



## Materials

**Posttraumatic Diagnostic Scale (PDS).** The posttraumatic diagnostic scale (PDS) is a 49 item self-report scale based on the DSM-IV diagnostic criteria for PTSD. Studies have reported high internal consistency with an alpha coefficient of .92 and a test-retest correlation of .89 (Foa, Cashman, Jaycox, & Perry, 1997).

**Beck Depression Inventory-II (BDI-II).** The BDI-II is a self administered inventory that contains 21 items, it is used to measure current levels of depression (Beck, Steer & Brown, 1996). Beck and colleagues (1996) reported a test-retest correlation of .93 on a sample of 26 clinic patients.

**Beck's Anxiety Inventory (BAI).** The BAI (Beck, Steer & Brown, 1990) is a 21 item self-report inventory measuring severity of anxiety, which has high internal consistency with an alpha coefficient of .92 and a test-retest correlation of .75.

**Impact of Event Scale- Revised (IES-R).** The IES-R is a self-report instrument consisting of 22 items aimed to measure level of stress reactions commonly associated with PTSD: intrusion, avoidance and hyper-arousal. The internal consistency of the scale is reported to be high; one study reported the intrusion subscale to have an alpha coefficient of .91 and the avoidance subscale to have an alpha coefficient of .85 and hyper arousal .90. Test-retest correlation of .57 for intrusion, avoidance .51, and hyper-arousal .59 has been reported (Weiss & Marmar, 1997).

**Directed Forgetting Task.** In the present study two lists of words were presented to the participants. Each list consisted of 8 positive, 8 neutral, 8 threat-related, and 8 rape-related words. Across participants, the lists served an equal number of times as the Remember-list (R) and the Forget-list (F). To generate these words, 7 students were asked to come up with as many as possible words in the four categories. For the threat-related words the students were instructed to come up with words that are associated with traumatic experiences, but not

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associated with rape (e.g. Traffic accident, Massacre, Fire). Three other students were asked to evaluate the words for emotional content on a scale from -3 to 3, additionally they were asked to indicate on a scale from 0-3 to what degree each word was associated with rape. The frequency of each word was estimated using the Oslo Corpus of Tagged Norwegian Texts database (<http://www.tekstlab.uio.no/norsk/bokmaal/english.html>). This database consists of 18.3 million words from the most common magazines, newspapers, books and public reports in Norway. A one-way ANOVA showed that there was no significant difference in frequency between levels of valence,  $F(3,76) = .41, ns$ . A one-way ANOVA showed that there was a significant difference in word length between levels of valence,  $F(3,76) = 4.54, p < .01$ . Words in the neutral valence category had significantly shorter word length compared to positive words  $t(30) = 3.60, p < .001$ , compared to threat-related words  $t(30) = 2.93, p < .005$ , and compared to trauma-specific words  $t(30) = 3.46, p < .001$ .

### Procedure

The participants were tested individually in a quiet lab by the first author. The experiment was run by an E-prime script, and consisted of four phases:

#### 1) To-be-forgotten list:

The participants were shown an instruction on the screen: *“You will now be shown a list of words. Try to remember these words”*. Following this instruction the participants were presented 8 positive words, 8 threat-related words and 8 trauma-specific words and 8 neutral words, in a random order. Each word was presented on a computer screen for 2000 msec, this was followed by an interval of 500 msec with a blank screen, a fixation cross for 500 msec, and a blank screen for another 500 msec. After the first list of 32 words had been presented, the participants were instructed to try to forget the presented words: *“Now try to forget the words you have seen. Try instead to remember the words you will be shown now.”*

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### 2) To-be-remembered list:

The next list of 32 words was then presented on the computer screen, in a random order with the same interval as described above. 8 positive words, 8 threat-related words and 8 trauma-specific words and 8 neutral words were presented.

### 3) Recall R-words:

Participants were then instructed to “*Write down as many words as possible from the last list*”, and were given 2 minutes in which to do so.

### 4) Recall F-words:

Participants were asked to: “*Write down as many words as possible from the first list*”.

This task also had a time frame of 2 minutes.

## Results

While the groups did not differ in age or years of education, the Trauma group scored higher on the clinical measures (see Table 1).

(Table 1)

**Correct recall of F and R-words.** The mean number of correctly recalled words from the original list was calculated for each word type, and type of instruction (Forget, Remember) as presented in Table 2.

(Table 2.)

A mixed ANOVA with the between subjects factor of Group (Trauma, Control) x Instruction (Forget, Remember) x Valence (Positive, Neutral, Threat-related, Trauma-Specific) was performed. There was a main effect of Instruction  $F(1, 43) = 72.97, p < .001, \eta^2 = .60$ . There was also a main effect of Valence  $F(3, 129) = 6.24, p < .001, \eta^2 = .14$ . This main effect reflected a pattern where significantly more neutral compared to positive words  $t(45) = 3.51, p < .005$  were recalled, significantly more trauma-specific compared to positive words  $t(45) = 4.44, p < .001$ , and significantly more negative compared to positive words were

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recalled  $t(45) = 2.56, p < .05$ . No other comparisons turned out to be significant. No significant effect of Group on recall was found  $F(1, 43) = 1.87, p = .18$ , and none of the interactions were significant.

An additional analysis was carried out after dividing the trauma group into a PTSD-group ( $n=9$ ) and a Trauma group ( $n=14$ ) according to a recommended cut off score of 27 on the PDS (Griffin, Uhlmansiek, Resick, & Mechanic, 2004). The same pattern of results was observed for this analysis.

### **F-words mistakenly recalled when asked to recall R-words**

The mean number of words from the F- list mistakenly recalled when asked to recall R-words condition was calculated for each word type, these data are shown in Table 3.

*(Table 3.)*

A repeated-measures ANOVA with the between subjects factor of Group (Trauma, Control) and the within subject factor Valence (Positive, Neutral, Threat-related, Trauma-Specific) was performed with the mistakenly recalled F-words. The main effect of Valence was not significant  $F(3, 129) = .64$ , and there was no main effect of group,  $F(1, 44) = .45$ . However, there was a significant interaction between Group and Valence,  $F(3, 132) = 4.36, p < .01, \eta^2 = .09$ . This interaction was broken down by independent samples t-tests for each valence, which showed that there was no significant difference between groups for Positive  $t(44) = .00$ , Threat-related  $t(44) = .75$ , and Neutral words  $t(44) = 1.04$ . However, for Trauma-specific words, the trauma group mistakenly reported more F-words when asked to recall R-words compared to controls,  $t(44) = 3.14, p < .005$ . Moreover, separate t-tests comparing number of mistakenly recalled Forget-words were computed for each group separately, these analyses showed that the trauma group recalled significantly more Trauma-specific F-words during recall of R-words compared to Neutral F-words  $t(22) = 3.03, p < .01$ , to Positive F-

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words  $t(22)= 2.10, p<.05$ , and to Threat-related F-words  $t(22)= 2.20, p<.05$ . For the control group there were no such significant differences.

Additional analyses were carried out after dividing the trauma group into a PTSD-group (n=9) and a Trauma group (n=14). The same pattern of results observed for the trauma group as a whole was also observed for both subgroups.

### **Correlations**

Pearson's correlations were performed to investigate possible relationship between mean numbers of correct recalled F- and R-words and scores on the IES, PDS, BDI and BAI (see table 4). To investigate a possible relationship between the frequency of "intrusive" recall of F trauma words in the R list and symptoms of intrusion reported on the IES, a Pearson's correlation was computed,  $r=.38, p<.05$ . Similar analyses were carried out for positive, neutral and negative words, no significant correlations were found.

*(Table 4.)*

### **Discussion**

The two aims of the present study were to investigate the modulation of intentional forgetting by valence, and the intrusive recollection of neutral, positive, threat-related and trauma-specific material in trauma-exposed participants and non trauma-exposed controls. The results showed that for correct recall significantly more neutral, negative and trauma-specific words were recalled compared to positive words. This pattern was found for both groups, and for both F- and R-words. Higher post-trauma symptom levels, as measured by the IES and the PDS, were associated with fewer correctly recalled R-words. This is in line with previous literature showing that PTSD and depression are associated with lower levels of correct recall of R-words (Cottencin et al., 2006; McNally et al, 1998). Also, significant

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negative correlations between correct recall of R-words and scores on the BDI and the BAI were found.

In line with our second hypothesis, the trauma-exposed participants mistakenly retrieved more trauma-specific F-words when asked to recall R-words, both relative to controls, and compared to the number of positive, neutral and threat-related F-words they mistakenly recalled. Moreover, a significant correlation between the frequency of “intrusive” recall of F trauma words and symptoms of intrusion reported on the IES was found. This can be interpreted in line with Power et al.’s (2000) suggestion about a stronger rebound effect for aversive personal-relevant information in depression and PTSD, and moreover the present findings suggest that this also happens in nonclinical groups of trauma-exposed individuals.

The patterns of results in the present study is partly consistent with Ehlers and Clark’s (2000) and Brewin’s (2001) theories. While these theories predict that voluntary recall of the traumatic event are impaired and involuntary recollection is enhanced, the results in the present study shows a pattern where involuntary recall of trauma-specific material is enhanced, however it was no evidence for impaired voluntary recall of trauma-specific material. The present findings are also partly consistent with Rubin et al.’s (2008) mnemonic model of PTSD that holds that emotional stress enhances both involuntary and voluntary memory. Thus, similarly to the current findings, this model predicts enhanced involuntary recall of trauma-specific material for the trauma group. However, the model also predicts higher voluntary recall of trauma-specific material, which we did not find in the present study.

The present study gives no support to either a hypothesis about a general or a trauma-specific deficit in intentional forgetting for trauma-exposed individuals, as measured by voluntary recall of F-words on the DF task. The absence of group differences for correct recall of any word valence for both R- or F-words contrasts with previous findings (Cottencin et al., 2006), suggesting a general deficit in intentional forgetting in PTSD. Our results are

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more in line with McNally et al.'s study (1998) where the results showed no difference between the groups in recall of trauma-related R-words or F- words. However, in McNally et al.'s (1998) study the PTSD patients demonstrated lower recall rates for positive and negative R-words, whereas this tendency was not found in the present study.

The conflicting results may be caused by differences in design. Former studies (e.g., Cottencin et al., 2006; McNally et al., 1998) have used an item-version of the DF task, whereas the present study employed a modified version of the list-version. In the modified version used in the present study all participants were first asked to recall the R-words, thus output order must be considered more carefully. It is not only the Remember cue that facilitates recall of R-words, but also the fact that the participants are asked to recall the R-words before the F-words. Thus, order of recall might have been an influencing factor for correct recall of F- and R-words. Moreover, the time between the encoding and recall of R-words was considerably shorter than the time between encoding and recall of F-words. This might have influenced differences in recall rates between F- and R-words. Additionally, in contrast to Cottencin et al.'s (2006) study sample, participants in the present study were not formally assessed for a diagnosis of PTSD. Thus, differences in post-trauma symptoms might have contributed to the conflicting results.

Differences in word length between levels of valence can be argued to have influenced the results in the present study. Words in the neutral valence category had significantly shorter word length compared to positive words, threat-related words, and trauma-specific words. However, for correct recall a pattern was found where significantly more neutral, threat-related and trauma-specific words compared to positive words were recalled. Thus, an explanation based on differences in word length alone does not fit the results in the present study.

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How can we explain the increase in involuntary intrusive recollection of trauma-specific words in the trauma group and the simultaneous lack of group differences in intentional forgetting or correct recall of R and F-words? The results do not suggest that the trauma-exposed participants have a general problem with intentional forgetting. Furthermore the recall test of the F-words suggest that they do not have a problem with intentional forgetting of trauma-specific material either. However, the trauma group did demonstrate a higher level of intrusive memories of trauma-specific F-words when asked to recall R-words. A source monitoring deficit for trauma-specific material for the trauma group is one possible explanation. Brennen, Dybdahl and Kapidžić (2007) used the DRM paradigm to study false memories in trauma-exposed participants with and without PTSD. In the DRM task participants are asked to remember lists of words, some of the members of each list are associatively related to a target word that has not been presented, a so-called ‘‘critical lure’’. Participants typically falsely recall or recognise a high level of critical lures. This tendency to produce false memories has been explained in terms of a source monitoring error, more precisely the participants are not able to separate words that they thought about when they saw the words list from words that were actually presented in the list. In Brennen et al.’s (2007) study the results showed that participants with PTSD mistakenly recalled more trauma-specific critical lures in the DRM paradigm compared to trauma-exposed controls. For neutral lists however there was no difference between groups in false recall. Brennen et al.’s (2007) results can be understood as a trauma-specific source monitoring error in PTSD. The results of the present study can be interpreted in line with this, but suggests that such a deficit also can arise in trauma-exposed individuals without a diagnosis of PTSD.

The present study has some limitations that need to be addressed. The sample in the present study was non-clinical, and perhaps different results would have emerged with a



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clinical sample. Furthermore, no clinical evaluation was made and PTSD symptoms were determined by self-report on the IES and the PDS alone.

It can be argued that different levels of integration of material have influenced the results. The trauma-specific material can be said to be more integrated than the positive, neutral and threat-related material, and a higher level of integration might influence source monitoring error. However, this explanation does not fit the pattern observed in the present study, because the control group did not show a tendency for higher level of mistakenly recalled trauma-specific F-words when asked to recall R-words. Another concern in the present study is the low number of correctly recalled words.

In summary the present study found no differences between trauma-exposed participants and controls for correct recall of F-and R-words. However, the trauma group mistakenly recalled more trauma-specific F- words when asked to recall R-words.

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**Tables**

*Table 1. Mean participant characteristics with associated t-values (standard deviation in brackets)*

	Trauma	Control	t (df)
Age	25.26 (6.10)	24.08 (4.64)	.73 (44)
Years of post-school education	4.71 (2.82)	4.96 (1.96)	-.33 (44)
Weeks since sexual assault	52.61 (72.74) Range: 4-260	-	-
Number previous trauma	1.17 (14)	.35 (.49)	2.67 (44)*
PDS	21.43 (11.23)	.73 (1.51)	8.76 (44)****
IES	34.40 (18.63)	7.57 (13.05)	5.45 (41)****
BDI-II	18.70 (10.48)	5.59 (6.93)	5.09 (43)****
BAI	12.91 (8.60)	5.36 (6.93)	3.20 (42)***

\* $p < .05$ , \*\*\* $p < .005$ , \*\*\*\* $p < .0001$

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*Table 2. Mean number of correctly recalled words (standard deviation in brackets)*

Word type	Trauma		Control	
	Forget	Remember	Forget	Remember
Positive	.36 (.58)	1.26 (1.18)	.87 (1.14)	1.78 (.95)
Neutral	1.00 (1.00)	1.91 (1.12)	1.22 (1.41)	2.17 (1.19)
Threat-related	.91 (.95)	1.43 (1.27)	.83 (1.92)	2.30 (1.18)
Trauma-specific	1.13 (1.19)	2.34 (1.23)	1.17 (.98)	2.13 (1.49)

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*Table 3. Mean numbers of F-words recalled when instructed to recall R-words only (standard deviation in brackets)*

Word type	Trauma	Control
Positive	.43 (.66)	.43 (.66)
Neutral	.32 (.57)	.52 (.73)
Threat-related	.39(.58)	.52(.59)
Trauma-specific	.87 (.76)	.26 (.54)

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Table 4. Pearson correlations between correct recall scores and clinical measures

		BDI-II	BAI	PDS	IES
R-Words	Trauma	-.39	-.41	-.55**	-.39
	Control	-.37	-.27	-.24	-.18
	Total	-.42**	-.41**	-.41**	-.32*
F-Words	Trauma	.05	-.08	-.10	.05
	Control	-.44**	-.36	-.37	-.07
	Total	-.18	-.24	-.15	-.04

\* $p < .05$ , \*\* $p < .01$



**Appendix. Translations of the words presented in the R-list and the F-list.**

<b>Positive</b>	<b>Neutral</b>
Festive	Ball
Successful	Grapes
Gift	Grass
Joy	Hammer
Inspired	Sofa
Praise	Salt
Funny	Tractor
Kind	Audio
Super	Brush
Nice	Arm
Friendship	Milk
Satisfied	Shop
Skilled	Train
Sympathetic	Video
Motivated	Plant
Comfortable	Building
<b>Threat-related</b>	<b>Trauma-Specific</b>
Hijacking	Violent
Floods	Abuse
Dismember	Assault
Fire	Guilt
Traffic Accident	Threatening
Disaster	Attack
Collision	Intercourse
Bombing	Humble
Plane crash	Harrasment
Mine Field	Invade
Assassination	Maltreatment
Storm	Aversion
Krig	Dirty
Murder	Sex
Casualty	Shame
Mugging	Brutally







Mental time travel after trauma: The specificity and temporal distribution of autobiographical  
memories and future-directed thoughts

Ines Blix and Tim Brennen

Center for the Study of Human Cognition, Department of Psychology, University of Oslo

Running head: TRAUMA, MEMORY AND THINKING ABOUT THE FUTURE

*Keywords:* autobiographical memory, overgeneral memory, future foreshortening,  
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Corresponding author: Ines Blix, Department of Psychology, University of Oslo, PO Box  
1094, 0317 Oslo, Norway

Email: [ines.blix@psykologi.uio.no](mailto:ines.blix@psykologi.uio.no)

Telephone: (+47) 22 84 5204

Fax: (+47) 22 84 50 01

**Abstract**

The present study investigated the relationship between trauma exposure and specificity and temporal distribution of autobiographical memories and future-directed thoughts. A group of sexual assault victims were compared with women without previous trauma exposure in relation to specificity of autobiographical memories, as measured by the Autobiographical Memory Task (AMT) and specificity of future-directed thoughts as measured by the Future Cueing Task (FCT). The temporal distribution of future-directed thoughts and autobiographical memories was studied by asking the participants to estimate when each memory reported on the AMT had occurred and when each future event reported on the FCT would occur. The results showed no difference between the trauma group and the controls on specificity of autobiographical memories and future-directed thoughts. In line with a review of Moore and Zoellner (2007), PTSD symptoms as measured by the Impact of Event Scale (IES) correlated negatively with specificity. Furthermore, we observed no difference in temporal distribution of future-directed thoughts or autobiographical memories between trauma-exposed participants and controls.

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## **Introduction**

Experiencing traumatic events influences what and how we remember (McNally, 2003). Studies with trauma-exposed individuals without a clinical diagnosis have shown that trauma exposure is associated with intrusive recall of trauma-related memories (for a review see Krans, Näring, Becker & Holmes, 2009), higher level of false memories (Zoellner, Foa, & Przeworski, 2000), and overgeneral retrieval of autobiographical memories (OGM) (e.g. Brennen et al., 2010). Moreover, a proportion of people exposed to trauma develop posttraumatic stress disorder (PTSD), a disorder that is characterised by intrusive memories and thoughts, flashback and fragmented memory for the traumatic event, and that has recently been called as a disorder of memory (McNally, 2003). Thus, the impact of trauma on memory is well established, however less is known about the relationship between trauma and future-directed thoughts. The present study investigated the impact of trauma on autobiographical memory and future directed thinking in a nonclinical sample of trauma-exposed individuals, and a control group.

Tulving (1985) suggested that the same episodic memory system underpins how we remember the past and imagine the future. Furthermore, he proposed that the ability to remember episodic memories from the past and to imagine specific events in the future is both forms of “mental time travel”. In other words, our episodic memory system provides us, in some limited sense, with the ability to travel both backwards and forwards in time, and thereby to relive episodes from our past as well as to imagine episodes that plausibly lie ahead in time. Studies using functional brain imaging have demonstrated a high correspondence of active areas in tasks tapping recollection of past experiences and construction of future experiences (e.g. Addis, Wong & Schacter, 2006; Szpunar, Watson, & McDermott, 2007), thus supporting the notion that the forms of mental time travel draw on the same cognitive



system. In line with this, several studies have demonstrated that there is an intimate relationship between memory and future-directed thinking. For example, deficits in autobiographical memory have been reported to be associated with deficits in future-directed thinking in various populations e.g. in amnesics (Hassabis, Kumaran, Vann & Maguire, 2007), schizophrenics (D'Argembeau, Raffard & Van der Linden, 2008), and depressed patients (Williams, Ellis, Tyers, Healy, Rose & MacLeod, 1996). Furthermore, valence and temporal distance have been found to influence phenomenological characteristics of autobiographical memories and future-directed thoughts the same way (D'Argembeau & Van der Linden, 2004). Moreover, Spreng and Levine (2006) showed that the temporal distribution of autobiographical memories and future-directed thoughts fit the same power function. More specifically, the most frequent "destinations" of mental time travel were close to the present time, and decreased as a function of time from now, for both the forward and backward variants.

### **The specificity of autobiographical memories**

In their pioneering study, Williams and Broadbent (1986) discovered that suicide attempters had difficulties retrieving specific autobiographical memories, instead tending to refer to more general categorical memories. That is, instead of retrieving memories from specific events, they tended to refer to more general categorical memories. For example, if asked to retrieve a memory for the word "happy", trauma-exposed individuals would be more likely to retrieve a general memory such as "every time I did well at school", as opposed to a specific memory, e.g. "The time I got an A on a maths test".

Subsequent research has demonstrated OGM in individuals exposed to a broad variety of traumatic events (e.g. Brennen et al., 2010; Dalgleish, Tchanturia, Serpell, Hems, Yiend, de

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Silva & Treasure, 2003; de Decker, Hermans, Raes & Eelen, 2003; Henderson, Hargreaves, Gregory & Williams, 2002; Hermans, Van den Broeck, Belis, Raes, Pieter & Eelen, 2004; Kuyken & Brewin, 1995; Wessel, Merckelbach & Dekkers, 2002; Williams, Williams & Ghadiali, 1998).

OGM has also been reported in PTSD (e.g. McNally, Lasko, Maclin & Pitman, 1995; McNally, Litz, Prassas, Shin & Weather, 1994) and ASD (Harvey, Bryant, & Dang, 1998). However, since these traumatic stress reactions follow exposure to potentially traumatising events, it has been difficult to determine whether it is the exposure to potentially traumatising events per se or if it is the psychological reaction to the trauma that affects autobiographical memory retrieval, though a review by Moore and Zoellner (2007) concluded that trauma per se is not likely to lead to OGM.

A few studies have investigated the relationship between OGM, trauma and symptoms of psychopathology prospectively, to try to establish whether OGM after trauma exposure constitutes a vulnerability factor for psychological disorders. For instance, in a study with survivors of a motor vehicle accident with and without ASD, Harvey, Bryant and Dang (1998) reported that difficulty retrieving specific autobiographical memories predicted PTSD severity at follow up six months later. In a study with fire fighters, Bryant, Sutherland and Guthrie (2007) showed that specificity prior to trauma predicted PTSD severity after trauma exposure. In contrast, Kangas, Henry and Bryant (2005) reported that OGM after receiving a cancer diagnosis did not predict subsequent PTSD severity.

Furthermore, a few studies have reported an association between OGM and vulnerability to depression. A study with college students reported that OGM and stressful life events predicted subsequent depression (Gibbs & Rude, 2004). A prospective study with women who were about to undergo in vitro fertilization reported that the number of specific

autobiographical memories at baseline was negatively related to depressive and anxiety symptoms after treatment (Minnen, Wessel, Verhaak & Smeenk, 2005). These findings suggest that OGM can serve as a vulnerability factor for depression. Moreover, a study by Brittlebank, Scott, Williams and Ferrier (1993) found that OGM was associated with failure to recover from clinical depression. In line with this a metaanalysis investigating whether OGM is a predictor of the course of depression, concluded that reduced specificity was associated with higher levels of depressive symptoms at follow-up (Sumner, Griffith & Mineka, 2010).

Williams (1996) proposed a model of the development of OGM, where he suggested that the mechanism underlying OGM is a truncated search in autobiographical memory. In his original model Williams proposed an affect regulation hypothesis where he explained that children growing up surrounded by a negative environment have a tendency to avoid retrieval of specific memories in order to avoid negative affect. This strategy of overgeneral retrieval may then become a stable trait that will continue to be used in adulthood, involving overgeneral retrieval of both positive and negative memories. Furthermore, this stable overgeneral retrieval style, while adaptive at first, was hypothesised to serve as a vulnerability factor towards the development of depression in adulthood. More recently, Williams (2006) suggested the CaRFAX model for OGM, where he proposed three mechanisms of OGM: Capture and rumination (CaR), functional avoidance (FA), and executive control dysfunction (X). Capture and rumination refers to how mnemonic information used to search for specific memories activates ruminative memories or thoughts and hence cause a truncated search. Executive resources plays an important role in retrieval of specific autobiographical memories, and a dysfunction in executive control or impairments in executive capacity can lead to a truncated search and thus underlie OGM. The mechanism of functional avoidance is

linked to Williams (1996) model, and refers to OGM as a strategy aimed at avoiding negative affect.

### **The specificity of future-directed thoughts**

McNally et al. (1995, p.629) suggested that “*an inability to remember the past may be related to an inability to imagine the future*”, thus in conditions where reduced specificity is found it might also be expected that future-directed thoughts have reduced specificity. In line with this, Williams et al. (1996) reported that when an overgeneral retrieval style for autobiographical memories was induced either by instruction or by administration of low versus high imageable words, the specificity for future-directed thoughts was also reduced. Furthermore, Williams et al. (1996) reported that a group of depressed suicidal inpatients described both the past and imagined the future more generically than controls.

Dickson & Bates (2006) found that dysphoric participants were less specific both in describing autobiographical memories, and when imagining the future. This tendency was also reported in a study investigating specificity of past and future thoughts in schizophrenia, here the specificity levels for past and future stories were significantly related in both the clinical group and the control group (D’Argembeau & Raffard, 2008). Holmes et al (2008) reported that high dysphoria compared to low dysphoria was associated with greater problems imagining vivid positive events. This tendency was not found for negative events.

While several studies have demonstrated a robust relationship between trauma, OGM and some forms of psychopathology, no study has so far investigated the specificity of future-directed thoughts after trauma. A relationship between trauma and specificity of future-directed thought might be of importance because, as suggested by Williams et al. (2007), an impaired ability to imagine specific events in the future can be related to the ability to solve

problems in daily life. Sutherland and Bryant (2008) studied social problem solving and autobiographical memory specificity in trauma-exposed participants with and without PTSD. The results showed that the participants with PTSD had a higher level of OGM and also poorer problem solving abilities compared to the trauma-exposed controls. Furthermore, social problem solving was related to OGM, suggesting that impaired problem solving is associated with reduced specificity in PTSD. Thus, impaired specificity of future-directed thoughts after trauma might be an important factor for explaining vulnerability to post-trauma psychopathology.

### **Future foreshortening**

Clinicians report that time perspective seems to be altered in trauma-exposed individuals (e.g. Terr, 1983). Furthermore, clinicians have noted that after experiencing a traumatic event the person's focus lies more in the present and is less in the future (Martz, 2010). Future foreshortening is listed in DSM-IV as a symptom in PTSD, and is defined as "an inability to make plans or to imagine having a career, family, marriage or normal lifespan after experiencing trauma" (APA, 2000). Despite this, only a few studies have focused on future-directed thinking after trauma. One study focusing on temporal orientation and long-term psychological distress in trauma exposed individuals showed that less future orientation was associated with greater psychological distress in trauma-exposed participants (Holman and Silver, 1998). Martz and Livneh (2007) investigated whether so-called non-adaptive post-trauma reactions to chronic illness and disability were associated with reduced ability to make long-term plans. No relationship between non-adaptive reactions to trauma and future time perspective was found. However, the results showed that adaptive psychosocial responses were associated with extended future time perspective.

McNally et al. (1995) studied the temporal distribution of retrieved memories in Vietnam veterans with and without PTSD. Memories retrieved on the AMT were coded according to whether the event had occurred the last month, the last year, and the last 5 years, the last 10 years or more than 10 years ago. The results showed that the retrieval curves for the controls and the PTSD participants were similar, with the exception that controls retrieved more memories from 10 years ago relative to PTSD participants. However, PTSD participants who still spontaneously wore war-regalia retrieved fewer memories from the last month, and more memories from 10 years ago, compared to non regalia-PTSD participants. The authors concluded that wearing regalia might represent a “psychological fixation” on the war and the altered temporal distribution of autobiographical memories can indicate that the individuals are in some sense “stuck in the past”.

### **The present study**

If autobiographical memory and future-directed thinking depend on the same episodic memory system, it is reasonable to expect that trauma exposure is also associated with alterations in future-directed thinking. The present study is the first to focus on specificity and temporal distribution of future-directed thoughts and autobiographical memories after trauma.

The aim of the present study was two-fold. The first aim was to investigate specificity of future-directed thoughts and autobiographical memories in trauma-exposed participants and controls. Moore and Zoellner’s (2007) review suggests that in adults it is symptoms of psychopathology in the aftermath of trauma, rather than trauma exposure per se that influences OGM. In line with this, we hypothesised that symptoms of traumatic stress would be associated with reduced specificity for autobiographical memories. We also hypothesised that symptoms of depression would be related with reduced specificity for autobiographical

memories and future directed thoughts. Furthermore, based on literature showing that the specificity of autobiographical memory and future-directed thoughts are related (D'Argembeau & Raffard, 2008; Williams et al., 1996) we hypothesised the relationship between symptoms of traumatic stress and specificity would be the same for future directed thoughts.

The second aim was to see if one can detect future foreshortening in trauma-exposed participants by comparing the temporal distribution of their future-directed thoughts and autobiographical memory with those of controls. Based on the symptom of future foreshortening described in DSM-IV we hypothesised that, relative to controls, trauma-exposed participants would imagine more future events in close temporal distance, and fewer events in more remote temporal distance.

### **Method**

#### **Participants**

The Trauma group consisted of 23 women, all of whom had experienced sexual assault in adulthood. The Control group consisted of 23 non trauma-exposed women. One participant from the trauma group was excluded from the analyses, due to a high proportion of no responses on both the AMT (80%) and the FCT (94%). There was also equipment failure for one participant in the control group. Participant characteristics of those included in the analyses are presented in Table 1. The participants in the trauma group were recruited from the Emergency Center in Bergen, the Emergency Center in Oslo, Dixi Resource Centre, and from the Center for Crisis Psychology in Bergen. The participants in the control group were recruited by posters at the University, on public transport and in grocery shops. The project

was approved by the Regional Committee for Medical Research Ethics, and another part of it is available in Blix and Brennen (in press).

### **Instruments**

**Posttraumatic Diagnostic Scale (PDS).** The PDS is a 49-item self-report scale based on the DSM-IV diagnostic criteria for PTSD. Studies have reported high internal consistency with an alpha coefficient of .92 and a test-retest correlation of .89 (Foa, Cashman, Jaycox, & Perry, 1997).

**Beck Depression Inventory-II (BDI-II).** The BDI-II is a self administered inventory that contains 21 items, it is used to measure current levels of depression (Beck, Steer & Brown, 1996). Beck and colleagues (1996) reported a test retest correlation of .93.

**Impact of Event Scale- Revised (IES-R).** The IES-R is a self-report instrument consisting of 22 items aimed to measure level of stress reactions commonly associated with PTSD; intrusion, avoidance and hyper-arousal. The internal consistency of the scale is reported to be high; one study reported the intrusion subscale to have an alpha coefficient of .91 and the avoidance subscale to have an alpha coefficient of .85 and hyper arousal .90. Test-retest correlation of .57 for intrusion, avoidance .51, and hyperarousal .59 has been reported (Weiss & Marmar, 1997). The questions in the IES are anchored in a traumatic experience in the individual's past. For the participants in the trauma-group, the event in the past would refer to the experience sexual-assault. The participants in the control group were asked to refer to the "most distressing or traumatic event they had experienced when completing the questionnaire".

**Autobiographical Memory Task.** The AMT consists of cue words, where the valences of the cue words alternates between positive, like "optimistic", negative, like "sad",



and neutral words, like “garden”. In the present study every cue word was embedded in a sentence, e.g. “Try to imagine an episode from the past associated with the word garden”. The cue words will be presented to the participants alternating positive, negative and neutral.

In response to each cue word, the participants were asked to recall a specific memory of a particular event that occurred within the time span of one day. The instruction was shown on the computer screen and stated: *“You will now see some sentences on the screen. The task is to describe a specific event that happened in the past to each sentence. A specific event is an episode that takes place within the time span of one day. The event that you describe can have happened either in close or distant past.”* The participants were first asked to practise on three cue words. A computer based version of the AMT was used and the answers were given in writing. Each word was present on the screen for as long as it took for the participant to write down the memory, however if no response was started after 60 seconds, a new cue sentence would appear on the screen. Following each response to the cue sentences they participants were asked to state when the described memory happened, they were asked to write down how many days, months or years it is since the episode happened.

**The Future Cuing Task (FCT).** The future cuing task was first used by Williams and colleagues (1996) to measure the specificity of with which participants imagine their future. The participants were asked to imagine future events in response to positive, negative and neutral cue words. The instruction was shown on the computer screen and stated: *“You will now see some sentences on the screen. The task is to describe a specific event in the future to each sentence. A specific event is an episode that takes place within the time span of one day. Try to imagine an event that is likely to happen, the event that you describe can happen either in close or distant future.”* As in the AMT, the cue sentences were shown on the computer screen for as long as it took for the participant to write down a story, however if no response

was started within 60 seconds a new cue sentence were presented. After each story the participants were asked to state in how many days, months or years this event would be likely to happen.

**Cue words used in the AMT and the FCT.** Two word lists, each composed by 5 positive, 5 negative and 5 neutral cue words were used. The frequency of each word was estimated using the Oslo Corpus of Tagged Norwegian Texts database (<http://www.tekstlab.uio.no/norsk/bokmaal/english.html>). The wordlists were also rated for emotional content by three raters, who did not participate in the main task. The raters were asked to indicate the emotional valence for each word on a scale from -3 to 3. List 1 and 2 was matched so that it was no difference in either frequency or emotional valence.

A one-way ANOVA with the independent variable of emotional valence showed that there were no significant difference in frequency of the words between levels of valence  $F(2,27) = .98, ns$ . Mean emotional content was calculated for each level of valence, positive words ( $M = 2.50, SD = .39$ ), Negative ( $M = 2.06, SD = .38$ ), Neutral words ( $M = .20, SD = .35$ ).

## **Procedure**

The participants were tested individually in a quiet laboratory by the first author. The participants were first asked to complete the AMT, and then the FCT. Two lists of words were used in the AMT/FCT, half of the participants were given list 1 in the AMT and list 2 in the FCT, and the other half were presented to list 2 in the AMT and list 1 in the FCT. Order of the words within both lists was counterbalanced.

Two independent raters evaluated both the responses on the AMT and the FCT in relation to specificity. The raters were instructed to categorise each response as either specific,

categorical, extended, semantic associate or as a non-response. A response was rated as categorical when it referred to a category of highly similar and often repeated events e.g. “Sad: Every time I quarrelled with my husband”. A response was categorised as extended memories refer to events that stretch out over a time span over one day; e.g. “Boring: When I was home from work with the flu”. A response was categorised as specific memories when it referred to one particular event/episode that occurred within the time span of 24 hours. “My birthday last year, I remember opening the present from a friend and ...”. A response was categorised as a semantic associate when it did not refer to an event but to knowledge about self or others.

When calculating interrater agreement the categorisations were divided into specific, overgeneral and no response. For the AMT the mean Cohen’s kappa was .77. For the FCT the mean Cohen’s Kappa was .68. In cases where the two raters diverged, a third rater determined the categorisation.

### **Results**

While the groups did not differ in age or years of education, the Trauma group scored higher on the clinical measures (see Table 1).

*(Table 1 about here)*

#### **Specificity**

The proportion of specific responses on the AMT and the FCT was calculated for each level of valence, means and SD are shown in table 2.

*(Table 2. about here)*

A mixed ANOVA was performed for specific responses with Task (Future vs. Past) and Valence (positive vs. negative vs. neutral) as within-subject factors, and Group (Trauma vs. Control) as between-subject factor. There was a significant main effect for Task,  $F(1,42) = 25.39, p < .001, \eta^2 = .27$ , reflecting a higher level of specific responses on the AMT compared to the FCT. No significant main effect of Valence  $F(1,42) = 2.48, ns$ , or Group was found,  $F(1,42) = .01, ns$ . No significant interactions were found.

An additional analysis was carried out after dividing the trauma group into a PTSD-group ( $n=9$ ) and a Trauma group ( $n=13$ ) according to a recommended cut off score of 27 on the PDS (Griffin, Uhlmansiek, Resick, & Mechanic, 2004). The same pattern of results was observed for this analysis.

### **Correlations**

Pearson's correlations were performed to investigate possible relationship between proportion of specific responses on the FCT and the AMT and scores on the IES, PDS, and BDI. A significant correlation was found between IES and proportion of specific AMT responses  $r = -.41, p < .01$ , when analysing separately for each level of valence a significant correlation was found between IES and specific responses to the negative cue words on the AMT  $r = -.39, p < .05$ , for neutral words the correlation was  $r = -.07, ns$ , for positive words the correlation was  $r = .05, ns$ . Since only five participants in the control group completed the PDS, the correlation between trauma symptoms as measured by the PDS and specificity was calculated only for the trauma group, a significant correlation was found between the PDS and specificity level in the trauma group ( $r = -.44, p < .05$ ) was found. No other correlations between autobiographical memory specificity and self-report measures were found. For FCT and self-report measures no significant correlations were found, the correlation between IES and proportion of specific FCT responses was  $r = .06, p = .70$ .

In addition, to test the hypothesis that trauma symptoms as measured by the IES would mediate an effect between trauma-exposure and on specificity scores we used a bootstrap approach to mediation as suggested by Preacher & Hayes (2004). The analysis, using 20000 bootstrap samples, showed that IES levels act as a mediator between trauma-exposure and autobiographical memory specificity (95% CI=0.0259, 0.1833, point estimate =0.12). Similar analysis performed with future specificity showed no indication of mediation. Similarly, analyses investigating the hypothesis that BDI scores would mediate an effect between trauma-exposure and specificity showed no indication of mediation for either autobiographical memory specificity or future specificity.

### **Relationship between future specificity and autobiographical memory specificity**

Pearson's correlation coefficients were calculated to examine the relationship between future specificity and autobiographical memory specificity. Across all participants, there was no significant correlation between proportion specific responses on the AMT and proportion specific responses on the FCT,  $r=.13$ , *ns*. However, when we compared specificity in response to positive cue words on the FCT and the AMT a significant positive correlation was found  $r=.42$ ,  $p<.01$ . For neutral cue words a significant negative correlation was found  $r=-.31$ ,  $p<.05$ . For negative cue words no significant correlation was found,  $r=.03$ ,  $p=.83$ .

### **Temporal distribution of autobiographical memories and future-directed thoughts**

Each response on the FCT and AMT was categorised into one of five time bins. The time bins used for the AMT and FCT responses were corresponding, on the FCT each response was coded according to whether the event were imagined to happen during the next week, the next month, the next six months, the next year, or in more than a year. On the AMT each response was coded according to whether the event had happened the last week, the last

month, the last six months, the last year, or more than a year ago. Mean proportions and standard deviations for each time bin were calculated separately for each group (see table 3).

For the FCT responses separate one-way ANOVAs with the independent variable of group showed that there were no difference between groups in proportion of responses for the time bins 'the next week',  $F(1,42) = 1.63, ns$ , 'the next six months',  $F(1,42) = 2.12, ns$ , 'the next year'  $F(1,42) = .89, ns$  or 'more than a year'  $F(1,42) = .76, ns$ . However, for the proportion of responses for 'the next month' the difference between the groups approached significance  $F(2,27)=3.8, p=.06$ , with a higher proportion of memories for the controls. For the AMT responses separate one-way ANOVAs with the independent variable of group showed that there was no difference between groups in proportion of responses for any of the time bins: 'the last week',  $F(1,42) = 1.19, ns$ , 'last month'  $F(1,42) = .01, ns$ , 'the last six months',  $F(1,42) = .90, ns$ , 'the last year'  $F(1,42) = .01, ns$  or 'more than a year ago'  $F(1,42) = .04, ns$ .

*(Table 3 about here)*

### **Discussion**

We predicted an association between trauma symptoms and reduced specificity for both autobiographical memories and future-directed thoughts. For autobiographical memories the correlational analyses showed that level of PTSD symptoms (as measured by the Impact of Event Scale) was negatively related to level of specificity for autobiographical memories. Furthermore, the mediation analyses showed that level of trauma symptoms as measured by IES act as a mediator between trauma exposure and autobiographical memory specificity. However, we observed no difference in specificity between the trauma and control group. This is in line with Moore and Zoellner's (2007) review which concluded that OGM is

associated with symptoms of psychopathology and not with trauma exposure per se.

However, in the present study we found no relationship between symptoms of depression and OGM. Furthermore there was no indication for a mediating role of depression.

For future directed thoughts no relationship between trauma symptoms and specificity was found, and no indication of mediation was found. Hence, in contrast to our hypothesis, no relationship between specificity of future-directed thoughts and trauma symptoms was found. Thus, the relationship between trauma symptoms and specificity for autobiographical memory and future-directed thoughts was not the same. This finding is somewhat in contrast to McNally's (1995) suggestion that OGM underlies problems with imagining the future in PTSD. However, it should be noted that the sample in the present study was small and the participants did not have a clinical diagnosis of PTSD.

The present findings do not concur with previous studies that have demonstrated that reduced specificity of autobiographical memories are related to reduced specificity of future-directed thoughts (D'Argembeau & Raffard, 2008; Dickson & Bates, 2006), and that specificity of past and future thoughts are influenced the same way by experimental manipulation (Williams et al., 1996). In the present study, a significant positive correlation was only found between specificity level for future-directed thoughts and autobiographical memories. However, for the memories and future-directed thoughts produced in response to neutral cue words a significant negative correlation was found, and for negative cue words no significant relationship was found. These findings do not concur with the results reported by Williams et al. (1996, Experiment 1), or with the findings of D'Argembeau et al. (2008) where a general relationship between memory and future specificity was found.

The different findings might have been influenced by differences in procedure and administration of the AMT and the FCT. In the present study a computer-based version of the

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AMT and FCT was administered, whereas in Williams et al. (1996) and D'Argembeau et al.'s (2008) study these tasks were administered as an interview. Furthermore, in D'Argembeau et al.'s (2008) study prompts were given when no specific response was given. As suggested by Yanes, Robert and Carlos (2008), OGM might be influenced by poor memory for task instructions. In the classical version of the AMT the participants are first instructed to recall specific memories to the cue words that follow. In the present study version the instruction was also given in the beginning, and in addition every cue was presented in a sentence that asked the participant to retrieve "a specific memory" or to "imagine a specific event". This reminder of the task instruction before every cue word might have contributed to a higher specificity level in general.

Also the different findings might also have been influenced by differences in cue words used across studies. Differences in concreteness of the words for example might influence how easy or difficult it is to retrieve a specific memory. Level of concreteness might be even more important in the FCT as imagining a specific episode in the future can be considered to be a more abstract and difficult task. The present results showed that the specificity level for autobiographical memory was higher compared to the specificity level for future-directed thoughts, for all levels of valence. This is in line with previous studies that have shown that the specificity level for autobiographical memory is higher than for future-directed thoughts (Anderson & Dewhurst, 2009; Dickson & Bates, 2006; Williams et al., 1996).

The present study has some limitations that need to be addressed. First, the sample in the present study was non-clinical, and perhaps different results would have emerged with a clinical sample. Furthermore, no clinical evaluation was made and PTSD symptoms were measured by self-report inventories alone.



The present study used a cue word method to elicit past and future episodic thoughts, which has the advantage of experimental control. However, it might be suggested that spontaneously generated past and future thoughts might better represent mental time travel in everyday life and consequently be a more ecologically valid method to study the influence of trauma on this form of cognition.

### **Future foreshortening**

Trauma exposure is associated with alterations in time perspective (Terr, 1984), and the DSM-IV lists “a sense of a foreshortened future” as a symptom of PTSD (APA, 2000). The present study investigated whether this might be reflected in different temporal pattern for future-directed episodic thoughts. We hypothesised that “future foreshortening” would be reflected in an increased focus on the close future and decreased focus on more remote future, and hence a pattern where trauma-exposed participants imagined more events in the near future. However, we did not find any support for altered temporal distribution for future-directed thoughts in trauma-exposed individuals.

Only 15 cue words were administered in the FCT and the AMT. A higher number cue words would allow for a more nuanced analysis of the temporal pattern. Hence, to draw more firm conclusions about trauma and temporal distribution of future-directed thoughts and autobiographical memories, future studies should use more cue words.

In summary, the present study shows a relationship between trauma symptoms and reduced specificity of autobiographical memories, however no such relationship was found for future-directed thoughts. The concept of mental time travel (Tulving, 1985; 2002) refers to our ability to mentally travel back and forward in time and these abilities are suggested to depend on the same episodic memory system. Hence, it follows that trauma should have the

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same influence on past and future thought. However, the present study provides some evidence that trauma symptoms only influence the specificity of mental time travel to the past, and not to the future.

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*Table 1. Mean participant characteristics with associated t-values (standard deviation in brackets)*

	<u>Trauma</u>	<u>Control</u>	<u>t(df), p</u>
Age	25.59 (6.02)	24.18 (4.72)	.86(42)
Years of higher education	4.93 (2.68)	4.88 (1.97)	.06(42)
Weeks since episode	54.45 (78.89)	-	-
Number previous trauma	1.22 (1.41)	.36 (.49)	2.71 (42)**
PDS	21.22 (11.45)	.77(1.54)	8.30(42)****
IES	34.00 (18.98)	7.90 (13.30)	5.07(39)****
BDI-II	18.63 (10.71)	5.85 (6.17)	4.76(41)****

\*\*  $p < .01$ , \*\*\*\*  $p < .0001$

*Table 2. Mean proportion specific responses on the AMT and the FCT for each level of valence (standard deviation in brackets).*

	AMT		FCT	
	Trauma	Controls	Trauma	Controls
Positive	.78 (.20)	.76 (.22)	.67 (.31)	.67 (.26)
Neutral	.79 (.18)	.78 (.20)	.57 (.26)	.62 (.26)
Negative	.73 (.21)	.80 (.19)	.60 (.24)	.49 (.27)
Total	.76 (.12)	.78 (.17)	.62 (.18)	.59 (.19)

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*Table 3. Mean proportion FCT and AMT responses for each time bin (standard deviations in brackets)*

	FCT		AMT	
	Trauma	Control	Trauma	Control
1 week	.42 (.26)	.33 (.18)	.16 (.14)	.21 (.15)
1 month	.17 (.13)	.25 (.18)	.11 (.10)	.11 (.11)
6 months	.28 (.19)	.21 (.15)	.20 (.13)	.16 (.12)
1 year	.06 (.09)	.09 (.08)	.11 (.11)	.11 (.12)
More than one year	.08 (.09)	.12 (.20)	.42 (.21)	.41 (.21)

**Appendix. Translation of the words used in the AMT and FCT**

	<b>Positive</b>	<b>Neutral</b>	<b>Negative</b>
<u>LIST 1</u>	Optimistic	Early	Outraged
	Hug	Conversation	Rejection
	Care	Park	Unsuccessful
	Fun	Boat	Disappointment
	Successful	Quick	Pain
	Funny	Cabin	Defeat
<u>LIST 2</u>	Kind	Train	Afraid
	Party	Mountains	Hurt
	Love	Different	Angry
	Consideration	Discussion	Illness

