



# Autobiographical memory for stressful events: The role of autobiographical memory in posttraumatic stress disorder

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## ABSTRACT

To provide the three-way comparisons needed to test existing theories, we compared (1) most-stressful memories to other memories and (2) involuntary to voluntary memories (3) in 75 community dwelling adults with and 42 without a current diagnosis of posttraumatic stress disorder (PTSD). Each rated their three most-stressful, three most-positive, seven most-important and 15 word-cued autobiographical memories, and completed tests of personality and mood. Involuntary memories were then recorded and rated as they occurred for 2 weeks. Standard mechanisms of cognition and affect applied to extreme events accounted for the properties of stressful memories. Involuntary memories had greater emotional intensity than voluntary memories, but were not more frequently related to traumatic events. The emotional intensity, rehearsal, and centrality to the life story of both voluntary and involuntary memories, rather than incoherence of voluntary traumatic memories and enhanced availability of involuntary traumatic memories, were the properties of autobiographical memories associated with PTSD.

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## 1. Introduction

Psychology has long tried to understand how extremely stressful, negative, and traumatic events affect memory. Freud's theories of repression have continued through works such as Horowitz (1976), and Janet's (1907) theories of dissociation through works such as of Van der Kolk and Fisler (1995). A common idea from these classic theories is that memories of trauma are different from other memories and require special mechanisms (for a critical review of this history, see McNally, 2003, pp. 159–185). In general terms, for these theories, high levels of emotion contribute to incomplete initial processing of the trauma producing an incomplete, fragmented, incoherent memory of the traumatic event, which is stored separately from other memories. A lack of complete processing keeps the memory active and often intrusive while attempts are made to integrate it into a more coherent form. Thus, the memory may come involuntarily, but be difficult to retrieve in a voluntary fashion. Two current manifestations of these views are Brewin's dual representation theory (Brewin, Dalgleish, & Joseph's 1996; Brewin, Gregory, Lipton, & Burgess, 2010) and Ehlers and Clark's (2000) cognitive model of PTSD (see Brewin & Holmes, 2003; Dalgleish, 2004 for reviews).

An efficient way to study memory for traumatic events is to use the existing diagnosis of posttraumatic stress disorder (PTSD). The diagnostic system provides measures of common symptoms in which a diagnosis of PTSD hinges on severity and duration. Thus, contrasting people with and without PTSD provides a range of responses including ones severe enough

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to be considered psychopathological. The current DSM-IV-TR diagnosis (American Psychiatric Association, 2000, pp. 467–468) includes 17 symptoms divided into three categories: the reliving, avoidance, and arousal symptoms. It is clear from these symptoms that autobiographical memory is central to the PTSD diagnosis in a way that is consistent with the classic theories of PTSD. In particular, the five reliving symptoms refer to repeated, disturbing thoughts, images, or dreams of traumas that come to mind involuntarily and with a strong sense of reliving and that change one's mood and create physiological reactions. Two avoidance symptoms require avoiding thoughts, conversations, or situations that might cue such involuntary memories of the trauma and a third refers to voluntary memory, which rather than being enhanced, is marked by an inability to willfully recall important parts of the trauma. Thus, the symptoms of PTSD that refer to memory indicate a problem in the enhanced availability and emotional content of unbidden or involuntary memories of traumas coupled with their incomplete voluntary memory (for a review see Berntsen, Rubin, & Bohni, 2008).

It is also clear from these symptoms that autobiographical memory in general and not just memories of the trauma are affected. Although trauma exposure is a requisite for a diagnosis of PTSD, it is unlikely on theoretical and empirical grounds that changes in autobiographical memory occur for just trauma-related memories and not for autobiographical memories in general (Rubin, Boals, & Berntsen, 2008). Reliving, avoidance, and arousal symptoms do not function with pinpoint accuracy to the trauma memory in isolation but extend to memories related to it in many ways from low level direct perceptual matches to the very abstract and symbolic similarities. Even repetitive intrusive memories do not have to repeat verbatim, but can relate to different aspects of a trauma (Berntsen & Rubin, 2008). Avoidance symptoms extend to avoiding situations a neutral observer may not think would be reminders of the trauma. Arousal symptoms involving hypervigilance extend to more than appropriate trauma related vigilance, and the increased startle response symptom occurs to stimuli unrelated to the trauma. Thus, from the symptoms and diagnosis of PTSD, there is good reason to examine changes in autobiographical memory in general rather than concentrating on the special properties of trauma memories as do the classic theories and more modern theories deriving from them.

The importance of autobiographical memory to the PTSD diagnosis and a shift in emphasis from the trauma memory to the autobiographical memory in general allows the principles of cognitive psychology to inform the more classic views of memory of trauma. To do this, we obtain a full description of theoretically relevant properties of autobiographical memories in conditions that contrast three central theoretical oppositions: PTSD versus control participants, traumatic versus comparison memories, and voluntary versus involuntary memories. We thereby provide the first comprehensive study of the properties of autobiographical memories using a clinically diagnosed PTSD population, one that has the comparisons needed to evaluate competing theories. We also provide the first detailed study of involuntary memories made as they occur, as opposed to retrospectively, in participants with and without PTSD, thereby avoiding the problems of retrospective reports (Berntsen, 2009; Ericsson & Simon, 1993).

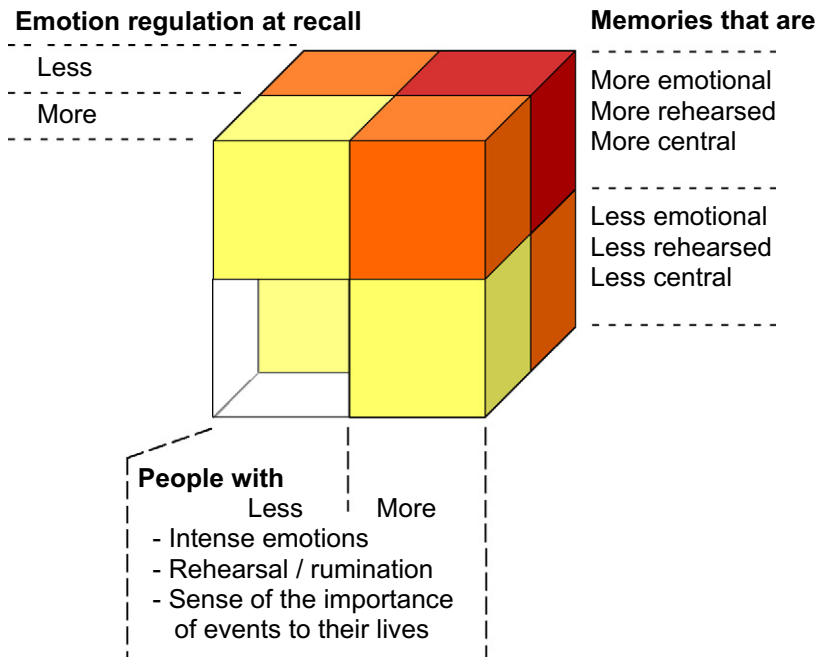
This study tests a well developed theory, which was published prior to the data reported here being available (Rubin, Berntsen & Bohni, 2008; Rubin, Boals, & Berntsen, 2008); it has widely tested measures of memory based on a coherent published view of autobiographical memory (Rubin, 2006); and it tests 20 theoretically motivated predictions. However, it is a conceptually difficult study because its design violates many expectations. First, we study both individual differences and experimental manipulations (Cronbach, 1957). Second, we specify multiple mechanisms that operate on different properties of memories. Third, we make a multitude of predictions. This complexity, however, is necessary if the complex phenomenon of memory and emotion for stressful events is to be understood.

### 1.1. *The autobiographical memory theory of PTSD (AMT)*

In the four decades since the initial formulation of the PTSD diagnosis, there have been advances in our knowledge of cognition, affect, and autobiographical memory. This knowledge leads to different predictions than our earlier understanding. We developed the AMT based on this knowledge and refined it using experiments with undergraduates who varied in the severity of their PTSD symptoms but who had no formal diagnosis (Berntsen, 1996; Berntsen & Rubin, 2006, 2007, 2008; Berntsen, Willert, & Rubin, 2003; Berntsen et al., 2008; Rubin, 2006; Rubin, Boals, & Klein, 2010; Rubin, Berntsen, et al., 2008; Rubin, Boals, et al., 2008). In simplest terms, the AMT predicts what happens when an extremely stressful or traumatic event is experienced by people with different cognitive and emotional styles.

The AMT has three factors to predict reactions to stressful events. Except to explicate details of the factors and how they reinforce each other, there is nothing more to the theory. Each of the three factors is shown on one of the three dimensions of Fig. 1. Each factor taken in isolation has enough empirical support from studies of cognition, emotion, and personality to have its predictions border on the obvious. Nonetheless, these factors, which apply to all memories rather than just trauma-related memories, are not commonly considered as the primary factors underlying PTSD symptoms nor are the extreme reactions of involuntary trauma-related memories in people with PTSD usually considered as just the result of the combination of these factors. To the extent that these three factors combine to account for symptoms of PTSD, more complex theories are superfluous and the explanations become special cases of broader theories from general psychology.

The three cognitive and affective mechanisms central to the availability factor of the AMT are shown on the vertical axis of Fig. 1. All three apply to all autobiographical memories, whether trauma related or not. All three increase the ease with which the memories will come to mind in the future, that is their availability (Tversky & Kahneman, 1973) or accessibility (Tulving & Pearlstone, 1966). They are: (1) the emotional intensity of the memory; (2) when and how often the memory has been retrieved in the past, as measured here by the retrospective reported frequency of voluntary and involuntary recall; and



**Fig. 1.** The three classes of mechanisms that affect stressful memories are represented on the three axes: on the horizontal axis, mechanisms that are more involved in stressful versus other memories; on the vertical axis, characteristics more typical of people with PTSD; and on the front to back axis, emotion regulation. These mechanisms correspond to the three factors of our ANOVA analyses: stressful versus comparison memories, participants with and without PTSD, and voluntary versus involuntary memories.

(3) centrality of the memory to the person's life story and identity. Because centrality involves how a memory fits into the core events of a person's life, it entails, but is more than, a normal integration with other autobiographical memories. These three mechanisms, which increase the encoding and maintenance of memories, are greater for extremely stressful events than for most other events (for reviews see: Rubin, Berntsen, et al., 2008; Rubin, Boals, et al., 2008). They also work by augmenting each other. Independent of their valence, more emotionally intense events come to mind more frequently both voluntarily and involuntarily (Hall & Berntsen, 2008), they have more vividness and reliving (Talarico, LaBar, & Rubin, 2004), and they tend to be about current concerns that get better integrated into a person's autobiographical memory and identity (Conway, 2005; Conway & Pleydell-Pearce, 2000). This rehearsal and centrality, in turn, helps maintain the memory and its emotional intensity.

These three mechanisms, which vary across all memories, also vary across all people as indicated in the individual differences factor on the horizontal axis of Fig. 1. In terms of individual differences rather than the remembered event, people vary in how emotionally intensely they experience all kinds of events (Larsen & Diener, 1987) and in how central extremely stressful events become to their life stories (Berntsen & Rubin, 2007; Rubin, Boals, et al., 2008). Because emotional intensity and centrality to the life story affect availability, availability will also vary across people causing differential rehearsal, and thus result in differences in the retention of memories and their emotional impact. Having PTSD is associated with increases in these three mechanisms, although no claims can be made about causality in either direction from the data presented. Conceptually, for stressful events, this cluster of three mechanisms is related to neuroticism (Rubin, Boals, et al., 2008; Rubin, Hoyle, & Leary, in press). Operationally, we assign people to one group or the other based on their PTSD diagnosis, predicting that this diagnosis will affect all memories, not just trauma-related memories. This is a prediction that the traditional theories do not make.

The fourth mechanism of emotion regulation is indicated on the front to back axis of Fig. 1. Because involuntary memories of all kinds, including those of traumatic events, come 'unbidden' or 'out of the blue' cued by thoughts or the environment in ways that are unexpected to the person instead of by a directed, voluntary search (Berntsen, 2009), they will benefit much less from mechanisms of emotion regulation (Gross, 2001). Therefore, all involuntary memories will occur with more emotional reaction and mood change (Berntsen & Hall, 2004). For traumatic events they will be more 'intrusive' than are their voluntary counterparts, producing more of the reliving symptoms of PTSD than voluntary memories. Such involuntary memories can be especially disturbing because their unbidden nature can be interpreted as a lack of control. Thus, the arousal and avoidance symptoms of PTSD will result as an attempt to monitor and avoid situations and thoughts that might cue such involuntary memories of the stressful memory.

If one starts in the lower left front cube, which is transparent, and moves up or to the right, emotional intensity, rehearsal, and centrality increase as indicated by yellow. Two moves add to a greater increase as indicated by orange. Only emotional

intensity is increased by a move to the back, allowing three increases and the strongest emotional intensity as indicated in red.

This is within the normal range and is not psychopathological. If a person is exposed to an extremely stressful or traumatic event, they will have a negative memory of that event, which is more available and better maintained. The memory therefore will have more sensory detail and more of the reliving symptoms of PTSD and will show them for longer. Because the reliving is for a stressful event, it will lead to the avoidance of stimuli that lead to recall and a general increase in arousal to possible related stimuli. The same event can affect people differently, with both the event and the person to whom it occurs being important in predicting symptoms. If a stressful event is traumatic and if the reliving, avoidance, and arousal symptoms are severe enough for long enough, a diagnosis of PTSD would follow. Thus, our approach is to start by assuming that PTSD can be understood as a normal response to an extreme stimulus, a response in which the memory of the event is central.

We contrast the AMT to the dominant and more traditional theories of PTSD that incorporate special mechanisms for trauma memories. Given the formal diagnosis and the strong historical precedent, it is not surprising that the special mechanisms view continues in current theories of PTSD. Nonetheless, there exists a substantial literature examining whether memories of trauma are special (Berntsen, 2009; Brewin, 2007; Geraerts et al., 2007; Kihlstrom, 2006; Jacobs & Nadel, 1998; McNally, 2003; Porter & Birt, 2001; Shobe & Kihlstrom, 1997). Here we ask about autobiographical memories in general, providing a context for this controversy.

As a set, the traditional theories make the following three clear predictions that are counter to the AMT, though any particular theory will not necessarily make all three as the first two descend from Freud through Horowitz (1976) and the third from Janet. First, involuntary memories of a stressful event will be more frequent than voluntary memories either because of poorer encoding or active inhibition. Second, voluntary memories of stressful events will be fragmented. Third, stressful events will tend to be dissociated from other autobiographical memories and thus be less central to the life story (but see, Lancaster, Rodriguez, & Weston, 2011). Both the traditional theories and the AMT predict that involuntary memories of stressful events will come with greater emotion, but the AMT predicts this for all involuntary memories and the traditional theories do not.

### 1.2. Testing the AMT

We use the basic-systems model of autobiographical memory (Rubin, 2005, 2006; Rubin, Schrauf, & Greenberg, 2003) to provide a well-documented, comprehensive inventory of the basic properties of autobiographical memory. According to the model, the mind and brain are divided into basic systems. These include separate systems for each of the senses, spatial imagery, language, emotion, narrative, a medial-temporal lobe explicit-memory system that binds all aspects of an autobiographical memory that are present at the same time in a fairly automatic way, and a frontal lobe search-and-retrieval system that selects the most relevant aspects of a network of activations and often operates in a more conscious, directed manner. Each system has a substantial intellectual history including studies involving neuroanatomy, neuropsychology (Greenberg & Rubin, 2003), neuroimaging (Cabeza & St. Jacques, 2007; Daselaar et al., 2008), cognitive-experimental psychology (Rubin et al., 2003), and individual differences research (e.g., Carroll, 1993).

We use a set of rating scales based on the basic-systems model, the Autobiographical Memory Questionnaire (AMQ), to ask participants about autobiographical memories as they are recalling them. The set of scales used here is given in Table 1. We have participants rate their voluntary and involuntary memories while they are having them as this produces a more valid indication of the ongoing processes than retrospective reports (Ericsson & Simon, 1993). Each of the rating scales have been used extensively in earlier studies of autobiographical memory and so we know a great deal about how they normally function and relate to each other and to personality and other individual differences measures as well as in other cultures (Rubin, Schrauf, & Greenberg, 2004; Rubin, Schrauf, Gulgoz, & Naka, 2007; Rubin & Siegler, 2004; Rubin et al., 2003; Sheen, Kemp, & Rubin, 2001). In addition to studies with healthy controls, the AMQ has been used for more and less stressful memories in combat veterans diagnosed with PTSD (Rubin, Feldman, & Beckham, 2003), for stressful memories of participants who varied in the severity of their PTSD symptoms (Berntsen et al., 2003), and to compare autobiographical memory in various anxiety disorders (Wenzel, Pinna, & Rubin, 2004). More recently, we have begun using the ratings combined with neuropsychological (Greenberg & Rubin, 2003; Greenberg, Eacott, Brechin, & Rubin, 2005) and neuroimaging methods (Daselaar et al., 2008). Thus, the scales are motivated by a theoretical view of memory and have been extensively tested behaviorally as well as in neuropsychological and neuroimaging studies.

To refine our theory, a simpler version of the current study was completed with undergraduates who varied in PTSD symptom severity, but who were not clinically diagnosed (Rubin, Boals, et al., 2008). In contrast, here we tested a more diverse community sample with more severe traumas and symptoms and a full clinical diagnosis.

### 1.3. Predictions

We designed our study as a two (PTSD or not) by two (highly stressful versus three kinds of comparison memories) by two (involuntary versus voluntary retrieval) design because these three dimensions define the minimal comparisons needed to test our theory and compare it to traditional theories of PTSD. We compare people with and without PTSD to examine how memory is altered in the disorder on memory. We vary all three dimensions simultaneously because there are contrasting

**Table 1**  
Autobiographical Memory Questionnaire (AMQ) variables.

Variable	Brief description of rating scales
Emotions	
<i>Intensity</i>	While remembering, the emotions that I feel are extremely intense
<i>Reaction</i>	I had a physical reaction (laughed, felt tense, sweaty, heart pound)
<i>Mood-change<sup>a</sup></i>	The memory changed my mood
<i>Valence</i>	While remembering, the emotions are extremely negative or positive
Rehearsal	
<i>Rehearsal</i>	Since it happened, I have thought or talked about this event
<i>Involuntary</i>	This memory has come to me out of the blue, without my trying
Centrality	
<i>Life story</i>	The event in my memory is a central part of my life story
Sensory and language processes	
<i>See</i>	While remembering the event, I can see it in my mind
<i>Field/observer</i>	I see it out of my own eyes rather than those of an outside observer
<i>Setting</i>	While remembering the event, I know the setting where it occurred
<i>Hear</i>	While remembering the event, I can hear it in my mind
<i>Smell</i>	While remembering the event, I can smell it
<i>In-words</i>	While remembering the event, it comes to me in words
Narrative	
<i>Story</i>	It comes to me in words or in pictures as a coherent story
<i>Pieces</i>	My memory comes to me in pieces with missing bits
Metacognitive judgments	
<i>Reliving</i>	While remembering the event, I feel as though I am reliving it
<i>Belief</i>	I believe the event in my memory really occurred – not imagined
Reported properties of events or memories	
<i>Specific</i>	The event occurred once at one particular time (within a day) and place
<i>Age-of-memory</i>	Please date the memory (month/day/year) [calculated from test date]
<i>Cued-by<sup>a</sup></i>	Was this memory cued by the environment, thoughts, a mix, or voluntary
<i>Trauma-related<sup>a</sup></i>	The event is related to or about one of the three stressful events I listed

<sup>a</sup> This question was included only in Study 2.

predictions about the interaction of these dimensions as well as predictions about comparisons among the resulting eight (i.e., 2 by 2 by 2) conditions. The AMT predicts main effects with increases in specific measures for people with PTSD, for stressful or traumatic memories, and for the involuntary memories. Any interactions should be a result of more than additive main effects. In contrast, the traditional view would predict decreases in the coherence of trauma memories, especially in people with PTSD, and crossover interactions on many measures when voluntary and involuntary memories are compared.

Table 2 presents the key predictions in the format that the tables of results will follow. Properties that measure the mechanisms of the AMT are shown as rows in Table 2 and as the vertical axis in Fig. 1. They are: emotional intensity as measured by a cognitive judgment of *intensity* and verbal reports of physiological *reaction*, rehearsal as measured by general *rehearsal*

**Table 2**  
Summary of theoretical predictions for the AMQ theory followed by the observed effects.

Variables increasing availability	All memories <sup>a</sup>		All participants					
	PTSD > controls		Stressful memories >			Involuntary > voluntary		
			Word-cued	Important		Theory obs.		
	Theory obs. <sup>b</sup>		Theory obs.	Theory obs.				
More emotion								
<i>Intensity</i>	+	+	+	+	+	+	+	+
<i>Reaction</i>	+	+	+	+	+	+	+	+
More rehearsal								
<i>Rehearsal</i>	+	+	+	+	+	+	–	–
<i>Involuntary</i>	+	+	+	+	+	+	+	0
More central								
<i>life story</i>	+	+	+	+	+	+	–	0

Note: +, –, and 0 indicates in (+), opposite to (–), or no effect (0) with respect to the headings of PTSD > controls, stressful memories > word-cued or important memories, and involuntary > voluntary memories. In the Theory columns, the +, and – are predictions; in the Observation columns, the +, and –, and 0 are  $p < .05$  results.

<sup>a</sup> PTSD > Controls taken from the correlation with the PCL in Table 8.

<sup>b</sup> Obs. refer to observed results.



and the frequency of *involuntary* memory, and the centrality of the *life story*. *Valence* is an emotion property, but is not one of the mechanisms of the AMT as both highly positive and highly stressful memories benefit from increased rehearsal and centrality to the life story. In general, emotional intensity, rather than valence, most affects other properties of autobiographical memories (Holland & Kensinger, 2010; Talarico et al., 2004).

The four pairs of columns each show our predictions based on the AMT and preview our results. The comparisons between the PTSD versus the control group is shown as the first of the four pairs of columns of theoretical predictions paired with the observed results in Table 2 and as the horizontal axis in Fig. 1. The comparisons between voluntary versus involuntary recall is shown as the last of the four pairs of columns in Table 2 and in terms of its presumed mechanism of emotion regulation as the front to back axis in Fig. 1. The comparisons between the stressful versus the word-cued and the stressful versus the important memories are shown as the middle two of the four pairs of columns of theoretical predictions paired with the observed result in Table 2. No comparison to positive memories is made because they are not different enough on the basic mechanisms of emotional intensity, rehearsal, and centrality to the life story to make any clear predictions. The +, −, and 0 indicates in (+), opposite to (−), or no effect (0) with respect to the headings of PTSD > controls, stressful memories > word-cued or important memories, and involuntary > voluntary memories. In the Theory columns, the +, and − are predictions; in the Observation columns, the +, and −, and 0 are  $p < .05$  results.

Table 2 has all '+' predictions for 'PTSD > Controls' and for 'Stressful Memories > Word-cued and Important' memories because the mechanisms shown in Fig. 1 predict this. The predictions for 'Involuntary > Voluntary' are slightly more complex. The three mechanisms of intensity, rehearsal, and centrality do not differ when the memories are encoded and retained and only centrality to the life story differs at recall because there is no willful search using life story as a search strategy (Berntsen, 2009). However, the fourth mechanism of emotion regulation has smaller effects on involuntary than voluntary memories. Thus, involuntary memories should have lower relevance to the life story and more emotional intensity. There may be no overall difference in availability (Rubin & Berntsen, 2009). However, because voluntary and involuntary memories are retrieved in different ways, involuntary memories should have been previously recalled more often involuntarily and voluntary memories more often voluntarily.

Some of these predictions may seem obvious given existing theories from general psychology, but this is another way of putting our basic argument that special memory process theories for PTSD may not be necessary. Moreover, the traditional theories devised for PTSD have no predictions for the main-effect differences shown in Table 2, because they make no predictions for differences for *all* kinds of memories in PTSD versus control participants, or for *all* participants stressful versus control memories, or for *all* involuntary versus voluntary memories. These predictions rely on more general theories. The predictions of the traditional view are about differences in particular cells and interactions, not main effects. In the ANOVA analyses that follow many of the traditional view predictions will be either interactions or difference in the specific means and *t*-tests, which are reported in the tables of results. In general, such effects will not occur.

## 2. Study 1: Voluntary memories

### 2.1. Method

#### 2.1.1. Participants

A total of 164 adults from the community were screened between 2004 and 2008 by a master's level clinician who was trained and worked regularly in a research setting. Participants were recruited via advertising for a study on memory for stressful or traumatic events and how they differ from more everyday memories. The participants, who gave informed consent before participating in the study received \$200. The Clinician Administered PTSD Scale was used to determine PTSD diagnostic status (CAPS; Blake et al., 1995; Weathers, Keane, & Davidson, 2001), and the structured clinical interview for DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 1994) was used to diagnose other possible Axis I disorders.

Current diagnoses were determined by a 1-month time frame for PTSD, major depressive disorder (MDD), and other anxiety disorders, and a 3-month time frame for current substance abuse or dependence. Any potential participants meeting criteria for current alcohol or other substance dependence/abuse, or psychotic disorders based on the clinical interviews were excluded, resulting in eight exclusions. Participants recruited for the control group were excluded if they met criteria for lifetime PTSD or if they met criteria for current subthreshold PTSD, resulting in 30 exclusions. Participants were also excluded if they were medically unstable ( $n = 1$ ) or if they could not complete the study procedures ( $n = 2$ ). Finally, six participants were excluded from these analyses due to missing data. Based on the structured clinical interviews, the remaining 117 study participants were classified into the PTSD ( $n = 75$ ) and control ( $n = 42$ ) groups. We did not require an A trauma of the control group, but 83% has one by the TLEQ and 73% by the CAPS.

#### 2.1.2. Materials

*Autobiographical Memory Questionnaire (AMQ)*. The AMQ, shown in Table 1, was used to measure properties of each nominated memory. All items used a 7-point scale, except *once* and *merged*, which are derived from a 3-point scale.

*Alcohol Use Disorders Identification Test (AUDIT)*. (Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). This 10 item measure assesses three factors: alcohol consumption, alcohol dependence, and adverse consequences of alcohol use. The range of possible scores is 0–40, with higher scores indicating increased probability of an alcohol use disorder.

*Beck Depression Index (BDI)*. The BDI-II (Beck, Steer, & Brown, 1996) is probably the most widely used test of depressive symptoms. There are 21 items rated on a 0–3 scale and the sum score is reported.

*Centrality of Event Scale (CES)*. The Centrality of Event Scale (CES; Berntsen & Rubin, 2006, 2007) measures the extent to which a traumatic memory forms a central component of personal identity, a turning point in the life story and a reference point for everyday inferences. The CES consists of 20 items rated on 5-point scales (1 = totally disagree; 5 = totally agree).

*Davidson Trauma Scale (DTS)*. The DTS (Davidson et al., 1997) sums values for each of the 17 symptoms of PTSD in the official DSM diagnosis. Each symptom is rated twice: once for frequency and once for severity using a 0–4 scale.

*Interpersonal Support Evaluation List Short Form (ISEL; Cohen, Mermelstein, Kamarck, & Hoberman, 1985)* is a 16-item measure of social support which asks about the perceived ability of potential social resources.

*Hollingshead Index of Socioeconomic Status (Hollingshead SES)*. On the Hollingshead SES (Hollingshead & Redlich, 1958), lower scores indicate higher socioeconomic status.

*NEO Personality Inventory (NEO)*. The 240 item NEO (Costa & McCrae, 1992) provides a comprehensive assessment of adult personality. Unlike the other tests used here, for the NEO the scales for the domains and facets are all *t*-scores based on standardized norms. Thus, 50 is the mean and 10 is the standard deviation of the standard comparison population.

*Positive and Negative Affect Schedule (PANAS)*. The PANAS (Watson, Clark, & Tellegen, 1988) consists of 10 positive affects and 10 negative affects to be rated a 5-point scale of the strength of each emotion.

*PTSD Check List (PCL)*. The PCL (Weathers, Litz, Huska, & Keane, 1994) measures ratings to the 17 official symptoms of PTSD. It uses a 1–5 scale, so the minimum score is 17.

*Traumatic Life Events Questionnaire (TLEQ)*. The TLEQ (Kubany et al., 2000) was developed as way of reminding people of possible traumas to get a more complete reporting by giving a series of 23 classes of possible traumas. Participants indicate whether the A1 and A2 PTSD criteria were met.

### 2.1.3. Procedure

Study 1 consisted of three sessions of 3–4 h. In session 1, participants were screened for inclusion and exclusion criteria, and provided demographic and individual differences information. We obtained a medical, drug and medication history and administered the AUDIT, BDI-II, CAPS, CES, DTS, PCL, SCID, TLEQ, a treatment history, and a urine sample for illegal drugs. If time did not permit, some of the instruments not needed to determine eligibility were postponed to later sessions. Session 2 included the AMQ for 15 word-cued autobiographical memories. The 15 cue words were common high imagery words we have used earlier: city, dress, fire, horse, kiss, lake, love, mother, mountain, ocean, party, plant, poetry, sick, and wine. We obtained these first to familiarize the participants with the scales and establish a range of responding before asking about the most-stressful, positive and important events. For each cue word participants were asked to write down on a form a brief description of several words that could be used to remind them of the memory. Next we administered the PANAS, ISEL, and NEO. In session 3, we obtained AMQ measures for the seven most-important, three most-stressful, and three most-positive autobiographical memories, a life story, and debriefed the participant.

Participants were asked to record the seven most-important events in their lives for which they had an autobiographical memory of a specific event that occurred at a specific time and place. The requests for emotional events were similar and asked participants for their three most negatively stressful or traumatic events and the three most-positive events in their lives. For the most-negative and most-positive events, participants were asked that if one or more of the important events listed was one of the most-negative or most-positive events. If so, they should use that event as a positive or negative event, but should draw a line through it in the important memories and replace it with another important memory in the space given to the right of the line. For each of the most-negative events the participants were asked if they met the A1 (traumatic event) and A2 (emotional reaction) criteria of the PTSD diagnosis.

## 2.2. Results

We use the  $p < .05$  level uncorrected for multiple comparisons for three reasons. First, much of what we intend to show is statistically significant results favoring one of the theoretical views but not favoring another view. Thus, we want to keep the .05 level to show clearly no effects for the alternative view. Second, we are interested in showing the same pattern of results over more than one measure of a concept and over more than one study, rather than focusing on each significant result. Third, for the AMT, in Table 2, we have specific predictions, which are based on our theory and our earlier work, and for which the .05 level is appropriate. Nonetheless, our key predictions remain if a Bonferroni correction is applied (.05/20 items of the AMQ = .0025).

Table 3 presents the demographic and test information for the participants. The differences between the sample of PTSD and control participants that would be expected from the literature on comorbidity and individual differences are present. In particular, depression is highly comorbid with PTSD, and in the proposal for the new diagnostic manual symptoms of depression is suggested to become a formal category of symptoms along with reliving, avoidance, and arousal ([www.dsm5.org/ProposedRevisions/Pages/proposedrevision.aspx?rid=165](http://www.dsm5.org/ProposedRevisions/Pages/proposedrevision.aspx?rid=165)). Nonetheless, the differences in dysphoria and depression could be contributing to our results. As shown in Table 3, PTSD participants included men and women, minorities and non-minorities, veterans and non-veterans. There were a wide range of index traumas including personal traumas (life threatening illness/accident/witnessing death; 33%), adult violence or sexual assault (30%), child violence or sexual assault (19%), combat (11%), and other trauma (7%).

**Table 3**  
Individual difference measures as a function of PTSD group.

	No PTSD		PTSD		F(1, 115)
	Mean	SD	Mean	SD	
<i>Demographics</i>					
Age	45.38	11.99	46.76	10.15	0.43
% Female	50.00		58.67		0.82 <sup>a</sup>
% Veterans	30.95		34.67		0.17 <sup>a</sup>
% Minority	64.29		73.33		1.05 <sup>a</sup>
Education	14.74	3.06	2.36	13.44	6.57 <sup>*</sup>
Hollingshead SES	49.33	17.47	56.51	13.11	6.31 <sup>*</sup>
<i>Current psychopathology, lifetime substance abuse or dependence</i>					
% Major depressive disorder	7.14		52.00		25.54 <sup>****,a</sup>
% Other anxiety disorder <sup>b</sup>	21.43		48.00		8.03 <sup>**,a</sup>
% Other disorder <sup>c</sup>	2.38		13.33		3.79 <sup>a</sup>
Substance abuse/dependence <sup>d</sup>	42.86		66.67		6.27 <sup>*,a</sup>
<i>Number of three stressful events that were reported as</i>					
A1 Events	1.48	1.13	1.99	1.01	6.63 <sup>*</sup>
A2 Emotions	1.60	1.27	2.53	0.78	24.59 <sup>****</sup>
A Traumas	1.14	1.16	1.87	1.04	11.94 <sup>***</sup>
<i>TLEQ trauma categories endorsed</i>					
All	5.81	3.35	11.59	3.90	65.21 <sup>****</sup>
A criteria	3.50	3.16	10.09	4.04	82.87 <sup>****</sup>
<i>Standardised tests</i>					
PCL	24.26	7.95	49.10	15.69	91.85 <sup>****</sup>
DTS	13.79	20.74	68.72	34.05	90.32 <sup>****</sup>
CES	3.19	1.06	4.00	0.78	22.24 <sup>****</sup>
BDI	5.71	6.64	21.25	12.21	58.09 <sup>****</sup>
PANAS P	33.38	8.44	32.15	8.17	0.60
PANAS N	16.50	7.31	24.64	8.58	26.87 <sup>****</sup>
NEO N	41.30	11.15	54.57	10.23	41.41 <sup>****</sup>
NEO E	43.64	8.95	40.73	10.68	2.91
NEO O	47.08	9.87	46.94	5.93	0.01
NEO A	57.24	8.67	52.29	10.94	6.18 <sup>*</sup>
NEO C	54.54	9.55	48.54	9.10	11.00 <sup>**</sup>
ISEL	13.84	2.72	11.30	4.34	11.83 <sup>***</sup>
AUDIT	3.98	7.40	5.39	8.69	0.78

Notes:  $n = 117$  except 116 for BDI and Audit and 114 for NEO.

<sup>\*</sup>  $p < .05$ .

<sup>\*\*</sup>  $p < .01$ .

<sup>\*\*\*</sup>  $p < .001$ .

<sup>\*\*\*\*</sup>  $p < .0001$ .

<sup>a</sup> Chi-square.

<sup>b</sup> Includes social phobia, specific phobia, ocd, gad, panic and agoraphobia.

<sup>c</sup> Includes dysthymic, pain, somatization, body dysmorphic, bipolar, and eating disorders.

<sup>d</sup> Includes alcohol abuse, alcohol dependence, substance abuse, and substance dependence.

Throughout we use the term stressful memories because not all of our memories are of traumatic events as defined by the current DSM, which requires that the memories be of actual or threatened death, serious injury, or threat to the physical integrity of participant or others (A1) and that the participant's response involved intense fear, helplessness, or horror (A2). However, as noted in Table 3, most of the stressful memories do meet the A1, A2, and overall A criteria.

### 2.2.1. Differences in autobiographical memories with PTSD

Table 4 presents the means for the PTSD group and controls for word-cued, most-important, most-positive and most-stressful autobiographical memories. There are two important observations to draw. First, having PTSD affects a broad range of autobiographical memories in similar ways, including autobiographical memories obtained by using word cues, participants' most-important, most-positive, and most-stressful memories. Second, some properties of autobiographical memory are highly affected whereas others are not. In particular, as predicted in Table 2, people with PTSD rated memories cued by all four methods as having more emotional intensity, as greater physiological reaction, as being more central to their life story, and higher rehearsal both in the frequency of their voluntary rehearsal and involuntary recall. The sensory measures of see, setting, and especially hear and smell and having a greater sense of reliving and belief in their accuracy tend to be higher in people with PTSD consistent with their memories being more rehearsal and having more emotional intensity.

Although the differences are not always significant, the memories of people with PTSD tended to be more coherent as a story, but contrary to the AMT and consistent with the traditional theories they tend to come more in pieces, a finding we



**Table 4**

Group differences on AMQ variables for word-cued, important, positive and stressful memories.

Variable	Word cued			Important			Positive			Stressful		
	Means		t-test	Means		t-test	Means		t-test	Means		t-test
	Control	PTSD		Control	PTSD		Control	PTSD		Control	PTSD	
<b>Emotions</b>												
<i>Intensity</i>	3.66	4.84	4.87****	4.18	5.41	4.72****	4.61	5.73	3.92***	4.77	6.21	5.94****
<i>Reaction</i>	3.08	4.38	4.61****	3.57	4.96	4.38****	3.78	5.07	3.57***	3.76	5.51	5.56****
<i>Valence</i>	0.89	0.72	-0.90	1.34	1.33	-0.04	2.03	2.50	2.47*	-1.25	-1.84	-1.96
<b>Rehearsal</b>												
<i>Rehearsal</i>	3.48	4.02	2.54*	4.04	4.93	3.69***	4.38	5.43	4.09****	4.47	5.17	2.57*
<i>Involuntary</i>	2.81	3.56	3.05**	3.05	4.39	4.55****	3.31	4.66	4.20****	3.48	4.96	4.73****
<b>Centrality</b>												
<i>Life story</i>	3.66	4.67	3.77***	5.25	5.93	2.64**	5.58	6.37	3.20**	5.37	6.27	3.30**
<b>Sensory and language processes</b>												
<i>See</i>	5.06	5.73	3.07**	5.27	5.94	3.17**	5.51	5.94	1.79	5.42	6.07	2.85**
<i>Field</i>	5.96	6.11	0.75	6.00	6.25	1.21	6.11	6.39	1.23	6.11	6.19	0.31
<i>Setting</i>	5.14	5.72	2.90**	5.44	5.95	2.47*	5.67	6.00	1.42	5.48	6.04	2.53*
<i>Hear</i>	3.60	4.84	4.69****	4.05	5.03	3.41***	4.44	5.42	3.09**	4.61	5.41	2.59*
<i>Smell</i>	2.56	3.69	3.88***	2.38	3.41	2.99**	2.65	3.54	2.21*	2.55	3.56	2.68**
<i>In-words</i>	3.23	3.71	1.49	3.73	4.18	1.23	3.83	4.48	1.61	4.01	4.43	1.07
<b>Narrative</b>												
<i>Story</i>	4.58	5.28	2.50*	5.15	5.70	2.06*	5.35	5.80	1.50	5.26	5.83	1.82
<i>Pieces</i>	3.03	3.45	1.38	2.93	3.25	0.95	2.89	3.18	0.75	2.93	3.68	2.03*
<b>Metacognitive judgments</b>												
<i>Reliving</i>	4.08	4.84	3.09**	4.31	5.40	3.96****	4.83	5.79	3.56***	4.44	5.72	4.29****
<i>Belief</i>	5.89	6.53	3.11**	6.19	6.72	2.99**	6.22	6.75	2.73**	6.21	6.71	2.80**
<b>Reported properties of events</b>												
<i>Specific</i>	0.60	0.52	-1.62	0.66	0.60	-0.97	0.65	0.53	-1.67	0.61	0.55	-0.87
<i>Age-of-memory<sup>a</sup></i>	18.22	20.68	1.18	19.65	16.90	-1.40	16.42	15.11	-0.60	14.33	17.03	1.32

Note: All t-test have 115 df.

\*  $p < .05$ .\*\*  $p < .01$ .\*\*\*  $p < .001$ .\*\*\*\*  $p < .0001$ .<sup>a</sup> Years between the event and the testing.

return to later. There are no significant effects, even at the  $p < .05$  level, for whether the memories come as third versus first person (*field*), are more specific, or how long ago they occurred (*age-of-memory*), however the lack of effect of the *field* measure may be a result of how the question was asked (Rice & Rubin, 2009).

Thus, people with and without PTSD reacted differently to the same properties over a range of traumatic and comparison autobiographical memories. The differences could be part of a change in traumatic memories that extended to all memories, or they could be a part of a cognitive style that promotes the formation of PTSD if a trauma occurred. Although this study does not address this issue directly, our earlier work with undergraduates, many of whom did not report a trauma or symptoms consistent with PTSD suggest this is at least partly a predisposing symptom (see Rubin, Boals, et al., 2008).

### 2.2.2. Effects of most-stressful versus other types of events on autobiographical memory measures

We compared the most-stressful memories to the word-cued memories to provide a comparison with a broad sampling of memories, to the most-important memories to provide a comparison with other important memories but ones that were not among the most emotional, and with the most-positive memories to examine the effects of valence. In Table 5, the type of comparison memory was one factor and PTSD group was the other factor. The effects of PTSD group were just discussed for each type of event separately. In the ANOVAs shown in Table 5 the effect of PTSD group replicate the basic findings shown in Table 4, and therefore are not shown again.

Means for each type of remembered event are shown in the left third of Table 5. The middle third of the table shows the comparison of the stressful events with word-cued memories, important memories, and positive memories. The three most-stressful memories were more negative, more emotionally intense, and had higher rehearsal than the other three classes of memories for participants with and without PTSD. The differences in emotional *intensity*, *rehearsal*, and *involuntary* recall also occurred when we compared participants with and without PTSD in Table 4. Other differences occurred for comparisons to one or two of the other classes of control memories. Compared to word-cued and important memories the stressful memories had higher ratings of *reliving*, *hear*, *reaction*, *life story*, and *rehearsal*. Again, these differences were found when we compared participants with and without PTSD in Table 4. Thus, many of the differences that occur in participants with as opposed to without PTSD also occur for all the participants' most-stressful as opposed to word-cued and important

**Table 5**

Means and ANOVAS for comparisons of memories for stressful events with word-cued, important, and positive events.

Variable	Means				ANOVA's $F(1, 115)$					
	For four memory types				Comparison: stressful versus			Interaction with PTSD group		
	Word-cued	Important	Positive	Stressful	Word-cued	Important	Positive	Word-cued	Important	Positive
Emotions										
<i>Intensity</i>	4.41	4.97	5.33	5.69	110.11****	41.96****	7.01**	1.27	1.04	1.82
<i>Reaction</i>	3.91	4.46	4.60	4.88	39.12****	7.01**	2.31	2.37	1.65	2.55
<i>Valence</i>	0.78	1.33	2.33	-1.63	226.86****	283.32****	411.27****	1.72	2.78	7.81**
Rehearsal										
<i>Rehearsal</i>	3.83	4.61	5.05	4.92	72.70****	7.17**	0.40	0.40	0.49	1.68
<i>Involuntary</i>	3.29	3.91	4.18	4.43	66.91****	17.14****	6.21*	8.12**	0.35	0.44
Centrality										
<i>Life story</i>	4.30	5.68	6.09	5.95	126.45****	5.55*	1.56	0.16	1.24	0.18
Sensory and language processes										
<i>See</i>	5.49	5.70	5.78	5.83	12.77***	1.91	0.04	0.02	0.02	1.19
<i>Field</i>	6.05	6.16	6.29	6.16	1.49	0.13	1.41	0.12	1.12	1.41
<i>Setting</i>	5.51	5.77	5.88	5.84	14.06***	0.61	0.65	0.04	0.06	1.43
<i>Hear</i>	4.39	4.68	5.07	5.13	33.01****	14.90***	0.49	2.41	0.54	0.54
<i>Smell</i>	3.29	3.04	3.22	3.19	0.24	1.35	0.09	0.10	0.00	0.15
<i>In-words</i>	3.54	4.02	4.25	4.28	27.09****	6.34*	0.39	0.05	0.03	1.23
Narrative										
<i>Story</i>	5.03	5.51	5.64	5.62	20.16****	1.13	0.09	0.27	0.00	0.31
<i>Pieces</i>	3.30	3.14	3.08	3.41	0.15	2.73	5.83*	1.04	2.73	4.23*
Metacognitive judgments										
<i>Reliving</i>	4.57	5.01	5.45	5.26	23.85****	4.94*	5.30*	4.02*	0.87	2.65
<i>Belief</i>	6.30	6.53	6.56	6.53	11.29**	0.01	0.21	0.74	0.08	0.03
Reported properties of events										
<i>Specific</i>	0.55	0.62	0.57	0.57	0.41	1.75	0.14	0.06	0.01	0.72
<i>Age-of-memory</i>	19.80	17.89	15.58	16.06	19.50****	7.79**	0.01	0.02	8.97**	4.08*

Note: All  $F(1, 115)$ , except *merged*, which is  $F(1, 73)$ ,  $F(1, 64)$ , and  $F(1, 62)$  for the word-cued, important, and positive comparisons, respectively. For means for the means of the three-way interaction of PTSD group by stressful versus another memory type, see Tables 3 and 4. The *age-of-memory* is in years.

\*  $p < .05$ .\*\*  $p < .01$ .\*\*\*  $p < .001$ .\*\*\*\*  $p < .0001$ .

memories. There are additional differences between the most-stressful and word-cued memories, which are not surprising, in that the word-cued memories were expected to be less important and emotional than the most-stressful memories.

As the right third of Table 5 shows, there were only six significant interactions. As can be seen from the means in Table 4, for *reliving*, *valence*, and *involuntary*, and *pieces*, the stressful memories in the PTSD group showed larger than additive main effects, that is, there were bigger difference in the PTSD group compared to the control group. For *age-of-memory*, important and positive memories occurred longer ago than stressful memories for the control group, but stressful memories occurred longer ago for the PTSD group. That is, for the PTSD group compared to the control group, the stressful memories (or the negative affect that led them to be chosen as among the three most-negative events) were better retained than important and positive memories.

### 3. Study 2: Involuntary memories

#### 3.1. Method

##### 3.1.1. Participants

During the last session of Study 1, participants were invited to enroll in an electronic diary study; 90 did and received \$150 each. Of these participants, 86 recorded seven or more involuntary memories in the course of 2 weeks (59 in the PTSD and 27 in the control group) and we restrict our analyses to these participants to obtain stable measures, except for our measure of number of involuntary memories which is based on all 90 participants.

##### 3.1.2. Materials

All participants were given a personal data assistant (PDA, PalmOne Zire31, Palm Inc.) to use for the 2 weeks of data collection. The PDA was locked into a program that presented a modified form of the AMQ used in Study 1 (Entryware V5.0, Technos Systems Inc). The questions were shortened to fit easily onto the screen of the PDA where needed, usually by

removing the phrase 'while remembering the event' which occurred in the printed versions. The original memory dating was simplified to the following 7-point scale: This event occurred within the last (1) day, (2) week, (3) month, (4) year, (5) 5 years, (6) 10 years, or (7) 30 years (8) more than 30 years. Three questions, shown in Table 1, were added to those used in Study 1 to probe issues directly related to the involuntary memories: did the memory change the participant's mood, what cued it, and did it relate to the trauma. All responses were recorded on the PDA and each entry was time stamped.

### 3.1.3. Procedure

Participants were instructed that involuntary memories are about events in their personal past that come without intention, that they can be cued by something in the environment or by a thought or by something that cannot be identified, but that they cannot be the result of trying to recall the memory. Participants were asked to carry the PDA with them whenever they could for 2 weeks so that they could answer questions about involuntary autobiographical memories as they occurred. After each involuntary memory the program asked them to also record a "different memory that occurred around the same time period." Participants were instructed that if they missed recording an involuntary autobiographical memory, they were not to go back and record it later. We checked on the participants' progress 1 day into the 2 week period.

### 3.2. Results

To help ensure that the ratings were done online and carefully, very short and long response times were removed based on informal testing and an examination of the distribution of response times. All ratings of involuntary or voluntary memories that the PDA recorded as taking less than 30 s ( $n = 18$ ) or more than 10 min ( $n = 43$ ) were removed, leaving a total of 2944 pairs of ratings. Participants in the control and PTSD groups recalled an average of 31.26 ( $SD = 27.84$ ) and 35.72 ( $SD = 25.00$ ) pairs of involuntary and voluntary memories, respectively ( $F(1, 84) = 0.55, p = 0.46$ ).

Table 6 shows the means for the involuntary and voluntary memories in the PTSD and control groups. First, compared to the control group, the PTSD group had memories that had more emotionally negative *valence*, emotional *intensity*, *reaction*, *mood change*, *rehearsal*, *involuntary* recall, centrality to the *life story*, auditory imagery (*hear*), and were more often *trauma*

**Table 6**  
Comparison of involuntary and voluntary memories from Experiment 2.

Variable	Means				ANOVAs $F(1, 84)$		
	Involuntary		Voluntary		Group	Voluntary/involuntary	Inter-action
	Control Group	PTSD group	Control group	PTSD group			
Emotions							
<i>Intensity</i>	2.82	4.00	2.63	3.78	17.88****	8.63***	0.04
<i>Reaction</i>	2.38	3.29	2.16	3.10	11.00**	12.87***	0.10
<i>Mood change</i>	3.05	4.30	2.86	3.97	17.73****	11.87***	0.95
<i>Valence</i>	0.31	-0.29	0.41	0.07	5.41*	8.07**	2.60
Rehearsal							
<i>Rehearsal</i>	3.22	3.91	3.37	4.24	8.66**	13.77****	1.84
<i>Involuntary</i>	3.19	4.14	3.10	4.10	10.99**	0.93	0.15
Centrality							
<i>Life story</i>	2.85	4.05	2.89	4.18	14.83***	1.37	0.43
Sensory and language processes							
<i>See</i>	5.85	5.95	5.77	5.96	0.40	0.46	0.74
<i>Field</i>	5.64	5.96	5.74	5.97	1.73	1.64	1.23
<i>Setting</i>	5.92	5.83	5.95	5.92	0.08	1.66	0.57
<i>Hear</i>	4.01	4.74	4.02	4.73	4.21*	0.01	0.02
<i>Smell</i>	1.92	2.44	1.94	2.40	2.26	0.01	0.31
<i>In-words</i>	3.26	3.64	3.23	3.55	0.83	1.23	0.38
Narrative							
<i>Story</i>	4.77	5.44	4.78	5.50	4.30*	0.38	0.15
<i>Pieces</i>	2.92	2.73	2.97	2.65	0.69	0.03	0.91
Metacognitive judgments							
<i>Reliving</i>	4.11	4.83	4.04	4.49	2.97	6.60*	2.69
<i>Belief</i>	5.82	6.18	5.85	6.23	2.95	1.47	0.04
Reported properties of events							
<i>Specific</i>	0.55	0.53	0.55	0.54	0.06	0.11	0.01
<i>Age-of-memory<sup>a</sup></i>	4.23	4.64	4.35	4.79	1.50	5.72*	0.08
<i>Trauma related</i>	0.28	0.44	0.26	0.42	5.78*	0.80	0.01

\*  $p < .05$ .

\*\*  $p < .01$ .

\*\*\*  $p < .001$ .

<sup>a</sup> Years between the event and the testing.

**Table 7**  
Comparison of trauma and non-trauma-related memories from Experiment 2.

Variable	Means		Trauma related ANOVAs $F(1, 69)$			
	Related		Main effect	Interactions		
	No	Yes		PTSD group	Involuntary	Three-way
Emotions						
<i>Intensity</i>	3.27	4.32	34.93****	3.13	0.01	0.30
<i>Reaction</i>	2.75	3.37	11.95***	0.03	0.60	0.25
<i>Mood change</i>	3.67	4.31	12.21***	0.60	0.88	0.13
<i>Valence</i>	0.47	-0.46	29.76****	4.80*	0.06	0.24
Rehearsal						
<i>Rehearsal</i>	3.33	4.40	60.70****	3.07	0.36	0.10
<i>Involuntary</i>	3.29	4.54	71.35****	3.49	2.37	2.39
Centrality						
<i>Life story</i>	3.15	4.78	59.65****	1.75	0.54	0.24
Sensory and language processes						
<i>See</i>	5.83	6.02	3.68	0.22	0.28	0.31
<i>Field</i>	5.75	5.93	3.55	0.00	2.63	6.37*
<i>Setting</i>	5.81	5.99	2.58	0.17	0.04	0.02
<i>Hear</i>	4.40	4.75	5.56*	0.62	2.19	0.25
<i>Smell</i>	2.16	2.51	2.51	4.24*	0.06	0.14
<i>In-words</i>	2.33	3.69	9.06**	0.74	8.55**	8.64**
Narrative						
<i>Story</i>	5.09	5.48	10.10**	0.10	1.53	0.20
<i>Pieces</i>	2.78	2.78	0.04	0.18	0.37	1.02
Metacognitive judgments						
<i>Reliving</i>	4.28	4.92	20.70****	1.89	0.00	0.15
<i>Belief</i>	6.01	6.21	5.05*	0.00	0.87	0.17
Reported properties of events						
<i>Specific</i>	0.63	0.46	12.60***	1.60	0.01	1.25
<i>Age-of-memory<sup>a</sup></i>	4.38	4.96	6.12*	1.19	0.00	2.71

Note: Only the effects involving being trauma related or not are shown, as other effects are shown with more participants earlier.

\*  $p < .05$ .

\*\*  $p < .01$ .

\*\*\*  $p < .001$ .

\*\*\*\*  $p < .0001$ .

<sup>a</sup> *Age-of-memory* is from the seven point rating scale described in the procedure.

*related*. These effects largely replicate findings in Study 1 for differences between the groups for voluntary memories under four different cuing conditions. Second, a number of differences were observed between involuntary memories and voluntary memories. The involuntary memories were accompanied by more negative *valence*, *intensity*, *reaction*, *mood change*, and *reliving*, and had less voluntarily *rehearsal*, and were more recent (*age-of-memory*). According to the AMT, most of these differences are explained in terms of dissimilar retrieval processes (associative and bottom up versus strategic and top down) operating upon the same autobiographical memory system. In particular, the associative and uncontrolled retrieval process that characterizes involuntary memories leaves less opportunity for emotion regulation (Gross, 2001), resulting in stronger emotional reaction at recall. Support for the idea that involuntary and voluntary processes retrieve different memories even though they are both affected equally by PTSD symptom severity comes from the retrospective rehearsal measures in Table 6. In particular, a voluntary versus involuntary retrieval by PTSD group ANOVA with *rehearsal* versus *involuntary* as a repeated measure of rehearsal yielded two significant effects. A main effect caused by the PTSD group having higher ratings, (4.10 versus 3.22,  $F(1, 84) = 10.40$ ,  $p < .01$ ) and the expected interaction,  $F(1, 84) = 18.31$  ( $p < .0001$ ). Third, the effects of PTSD group did not interact with whether recall was voluntary or involuntary. As shown in Table 6, involuntary and voluntary recall followed the same pattern of results regardless of having PTSD or not; there were main effects of PTSD group and of voluntary versus involuntary.

In Study 1, participants rated memories for their three most-negative events. In Study 2, because we could not specify the type of involuntary memory we would like to have come to mind, we had participants indicate on the PDA whether the memory they recorded was about, related to, or unrelated to one of their three most-negative events. Participants reported that 37% of their involuntary and 36% of their voluntary memories were directly about or related to one of their three most-negative events. The ANOVAs in Table 7 are based on the 71 participants who recorded both an involuntary and a voluntary memory that was about or related to one of their three most-negative events; 17 from the control group and 54 from the PTSD group. Because we have already reported on involuntary versus voluntary memories and control versus PTSD groups on a larger sample of memories and participants in the ANOVAs in Table 6, here we report only on main effects and interactions involving the trauma-related factor. The main effects shown in Table 7 are similar to the ones shown earlier for the voluntary memories comparisons of word-cued and important memories with the most-stressful events of Study 1. That is,

both trauma-related voluntary and involuntary memories involved more negative *valence*, *intensity*, *reaction*, *mood change*, *rehearsal*, *involuntary recall*, *life story* relevance, *reliving*, *belief*, and auditory imagery (*hear*) as compared to memories that were unrelated to the trauma. They also came more in words and were less *specific* in that the memories were for events that spanned more than 1 day, and occurred longer ago (*age-of-memory*). Of note, trauma-related memories were rated as more available than memories with no reference to the trauma.

There were few interactions with the trauma-related factor. There were two-way interactions of being trauma related and PTSD group on *smell* and *valence* and a three-way interaction for *field*, all at the .05 level, which had no simple interpretations. The interaction of voluntary/involuntary and being trauma related on *in-words* appears to be caused by voluntary memories of traumas coming more in words. The three-way interaction for *in-words* is caused by this being especially strong in the control group. None of the interactions were those one would expect from theories considered here.

In spite of the lack of interactions, there were substantial main effects that when added together are consistent not only with the AMT, but also with clinical observations of emotionally powerful, recurring involuntary memories in PTSD. If we compare voluntary, trauma-unrelated memories occurring to control participants (the transparent cube in Fig. 1) to involuntary, trauma-related memories occurring to participants with PTSD (the red cube in Fig. 1), the variables in the Emotions, Rehearsal, and Centrality of Memories sections of Tables 6 and 7, which contain *valence*, *mood change*, and the availability-increasing mechanisms shown in Fig. 1 and Table 2, all differ by between 1.11 and 2.04 units on the 7-point rating scales. The means for these two extreme cells for these variables are: *Valence* (0.44 versus  $-0.74$ ), *Intensity* (2.44 versus 4.40), *Reaction* (1.91 versus 3.56), *Mood Change* (2.77 versus 4.27), *Rehearsal* (3.22 versus 4.33), *Involuntary* (2.95 versus 4.60), and *Life story* (2.69 versus 4.73) (minimum  $F(1, 82) = 20.87$ , all  $p$ 's < .0001). Thus, the results support basic clinical observations concerning the properties of intrusive memories, but challenge the special mechanisms theories of why they occur.

### 3.3. Discussion

As in Study 1, there were consistent differences between the PTSD and control groups in the measures of emotion and rehearsal and centrality of memories listed in Tables 6 and 7. The PTSD group had more emotional reactions to their memories and considered them as more rehearsed and central to their life story than the control group. These effects were unaffected by whether recall was involuntary or voluntary, contrary to the traditional view but consistent with predictions derived from the AMT. Several differences were observed between involuntary versus voluntary recall, especially in the measures of emotions. These findings replicated and extended previous work on involuntary autobiographical memories and are consistent with the idea that differences in the characteristics of the two types of memory can be explained in terms of different retrieval mechanisms operating on the same memory system (Berntsen, 2009). In particular, because involuntary memories arise associatively with no preceding search description, they allow for less emotion regulation, and thus more emotional reaction and mood change, than the voluntary memories.

Study 2 also showed that trauma-related memories differed systematically from memories with no relation to the trauma, especially with regard to emotional reaction at the time of recall. Importantly, and as predicted by the AMT, involuntary recall did not access trauma-related memories more frequently than voluntary recall. Also of theoretical importance, the PTSD group rated their memories as more coherent, a difference not modified by voluntary versus involuntary retrieval. These findings also support the AMT in that a tendency to react with intense affect to all memories, rather than the increased incoherence of voluntary trauma-related memories, appears to be a key factor in PTSD.

#### 3.3.1. Correlations of the AMQ and individual differences measures combining Studies 1 and 2

Table 8 provides correlations of the AMQ measures with the individual differences measures. A value was obtained for each measure by averaging over the 28 memories collected from each participant in Study 1 (i.e., the 15 word-cued, seven most-important memories, three most-stressful, and three most-positive memories). The number of involuntary memories, as well as the proportion of trauma-related voluntary and involuntary memories that each individual produced in Study 2 are also included. Because individuals were selected to either have current PTSD or not to have lifetime PTSD or current sub-threshold PTSD, the scores on the PCL and DTS were not distributed normally, but showed a fairly uniform distribution without being bimodal. Thus, the absolute values of the correlations of the PCL and DTS, and to a lesser extent other variables, may be greater than they would be in a more randomly selected sample. Nonetheless, the comparison of the differences in the magnitude of the correlations of the individual differences variables with the AMQ measures of the properties of the memories is informative and supports and helps clarify the main ANOVA findings.

The correlations are theoretically reasonable and consistent with the results we presented earlier in that they tended to involve emotional intensity, rehearsal, and life story measures. In fact, these availability-increasing mechanisms of the AMT as well as the percent of trauma-related memories from Study 2 were correlated with the same individual differences measures: measure of the symptom severity of PTSD (PCL, DTS) and dysphoria (BDI), how central a negative event is to one's identity (CES), two measures related to neuroticism (PANAS-Negative Affect, NEO-N), a lack of social support (negative correlations with the ISEL), and the number of categories of trauma experiences (TLEQ/A). The pattern is remarkably similar over these measures. The correlation with the ISEL is of the same magnitude, but not significant for the percent of trauma-related memories because the sample size is slightly smaller in Study 2. As in the earlier tables, *valence* does not behave in a similar way to intensity measures. Of note, there were no significant correlations with the number of involuntary memories reported except for the number of categories of trauma experiences as measured by the TLEQ/A.



**Table 8**  
Correlations of individual differences measures with AMQ and number of involuntary memories.

	PCL	DTS	CES	BDI	PANAS		NEO					ISEL	Audit	TLEQ/A
					Pos	Neg	N	E	O	A	C			
<b>Emotions</b>														
<i>Intensity</i>	.48****	.50****	.40****	.42****	.09	.36****	.30***	-.12	.04	-.18	-.17	-.28**	.13	.38****
<i>Reaction</i>	.47****	.46****	.32***	.41****	.03	.40****	.32***	-.16	.03	-.15	-.18	-.31***	.14	.38****
<i>Valence</i>	-.02	.04	.02	-.06	.16	-.09	-.18	.21*	-.09	.09	.07	.20*	-.08	-.04
<b>Rehearsal</b>														
<i>Rehearsal</i>	.35****	.36****	.38****	.26**	.23*	.17	.19*	-.00	-.02	-.10	-.10	.05	.05	.32***
<i>Involuntary</i>	.47****	.51****	.43****	.39****	.12	.26**	.29**	-.15	-.10	-.14	-.17	-.19*	.17	.36****
<b>Centrality</b>														
<i>Life story</i>	.39****	.39****	.43****	.31***	.11	.23*	.17	-.03	.10	-.18	-.17	-.20*	.15	.31***
<b>Sensory and language processes</b>														
<i>See</i>	.23*	.25**	.24**	.23*	.14	.16	.10	.00	-.02	.16	-.04	-.01	-.02	.29**
<i>Field</i>	.10	.12	.20	.04	.21	.01	-.00	.11	.07	-.05	.03	.04	.02	.12
<i>Setting</i>	.21*	.21*	.22*	.20*	.23*	.09	.02	.05	.09	.15	.04	.02	.02	.25**
<i>Hear</i>	.39****	.43****	.32***	.31***	.05	.28**	.13	-.06	-.10	.02	-.08	-.13	.07	.36****
<i>Smell</i>	.44****	.45****	.25**	.27**	.05	.33****	.10	-.09	-.11	-.13	-.08	-.12	.06	.31***
<i>In-words</i>	.15	.18	.29**	.10	.17	.11	-.02	-.03	-.23*	-.10	.02	-.01	.10	.16
<b>Narrative</b>														
<i>Story</i>	.14	.12	.20*	.12	.25**	.08	.03	.06	.07	.02	.05	-.04	.03	.21*
<i>Pieces</i>	.33***	.29**	.28**	.28**	-.22*	.32***	.23*	-.26**	-.02	-.18	-.26**	-.35****	.29**	.09
<b>Metacognitive judgments</b>														
<i>Reliving</i>	.32***	.35****	.18*	.24**	.09	.19*	.16	-.04	-.09	-.07	-.11	-.12	.01	.34****
<i>Belief</i>	.24**	.24**	.31***	.18	.20*	.20*	.09	.08	.22*	.06	.05	-.02	.01	.25**
<b>Reported properties of events</b>														
<i>Specific</i>	-.24**	-.25**	-.27**	-.07	-.08	-.18*	-.13	.09	.05	.18	.09	.10	.00	-.27**
<i>Age-of-memory<sup>a</sup></i>	.03	-.01	.13	.14	-.06	.04	-.08	-.22*	.08	.16	.07	-.31***	-.09	-.02
<b>Involuntary memories</b>														
<i>Number<sup>b</sup></i>	.19	.16	.14	.12	-.02	-.05	-.06	-.08	-.19	.08	.09	-.07	.12	.24*
<b>% Trauma related</b>														
<i>Involuntary</i>	.42****	.38***	.27*	.31**	-.15	.25*	.29**	-.30**	-.26*	-.11	-.11	-.20	.17	.33**
<i>Voluntary</i>	.38***	.35***	.26*	.28*	-.14	.23*	.29**	-.26*	-.30**	-.14	-.14	-.19	.14	.31**

Notes:  $n = 117$ , except 116 for BDI and audit and 114 for NEO, and for 90 for no. involuntary and 86 for the trauma related variables.

<sup>a</sup> Years between the event and the testing.

<sup>b</sup> Number of involuntary memories produced by each participant.

According to the AMT, one would not expect an increase in the overall incoherence of memories with increased PTSD symptom severity or related variables; this was supported by the lack of any negative correlations of *story* with the individual differences measures. *Pieces*, which theoretically should have similar correlation to *story* but with the opposite sign, did not behave as expected. The ISEL, which measures social support, had its largest numerical absolute correlation with *pieces* and the AUDIT had its only significant correlation with *pieces*. This makes sense if increased alcohol use and decreased social support, with the resulting lack of conversations about memories, increase fragmentation. If the effects of the ISEL are partialled out the only remaining significant correlation with *pieces* is with the AUDIT. A similar pattern results occurs if the *pieces* measure of just the three most-stressful memories is predicted with the same variables, though with slightly smaller correlations. Again, if the effects of the ISEL are partialled out the only remaining significant correlation is with the AUDIT. We note that the effects of the AUDIT occurred in spite of our exclusion of participants with current alcohol or substance abuse or dependence. Thus the correlations with *pieces* do not offer strong support for either AMT or a more traditional view of trauma and memory, but suggests other mechanisms that lead to fragmentation of all memories in PTSD.

#### 4. General discussion

We proposed a theory, the AMT, which is based on current knowledge of cognition, affect, and autobiographical memory, as a contrast to traditional theories that evolved from scientific knowledge available four decades ago when the PTSD diagnosis was first introduced. We confirm many of the key observations made at that time for involuntary memories in people with PTSD. By adding additional measures of the properties of memories, measuring both voluntary and involuntary memories as they were occurring, measuring comparison memories that were not trauma related, and including a non-PTSD control group, we demonstrated that many of these observations were not unique to the traumatic memories of PTSD, but were consistent with general memory principles that apply to all memories in all people.

In order to provide the three-way set of comparisons needed to test these contrasting views, we obtained involuntary and voluntary memories, of highly stressful and control events, in participants who did and did not have a PTSD diagnosis. All memories in participants with PTSD had more emotional intensity, received higher rated frequency of voluntary and involuntary retrieval, more centrality to the life story, but not less narrative coherence. For stressful memories in all participants, the same differences were observed. There were minimal interactions among the three factors. The increase in emotional intensity of stressful events with PTSD is consistent with both the traditional views and the AMT. However, the increased rehearsal of voluntary trauma-related memories and the lack of decreased coherence are inconsistent with the traditional view. Involuntary memories were similar to voluntary memories except that they had more emotional intensity and were willfully rehearsed less often. This held for all participants, both those with and without PTSD. These results are consistent with the AMT but not the traditional theories.

When anyone experiences a trauma, there will be a tendency for it to be recalled with more emotional intensity, recalled more frequently both voluntarily and involuntarily, and to be judged more central to the life story. Similarly, when a person with PTSD recalls any event, there will be a tendency for it to be recalled with more emotional intensity, recalled more frequently both voluntarily and involuntarily, and to be judged more central to the life story. In addition, when anyone recalls an involuntary memory, there will be a tendency for it to be recalled with more emotional intensity. These effects combine to produce memories of trauma in people with PTSD that are especially emotionally intense, frequently recalled, and central to the life story, and if the recall is involuntary they will tend to be even more intense.

Table 2 presented 20 specific predictions of which 20 were in the correct nominal direction and 18 of 20 were significant at the .05 level. The only observation that directly contradicted the AMT was that the PTSD group had memories that came more in *pieces*, which supports the traditional view that those with PTSD have more fragmented memories. The individual differences measures indicate that fragmentation may be related to (and possibly mediated by) alcohol abuse and lack of social support rather than PTSD severity. This hypothesis should be evaluated in future studies.

Our results have theoretical implications for the therapeutic process, but suggest little change in most current practice. Based on the current results, one might expect that efficacious therapies would reduce the negative emotional effects of a traumatic memory, its high rehearsal, and its importance to the life story. There are multiple cognitive behavioral therapy approaches that have been associated with improvements in PTSD symptoms such as cognitive processing therapy (Resick et al., 2008) and prolonged exposure therapy (Schnurr et al., 2007). Although such therapies differ widely among themselves in theoretically important ways and are often based on premises that are counter to the AMT, aspects of these interventions already seem to address memory processes identified in this study either through repeated exposure to the memory in a safe environment where the emotional associations can be reduced or by providing alternative interpretations of the traumatic event that would make the memory less disturbing. It may be useful in intervention studies to evaluate how memory processes may change as a result of these interventions.

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