Exploring the Nature of Traumatic Memory: Combining Clinical Knowledge with Laboratory Methods

Bessel A. van der Kolk
James W. Hopper
Janet E. Osterman

SUMMARY. For over 100 years clinicians have observed and described the unusual nature of traumatic memories. It has been repeatedly and consistently observed that these memories are characterized by fragmentary and intense sensations and affects, often with little or no verbal narrative content. Yet, possibly because traumatic memories cannot be precipitated under laboratory conditions, the organization of traumatic memories has received little systematic scientific investigation. In our laboratory we have developed an instrument, the Traumatic Memory Inventory (TMI), which systematically assesses the ways that memories of traumatic experience are organized and retrieved over time. In this article we report findings from our third study using the TMI, of 16 subjects who had the traumatic experience of awakening from general anesthesia during surgery. We assessed changes in traumatic memory characteristics over time and differences between mem-

Portions of this article were presented at the 1998 Meeting on Trauma and Cognitive Science, at the University of Oregon, Eugene, Oregon, July, 1998; The Fourth International Symposium on Memory and Awareness in Anaesthesia Harrow, United Kingdom, July, 1998; and the 14th Annual Meeting of the International Society for Traumatic Stress Studies, Washington, D.C., November, 1998.

Address correspondence to: Bessel A. van der Kolk, Director, The Trauma Center, 227 Babcock Street, Brookline, MA 02446 (E-mail: bvanderk@traumacenter.org).

[Haworth co-indexing entry note]: "Exploring the Nature of Traumatic Memory: Combining Clinical Knowledge with Laboratory Methods." van der Kolk, Bessel A., James W. Hopper, and Janet E. Osterman. Co-published simultaneously in *Journal of Aggression, Maltreatment & Trauma* (The Haworth Maltreatment & Trauma Press, an imprint of The Haworth Press, Inc.) Vol. 4, No. 2 (#8), 2001, pp. 9-31; and: *Trauma and Cognitive Science: A Meeting of Minds, Science, and Human Experience* (ed: Jennifer J. Freyd, and Anne P. DePrince) The Haworth Maltreatment & Trauma Press, an imprint of The Haworth Press, Inc., 2001, pp. 9-31. Single or multiple copies of this article are available for a fee from The Haworth Document Delivery Service [1-800-342-9678, 9:00 a.m. - 5:00 p.m. (EST). E-mail address: getinfo@haworthpressinc.com].

ories of subjects with and without current Post-Traumatic Stress Disorder. Our findings suggest the need for more rigorous methods for the assessment of the evolution of traumatic memories. In order to develop a comprehensive and integrated understanding of the nature of traumatic memory, we need to combine careful clinical observations with replicable laboratory methods, including those of cognitive science and neuroscience.

KEYWORDS. Memory, awareness during anesthesia, Post-Traumatic Stress Disorder, traumatic memories

INTRODUCTION

The understanding of how people process traumatic events has, until recently, been entirely within the domain of clinical practice and observation. Traditionally, the fields of clinical psychology and psychiatry on the one hand, and cognitive science and neuroscience on the other, have had such widely divergent samples, methodologies and concepts on which they based their understandings of memory processes, that there has been a veritable confusion of tongues between these disciplines. During the past decade, when the observation that people may lose all memory for sexual abuse experiences and retrieve them at a later time was brought to the public's attention, many cognitive scientists took an incredulous stance. Yet for over a century this observation had been consistently reported in the psychiatric literature on other traumatized populations. Despite dozens of reports, starting with Pierre Janet (1889) in the 1880s, followed by Breuer and Freud (1893), repeated during the first World War (Myers, 1915; Southard, 1919), the second World War (Sargant and Slater, 1941) and the Vietnam War (van der Kolk, 1987), most laboratory scientists disregarded the validity of these observations. In the past decade a small group of cognitive scientists began to take clinical reports seriously (Freyd, 1991, 1994; Morton, 1994; Schooler, 1994). However, because amnesia and delayed recall for traumatic experiences had never been observed in the laboratory, many cognitive scientists adamantly denied that these phenomena existed (e.g., Loftus, 1993; Loftus & Ketcham, 1994), or that retrieved traumatic memories could be accurate (Kihlstrom, 1995).

In both science and therapy we often are confronted with unexpected findings. Whether one is a laboratory scientist or a clinician, such phenomena ideally should provoke new insights and creative theoretical and methodolog-

ical advances. Laboratory scientists' practice of ''controlled'' research may render them more prone to observe the phenomena that they set out to measure, while clinicians cannot help but be frequently confronted with unexpected phenomena that don't fit their constructs and models. This often forces them to suspend disbelief and to attend to the unfolding of clinical data for which they have no pre-existing explanations.

Among memory researchers, the issue of whether increased affect enhances or diminishes the accuracy of memory has been hotly debated. The work of Christianson (1992a, 1992b), as well as Yuille and Cutshall (1986), does seem to settle one issue: while there appears to be decreased accuracy for remembering irrelevant details, the central details of stressful events often are remembered with great clarity and accuracy (Loftus, Loftus, & Messo, 1987). However, many traumatized individuals have trouble remembering even the central details of their experience for some period of time (for a comprehensive review, see Brown, Scheflin & Hammond, 1998).

In order to sharpen any discussion on how trauma affects memory we first need to define what is meant by ''traumatic memory.'' The *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV; APA, 1994), definition for Posttraumatic Stress Disorder (PTSD) defines a traumatic memory as a memory of a personally traumatic event. The first DSM-IV criterion for PTSD stipulates that (1) ''the person experienced, witnessed or was confronted with an event or events that involved actual or threatened death or serious injury, or a threat to the physical integrity of self or others,'' and (2) ''the person's experience involved intense fear, helplessness, or horror'' (APA, 1994, pp. 427 & 431). The second component of traumatic memory is that the memory is experienced as if the event and one's responses to it-sensory, cognitive, emotional and physiological-were happening all over again. Most typically, intense flashbacks and nightmares force traumatized people to cope with constant recurrences of memories without the prospect of relief. The recurrent intrusive recollections and the nightmares themselves become new triggers of panic, which may evoke a variety of avoidance and numbing maneuvers that help dissociate the affective intensity of the experience.

Despite the power of these clinical observations, these phenomena have not been systematically studied in the laboratory. The problem is *not* that laboratory science cannot study traumatic memories, but that laboratory science cannot study traumatic memories under conditions in which *the memories studied are for events that take place in the laboratory.* The event encoded into memory simply cannot be a ''controlled'' variable in the laboratory science sense, as in landmark work of Loftus and her colleagues with systematically altered films of car accidents (Loftus, 1975, 1979). This is so

because, for *ethical* reasons, not scientific ones, the extreme terror and helplessness that precede the development of PTSD simply cannot be replicated in such a setting. Roger Pitman (personal communication, July 1996) attempted to simulate a truly traumatic stressor by having college students watch ''The Faces of Death,'' a film consisting of actual footage of deaths and mutilations of people and animals, in the laboratory. Even this stimulus, which is probably as extreme as any institutional review board would allow, failed to precipitate PTSD symptoms in these normal volunteers.

Hence it appears inescapable that to study the nature of traumatic memories one must study the memories of people who have actually been traumatized. Ideally, one's sample would consist of people who had experienced a trauma that was videotaped, and their memories would be assessed immediately after the event. Studies of flashbulb memories (Brown & Kulik, 1977) have come close to this, but the events were not sufficiently traumatic to produce the extremes of terror, helplessness and horror associated with being a direct victim of domestic violence, rape, a major car accident, etc. Less ideal but still quite good is to recruit crime victims, patients in emergency rooms, or other victims of recent trauma and follow the progression of their recollection of the traumatic events. Even studying witnesses of crimes that can be reconstructed very reliably (Yuille & Cutshall, 1986), however, may involve subjects insufficiently traumatized to develop PTSD.

In clinical practice, one often has an opportunity to witness the evolution of traumatic memories beginning shortly after the actual occurrence of the event. It is not unusual for traumatized children (including those who have been raped or witnessed a parent's murder) to initially give a seemingly accurate account of what has happened, but, a year later, to deny that the event occurred and that they have any memory of it. This common clinical observation was supported by Burgess and colleagues' (1995) systematic prospective study of 34 severely abused children. They found that both narrative and implicit memories (behavioral re-enactments) persisted for some time after the abuse, but that the narrative memory was relatively incomplete and fragmented for 41% of the children. Five to ten years after the abuse, many of the children had lost the narrative memory of the abuse, but all of them showed clear signs of implicit, behavioral memories, which manifested themselves as somatic complaints, flashbacks, and behavioral reenactments of abuse-related scenarios that had previously been reported.

There have been very few systematic studies of the memory processes of acutely traumatized adults. Harvey, Bryant and Dang (1998) assessed motor vehicle accident victims' ability to recall specific traumatic memories in response to cue words within one week of the trauma, and severity of PTSD symptoms 6 months later. They found that poor recall of specific trauma memories within the first week predicted 25% of the variance in PTSD

severity at follow-up. Mechanic, Resick and Griffin (1998), studying memory in 92 rape victims, found that within two weeks following the rape there was significant amnesia in a third (37%) of the victims. At a 3-month follow-up, only about one sixth (16%) of the completing subjects had significant amnesia. The rape victims' memory deficits were trauma specific; they did not suffer from generalized memory deficits. Based on all the findings of this study, Mechanic et al. (1998) concluded that (1) following rape there is a high incidence of recovered memory, (2) amnesia and recovered memory occur more often in response to victimization by known perpetrators, which is congruent with Freyd's (1996) theory of betrayal trauma, and (3) dissociation but not ordinary memory processes like forgetting seems to play a primary role in the encoding, storage, and retrieval of traumatic memories.

THE DEVELOPMENT OF THE TRAUMATIC MEMORY INVENTORY

Shobe and Kihlstrom (1997) recently published an article claiming that traumatic memories are qualitatively not any different from memories of ordinary events. Without actually having studied the memories of traumatized individuals themselves, they dismissed all existing observational studies of the memories of individuals with PTSD out of hand. Their rationale for doing so is found in the article's final section, ''Clinical lore and scientific evidence.''

> Although their ideas about the underlying mechanisms are different, Terr, van der Kolk and Whitfield all agree on the outcome: Memories of trauma, or at least of certain forms of trauma, are encoded by processes, such as repression and dissociation, that make them difficult to retrieve as coherent verbal narratives. The result is that traumatic memories are primarily available as isolated, nonverbal, sensory, motor, and emotional fragments. If this conclusion were valid. . . . (1997, p. 74)

Shobe and Kihlstrom have reversed the order of things. First, clinicians working with traumatized individuals found themselves confronted with unexpected observations: incoherent memories of ''isolated, nonverbal, sensory, motor, and emotional fragments.'' Second, once they were struck by the consistency of this observation, clinician-scientists looked for theoretical constructs to make sense of the data.

Initially, the constructs of repression and dissociation were the best they could find. It is not that pioneering students of traumatic memory ignored laboratory evidence, or that they did not search among laboratory scientists' constructs for ones that could help them explain the data they were encoun-

tering. It is just that when it came to delayed recall and the *fragmentary* nature of many traumatic memories, clinician-scientists encountered a conceptual void in the laboratory memory research literature. Laboratory scientists had studied memories for events they had created under controlled conditions, and thus had never encountered fragmentary traumatic memories. In short, laboratory scientists never had a reason to create constructs explicitly addressing fragmentary traumatic memories.

After first encountering inescapable empirical evidence of how traumatic memories can differ from non-traumatic ones, and second, searching for constructs to describe and explain their observations, more recent students of traumatic memory then set out to conduct systematic research on the characteristics of traumatic memory. Early studies focused on the controversial phenomena of amnesia and delayed recall (e.g., Briere & Conte, 1993; Elliott, 1997; Feldman-Summers & Pope, 1994; Williams, 1994, 1995). Laboratory memory scientists like Kihlstrom (1995) and Loftus (1993) have vigorously attacked this line of research. However, others including Freyd (1991, 1994, 1996), Morton (1994) and Schooler (1994) have taken seriously the observations of clinicians and clinician-scientists' research on traumatic memory. These researchers have led the way in applying cognitive science constructs to the full complexity of traumatic memories, including phenomena like delayed recall and fragmentation.

Despite or perhaps because of the traumatic memory debate's polarized nature and the associated dismissals of existing studies, the central questions remain: (1) Can sensory imprints in the form of vivid fragments or flashbacks of images, sounds, smells, bodily sensations and affects properly be classified as ''memories''? (2) In what ways are memories of traumatic experiences qualitatively different from those of ordinary events? (3) Do traumatic memory fragments change in character over time, as narratives are known to do? (4) Could there be sensory imprints that disappear and are later retrieved as pristine representations of what actually happened?

How can we begin to approach these questions? Answers will only come from integrative studies that combine the most appropriate ideas and methods of both clinicians and laboratory researchers. Our laboratory has made an attempt by developing an instrument called the Traumatic Memory Inventory (TMI; van der Kolk & Fisler, 1995) to enable detailed examination of the nature of traumatic and non-traumatic memories. The original TMI was designed to capture the richness and complexity of traumatic memories as experienced by traumatized people and observed by clinicians on a daily basis. It provided a structured way of recording whether and how memories of traumatic experiences are retrieved differently from memories of personally significant but non-traumatic events. In order to examine the retrieval of traumatic memories in a systematic way, the TMI specifically inquires about

sensory, affective and narrative ways of remembering, about triggers for unbidden recollections of traumatic memories, and about ways of dealing with them.

The TMI gathers data on several characteristics of traumatic memories that distinguish them from non-traumatic memories. It begins by probing for background and contextual information, including (1) the nature and (2) duration of the trauma(s); (3) whether the subject had always remembered (''Have you always known that this trauma happened to you in all of its details?''), and if not, when and where the subject became conscious of the trauma; (4) the circumstances under which subject first experienced intrusive memories, and circumstances under which they occur presently. It then inquires in detail about (5) the sensory modalities in which memories were and are currently experienced, that is, (a) as images (''What did you see?''), (b) as sounds (''What did you hear?''), (c) as smells (''What did you smell?''), (d) as tactile or bodily sensations (''What did you feel in your body?''), and (e) as emotions (''What did you feel emotionally?''). Next subjects are asked whether they experienced all of the components present together (''Did you see, feel, smell and hear at the same time?''), and if they remembered it as a coherent narrative (''Were you capable of telling other people what had happened?''). The sensory, affective, fragmentation and narrative data are collected for how subjects remembered the trauma (a) initially, (b) while most bothered by the memory or at ''peak'' intensity, and (c) currently. The original TMI gathered data as well on related clinical information, including (1) the nature of nightmares, (2) the precipitants of flashbacks and nightmares, and (3) ways the subject attempts to gain mastery over intrusive recollections (e.g., by eating, working, taking drugs or alcohol, cleaning, etc.). Finally, the original TMI inquires about confirmation, including court or hospital records, direct witnesses, a relative who went through the same trauma, or other forms of definite or probable confirmation.

The strengths and weaknesses of the original TMI both stem from its origins in clinical observation of fragmentary traumatic memories. With its detailed exploration of memory characteristics, like each sensory and affective component, and its linking of these phenomena to specific and quite different remembering contexts (initial, most distressing, and current), the TMI respected the richness and complexity of fragmentary traumatic memories. On the other hand, like data available in the clinical setting, those gathered with the original TMI are retrospective, with all the potential for distortion that entails. Still greater threats to validity and reliability come from the fact that the TMI is not only retrospective, but relies on subjects' *memories of how they remembered*, sometimes years or even decades in the past.

PREVIOUS STUDIES AT THE TRAUMA CENTER: THE TMI AND SCRIPT-DRIVEN IMAGERY

Our research group has been interested in describing how memories of traumatic events are similar to and different from memories of ordinary experiences. We have published two previous articles (van der Kolk & Fisler, 1995; van der Kolk, Burbridge, & Suzuki, 1997) describing how memories of traumatic events, but not ordinary ones, are initially primarily retrieved as isolated sensations–as visual images, smells, sounds, affective states, and bodily sensations– and how, only with time, are many traumatized individuals able to construct a narrative that verbally describes their traumatic experience in communicable language.

In our previous studies utilizing the TMI, as described above, we asked our subjects the same questions about a personally highly significant experience, such as a wedding or graduation ceremony, and collected the same information about those memories. We have consistently found that subjects tend to consider these questions about the non-traumatic memory nonsensical: none has olfactory, visual, auditory, kinesthetic re-living experiences related to such events. Subjects also deny having vivid dreams or flashbacks about them. They never claim to have periods in their lives when they have amnesia for any of those events; nor do any claim to have photographic recollections of them. Environmental triggers do not suddenly bring back vivid and detailed memories of these events, and none of the subjects ever reports feeling a need to make special efforts to suppress memories of these events.

In both of our previous studies, the first mainly of subjects with histories of severe childhood trauma, and the second of subjects with adult trauma, such as rapes, motor vehicle accidents, and physical assaults, many subjects reported that they initially had no narrative memory at all for the event: they could not tell a story about what had happened, regardless of whether they always knew that the trauma had happened, or whether they retrieved memories of the trauma at a later date. All these subjects, regardless of the age at which the trauma occurred, claimed that they initially ''remembered'' the trauma in the form of somatosensory and affective flashback experiences. These flashbacks occurred in a variety of modalities: visual, olfactory, affective, auditory and kinesthetic, but often these modalities did not initially occur together. As the traumatic memories came into consciousness with greater intensity, more sensory modalities were activated along with the affective component, and over time there emerged a capacity to tell themselves and others about what had happened.

Other investigators have reported similar findings. Roe and Schwartz (1996) found that 60% of their abused inpatients reported that their first recovered memory of abuse occurred in the form of a somatosensory flash-

back, and that only over time were they able to articulate a narrative memory. Cameron (1996) similarly found that initially amnestic sexual abuse survivors, compared to those with continuous memories, were significantly more likely to have memories manifest as ''sensory memories,'' and to have narrative memories initially return in ''bits and pieces.'' Christianson (1992b) also reported that the recovered memories of their subjects initially returned in the form of flashbacks, body-sensory experiences, dreams, sudden intense emotions, or avoidance behaviors, and with respect to narrative memory, as fragments. Koss et al. (1996) found that the severity of the rape experience per se, as well as the victim's appraisal of the event, independently contributed to the lack of clarity of detail and disorganization of the narrative rape memory. Foa and colleagues (Foa, Molnar, & Cashman, 1995) developed a coding system to assess changes in rape narratives associated with exposure treatment for PTSD, and found that significant improvement in PTSD symptoms was associated with significant decreases in the fragmentation of narratives.

In an attempt to elucidate neurobiological underpinnings of these phenomena, we asked some subjects with PTSD from our prior studies to undergo a procedure in which we made Positron Emission Tomography (PET) images of their brains while we evoked memories of traumatic and neutral events (Rauch et al., 1996). We then compared levels of region-specific brain activation in each condition, and found that, compared to the neutral memory, during the traumatic memory subjects with PTSD had decreased activation of Broca's area and increased activation in the right medio-temporal region. Consistent with this and other neuroimaging studies (Shin et al., 1997; Shin et al., 1999), and neurobiological models of emotional memory (e.g., LeDoux, 1996; Squire & Zola-Morgan, 1991), we have proposed (van der Kolk, 1994, 1996) the following model. Under conditions of extreme stress there is failure of hippocampal memory processing, which results in an inability to integrate incoming sensory input into a coherent autobiographical narrative, leaving the sensory elements of experience unintegrated and unattached. These sensory elements then are prone to return during flashbacks, which occur when a sufficient number of sensory elements of the trauma are activated by current reminders.

Our PET study incorporated an important methodological innovation, script-driven imagery, to evoke both traumatic and control neutral memories in an individualized yet standardized way. Script-driven imagery is a laboratory method pioneered by Lang and colleagues (e.g., Lang, Levin, Miller, & Kozac, 1983) and applied to the psychophysiology of PTSD by Pitman, Orr and colleagues (e.g., Pitman, Orr, Forgue, de Jong, & Claiborn, 1987), who were co-investigators on this study. This study demonstrated that although researchers cannot control the events that create traumatic memories, using

this approach they *can* exert considerable control over the conditions under which those memories are evoked and phenomenological data about them are gathered (see Hopper & van der Kolk, 2001, this volume).

THE CURRENT STUDY: MEMORIES FOR "AWARENESS" DURING ANESTHESIA

In this study we used the original TMI with a homogeneous group of subjects who were not victims of interpersonal abuse, as were most of our previous subjects, but who regained consciousness in the middle of surgical procedures (known euphemistically in the anesthesia literature as ''awareness'').

The aim of this study was to replicate the findings of our prior research (van der Kolk & Fisler, 1995; van der Kolk et al., 1997) on the characteristics of traumatic memories, but in a sample of homogenous, non-interpersonal abuse memories that, if they involved delayed recall, were not recovered in therapy. The subjects of this study had woken up from general anesthesia while still in surgery. Research has shown that even those who do not suffer physical pain during their aware experience report experiences of extreme fear and helplessness (Ranta et al., 1998; Schwender et al., 1998). In this study we used the original TMI to gather retrospective data on memories of awareness at three points in time: when they initially remembered awakening from anesthesia, when they were most disturbed by their memory, and at the time of the study.

Method

Design. Retrospective self-report data on memories of awareness under anesthesia were compared for subjects with and without current PTSD secondary to their awareness experiences. Six characteristics of memories of awareness under anesthesia were compared in subjects with and without PTSD, at three points in time. Two hypotheses were made about all subjects' memories: First, that compared to initial and peak intensity memories, current memories would include a coherent verbal narrative. Second, that sensory and affective components of memory would be more prevalent initially and at peak intensity than currently. Two related predictions were made about differences between the memories of subjects with and without current PTSD for their experiences of awareness under anesthesia across all stages of remembering (initial, peak and current). First, subjects with PTSD would be less likely than those without to report having a coherent narrative. Second,

subjects with PTSD would be more likely than those without to remember their awareness experience as sensory and affective components.

Participants. Sixteen subjects reporting awareness under anesthesia were recruited via advertisements in newspapers and fliers posted in hospitals, self-referral following exposure to print and television news stories, or referral by anesthesiologists. The subjects were men and women 18 years of age or older who had experienced awareness under general anesthesia. Three subjects were younger than 18 at the time of surgery (two eight and one 16 years old). Subjects were interviewed between 3 months and 35 years postoperatively (mean of 17.9 years). The subjects with awareness were subsequently divided into two groups, those with (N = 9) and without (N = 7) current PTSD diagnosis. IRB approval was obtained from both institutions where the study was performed, and written informed consent was obtained from all subjects. Interviews were conducted at a public university teaching hospital and a private outpatient psychiatric clinic specializing in the treatment of traumatized populations, and in community settings.

Materials. Subjects were assessed by trained interviewers for PTSD diagnosis and severity of PTSD symptoms with the Clinician Administered PTSD Scale (CAPS; Blake et al., 1995), a structured interview which has been shown to yield reliable data and has been validated for the purpose of assessing PTSD symptoms and their severity. The target PTSD ''Criterion A'' event for the CAPS was the subject's experience of awareness under anesthesia. CAPS items concerning reexperiencing (criterion B), avoidant and numbing (C), and hyperarousal (D) symptoms were focused on the effects of experiencing awareness. Characteristics of subjects' memories of the awareness experience were assessed with the original TMI (described above). The TMI was used to gather data on the presence or absence of six experienced characteristics of the memories, including four sensory components (visual images, sounds, bodily sensations, smells), an affective component, and access to a verbal narrative.

Results

This study's small sample size and the categorical nature of its variables of interest precluded statistical analyses of the hypotheses. That is, chi square statistics are only valid when all cell sizes are greater than five, a condition not met because, as we discovered, people who have experienced awareness during surgery with general anesthesia tend to avoid contact with health professionals. Indeed, this was the most difficult trauma population from which we have ever attempted to recruit subjects.

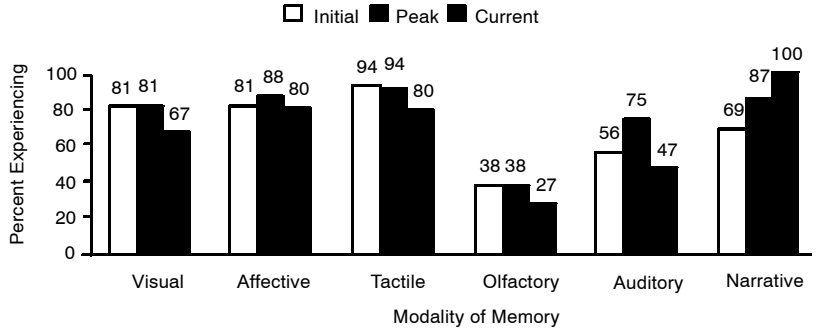
Participant characteristics. There was a trend for subjects with current PTSD to be younger than subjects without current PTSD (means of 44 and 53.4 years, respectively, $t(14) = 2.06$, $p = .059$), but no significant difference

was found for years since the surgery (means of 15.8 and 20.6 years, respectively). Subjects with PTSD had a mean total CAPS score of 75.9 (range = 57-96, *SD* = 12.52), compared to the mean of 21.7 (range = 9-41, *SD* = 11.32) for subjects without current PTSD, $t(14) = 8.94$, $p < .001$. The range of CAPS scores in the subjects with PTSD indicate a moderate to severe range of symptomatology, based on normative data from a large-scale psychometric study (Blake et al., 1995).

Amnesia and delayed recall. Six of 16 or 37.5% of the subjects reported a period of amnesia, during which they ''had no memories'' and did not even ''know that something had happened.'' Four of those six subjects had PTSD at the time of the study. One subject reported that she had always known that it happened, but didn't remember some of the details. The remaining nine (56.3%) said they had always known that it happened in all of its details.

Changes in memory characteristics over time. Three subjects reported that their ''initial'' and ''peak'' memory was the same; that is, they remembered their earliest memory as most disturbing. For those cases, the same values were entered for both initial and peak periods. Figure 1 depicts the sensory, affective and narrative modalities for all subjects over the three time periods assessed with the TMI. Of 16 subjects, 18.8% (3 of 16) reported having no narrative for the experience of awareness when they first remembered it (were not ''able to tell another person a story about what had happened''). Two subjects were not sure and 68.8% (11 of 16) reported initially having a narrative memory. As predicted, over time subjects acquired the ability to communicate their memory as a narrative, with 87% having a narrative at peak intensity and 100% at the time of the study. In contrast to our prediction, on the whole subjects reported surprisingly little change in other modalities of memory over time. The one

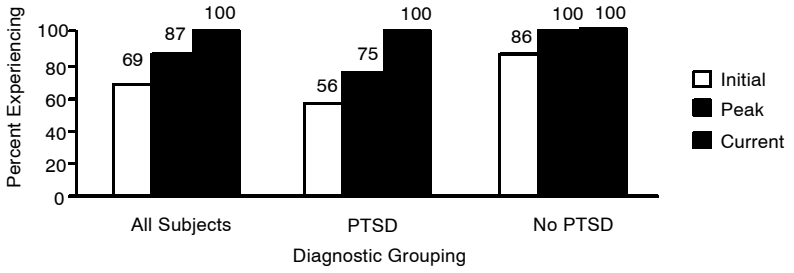
FIGURE 1. Modalities of Memory in Subjects with Awareness Under Anesthesia



exception appeared to be the auditory component, which was experienced by more subjects when the memory was most disturbing than initially or currently.

Comparisons of memory characteristics in subjects with and without PTSD. Though the numbers in each group were small (9 with PTSD and 7 without), changes in memory characteristics over time were compared between them. As predicted and shown in Figure 2, subjects with PTSD were more likely than those without to report that initially they did not have a narrative memory. All but one of the seven non-PTSD subjects initially had a narrative memory (one was unsure), compared to five of nine subjects with current PTSD (again, one was unsure). At peak intensity, all non-PTSD subjects but only three-quarters of the current PTSD subjects reported having a narrative memory. At the time of the study, as noted above, all subjects in both groups had narratives. In this small sample, differences were not found between groups for the prevalence of sensory and affective modalities. However, we did find that most subjects with PTSD relived the surgery in the form of sensations and affects–when they initially remembered, when the memory was most disturbing to them, and at the time of the study. By definition, subjects with current PTSD had traumatic memories at the time of the study. Subjects without PTSD, in contrast, currently had distressing but not traumatic memories, and there was a trend for fewer of them to report reliving of sensations and affects from the surgery in their current memories (i.e., somewhat lower percentages for tactile, olfactory and affective modalities; data not shown).

FIGURE 2. Narrative Memory in Subjects with Awareness Under Anesthesia



DISCUSSION

This study confirms that traumatic memories associated with Post-Traumatic Stress Disorder may initially lack narrative elements, even as the trauma is intrusively relived as sounds, smells, bodily sensations and visual images. The most unexpected finding was that all memories for traumatic experiences–whether subjects met criteria for PTSD or not–tended to have sensory and affective components. We consider the possible reasons for these findings and their implications for future research.

Narrative memory. Consistent with our prediction, six out of seven subjects without PTSD had an initial verbal narrative of the trauma, compared with five out of nine of those with current PTSD. In our first study using the original TMI (van der Kolk & Fisler, 1995), all subjects met criteria for current PTSD, and none reported having an initial narrative memory. This discrepancy may be accounted for by two differences in the nature of the subjects' traumatic experiences. All but one of the subjects in this study experienced the trauma of awareness in adulthood, while over 75% of the subjects in the first study were traumatized as children. In addition, the nature of the traumas were different, with most subjects in the first study having experienced assault by a caregiver or family member, as opposed to the accidental and undetected trauma of awareness under anesthesia. In both studies, however, there was a clear pattern of narrative formation over time, even though sensory and affective intrusions continued in subjects with PTSD.

The results of our second study using the TMI (van der Kolk et al., 1997) appear to fall somewhere in the middle. The sample consisted of adults with PTSD secondary to childhood trauma with a period of amnesia, childhood trauma without amnesia, or adult trauma. Every subject in both child trauma groups initially lacked a narrative, compared to 78% of subjects with adult traumas. At the time of the study, every subject with adult trauma or continuous memories for childhood trauma had a narrative, versus 83% of those who had experienced amnesia for childhood traumas. In addition, all subjects with childhood trauma had experienced sexual or physical abuse, while some of the adult trauma group had experienced accidents rather than assaults. Still, the majority of subjects in all three groups of this second study reported that they initially experienced their memories as sensations and affects.

Taken together, these findings from the first three TMI studies suggest that future research should determine whether the absence of narrative in a traumatic memory is independently affected by (a) whether or not the trauma involved interpersonal violence, and (b) whether it occurred in childhood or adulthood.

Sensory and affective modalities of traumatic memory. In contrast to our prior TMI research, in the present study we found no changes in sensory and

affective memory modalities over time. Interestingly, we did not find differences in these memory components between subjects with PTSD and non-PTSD at any stage of remembering. These results are inconsistent with over 100 years of clinical observation and the findings of our two previous TMI studies. One possible explanation is the small sample size and the fact that half of the sample did not have PTSD. Most likely, this discrepancy is a function of a limitation of the original TMI: it assesses whether sensory and affective memory components were present or absent, but not how intensely these intrusions were experienced. For example, a subject who initially remembered, ''hearing the surgeon's voice as if he were in the room with me,'' might currently report having ''a sense of hearing his voice again.'' However, both were scored as a ''yes'' on auditory re-living.

Clearly there is a need to develop laboratory methods that can capture the potential complexity of the changes in traumatic memories over time. We believe that a standardized method of evoking memories, when combined with an instrument that rates the relative intensity of memory components, allows more precise assessment of the nature of traumatic intrusions. We discuss the development of such a method in a companion paper (Hopper & van der Kolk, 2001, this volume). The approach detailed there allows us to capture, both qualitatively and quantitatively, changes in traumatic remembrance due to effective treatment or the passage of time, and to correlate these changes with alterations in brain activation and physiological activity.

GENERAL DISCUSSION

The nature of traumatic memories has preoccupied psychiatrists since the very beginnings of their discipline. Over a hundred years ago the French psychiatrist Pierre Janet (1889) proposed that when people experience ''vehement emotions'' their minds may become incapable of matching their frightening experiences with their existing cognitive schemes. As a result, he proposed, the memories of the experience cannot be integrated into personal awareness. Instead, they were split off (dissociated) from conscious awareness and from voluntary control. Thus, the first comprehensive formulation of the effects of trauma on the mind was based on the notion that failure to integrate traumatic memories due to extreme emotional arousal results in the symptoms of what we call PTSD today. Janet stated, ''they are unable to make the recital which we call narrative memory, and yet they remain confronted by [the] difficult situation'' (1919/1925, p. 661). This results in ''a phobia of memory'' (1919/1925, p. 661) that prevents the integration (''synthesis'') of traumatic events and splits these traumatic memories off from ordinary consciousness (1898, p. 145). As a result, Janet claimed, the memory traces of the trauma linger as terrifying perceptions, obsessional

preoccupations and somatic reexperiences such as anxiety reactions, and cannot be ''liquidated'' as long as they have not been translated into a personal narrative (Janet, 1889, 1930).

Around this time as well, Breuer and Freud wrote their 1893 monograph, ''On the nature of hysterical phenomena,'' worth quoting at length:

> *Hysterics suffer mainly from reminiscences.*
>
> At first sight it seems extraordinary that events experienced so long ago should continue to operate so intensely–that their recollection should not be liable to the wearing away process to which, after all, we see all our memories succumb. The following considerations may perhaps make this a little more intelligible.
>
> The fading of a memory or the losing of its affect depends on various factors. The most important of these is *whether there has been an energetic reaction to the event that provokes an affect*. By ''reaction'' we understand the whole class of voluntary and involuntary reflexes . . . in which . . . the affects are discharged. If this reaction takes place to a sufficient amount a large part of the affect disappears as a result. . . .
>
> ''Abreaction,'' however, is not the only method of dealing with the situation that is open to a normal person who has experienced a psychical trauma. A memory of such a trauma, even if it has not been abreacted, enters the great complex of associations, it comes alongside other experiences, which may contradict it, and is subjected to rectification by other ideas. . . . In this way a normal person is able to bring about the disappearance of the accompanying affect through the process of association.
>
> We must, however, mention another remarkable fact,. . . namely, that these memories, unlike the memories of their lives, are not at the patients' disposal. On the contrary, *these experiences are completely absent from the patient's memory when they are in a normal psychical state, or are only present in a highly summary form*. . . .
>
> It may therefore be said that the ideas which have become pathological have persisted with such freshness and affective strength because they have been denied the normal wearing-away processes by means of abreaction and reproduction in states of uninhibited association (1893, pp. 7-11, italics in original).

Every contemporary study of traumatic memories has essentially corroborated Janet's and Freud's initial observations that traumatic memories persist primarily as implicit, behavioral and somatic memories, and only secondarily as vague, overgeneral, fragmented, incomplete, and disorganized narratives. Previous work by Foa (1995) and our case studies (Hopper & van der Kolk,

2001, this volume) suggest that these memories change as people recover from their PTSD.

The critical issue in studying traumatic memories, then, is to harmonize clinicians' observations and clinician-scientists' investigations with the exploding knowledge about the psychology and psychobiology of post-traumatic stress. For some time, the investigation of traumatic memory seems to have taken a detour by focusing on the issue of the ''repression'' or ''dissociation'' of traumatic memories. However, methods for assessing past amnesia for traumatic events are easier to develop than those for measuring the complexity of traumatic memory–what happens to the encoding and retrieval of memories related to overwhelming emotional experiences.

There is a need to develop new methodologies, which cannot consist of exposure to laboratory-generated stressful stimuli, but must be grounded in subjects' actual traumatic experiences. The field of PTSD has already developed standardized methods of memory evocation (e.g., individualized scripts) and structured interviews designed to assess traumatic memory characteristics (e.g., the TMI). Two other design features hold the key to valid and reliable research on the nature of traumatic memories. The first is prospective assessment of memories and changes in them over time. The second is to conduct such assessments in controlled outcome studies of treatments capable of transforming traumatic memories into relatively normal memories. Our laboratory has begun to conduct research incorporating all four of these methods (Hopper & van der Kolk, 2001, this volume).

It is also necessary to correlate the nature of retrieved memories with reliable and valid measures of PTSD and dissociative symptomatology. Finally, researchers need to correlate the mental phenomena of traumatic remembrances with biological parameters. The latter include measures of regional brain activation (e.g., functional Magnetic Resonance Imaging [fMRI], electroencephalogram [EEG], and magnetoencephalogram [MEG]), and peripheral physiological responses (e.g., heart rate, heart rate variability, skin conductance, blood pressure, and muscular activity).

Memories of traumatic experiences may not be primarily retrieved as narratives. Our own and others' research has suggested that PTSD traumatized people's difficulties with putting memories into words are reflected in actual changes in brain activity. In our PET neuroimaging study (Rauch et al., 1996), during exposure to traumatic reminders we found marked lateralization with increased activation in the right hemisphere (thought to be dominant for evaluating the emotional significance of incoming information and regulating the autonomic and hormonal responses to that information). In contrast, Broca's area (in the left inferior frontal cortex) had a simultaneous significant decrease in oxygen utilization, a finding replicated in two subsequent PET studies (Shin et al., 1997; Shin et al., 1999). This could signify

that, during activation of a traumatic memory, the brain is ''having'' its experience: the person may feel, see, or hear the sensory elements of the traumatic experience, but he or she may be physiologically impaired from being able to translate this experience into communicable language. When they are ''having'' their traumatic recall, victims may suffer from ''speechless terror'' in which they may be literally ''out of touch with their feelings.'' Their bodies may respond as if they are being traumatized again, with the secretions of the various neurohormones that are mobilized on those occasions, but the retrieval of the memory is dissociated, and the victim does not seem to be able to ''own'' what is happening.

How can we understand these findings? We previously have proposed the following understanding of these phenomena from a neurobiological information processing point of view (van der Kolk et al., 1996). When the brain processes incoming information, sensory input enters the CNS via the sensory organs. After initial processing by the thalamus, sensory information is evaluated for its existential relevance both by the amygdala and the prefrontal cortex. It has been well established that the amygdala attaches emotional significance to sensory input. The information evaluated by the amygdala is then passed on to areas in the brainstem that control behavioral autonomic and neurohormonal response systems. By way of these connections, the amygdala transforms sensory stimuli into emotional and hormonal signals, thereby initiating emotional responses (LeDoux, 1992).

LeDoux (1992) proposes that, since input from the thalamus arrives at the amygdala before information from the neocortex, this earlier arrived sensory input from the thalamus ''prepares'' the amygdala to process the later arriving information from the cortex. Thus, the emotional evaluation of sensory input precedes conscious emotional experience: people may become autonomically and hormonally activated before having been able to make a conscious appraisal of what they are reacting to. Thus, a high degree of activation of the amygdala and related structures can generate emotional responses and sensory impressions that are based on fragments of information, rather than full-blown perceptions of objects and events.

After the amygdala assigns emotional significance to sensory input, other brain structures further evaluate the meaning of this information. This includes the hippocampus, whose task it is to begin organizing and categorizing this information with previously existing information about similar sensory input. The strength of the hippocampal activation is affected by the intensity of input from the amygdala: the more significance assigned by the amygdala, the stronger the input will be attended to, and the better the memory will be retained. However, this interaction has an inverted U-shaped function: in animals, high levels of stimulation of the amygdala interfere with hippocampal functioning (Adamec, 1991; Squire & Zola-Morgan, 1991). This means

that very high levels of emotional arousal may significantly disrupt the proper evaluation and categorization of experience by interfering with hippocampal function. We have hypothesized (van der Kolk, 1994) that, when this occurs, sensory imprints of experience are stored in memory, but because the hippocampus is impaired in its integrative function, these various imprints are incompletely unified into a whole. The experience may be laid down, and later retrieved, largely or primarily as isolated images, bodily sensations, smells and sounds that feel alien, and separate from other life experiences. Because the hippocampus was impaired in its usual role in helping to localize the incoming information in time and space, these fragments continue to lead an isolated existence. This would render traumatic memories timeless, and ego-alien.

CONCLUSIONS

Incoming sensory input ordinarily is analyzed and automatically synthesized into the large store of pre-existing information. When sensory input is personally significant these sensations may be transcribed into a personal narrative, without the subject having conscious awareness of the processes that translate sensory impressions into a personal story. Our research as shown that, in contrast with the way people seem to process ordinary information, traumatic experiences are often initially imprinted as sensations or feeling states, and are not collated and transcribed into personal narratives. Both our interviews with traumatized people, and brain imaging studies of them, seem to confirm that traumatic memories come back as emotional and sensory states, with limited capacity for verbal representation. We have proposed that this failure to process information on a symbolic level, which is essential for proper categorization and integration with other experiences, is at the very core of the pathology of PTSD.

The irony is that, while the sensory perceptions reported in PTSD may well reflect the actual imprints of sensations that were recorded at the time of the trauma, all narratives that weave sensory imprints into a socially communicable story are subject to condensation, embellishment and contamination. While trauma may leave an indelible imprint, once people start talking about these sensations, and try to make meaning of them, it is transcribed into ordinary memory, and, like all ordinary memory, it is prone to become distorted. People seem to be unable to accept experiences that have no meaning: they will try to make sense of what they are feeling. Once people become conscious of intrusive elements of the trauma, they are liable to try to fill in the blanks, and complete the picture.

Like all stories that people construct, our autobiographies contain elements of truth, of things that we wish did happen, but that did not, and elements that are meant to please the audience. The stories that people tell

about their traumas are as vulnerable to distortion as people's stories about anything else. However, the question of whether the brain is able to take pictures, and whether some smells, images, sounds, or physical sensations may be etched onto the mind, and remain unaltered by subsequent experience and by the passage of time, still remains to be answered.

REFERENCES

Adamec, R. E. (1991). Partial kindling of the ventral hippocampus: Identification of changes in limbic physiology which accompany changes in feline aggression and defense. *Physiology and Behavior*, *49*, 443-453.

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

Blake, D. D., Weathers, F. W., Nagy, L. M., Kaloupek, D. G., Gusman, F. D., Charney D. S., & Keane, T. M. (1995). The development of a Clinician-Administered PTSD Scale. *Journal of Traumatic Stress*, *8*, 75-90.

Breuer, J., & Freud, S. (1893). On the psychical mechanism of hysterical phenomena: Preliminary communication. In J. Strachy (Ed. and Trans.) *The standard edition of the complete psychological works of Sigmund Freud* (Vol. 2.) (pp. 3-17). London: Hogarth Press.

Briere, J., & Conte, J. (1993). Self-reported amnesia for abuse in adults molested as children. *Journal of Traumatic Stress*, *6*, 21-31.

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

Brown, D., Scheflin, A. W., & Hammond, C. (1998). *Memory*, *trauma treatment*, *and the law.* New York: Norton.

Burgess, A. W., Hartman, C. R. & Baker, T. (1995). Memory presentations of childhood sexual abuse. *Journal of Psychosocial Nursing*, *33*, 9-16.

Cameron, A. (1996). Comparing amnesic and nonamnesic survivors of childhood sexual abuse: A longitudinal study. In. K. Pezdek & W. P. Banks (Eds.), *The Recovered Memory/False Memory Debate*, pp. 41-68. New York: Academic Press.

Christianson, S. A. (1992a). Emotional stress and eyewitness memory: A critical review. *Psychological Bulletin*, *112*, 284-309.

Christianson, S. A. (1992b). Remembering emotional events: Potential mechanisms. In S. A. Christianson (Ed.), *Handbook of emotion and memory*: *Research and theory* (pp.307-340). Hillsdale, NJ: Erlbaum.

Elliott, D. M. (1997). Traumatic events: Prevalence and delayed recall in the general population. *Journal of Consulting and Clinical Psychology*, *65*, 811-820.

Feldman-Summers, S., & Pope, K. S. (1994). The experience of ''forgetting'' childhood abuse: A national survey of psychologists. *Journal of Consulting and Clinical Psychology*, *62*, 636-639.

Foa, E. B., Molnar, C., & Cashman, L. (1995). Change in rape narratives during exposure therapy for posttraumatic stress disorder. *Journal of Traumatic Stress*, *8*, 675-690.

Freyd, J. J. (1991, August 21-22). Memory repression, dissociative states, and other cognitive control processes involved in adult sequelae of childhood trauma. In-

vited paper given at the Second Annual Conference on A Psychodynamics-Cognitive Science Interface, Langley Porter Psychiatric Institute, University of California, San Francisco.

Freyd, J. J. (1994). Betrayal trauma: Traumatic amnesia as an adaptive response to childhood abuse. *Ethics & Behavior*, *4*, 307-329.

Freyd, J. J. (1996). *Betrayal trauma*: *The logic of forgetting childhood abuse*. Cambridge: Harvard University Press.

Harvey, A. G., Bryant R. A., & Dang, S. T. (1998). Autobiographical memory in acute stress disorder. *Journal of Consulting and Clinical Psychology*, *66*, 500-506.

Hopper, J. W., & van der Kolk, B. A. (2000). Retrieving, assessing, and classifying traumatic memories: A preliminary report on three case studies of a new standardized method. *Journal of Aggression*, *Maltreatment & Trauma*.

Janet, P. (1889). *L'Automatisme psychologique* [Psychological automatisms]. Paris: Félix Alcan.

Janet, P. (1898). *Névroses et idées fixes* [Neuroses and fixed ideas] (Vols. 1 & 2). Paris: Félix Alcan.

Janet, P. (1911). *L'état mental des hysteriques* [The mental state of hysterics] (2nd ed.). Paris: Félix Alcan.

Janet, P. (1919/1925). *Psychological healing* (Vols. 1 & 2). New York: MacMillan. (Original book, *Les médications psychologiques*, published in 1919).

Janet, P. (1930). Autobiography. In C.A. Murchinson (Ed.), *A history of psychology in autobiography*, *vol 1*. Worcester, MA: Clark University.

Kihlstrom, J. F. (1995). The trauma-memory argument. *Consciousness & Cognition*, *4*, 63-7.

Koss, M. P., Figueredo, A. J., Bell, I., Tharan, M., & Tromp, S. (1996). Traumatic memory characteristics: A cross-validated mediational model of response to rape among employed women. *Journal of Abnormal Psychology*, *105*, 421-432.

Koss, M. P., Tromp, S., Figueredo, A. J., Bell, I., & Tharan, M. (1995). Are rape memories different? A comparison of rape, other unpleasant, and pleasant memories among employed women. *Journal of Traumatic Stress*, *8*, 607-627.

Lang, P. J., Levin, D. N., Miller, G. A., & Kozac, M. J. (1983). Fear behavior, fear imagery, and the psychophysiology of emotion: The problem of affective-response integration. *Journal of Abnormal Psychology*, *92*, 275-306.

LeDoux, J. E. (1992). Brain mechanisms of emotion and emotional learning. *Current Opinion in Neurobiology*, *2*, 191-197.

LeDoux, J. (1996). *The Emotional Brain*. New York: Simon and Schuster.

Loftus, E. F. (1975). Leading questions and the eyewitness report. *Cognitive Psychology*, *7*, 560-572.

Loftus, E. F. (1979). *Eyewitness testimony.* Cambridge, MA: Harvard University Press.

Loftus, E. F. (1993). The reality of repressed memories. *American Psychologist*, *48*, 518-537.

Loftus, E. F., & Ketcham, K. (1994). *The myth of repressed memory*: *False memories and allegations of sexual abuse*. New York: St. Martin's Press.

Loftus, E. F., Loftus, G. R., & Messo, J. (1987). Some facts about "weapon focus." *Law and Human Behavior*, *11*, 55-62.

McFarlane, A.C., Weber, D. L., & Clark, C. R. (1993). Abnormal stimulus processing in posttraumatic stress disorder. *Biological Psychiatry*, *34*, 311-320.

Mechanic, M. B., Resick, P. A., & Griffin, M. G. (1998). A comparison of normal forgetting, psychopathology, and information-processing models of reported amnesia for recent sexual trauma. *Journal of Consulting and Clinical Psychology*, *66*, 948-957.

Morton, J. (1994). Cognitive perspectives on memory recovery. *Applied Cognitive Psychology*, *8*, 389-398.

Myers, C. S. (1915). A contribution to the study of shell-shock. *Lancet*, *185*, 316-320.

Pitman, R. K., Orr, S. P., Forgue, D. F., de Jong, J., & Claiborn, J. M. (1987). Psychophysiologic assessment of posttraumatic stress disorder imagery in Vietnam combat veterans. *Archives of General Psychiatry*, *44*, 970- 975.

Ranta, S. O., Laurila R., Saario J., Ali-Melkkilä, T., & Hynynen, M. (1998). Awareness with recall during general anesthesia: Incidence and risk factors. *Anesthesia and Analgesia*, *86*, 1084-1089.

Rauch, S., van der Kolk, B. A., Fisler, R., Alpert, N., Orr, S., Savage, C., Jenike, M., & Pitman, R. (1996). A symptom provocation study of posttraumatic stress disorder using positron emission tomography and script-driven imagery. *Archives of General Psychiatry*, *53*, 380-387.

Roe, C. M., & Schwartz, M. (1996). Characteristics of previously forgotten memories of sexual abuse: A descriptive study. *Journal of Psychiatry and Law*, *24*, 189-206.

Sargant, W., & Slater, E. (1941). Amnesic syndromes in war. *Proceedings of the Royal Society of Medicine*, 34, 757-764.

Schooler, J. W. (1994). Seeking the core: The issues and evidence surrounding recovered accounts of sexual trauma. *Consciousness and Cognition*, *3*, 452-469.

Schwender D., Kunze-Kronawitter H., Dietrich P., Klasing S., Frost H., & Madler C. (1998). Conscious awareness during general anaesthesia: Patients' perceptions, emotions, cognition and reactions. *British Journal of Anaesthesia*, *80*, 133-139.

Shin, L. M., Kosslyn S. M., McNally, R. J., Alpert N. M., Thompson, W. L., Rauch S. L., Macklin, M. L., & Pitman, R. K. (1997). Visual imagery and perception in posttraumatic stress disorder. A positron emission tomographic investigation. *Archives of General Psychiatry*, *54*, 233-241.

Shin, L. M., McNally, R. J., Kosslyn, S. M., Thompson, W. L., Rauch, S. L., Alpert, N. M., Metzger, L. J., Lasko, N. B., Orr, S. P., & Pitman, R. K. (1999). Regional cerebral blood flow during script-driven imagery in childhood sexual abuse-related PTSD: A PET investigation. *American Journal of Psychiatry*, *156*, 575-584.

Shobe, K. K., & Kihlstrom, J. (1997). Is traumatic memory special? *Current Directions in Psychological Science*, *6*, 70-74.

Southard, E. E. (1919). *Shell-shock and other neuropsychiatric problems*. Boston: W.W. Leonard.

Spitzer, R. L., Williams, J. B. W., & Gibbon, M. (1987). *Structured Clinical Interview for DSM-III-R*. New York: New York State Psychiatric Institute, Biometrics Research Department.

Squire, L. R., & Zola-Morgan, S. (1991). The medial temporal lobe memory system. *Science*, *153*, 2380-2386.

van der Kolk, B. A. (1987). *Psychological trauma*. Washington, DC: American Psychiatric Press.

van der Kolk, B. A. (1994). The body keeps the score: Memory and the emerging psychobiology of posttraumatic stress. *Harvard Review of Psychiatry*, *1*, 253-265.

van der Kolk, B. A., McFarlane, A. C., & Weisaeth, L. (1996). *Traumatic Stress*: *The effects of overwhelming experience on mind*, *body and society.* New York: Guilford Press.

van der Kolk, B. A., Burbridge, J. A., & Suzuki, J. (1997). The psychobiology of traumatic memory: Clinical implications of neuroimaging studies. In R. Yehuda & A. C. McFarlane (Eds.), *Annals of the New York Academy of Sciences (Vol. 821)*: *Psychobiology of Posttraumatic Stress Disorder* (pp. 99-113). New York: New York Academy of Sciences.

van der Kolk, B. A., & Fisler, R. (1995). Dissociation and the fragmentary nature of traumatic memories: Overview and exploratory study. *Journal of Traumatic Stress*, *8*, 505-536.

Williams, L. M. (1994). Recall of childhood trauma: A prospective study of women's memories of child sexual abuse. *Journal of Consulting and Clinical Psychology*, *62*, 1167-1176.

Williams, L. M. (1995). Recovered memories of abuse in women with documented child sexual victimization histories. *Journal of Traumatic Stress*, *8*, 649-673.

Yuille, J. C., & Cutshall, J. L. (1986). A case study of eyewitness memory of a crime. *Journal of Applied Psychology*, *71*, 291-301.