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Memory and Posttraumatic Stress Disorder

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This chapter will focus on the memories of those who have endured traumatic events as adults, particularly those who suffer from posttraumatic stress disorder (PTSD). PTSD is a relatively new diagnostic category that incorporates symptoms resulting from exposure to life-threatening events. Many of these symptoms are related to memory. For example, the re-experiencing symptom cluster is defined by the persistence of traumatic memories in forms that are distressing and sometimes distorted, such as intrusive thoughts, nightmares, or dissociative flashbacks. Paradoxically, in addition to persistent and intrusive memories, survivors often complain of an inability to recall important aspects of their traumatic experience, a phenomenon formerly called "psychogenic amnesia." Additionally, individuals with PTSD also suffer from other symptoms related to memory such as poor concentration and impaired attention.

Whereas a substantial proportion of trauma survivors are symptomatic in the immediate aftermath of a trauma, only a subset develops PTSD. Therefore, the literature on memory impairments in PTSD will not apply to all trauma survivors. However, studying this symptomatic subset may further our understanding of traumatic memories and how they are processed. The memory alterations in PTSD may reflect phenomena that are unique or that are similar to, but more exaggerated than, phenomena experienced by trauma survivors who do not develop PTSD. The goals of this chapter are to summarize existing knowledge about the relationship between trauma and memory in survivors who do and do not develop PTSD.

The Phenomenology of Memory Disturbances in PTSD

Individuals at risk for developing PTSD are those who have undergone a severe, traumatic event. In DSM-IV, a traumatic event is defined as one in which the individual has experienced, witnessed, or been confronted with an event or events that involved actual or threatened death, or serious injury, or threat to the physical integrity of the self or others.[1] In order to meet criteria for PTSD, the individual must experience a host of symptoms from the three symptom clusters: re-experiencing, avoidance, and arousal. The full criteria are met if these symptoms persist for at least one month and cause clinically significant impairment. Those symptoms that directly or indirectly relate to memory will be described below, with an emphasis on their relationship to the inciting traumatic event.

Reliving and Re-experiencing

Traumatic events seem to leave indelible memory traces. Some individuals find significant meaning in "not forgetting" their trauma. For example, a war veteran may consciously or unconsciously believe that by actively remembering combat experiences he is paying tribute to a fellow soldier. A Holocaust victim may view remembering as a way to bear witness to the tragedy and brutality of Nazi Germany. But for some trauma victims there may be little or no personal meaning or moral obligation in their persistent remembering; despite their best efforts, they continue to relive the trauma simply because they cannot forget it. The trauma has left an impression that repeatedly intrudes into consciousness. Attempts to suppress or block memories are often unsuccessful. The traumatic recollection can appear in the waking state as intrusive thoughts, illusions or hallucinations, or in the dream state, as horrifying nightmares. These phenomena, classified as the *cluster B* symptoms in DSM-IV, are referred to as the re-experiencing symptoms of PTSD. The re-experiencing symptoms are uncommonly vivid and may remain so for the lifetime of the individual. Most individuals suffering from PTSD find these re-experiencing symptoms highly distressing and even tormenting—so much so, that they frequently come to treatment wanting "to forget."

Reliving experiences differ from the normal recall of traumatic memory in several ways, one of which is their intrusiveness. The frequency with which the memories are evoked, the intensity of the accompanying pain and arousal, and the persistence of them over time all contribute to the subjective sense of intrusiveness. Additionally, although the remembered event should seem familiar, the form the memory takes may make it seem strange or foreign. This is particularly likely if the memory occurs as an illusion or a fragmented image, such as a dismembered body, an assailant's face, a victim's cry. Out of context, these perceptions seem senseless to the patient, who may fear she or he is "going crazy." Once evoked, the memory is often played over and over again. The

inability to contain a memory once it has been recalled, or to suppress or control it, reinforces a feeling of helplessness. Rather than fade over time, the negative feelings associated with the original trauma may remain bound to the memory and may be compounded by distress over the persistence of the memories themselves.

In some cases, the remembering experiences are not perceived as memories but as if the trauma were being relived. A description of a reliving experience can be found in *Dispatches*, a memoir written by Michael Herr, who was a war correspondent in Vietnam.[2]

> During my first month back I woke up one night and knew that my living room was full of dead Marines. It actually happened three or four times, after a dream I was having those nights (the kind of dream one never had in Vietnam), and that first time it wasn't just some holding dread left by the dream, I knew they were there, so that after I'd turned on the light by my bed and smoked a cigarette I lay there for a moment thinking that I'd have to go out soon and cover them.

This passage illustrates the clarity and certainty that accompany reliving experiences, qualities which contribute to their being perceived as current reality. Visual images often predominate in flashbacks, but smells, sounds, and tastes can be incorporated as well. An array of emotions present during the initial traumatization may accompany the images, including fear, rage, excitement, or helplessness. During a flashback a patient may not only feel but also act as if the event were recurring. He or she may duck for cover or act violently in perceived self-defense. Similarly, nightmares may be accompanied by behaviors related to a specific traumatic event. Companions will report that the patient thrashes, screams, or makes verbal references during a nightmare as he or she appears to relive aspects of the trauma. Profuse sweating and autonomic arousal may accompany nightmares that can be so disturbing that the victim dreads going back to sleep for fear of having another nightmare.

Traumatic memories are often recalled with extreme clarity and perceived as highly accurate. Such an experience is described by Oliver Lyttelton, a WW I veteran.[3]

> Fear and its milder brothers, dread and anticipation, first soften the tablets of memory, so that impressions which they bring are clearly and deeply cut, and when time cools them off the impressions are fixed like the grooves of a gramophone record, and remain with you as long as your faculties. I have been surprised how accurate my memory has proved about times and places where I was frightened.

Although it is often assumed by patient and clinician that the content of the re-experiencing phenomena reflects events as they actually happened, this is not easily demonstrated. However, as will be discussed later in Eyewitness Memory, one's confidence in a memory does not always correspond to its accuracy. Indeed the vividness of traumatic memories and the intensity of the accompanying arousal that makes them seem indelible and immutable may also contribute to the process whereby remembered events are misinterpreted as current reality. Very commonly patients report "I remem-

ber it like it was yesterday," suggesting a loss of distinction between the recent and the remote past. Sometimes the temporal boundary is lost altogether; the experience and the memory seem one and the same. For example Vietnam veterans with PTSD frequently say "For a minute I was back in Nam." In this instance it is as if internally-generated images of remote events are briefly perceived as external events happening in the here and now. The reliving and re-experiencing symptoms, though derived from seemingly indelible and immutable traumatic memories, may arise from a blurring of the distinction between an accurate memory and an emotionally evocative image related to traumatization.

Avoidance and Emotional Numbing

The *cluster C* symptoms of PTSD are defined by the persistent avoidance of stimuli associated with the trauma and a numbing of general responsiveness which was not present before the trauma. Several of the individual symptoms of this cluster are specific to having been traumatized: (*1*) efforts to avoid thoughts, feelings, or conversations associated with the trauma, (*2*) efforts to avoid activities, places, or people which arouse recollections of the trauma, and (*3*) an inability to remember an important aspect of the trauma. The last was formerly called "psychogenic amnesia."

At first glance, it appears paradoxical that an individual would be distressed by both repeatedly remembering an event and by forgetting important aspects of it. The "amnesia" associated with PTSD causes distress because the patient is aware that he or she has lost information. In this sense, the "amnesia" is partial and differs from classic accounts in which the patient is unaware that information has been forgotten. The "amnesia" associated with PTSD may be the result of several processes. If some aspects of the trauma were never encoded, then the memory was always incomplete and the amnesia represents a gap. A failure to encode could result from selective attentional processing. During states of extreme arousal the most salient details are preferentially attended to (a process that will be described in more detail in Naturalistic Studies in Nonclinical Samples). If this process occurs at the time of the trauma the resulting memory may be fragmented. Psychogenic amnesia may also involve the active suppression or repression of memories that are too painful to think about. This explanation is in keeping with the mechanism posited for the other "avoidant" symptoms, that is, that the individual engages in behavioral or cognitive efforts to avoid remembering the trauma. Another possibility is that traumatic memories are processed in the same ways as other memories and the inability to remember aspects of the trauma is a result of "normal forgetting." The persistence of some memories and loss of others may result from a differential rate of decay. That PTSD patients complain both of excessive forgetting and remembering suggests that it is not only the memory but the distortion of memory and the inability to control it which are distressing for trauma survivors.

Behavioral and cognitive avoidance allows survivors to partially regulate their affect

and adapt to having been traumatized. For example, survivors of assault may make elaborate efforts to avoid places reminiscent of the assault. Combat veterans may avoid war movies and war memorials. Vietnam veterans may strenuously avoid areas where they are likely to encounter Asians for fear of being reminded of "the enemy." Avoidant symptoms also can interfere with treatment-seeking, as some survivors fear discussing and being reminded of their traumatic experiences. Avoidance also can extend beyond obvious reminders of the trauma, and into a more generalized withdrawal from intimate contacts and meaningful activity. This expansion of avoidance beyond obvious reminders of the trauma is captured by the remaining symptoms in *cluster C:* markedly diminished interest or participation in significant activities, feeling of detachment or estrangement from others, restricted range of affect, and a sense of a foreshortened future. Although avoidant symptoms may seem adaptive in the short-term, if they progress and persist, significant social and functional impairment ensues. In the most severe cases, the person detaches from work, family, and friends, believing, it seems, that this will keep him or her out of harm's way. Instead they are often angry and isolated, living a highly restricted existence, consumed by the past.

Hyperarousal

Unlike the cluster B or C symptoms, none of the *cluster D* symptoms, the hyperarousal symptoms, are specific to having been traumatized, although reminders of the trauma may provoke or exacerbate them. They hyperarousal symptoms include difficulty falling or staying asleep, irritability or outbursts of anger, difficulty concentrating, hypervigilance, and exaggerated startle response.

The symptoms of increased arousal may be viewed as indirectly related to memory for traumatic events. Immediately preceding and during the event, traumatized individuals generally report feeling alert, aroused, terrified, and in many cases, overwhelmed. After the trauma they often find themselves in a chronic state of arousal. For example, combat veterans frequently talk of sleeping with "one eye open" or constantly scanning the environment for possible dangers. Many report chronically feeling "on guard" even when no apparent threat exists. Some individuals routinely find themselves sitting with their back to the wall and avoiding crowds where it is not possible to monitor innumerable potential sources of threat. To protect themselves and their families, they may establish rituals related to safety, such as multiple nightly checks of locks in their home. They are easily startled by loud or unexpected noises. The Fourth of July, with its explosion of fireworks, is known to be an especially unpleasant holiday for combat veterans who often search in vain for safe, quiet havens.

Poor sleep, hypervigilance, and exaggerated startle do not exclusively accompany or follow specific memories of a past trauma; for some, these symptoms are present much of the time. The individual chronically appears to be living with a "memory" of threat or danger that persists often outside of the individual's conscious awareness. The mind

and body seem to respond as if a threat or danger is still present even years after having survived. Thus, following a severe trauma, some individuals subjectively begin to view the world as a consistently dangerous and unpreditable place.

Eyewitness Memory

As just described, trauma survivors can be overwhelmed by both repetitive intrusive recollections and a distressing inability to remember some details of a trauma. In order to fully understand how traumatic memories are processed, it is useful to know exactly what transpired. However, attempts to know for certain what happened during a traumatic event or any life event will be hampered by the imperfection of memory itself. These limitations are delineated in *The Drowned and the Saved* by Primo Levi[4]—writer, chemist, and survivor of Auschwitz.

> The memories which lie within us are not carved in stone; not only do they tend to become erased as the years go by, but often they change, or even grow, by incorporating extraneous features. Judges know this very well: almost never do two eyewitnesses of the same event describe it in the same way and with the same words, even if the event is recent and if neither of them has a personal interest in distorting it. This scant reliability of our memories will be satisfactorily explained only when we know in what language, in what alphabet they are written, on what surface, and with what pen: to this day we are still far from this goal. (p. 23)

This "scant reliability" of memory is an inherent obstacle in the evaluation of traumatic memories as well as a subject of study itself. The effect of emotion and arousal on the reliability of memory is germane to the study of eyewitness memory and traumatic memory. The literature on emotion and memory will be reviewed in detail elsewhere in this volume; however, experimental and naturalistic studies relevant to the fate of traumatic memories will be reviewed below.

Experimental Studies

Laboratory-based studies have attempted to delineate the effects of emotion and arousal on the accuracy of memory. An important direction of research on emotion and memory began with Easterbrook's hypothesis that arousal leads to a "narrowing of attention."[5] One methodologic approach has been to compare the memories of two groups of witnesses who watch scenes that are identical, with the exception that arousing or violent elements have been incorporated into one of the conditions. Using this approach, several studies have found that arousal decreases the overall accuracy of memories. In one study, subjects watched a film of a bank robbery. The two versions of the film were identical except that the ending of one was violent. The group that

watched the violent version had poorer memory for the film than the group that watched the neutral version. Importantly, the differences in memory concerned details occurring early in the scene, details that were identical in both versions.[6] In a separate study, the accuracy of subjects' testimony after viewing a videotape of a mugging was assessed. Those who watched the violent version had less accurate recall than those who watched the nonviolent version.[7] In addition to accuracy, the subjects' confidence in their own testimony was measured. In the group that viewed the nonviolent version, confidence was related to accuracy for details, such as identification of the perpetrator. However, for those who watched the violent version, there was no significant relationship between confidence and accuracy. Other investigators also have reported a lack of relationship between accuracy and confidence in memory recall.[8,9] In one study an inverse relationship was found; that is, the more confident the subject, the less likely he or she was to have accurate recall.[10]

The above laboratory studies suggest that arousal may decrease the accuracy of detailed memory over even a short retention interval. But is this effect of arousal general or selective? It is possible that reduced accuracy for some details is the price paid for increased attention to others. This possibility is suggested by the phenomena of "weapon focussing"; some victims can provide elaborate detail for critical aspects of the trauma, such as the weapon used, but little detail for other aspects. Several studies provide empiric evidence for weapon focussing. In one study, eye movements were monitored while subjects watched one of two versions of a videotaped bank scene. The duration and number of eye fixations were greater for a gun pointed at a cashier than for the comparison item, a check, in the neutral version. In addition to focussing on the weapon, upon subsequent testing, subjects in the weapon condition had poorer memory for the overall scene than did those in the neutral condition.[11] In a similar study, subjects were exposed to a staged scene; and while the event was staged, a fear-arousing stimulus, a syringe carried by an assistant, was introduced. The subjects in the emotionally arousing scene could provide significant details about the syringe, but compared with those who witnessed the neutral version of the scene, they were less able to recognize the assistant in a lineup.[12] These studies suggest that attention to central details is heightened in arousing situations, perhaps at the cost of attention to peripheral details. If this process operates at the time of a trauma, it may underlie the fragmentation of memories, during which some aspects are overremembered and other aspects seem inexplicably inaccessible.

Naturalistic Studies in Nonclinical Samples

It is not clear whether the results of laboratory simulation studies can be generalized to real-life events or traumas. Although the laboratory studies may induce physiological arousal, this is only one aspect of the emotional response to trauma, which commonly includes terror and helplessness and may cause marked dissociation. However, these

studies do provide an important framework for understanding naturalistic studies of memory for violence or trauma. There are many methodological difficulties in attempting to examine the accuracy of eyewitness memory in naturalistic settings where the precise details of an event cannot be known. One approach has been to collect information from multiple witnesses and compare individual accounts to the composite account. Another approach is to study what happens to eyewitness memories over time by comparing recall after the event to delayed recall of the event. Such an approach does not measure the accuracy of memories, but rather, their stability over time.

One of the first naturalistic studies of eyewitness memory described the types of details crime victims provide to police about their assailants.[13] Included among the subjects were two homicide victims who provided reports before they died. The completeness of the memories rather than their accuracy was addressed by this study. With respect to the type of details remembered, the majority could recall physical characteristics that defined the perpetrator, such as sex, build, complexion, age; they were less likely to recall details like hair or eye color. Crime reports were also compared as a function of the type of crime and the degree of injury. Robbery victims provided more detail than survivors of rape or assault. Uninjured victims provided more information than injured victims. To the extent that a crime report is a measure of memory for a trauma, these findings that victims of more serious crimes could provide less information are consistent with the notion that trauma interferes with the formation of detailed memories.

In another naturalistic study the recall of 13 eyewitnesses of a crime was studied in which a store was robbed, the owner wounded and the thief murdered.[14] The initial accounts given to the police, both free accounts and responses to questions, were recorded verbatim and compared to interviews conducted for research purposes 4–5 months later. Overall, the accuracy for details central to the crime was high. There was little decay in memory over the interval, except for memory of colors, and for some witnesses, estimates of age and height. To assess the effect of arousal on recall, self-reports of stress at the time of the crime were obtained. Witnesses with the highest levels of reported stress had an average accuracy of 93% for detail at the initial report and 88% at follow-up, rates which were slightly higher than those who did not report being stressed. Consistent with their self-reports, the stressed group, but not the other group, was symptomatic immediately after the event and had difficulty sleeping. The results suggest that emotional stress does not have a deleterious effect on recall. In fact, it may have enhanced recall. However, interpretation of the effect of traumatic stress on memory is confounded by the fact that those who were most stressed also had greater direct involvement in the incident. In a similar study, witnesses to a post office robbery, both victims and bystanders, were interviewed by researchers after a delay of between 4 and 15 months. The consistency of initial and later reports was high for details central to the crime (e.g., clothing, the weapon), but was not as good for details surrounding the event. Accuracy was higher for victims than for bystanders. The enhanced accuracy of the victims cannot be clearly attributed to the effect of stress, however, as the victims' self-reported ratings of stress were no greater than those of the bystanders. Therefore, while both studies found that those more closely involved in a crime have more accurate memory than bystanders, it is not clear that this enhancement is due to stress and arousal per se, as opposed to other factors, such as proximity.

The studies cited above measured the accuracy and consistency of traumatic memories over relatively short periods of time. Few naturalistic studies have assessed the fate of traumatic memories over vey long periods of time. The occasion to do so arose when a case against DeRijke, a Kapo accused of Nazi crimes in a Dutch prison, was reopened in 1984 and the veracity of eyewitness accounts some 40 years after the fact was called into question.[15] Data was collected from 72 surviving witnesses of the Dutch prison, some of whom had initially provided testimony between 1942 and 1947 after leaving the prison. On the whole, witnesses agreed about basic facts and provided complementary accounts of the types of punishments and brutalities suffered in the prison. Although the majority remembered DeRijke, several survivors didn't recognize a picture of him or recall his name, despite evidence that they had been repeatedly tortured by him. By comparing accounts provided decades apart, this study investigated not only the fate of memories of what had been routine violence for these survivors but also memory of unique traumatic events. Several witnesses forgot unique details. One recalled witnessing a murder but misattributed the murder to the victim rather than the perpetrator. Two had forgotten about murders they had previously reported witnessing. One of the two, when confronted with the inconsistency, denied having ever made the report. This naturalistic study demonstrates that on the whole, traumatic memories can be accurate and stable over very long retention intervals. However, the notable exceptions demonstrate that even the most horrific of experiences are not immune to forgetting or distortion.

Eyewitness Memory and PTSD

Several questions arise about whether the fate of traumatic memories differs in those with PTSD from other trauma survivors. One question is whether patients with PTSD are more likely to remember details of their trauma. A second question is whether the memories are more likely to be accurate or distorted. And if they are distorted, is it in a way that magnifies or minimizes the trauma?

There has been little overlap between the eyewitness memory literature and the PTSD literature. Only recently have studies begun to systematically examine the question of whether PTSD affects the accuracy of memories and if so, how. The first was a longitudinal study of Australian firefighters exposed to devastating brush fires. Recall of the event was recorded 4 months after exposure and again at 11 months.[16] A major difference in the retrospective recall of the traumatic event was found between those who did develop PTSD and those who did not. Among those with chronic PTSD, recall of personal injury did not change during this interval. In sharp contrast, among those

without PTSD, only 43% (13 of 30) of those who had reported injuries at 4 months reported them when asked again at 11 months. The significant reduction of reporting of exposure to disaster in the group without PTSD suggests that traumatic memories are better retained or more accessible in those with PTSD. A limitation of this study is the absence of information at a time point earlier than 4 months. However, if symptoms are related to recall, this raises the question of whether survivors are "better off" not remembering their traumatic events. It may be that decreased accessibility to or retention of painful memories has a protective effect which fosters adaptation. A provocative study of dream recall is consistent with this possibility. Dream recall was measured in a sleep laboratory in Holocaust survivors and controls who had not been traumatized. It was found that well-adapted Holocaust survivors had decreased dream recall compared with both controls and poorly adapted survivors.[17] Dream recall is not directly comparable to conscious recollection, but to the extent that positive adaptation is associated with forgetting; this compels us to reexamine the nature of psychogenic amnesia. The study of firefighters suggests that amnesia may actually be greater in those who do not go on to develop PTSD. This provides further support to the notion that the symptom of psychogenic amnesia in PTSD may be less about forgetting than about the distress forgetting causes. That aspects of the trauma have been forgotten may simply be highlighted in PTSD patients who feel besieged by so many other remembered aspects of the trauma.

In another study of PTSD and eyewitness memory, witnesses to a shooting were questioned at two points in time following the event.[18] All subjects changed their report of the events in some way. However, those who developed PTSD symptoms tended to have distortions which magnified their perceptions of and emotional reactions to the shooting, including their assessment of the potential threat to life. In another study, the self-reported combat exposure of Desert Storm veterans was measured 1 month and then again 2 years after returning from the war. There were many instances of inconsistent recall for events that were highly traumatic and objective in nature. Further, with an increase in trauma-related symptoms over time, there tended to be an amplification of memory for traumatic events.[19] Thus both studies suggest that PTSD patients may be more likely to distort memories of the traumatic event in a malignant direction.

These studies raise the question of what effect symptoms, such as frequent re-evocations, have on the accuracy of the memory for the inciting event. Within the limitations of the small number of naturalistic studies cited above, it may be that posttraumatic stress disorder increases the likelihood that a survivor recalls having been traumatized but at the same time increases the likelihood that the memories become distorted. Much evidence suggests that for a given memory there are multiple individual components which are stored separately and activated simultaneously. This is in contrast to a model in which memories are relatively fixed and are either retrieved intact or not retrieved at all. Different elements may be evoked at different times; extraneous material may be evoked as well and incorporated into the memory. The replaying of traumatic memories may strengthen the memory, while the sheer number of repetitions

may simultaneously increase the likelihood extraneous elements become incorporated. If such a process occurs, it is conceivable that PTSD patients, victims of trauma and their memories, could come to perceive themselves as victims of traumas even more horrific than those initially sustained.

Memory and PTSD: Neuropsychological Findings

Memory for Traumatic Stimuli

The nature of traumatic memories has been discussed above. Given that there are differences among traumatic memories in PTSD and non-PTSD survivors, it is reasonable to examine whether the differences can be accounted for by neuropsychological abnormalities. The neuropsychological studies that have examined this question can be broadly grouped into two categories: those that use trauma-related stimuli and those that use neutral stimuli.

A series of experiments has clearly demonstrated that patients with PTSD process information relevant to their trauma differently from other types of information by using a modified version of the Stroop Word–Color Interference Task. To understand the significance of these findings it is first necessary to understand the original experiments conducted by Stroop in 1935 and the ways in which the task has been modified (for a review, see MacLeod 1991).[20]

The stimuli used in the original experiments by Stroop were five words and their matching ink colors: *red, blue, green, brown* and *purple*. The stimulus cards were designed so that the words were printed in incongruent colors (for example, the word *yellow* printed in red ink). In the first part of the study, subjects were asked to read the words aloud. In the second part they were asked to *name the ink color* of the printed words. The subjects did not take any longer to read the words printed in incongruent colors than to read words printed in black ink; they did take longer to name the color of the incongruent words than to name the color of solid-color squares. The interference from the incongruent words on color-naming is called *Stroop interference*.[20]

There is an extensive body of research exploring Stroop interference. Delays in color-naming are thought to be caused by interference from words that stimulate involuntary semantic activation, and distract the subject from the task.[20] Studies examining whether the meaning of the printed word (i.e., the "irrelevant" verbal stimuli) affects interference have shown that color-related words and words with great emotional meaning are particularly likely to interfere with color-naming.[20]

The Stroop Interference Test has been used to test the hypothesis that subjects with PTSD have an attentional bias toward traumatic stimuli. The first of these studies was conducted on rape victims with PTSD, whose responses were compared with those of rape victims without PTSD and nontraumatized comparison subjects.[21] The color-naming latency (the time between stimulus presentation and the color-naming response)

was recorded for words of four different categories: (*1*) trauma-specific threat words (e.g., *assault, attack, V.D.*), (*2*) general threat words (e.g., *coffin, death, tumor*), (*3*) neutral words, and (*4*) nonwords. Rape victims with PTSD took significantly longer to color-name threat-specific words from the other three categories. Neither the rape victims without PTSD nor the nontraumatized comparison group differed in their response latencies to the four categories of words. Similarly, in a separate study, rape victims with PTSD, but not those without PTSD or nontraumatized controls, took longer to color-name highly threatening words (e.g., *rape*) compared with moderately threatening (e.g., *crime*), positive, or neutral words.[22] The interference from highly threatening words correlated with intrusive symptoms, but not with avoidant symptoms of PTSD, which suggests that the information-processing abnormality responsible for the Stroop interference may underlie the mechanisms of intrusive thoughts.

That trauma-related words cause Stroop interference in PTSD patients has also been demonstrated in combat veterans.[23,24] Vietnam veterans with PTSD and Vietnam veterans without PTSD were asked to color-name words from four different categories, one of which were trauma-related words (e.g., *bodybags, firefight*).[23] Veterans with PTSD, but not the controls, showed Stroop interference for the combat-related words; the groups did not differ in the color-naming latency to the other three word categories. Interference did not correlate with severity of combat exposure but did correlate with severity of PTSD symptoms, which suggests that interference is related to PTSD rather than to trauma per se.

The consistency of these results highlights several points. In all of the above studies, Stroop test results differed between trauma survivors with PTSD and those without PTSD. This suggests that selective processing is a feature of the disorder itself, rather than a nonspecific sequelae of trauma per se. Supporting this notion is the finding that interference is not associated with the severity of trauma, but rather with the degree of PTSD symptomatology.[22,23] The interference was found in groups of PTSD subjects whose traumas differed in type, severity, and duration. These results show that PTSD patients have a specific bias in information-processing for traumatic stimuli. Rapid completion of the color-naming task involves ignoring the "irrelevant verbal stimuli." For subjects with PTSD, when the irrelevant verbal stimulus is also a reminder of their trauma, it is difficult to ignore. The interference from trauma-related stimuli parallels the experience of intrusive cognition in PTSD patients who are easily stimulated by trauma-related cues. It has been hypothesized that traumatic memories are more accessible to conscious recall in patients with PTSD than in other control populations. The Stroop findings are consistent with the notion that traumatic memories are stored in a primed or partially activated state in PTSD patients, which may account for their involuntary intrusion into awareness and their rapid activation in the presence of reminders.[24]

Another information-processing study raised the question of whether PTSD subjects have not only enhanced memory for trauma-related stimuli but also diminished recall for stimuli unrelated to trauma. Subjects were presented with four different types of words: combat words, positive words, neutral words, and social threat words.[25] For the cued-recall portion of the test, subjects were asked to complete three-letter word stems with the missing letters from words that had previously been presented. Both PTSD patients and controls recalled more combat words than other categories of words. To test for a relative bias toward recall of combat words, the number of neutral words recalled was subtracted from the number of words recalled in each of the three other categories (positive, combat, social threat). The PTSD patients remembered more combat words relative to neutral words than did veterans without PTSD. In other words, they showed a relative but not an absolute bias for remembering trauma-related words. As noted by the authors, a relative bias can result from a bias toward remembering trauma words, a bias against remembering neutral or positive words, or both. The results of this study suggest that there may be a bidirectional alteration in memory with enhanced memory for trauma and decreased memory for other stimuli. Data presented in the next section provides some supportive evidence for a deficit in declarative memory for nontraumatic material.

The cued-recall task discussed above tests explicit memory or conscious memory. However, traumatized patients may continue to "remember" the trauma in unconscious ways, such as through reenactment or hypervigilance. Therefore, implicit memory for trauma—that is, memory which does not require intentional recollection of the event—was tested as well. Implicit memory was tested by asking subjects to complete three-letter word stems with the first word that comes to mind. PTSD subjects, but not controls, were more likely to complete the stems with combat words than with the other categories of words, confirming that PTSD patients exhibit an implicit memory bias for combat words as well.[25]

At a minimum, these data supplement the clinical impression and other empiric data that traumatic material is represented differently in PTSD patients. Importantly, the bias toward trauma-related material was demonstrated not only for conscious memory but also for unconscious memory. As such, these studies have delineated information-processing abnormalities that may help to explain some of the phenomena of PTSD, such as intrusive thoughts or nightmares. Furthermore the data raise the question of whether the heightened memory for trauma occurs against a background of impaired memory for neutral material, a question which will be further explored below.

Memory for Nontraumatic Stimuli

Several recent studies have demonstrated cognitive impairments in individuals with PTSD that are unrelated to traumatic material. One of the first studies that used formal neuropsychological testing to study traumatized veterans was conducted with WW II veterans some 40 years after the war. Compared to combat veterans, former POWs had impairments in multiple subsets of the Wechsler Adult Intelligence Scale-Revised and the Wechsler Memory Scale.[26] This was an important study in demonstrating the

magnitude of cognitive impairment in POWs. The POWs had been exposed to more severe and sustained psychological trauma than the combat veterans and the POWs had a significantly higher rate of PTSD, which raises the question of whether trauma or its sequelae cause cognitive decline. However, the POW group was also more likely to have had head trauma or malnutrition, which likely contributed to the differences. Subsequent studies have attempted to tease apart these factors.

In one study, Vietnam combat veterans with PTSD were found to have significant short- and long-term memory deficits on standard neuropsychological testing as compared with normal controls.[27] The PTSD patients had poorer immediate and delayed recall on the verbal component of the Wechsler Memory Scale and poorer scores on the Selective Reminding Test (they scored lower on all subcomponents of the test, including total recall, long-term retrieval, long-term storage, and consistent long-term retrieval). Importantly, the groups did not differ in important variables that could affect performance, namely, number of years of substance abuse, education, IQ, and not having significant head trauma. This study suggests not only that there may be deficits in memory and attention for nontraumatic stimuli, but also that the deficits may be diffuse and occur at multiple levels of information processing.

Another important question about the cognitive deficits seen in PTSD is whether they are unique or are comparable to the deficits seen in other psychiatric patients. To examine this question Gil et al. compared PTSD patients with a comparison psychiatric group and a normal control group. Twelve Israeli PTSD patients were studied who had been exposed to a range of traumas, including terrorist attacks, car accidents, and attacks while in the army.[28] No significant differences were found between PTSD patients and other psychiatric patients with affective or anxiety disorders who had a similar degree of psychopathology as the PTSD patients, and no history of trauma. The patient groups were balanced in terms of demographics, IQ, and subjective complaints of poor concentration, and they did not differ in any array of verbal and nonverbal memory tests and attention tests. Therefore, while the PTSD patients' performance was impaired, it was comparable in nature and magnitude to that of other nonpsychotic patients.

In contrast, multiple cognitive abnormalities were found in the PTSD group, compared with the normal controls. Importantly, though, the PTSD patients had a significantly lower IQ than the control group (88.1 ± 11.4 vs. 108.1 ± 8.8), which the authors suggest represents a decline from their baseline. Given such a discrepancy in IQ it is unclear whether the diffuse impairments in memory and attention reflect a mismatching of patients and controls or are so significant as to lead to intellectual decline. If the findings represent a true intellectual decline, this is especially remarkable, since patients with identifiable risk factors for organic deficits were excluded (head trauma, alcohol or substance abuse, psychosurgery, electroconvulsive therapy).

In contrast, there are some studies which do not provide support for cognitive impairments. For example, in one study, Vietnam veterans with PTSD (N = 22) completed a full neuropsychological battery as part of routine inpatient care and the

results were compared to age-scaled norms.[29] On the whole, the group performed in the average range. They did not differ from established norms on the Trail-Making Test, the Serial Digit Learning Test, the Temporal Orientation Test, and the Stroop Color and Word Test. On the Wechsler Adult Intelligence Scale (WAIS) they performed less well on the Digit Span and the Digit Symbol Tests, tests that are susceptible to the effects of anxiety. In another study of Vietnam veterans, neuropsychological testing was performed in tandem with neurological soft signs and EEGs.[30] Medication-free combat veterans with posttraumatic stress disorder were compared to non-PTSD combat controls. The veterans were compared on the Wechsler Memory Scale, the Denman Memory test, the Trail-Making test, the Wisconsin Card Sorting Test, and the Wechsler Adult Intelligence Scale. The PTSD and non-PTSD groups did not differ on these neuropsychological tests. The lack of difference is particularly striking since the PTSD group had more neurological soft-sign abnormalities. In another study of Vietnam veterans with PTSD, multiple cognitive deficits were not found, but circumscribed deficits were.[31] Combat veterans with PTSD were compared with normal controls of equivalent IQ and education. The groups did not differ in initial attention, immediate memory, or cumulative learning on the California Verbal Learning Test, a test of multiserial learning. However, the PTSD patients exhibited a significant amount of retroactive interference; that is, shortly after learning new material they were less able to recall previously learned information. This deficit persisted, thereby decreasing long-term recall of the same previously learned material.

Overall, then, the existing literature provides consistent evidence for information-processing abnormalities involving traumatic material and provocative but inconsistent evidence for abnormalities of neutral material in patients with PTSD. Furthermore, because the above studies were conducted many years after the identified trauma, it is not clear which factors account for the findings. Additional research is clearly needed to better characterize the extent, nature, and course of the deficits.

Potential etiologies for information-processing abnormalities are as diverse as the biological and psychological theories that have been proposed to explain the emergence of PTSD following traumatization. Information regarding the onset of the abnormalities and their course may help elucidate whether the etiologic factors are pretraumatic, peritraumatic, or posttraumatic. Pretraumatic factors could include both preexisting cognitive deficits or predisposing neuropsychological sensitivities. Individuals may have circumscribed or global cognitive deficits prior to being traumatized. When cognitive testing is performed years later, after the trauma, the detected abnormality in information processing would then likely reflect these preexisting deficits as well as both peri- and posttraumatic factors. Clearly, additional prospective studies of at-risk populations (e.g., soldiers, police, firefighters) are needed to determine whether pretraumatic differences in factors such as attention, memory, arousal, cognitive function, hypnotizability, anxiety, or capacity to form images might predict who does and who does not develop PTSD and memory disturbances following trauma.

There are also peritraumatic factors that could affect memory function. The most

obvious source for later deficits is the physical trauma that may accompany psychological trauma. Head trauma, malnutrition, hypoxia, and infectious diseases can all have long-term sequelae. Severe stress and psychological trauma itself also cause a whole host of biological changes in the peritraumatic period. There are multiple possible psychic responses to trauma, such as dissociation and denial, which can affect traumatic memory. Fear-conditioning and other learning experiences may contribute to changes in learning and memory. Posttraumatic factors include a multitude of biological abnormalities that have been described in PTSD in the sympathetic nervous system and the hypothalamic pituitary axis, as well as the development of comorbid conditions, such as substance abuse or depression.

Conclusion

In summary, alterations in memory are at the very core of posttraumatic stress disorder. The memory alterations are numerous and diverse. Patients experience these abnormalities through re-experiencing and reliving the trauma, forgetting some aspects of the trauma, being intensely distressed by reminders of the trauma, and having difficulty concentrating. Importantly, the memory alterations seen in PTSD are not seen in all trauma survivors. Patients with PTSD differ from other trauma survivors in their recall of the traumatic event, in the ways in which memory for the event is altered, and in the ways they continue to process information related to victimization. The extent of these memory alterations remains to be elucidated, as there is evidence that a broad range of cognitive functions may be affected. This discussion highlights the profound and myriad effects that severe trauma can exert on memory years after the inciting event. Given the differences between PTSD and non-PTSD survivors, however, the abnormalities seen in PTSD should not be considered synonymous with the effect of trauma on memory. Further research on the onset, course, and magnitude of the memory and attention impairments in PTSD have important implications for understanding the pathophysiology of this frequently disabling disorder.

References

1. Diagnostic and Statistical Manual of Mental Disorders, 4th Ed. (DSM-IV). Washington, DC: American Psychiatric Association, 1994.
2. Herr M: Dispatches. New York: Knopf, 1977.
3. Lyttelton O: From peace to war: A study in contrasts. *In* Fussell P, The Great War in Modern Memory. New York and London: Oxford University Press, 1975, p. 191.
4. Levi P: The Drowned and the Saved. New York: Summit Books, 1988.
5. Easterbrook JA: The effect of emotion on cue utilization and the organization of behavior. Psychol Rev 1959; 66:183–201.

6. Loftus E, Burns T: Mental shock can produce retrograde amnesia. Memory Cogn 1982; 10:318–323.
7. Clifford B, Hollin C: Effects of the type of incident and the number of perpetrators on eyewitness memory. J Appl Psychol 1981; 66:364–370.
8. Clifford B, Scott J: Individual and situational factors in eyewitness identification. J Appl Psychol 1978; 63:352–359.
9. Yarmey AD: The Psychology of Eyewitness Memory. New York: Free Press, 1979.
10. Loftus E: Eyewitness Testimony. Cambridge, MA: Harvard University Press, 1979.
11. Loftus E, Loftus G, Messo J: Some facts about "weapon focus." Law Hum Behav 1987; 11:55–62.
12. Kramer T, Buckhout R, Eugenio P: Weapon focus, arousal and eyewitness memory: attention must be paid. Law Hum Behav 1990; 14:167–184.
13. Kuehn L: Looking down a gun barrel: person perception and violent crime. Percept Motor Skills 1974; 39:1156–1164.
14. Yuille JC, Cutshall JL: A case study of eyewitness memory for a crime. J Appl Psychol 1986; 71:291–301.
15. Wagenaar WA, Groeneweg J: The memory of concentration camp survivors. Appl Cogn Psychol 1990; 4:77–87.
16. McFarlane AC: The longitudinal course of posttraumatic morbidity: the range of outcomes and their predictors. J Nerv Ment Dis 1988; 176:30–39.
17. Kaminer J, Lavie P: Sleep and dreaming in Holocaust survivors: dramatic decrease in dream recall in well-adjusted survivors. J Nerv Ment Dis 1991; 179:664–669.
18. Schwarz ED, Kowalski JM, McNally RJ: Malignant memories: post-traumatic changes in memory in adults after a school shooting. J Traumatic Stress 1993; 6:545–553.
19. Southwick SM, Morgan CA, Nicolaou AI, Charney DS: Consistency of memory for traumatic events. 1996, manuscript.
20. MacLeod CM: Half a century of research on the Stroop effect: an integrative review. Psychol Bull 1991; 109:163–203.
21. Foa EB, Feske U, Murdock TB, Kozak MJ, McCarthy PR: Processing of threat-related information in rape victims. J Abnorm Psychol 1991; 100:156–162.
22. Cassiday KL, McNally RJ, Zeitlin SB: Cognitive processing of trauma cues in rape victims with post-traumatic stress disorder. Cogn Ther Res 1992; 16:283–295.
23. McNally RJ, English GE, Lipke HJ: Assessment of intrusive cognition in PTSD: use of the modified Stroop paradigm. J Traumatic Stress 1993; 6:33–38.
24. McNally RJ, Kaspi SP, Riemann BC, Zeitlin SB: Selective processing of threat cues in posttraumatic stress disorder. J Abnorm Psychol 1990; 99:398–402.
25. Zeitlin SB, McNally RJ: Implicit and explicit memory bias for threat in post-traumatic stress disorder. Behav Res Ther 1991; 29:451–457.
26. Sutker PB, Winstead DK, Galina ZH, Allain AN: Cognitive deficits and psychopathology among former prisoners of war and combat veterans of the Korean conflict. Am J Psychiatry 1991; 148:67–72.
27. Bremner JD, Scott TM, Delaney RC, Southwick SM, Mason JW, Johnson DR, Innis RB, McCarthy G, Charney DS: Deficits in short-term memory in posttraumatic stress disorder. Am J Psychiatry 1993; 150:1015–1019.
28. Gil T, Calec A, Greenberg D, et al: Cognitive functioning in posttraumatic stress disorder. J Traumatic Stress 1990; 1:29–45.
29. Dalton JE, Pederson SL, Blom BE, Besyner: Neuropsychological screening for Vietnam veterans with PTSD. VA Practitioner 1986; 3:37–47.

30. Gurvits TV, Lasko NB, Schachter SC, Kuhne AA, Orr SP, Pitman RK: Neurological status of Vietnam veterans with chronic posttraumatic stress disorder. J Neuropsychiatry Clin Neurosci 1993; 5:183–188.
31. Yehuda R, Keefe RSE, Harvey PD, Levengood RA, Gerber DK, Geni J, Siever LJ: Learning and memory in combat veterans with posttraumatic stress disorder. Am J Psychiatry 1995; 152:137–139.