and the shakes, you may have flashbacks. In people who hypersecrete CRF, the startle response is overactive. For example, if you sneak up behind most people and suddenly clap your hands, you'll see a startled jump the first time, but not by the third or fourth repetition. But people with too much CRF don't habituate: they'll respond as much to the fourth clap as to the first."[11]

A third set of changes occurs in the brain's opioid system, which secretes endorphins to blunt the feeling of pain. It also becomes hyperactive. This neural circuit again involves the amygdala, this time in concert with a region in the cerebral cortex. The opioids are brain chemicals that are powerful numbing agents, like opium and other narcotics that are chemical cousins. When experiencing high levels of opioids ("the brain's own morphine"), people have a heightened tolerance for pain—an effect that has been noted by battlefield surgeons, who found severely wounded soldiers needed lower doses of narcotics to handle their pain than did civilians with far less serious injuries.

Something similar seems to occur in PTSD.[12] Endorphin changes add a new dimension to the neural mix triggered by reexposure to trauma: a *numbing* of certain feelings. This appears to explain a set of "negative" psychological symptoms long noted in PTSD: anhedonia (the inability to feel pleasure) and a general emotional numbness, a sense of being cut off from life or from concern about others' feelings. Those close to such people may experience this indifference as a lack of empathy. Another possible effect may be dissociation, including the inability to remember crucial minutes, hours, or even days of the traumatic event.

The neural changes of PTSD also seem to make a person more susceptible to further traumatizing. A number of studies with animals have found that when they were exposed even to *mild* stress when young, they were far more vulnerable than unstressed animals to trauma-induced brain changes later in life (suggesting the urgent need to treat children with PTSD). This seems a reason that, exposed to the same catastrophe, one person goes on to develop PTSD and another does not: the amygdala is primed to find danger, and when life presents it once again with real danger, its alarm rises to a higher pitch.

All these neural changes offer short-term advantages for dealing with the grim and dire emergencies that prompt them. Under duress, it is adaptive to be highly vigilant, aroused, ready for anything,

impervious to pain, the body primed for sustained physical demands, and—for the moment—indifferent to what might otherwise be intensely disturbing events. These short-term advantages, however, become lasting problems when the brain changes so that they become predispositions, like a car stuck in perpetual high gear. When the amygdala and its connected brain regions take on a new setpoint during a moment of intense trauma, this change in excitability—this heightened readiness to trigger a neural hijacking—means all of life is on the verge of becoming an emergency, and even an innocent moment is susceptible to an explosion of fear run amok.

EMOTIONAL RELEARNING

Such traumatic memories seem to remain as fixtures in brain function because they interfere with subsequent learning—specifically, with relearning a more normal response to those traumatizing events. In acquired fear such as PTSD, the mechanisms of learning and memory have gone awry; again, it is the amygdala that is key among the brain regions involved. But in overcoming the learned fear, the neocortex is critical.

Fear conditioning is the name psychologists use for the process whereby something that is not in the least threatening becomes dreaded as it is associated in someone's mind with something frightening. When such frights are induced in laboratory animals, Charney notes, the fears can last for years.[13] The key region of the brain that learns, retains, and acts on this fearful response is the circuit between the thalamus, amygdala, and prefrontal lobe—the pathway of neural hijacking.

Ordinarily, when someone learns to be frightened by something through fear conditioning, the fear subsides with time. This seems to happen through a natural relearning, as the feared object is encountered again in the absence of anything truly scary. Thus a child who acquires a fear of dogs because of being chased by a snarling German shepherd gradually and naturally loses that fear if, say, she moves next door to someone who owns a friendly shepherd, and spends time playing with the dog.

In PTSD spontaneous relearning fails to occur. Charney proposes that this may be due to the brain changes of PTSD, which are so strong that, in effect, the amygdala hijacking occurs every time

something even vaguely reminiscent of the original trauma comes along, strengthening the fear pathway. This means that there is never a time when what is feared is paired with a feeling of calm—the amygdala never relearns a more mild reaction. "Extinction" of the fear, he observes, "appears to involve an active learning process," which is itself impaired in people with PTSD, "leading to the abnormal persistence of emotional memories."[14]

But given the right experiences, even PTSD can lift; strong emotional memories, and the patterns of thought and reaction that they trigger, *can* change with time. This relearning, Charney proposes, is cortical. The original fear ingrained in the amygdala does not go away completely; rather, the prefrontal cortex actively suppresses the amygdala's command to the rest of the brain to respond with fear.

"The question is, how quickly do you let go of learned fear?" asks Richard Davidson, the University of Wisconsin psychologist who discovered the role of the left prefrontal cortex as a damper on distress. In a laboratory experiment in which people first learned an aversion to a loud noise—a paradigm for learned fear, and a lower-key parallel of PTSD—Davidson found that people who had more activity in the left prefrontal cortex got over the acquired fear more quickly, again suggesting a cortical role in letting go of learned distress.[15]

REEDUCATING THE EMOTIONAL BRAIN

One of the more encouraging findings about PTSD came from a study of Holocaust survivors, about three quarters of whom were found to have active PTSD symptoms even a half century later. The positive finding was that a quarter of the survivors who once had been troubled by such symptoms no longer had them; somehow the natural events of their lives had counteracted the problem. Those who still had the symptoms showed evidence of the catecholamine-related brain changes typical of PTSD—but those who had recovered had no such changes.[16] This finding, and others like it, hold out the promise that the brain changes in PTSD are not indelible, and that people can recover from even the most dire emotional imprinting—in short, that the emotional circuitry can be reeducated. The good news, then, is that traumas as profound as those causing PTSD can heal, and that the route to such healing is through relearning.

One way this emotional healing seems to occur spontaneously—at least in children—is through such games as Purdy. These games, played over and over again, let children relive a trauma safely, as play. This allows two avenues for healing: on the one hand, the memory repeats in a context of low anxiety, desensitizing it and allowing a nontraumatized set of responses to become associated with it. Another route to healing is that, in their minds, children can magically give the tragedy another, better outcome: sometimes in playing Purdy, the children kill him, boosting their sense of mastery over that traumatic moment of helplessness.

Games like Purdy are predictable in younger children who have been through such overwhelming violence. These macabre games in traumatized children were first noted by Dr. Lenore Terr, a child psychiatrist in San Francisco.[17] She found such games among children in Chowchilla, California—just a little over an hour down the Central Valley from Stockton, where Purdy wreaked such havoc—who in 1973 had been kidnapped as they rode a bus home from a summer day camp. The kidnappers buried the bus, children and all, in an ordeal that lasted twenty-seven hours.

Five years later Terr found the kidnapping still being reenacted in the victims' games. Girls, for example, played symbolic kidnapping games with their Barbie dolls. One girl, who had hated the feeling of other children's urine on her skin as they lay huddled together in terror, washed her Barbie over and over again. Another played Traveling Barbie, in which Barbie travels somewhere—it doesn't matter where—and returns safely, which is the point of the game. A third girl's favorite was a scenario in which the doll is stuck in a hole and suffocates.

While adults who have been through overwhelming trauma can suffer a psychic numbing, blocking out memory of or feeling about the catastrophe, children's psyches often handle it differently. They less often become numb to the trauma, Terr believes, because they use fantasy, play, and daydreams to recall and rethink their ordeals. Such voluntary replays of trauma seem to head off the need for damming them up in potent memories that can later burst through as flashbacks. If the trauma is minor, such as going to the dentist for a filling, just once or twice may be enough. But if it's overwhelming, a child needs endless repetitions, replaying the trauma over and over again in a grim, monotonous ritual.

One way to get at the picture frozen in the amygdala is through art,

which itself is a medium of the unconscious. The emotional brain is highly attuned to symbolic meanings and to the mode Freud called the "primary process": the messages of metaphor, story, myth, the arts. This avenue is often used in treating traumatized children. Sometimes art can open the way for children to talk about a moment of horror that they would not dare speak of otherwise.

Spencer Eth, the Los Angeles child psychiatrist who specializes in treating such children, tells of a five-year-old boy who had been kidnapped with his mother by her ex-lover. The man brought them to a motel room, where he ordered the boy to hide under a blanket while he beat the mother to death. The boy was, understandably, reluctant to talk with Eth about the mayhem he had heard and seen while underneath the blanket. So Eth asked him to draw a picture—any picture.

The drawing was of a race-car driver who had a strikingly large pair of eyes, Eth recalls. The huge eyes Eth took to refer to the boy's own daring in peeking at the killer. Such hidden references to the traumatic scene almost always appear in the artwork of traumatized children; Eth has made having such children draw a picture the opening gambit in therapy. The potent memories that preoccupy them intrude in their art just as in their thoughts. Beyond that, the act of drawing is itself therapeutic, beginning the process of mastering the trauma.

EMOTIONAL RELEARNING AND RECOVERY FROM TRAUMA

> Irene had gone on a date that ended in attempted rape. Though she had fought off the attacker, he continued to plague her: harassing her with obscene phone calls, making threats of violence, calling in the middle of the night, stalking her and watching her every move. Once, when she tried to get the police to help, they dismissed her problem as trivial, since "nothing had really happened." By the time she came for therapy Irene had symptoms of PTSD, had given up socializing at all, and felt a prisoner in her own house.

Irene's case is cited by Dr. Judith Lewis Herman, a Harvard psychiatrist whose groundbreaking work outlines the steps to recovery from trauma. Herman sees three stages: attaining a sense of safety, remembering the details of the trauma and mourning the loss it has brought, and finally reestablishing a normal life. There is a biological

logic to the ordering of these steps, as we shall see: this sequence seems to reflect how the emotional brain learns once again that life need not be regarded as an emergency about to happen.

The first step, regaining a sense of safety, presumably translates to finding ways to calm the too-fearful, too easily triggered emotional circuits enough to allow relearning.[18] Often this begins with helping patients understand that their jumpiness and nightmares, hypervigilance and panics, are part of the symptoms of PTSD. This understanding makes the symptoms themselves less frightening.

Another early step is to help patients regain some sense of control over what is happening to them, a direct unlearning of the lesson of helplessness that the trauma itself imparted. Irene, for example, mobilized her friends and family to form a buffer between her and her stalker, and was able to get the police to intervene.

The sense in which PTSD patients feel "unsafe" goes beyond fears that dangers lurk around them; their insecurity begins more intimately, in the feeling that they have no control over what is happening in their body and to their emotions. This is understandable, given the hair trigger for emotional hijacking that PTSD creates by hypersensitizing the amygdala circuitry.

Medication offers one way to restore patients' sense that they need not be so at the mercy of the emotional alarms that flood them with inexplicable anxiety, keep them sleepless, or pepper their sleep with nightmares. Pharmacologists are hoping one day to tailor medications that will target precisely the effects of PTSD on the amygdala and connected neurotransmitter circuits. For now, though, there are medications that counter only some of these changes, notably the antidepressants that act on the serotonin system, and beta-blockers like propranolol, which block the activation of the sympathetic nervous system. Patients also may learn relaxation techniques that give them the ability to counter their edginess and nervousness. A physiological calm opens a window for helping the brutalized emotional circuitry rediscover that life is not a threat and for giving back to patients some of the sense of security they had in their lives before the trauma happened.

Another step in healing involves retelling and reconstructing the story of the trauma in the harbor of that safety, allowing the emotional circuitry to acquire a new, more realistic understanding of and response to the traumatic memory and its triggers. As patients retell the horrific details of the trauma, the memory starts to be

transformed, both in its emotional meaning and in its effects on the emotional brain. The pace of this retelling is delicate; ideally it mimics the pace that occurs naturally in those people who are able to recover from trauma without suffering PTSD. In these cases there often seems to be an inner clock that "doses" people with intrusive memories that relive the trauma, intercut with weeks or months when they remember hardly anything of the horrible events.[19]

This alternation of reimmersion and respite seems to allow for a spontaneous review of the trauma and relearning of emotional response to it. For those whose PTSD is more intractable, says Herman, retelling their tale can sometimes trigger overwhelming fears, in which case the therapist should ease the pace to keep the patient's reactions within a bearable range, one that will not disrupt the relearning.

The therapist encourages the patient to retell the traumatic events as vividly as possible, like a horror home video, retrieving every sordid detail. This includes not just the specifics of what they saw, heard, smelled, and felt, but also their reactions—the dread, disgust, nausea. The goal here is to put the entire memory into words, which means capturing parts of the memory that may have been dissociated and so are absent from conscious recall. By putting sensory details and feelings into words, presumably memories are brought more under control of the neocortex, where the reactions they kindle can be rendered more understandable and so more manageable. The emotional relearning at this point is largely accomplished through reliving the events and their emotions, but this time in surroundings of safety and security, in the company of a trusted therapist. This begins to impart a telling lesson to the emotional circuitry—that security, rather than unremitting terror, can be experienced in tandem with the trauma memories.

The five-year-old who drew the picture of the giant eyes after he witnessed the grisly murder of his mother did not make any more drawings after that first one; instead he and his therapist, Spencer Eth, played games, creating a bond of rapport. Only slowly did he begin to retell the story of the murder, at first in a stereotyped way, reciting each detail exactly the same in each telling. Gradually, though, his narrative became more open and free-flowing, his body less tense as he told it. At the same time his nightmares of the scene came less often, an indication, says Eth, of some "trauma mastery." Gradually their talk moved away from the fears left by the trauma to more of

what was happening in the boy's day-to-day life as he adjusted to a new home with his father. And finally the boy was able to talk just about his daily life as the hold of the trauma faded.

Finally, Herman finds that patients need to mourn the loss the trauma brought—whether an injury, the death of a loved one or a rupture in a relationship, regret over some step not taken to save someone, or just the shattering of confidence that people can be trusted. The mourning that ensues while retelling such painful events serves a crucial purpose: it marks the ability to let go of the trauma itself to some degree. It means that instead of being perpetually captured by this moment in the past, patients can start to look ahead, even to hope, and to rebuild a new life free of the trauma's grip. It is as if the constant recycling and reliving of the trauma's terror by the emotional circuitry were a spell that could finally be lifted. Every siren need not bring a flood of fear; every sound in the night need not compel a flashback to terror.

Aftereffects or occasional recurrences of symptoms often persist, says Herman, but there are specific signs that the trauma has largely been overcome. These include reducing the physiological symptoms to a manageable level, and being able to bear the feelings associated with memories of the trauma. Especially significant is no longer having trauma memories erupt at uncontrollable moments, but rather being able to revisit them voluntarily, like any other memory—and, perhaps more important, to put them aside like any other memory. Finally, it means rebuilding a new life, with strong, trusting relationships and a belief system that finds meaning even in a world where such injustice can happen.[20] All of these together are markers of success in reeducating the emotional brain.

PSYCHOTHERAPY AS AN EMOTIONAL TUTORIAL

Fortunately, the catastrophic moments in which traumatic memories are emblazoned are rare during the course of life for most of us. But the same circuitry that can be seen so boldly imprinting traumatic memories is presumably at work in life's quieter moments, too. The more ordinary travails of childhood, such as being chronically ignored and deprived of attention or tenderness by one's parents, abandonment or loss, or social rejection may never reach the fever pitch of trauma, but they surely leave their imprint on the emotional

brain, creating distortions—and tears and rages—in intimate relationships later in life. If PTSD can be healed, so can the more muted emotional scars that so many of us bear; that is the task of psychotherapy. And, in general, it is in learning to deal skillfully with these loaded reactions that emotional intelligence comes into play.

The dynamic between the amygdala and the more fully informed reactions of the prefrontal cortex may offer a neuroanatomical model for how psychotherapy reshapes deep, maladaptive emotional patterns. As Joseph LeDoux, the neuroscientist who discovered the amygdala's hair-trigger role in emotional outbursts, conjectures, "Once your emotional system learns something, it seems you never let it go. What therapy does is teach you to control it—it teaches your neocortex how to inhibit your amygdala. The propensity to act is suppressed, while your basic emotion about it remains in a subdued form."

Given the brain architecture that underlies emotional relearning, what seems to remain, even after successful psychotherapy, is a vestigial reaction, a remnant of the original sensitivity or fear at the root of a troubling emotional pattern.[21] The prefrontal cortex can refine or put the brakes on the amygdala's impulse to rampage, but cannot keep it from reacting in the first place. Thus while we cannot decide *when* we have our emotional outbursts, we have more control over *how long* they last. A quicker recovery time from such outbursts may well be one mark of emotional maturity.

Over the course of therapy, what seems to change in the main are the *responses* that people make once an emotional reaction is triggered—but the tendency for the reaction to be triggered in the first place does not disappear entirely. Evidence for this comes from a series of studies of psychotherapy conducted by Lester Luborsky and his colleagues at the University of Pennsylvania.[22] They analyzed the main relationship conflicts that brought dozens of patients into psychotherapy—issues such as a deep craving to be accepted or find intimacy, or a fear of being a failure or being overly dependent. They then carefully analyzed the typical (always self-defeating) responses the patients made when these wishes and fears were activated in their relationships—responses such as being too demanding, which created a backlash of anger or coldness in the other person, or withdrawing in self-defense from an anticipated slight, leaving the other person miffed by the seeming rebuff. During such ill-fated encounters, the patients, understandably, felt flooded by upsetting feelings—

hopelessness and sadness, resentment and anger, tension and fear, guilt and self-blame, and so on. Whatever the specific pattern of the patient, it seemed to show up in most every important relationship, whether with a spouse or lover, a child or parent, or peers and bosses at work.

Over the course of long-term therapy, however, these patients made two kinds of changes: their emotional reaction to the triggering events became less distressing, even calm or bemused, and their overt responses became more effective in getting what they truly wanted from the relationship. What did not change, however, was their underlying wish or fear, and the initial twinge of feeling. By the time the patients had but a few sessions left in therapy, the encounters they told about showed they had only half as many negative emotional reactions compared to when they first started therapy, and were twice as likely to get the positive response they deeply desired from the other person. But what did not change at all was the particular sensitivity at the root of these needs.

In brain terms, we can speculate, the limbic circuitry would send alarm signals in response to cues of a feared event, but the prefrontal cortex and related zones would have learned a new, more healthy response. In short, emotional lessons—even the most deeply implanted habits of the heart learned in childhood—can be reshaped. Emotional learning is lifelong.