COMMENTARY

A Lighter Shade of Trauma
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On the morning of Monday, August 29, 2005, Hurricane Katrina made landfall in southeast Louisiana. The levee system of New Orleans failed catastrophically. Storm surges penetrated the entire city and lingered for weeks. Hurricane Katrina became known as one of the most intense, costliest, and deadliest natural disasters ever recorded in the history of the United States. Almost exactly 3 years later, on August 31, 2008, Hurricane Gustav made landfall along the still recovering Louisiana coast. Lessons learned from Hurricane Katrina prompted one of the largest evacuations in U.S. history, with 1.9 million people leaving southern Louisiana, including 200,000 residents of New Orleans. The levees held, and although the winds crippled the power system and blew off many rooftops and trees, the damage and death toll were significantly lower than the devastating consequences of Hurricane Katrina.

A recent study by Weems et al. (1) examined the course of traumatic memories in youth in New Orleans attending school in a neighborhood that sustained massive flooding during Hurricane Katrina. Their findings were intuitive. A group of youth studied 1 month after Hurricane Gustav recalled fewer negative memories of Hurricane Katrina and demonstrated reduction in symptoms of posttraumatic stress disorder (2). Why would exposure to another devastating storm improve psychological well-being rather than aggravate it? The authors speculated this has to do with a phase of memory called reconsolidation.

Memories form through a consolidation process in which long-term structural changes occur in synaptic connections of nerve cells. For the most part of the 20th century, the prevailing hypothesis was that consolidation is a one-time process for storing memories in a fixed and unchangeable form (3). During the last decade, however, robust evidence is indicating an alternative view: Not only the first formation of memory but every recall of it initiates a consolidation-like storage process, that is, reconsolidation (4). In this issue of Biological Psychiatry, Liu et al. (5) report new findings on reconsolidation of laboratory-made threat memories, which might provide a mechanistic explanation for the fading memories of individuals who survived the two hurricanes.

According to the reconsolidation theory, an active memory undergoing reconsolidation might be vulnerable in two ways. At the biological level, pharmacologic agents, such as protein synthesis inhibitors (6), or cruder manipulations, such as electroconvulsive shock stimulation (7), could block various stations in the cascade of synaptic, cellular, or molecular events of reconsolidation. At the behavioral level, new information or different experiences taking place at the time of reconsolidation might infiltrate the reconsolidating memory (8). Physiologic blockade typically renders the memory inaccessible (perhaps even erased).

Behavioral interference keeps the memory accessible but altered by the new information (8,9).

Liu et al. questioned the nature of the cues that trigger the recall of memory before reconsolidation. Memories often resurface when we encounter cues associated with the original event. The smell of gasoline for example, might trigger a traumatic memory from the battlefield. By tampering with reconsolidation, the triggering cue would lose the ability to retrieve the memory. Real-life events often engage multiple cues, however, granting each one access to memory. Omitting one association, such as the smell of gasoline, would prevent the return of memory only until another associated cue, such as the sight of fire, would come along and trigger the memory. Liu et al. speculated that triggering reconsolidation by reexposure to the negative event itself (10) might eliminate associations with all related cues altogether.

To examine this hypothesis, Liu et al. recruited healthy human volunteers to participate in a three-step experiment. On day 1, the participants underwent classic threat conditioning (or Pavlovian conditioning) where they learned to associate a neutral stimulus such as the shape of a blue square (conditioned stimulus [CS]) with an electric shock (unconditioned stimulus [US]). On day 2, the participants were randomly assigned into three groups. Two groups were reminded of the CS-US association by exposure to a milder US (an electric shock of half intensity); the third group was not reminded of the CS-US association. Subsequently, all participants underwent a learning session in which the meaning of the CS was different. Instead of associating the CS with the shock, the participants associated it with no shock. This protocol is known as extinction training, where the CS is presented repeatedly but without the negative outcome creating a “CS-nothing” association, which mimics the widely used exposure therapy for anxiety disorders. During this step, the three groups differed as follows: One group underwent extinction 10 min after the reactivation of the CS-US association by exposure to the mild electric shock. The second group underwent extinction 24 hours after reactivation. The third group, who was not reminded of the CS-US association, simply underwent extinction.

The important difference between the groups lies in the timing of reconsolidation relative to extinction. Reconsolidation, similar to consolidation, is a time-limited process, roughly lasting several hours (about 6 hours in a typical threat conditioning experiment). Only the 10-min group underwent extinction during reconsolidation; the other groups did not. The no-reactivation group underwent only extinction because reconsolidation was never initiated. The 24-hour group underwent extinction outside the reconsolidation window, after reconsolidation had a chance to be completed with no interference. On day 3 (or day 4 for the latter group), all participants were exposed again to the CS to see whether the conditioned defense response would resurface or whether introducing extinction during reconsolidation had modified it. Throughout the experiment, the experimenters assessed defense responses by measuring subtle changes in the participants’ skin conductance, which is indicative of arousal when viewing the CS. Consistent with previous studies (8), Liu et al. found that extinction during reconsolidation triggered by the mild US prevented the return of defense responses to the CS. Using parametric variations of this basic protocol, the authors
turned to examine their main research question: Would this procedure eliminate responses not only to one CS but also to other CSs associated with the same US?

In a series of experiments, Liu et al. showed that extinction of two different CSs associated with the same US during US-triggered reconsolidation prevented the return of defense responses to both CSs. The authors achieved this result even when extinguishing only one of the CSs during reconsolidation and when reactivating and extinguishing remote (6 months old) CS-US associations. This set of studies may provide a highly simplified but valid laboratory model of real-life traumatic events such as Hurricane Katrina (Figure 1). Based on the reconsolidation theory, Weems et al. (1) predicted that exposure to a milder hurricane would alleviate the negative consequences of Hurricane Katrina. As expected, they found that youth with high exposure to Hurricane Katrina but low exposure to Hurricane Gustav retrieved fewer Katrina-related negative memories (1) and exhibited reduced posttraumatic stress disorder symptoms (2). Viewed through the lens of threat conditioning, Hurricane Katrina may be the initial US, which was associated with various CSs such as winds blowing through the schoolyard or rainfall puddles. Hurricane Gustav would be the milder US that triggered and initiated reconsolidation of Hurricane Katrina memories. The less stressful Hurricane Gustav exposure would be the equivalent of CS extinction during reconsolidation. The new, less negative information that Hurricane Gustav provided would be incorporated into the Hurricane Katrina memory, reducing the emotional impact of the CSs associated with it.

With Hurricane Gustav–updated Hurricane Katrina memories, New Orleans youth could now walk around the neighborhood more resistant to the constant reminders of the traumatic Hurricane Katrina event.

The observation by Weems et al. of the naturalistic course of traumatic memories, and the mechanism of it proposed by Liu et al., strengthen the ecological and face validity of the reconsolidation theory. Could such findings have real implications for treatment of traumatic memories? Should we deliberately expose patients with posttraumatic stress disorder to a milder form of the traumatic event to modify traumatic memories? This reexposure is perhaps the true meaning of getting back on the horse after a fall. Reexposure coupled with lower stress and less severity may be a powerful albeit rare way to rewrite painful memories. Many forms of psychotherapy using tools such as guided imagery, scripting, reevaluation, and storytelling perhaps attempt to replace reexposure to actual mild threat with recreation of the traumatic experience in mental space to achieve a similar healing effect. In real life, for grave and milder events to occur in that order, serendipity might play a larger role.

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