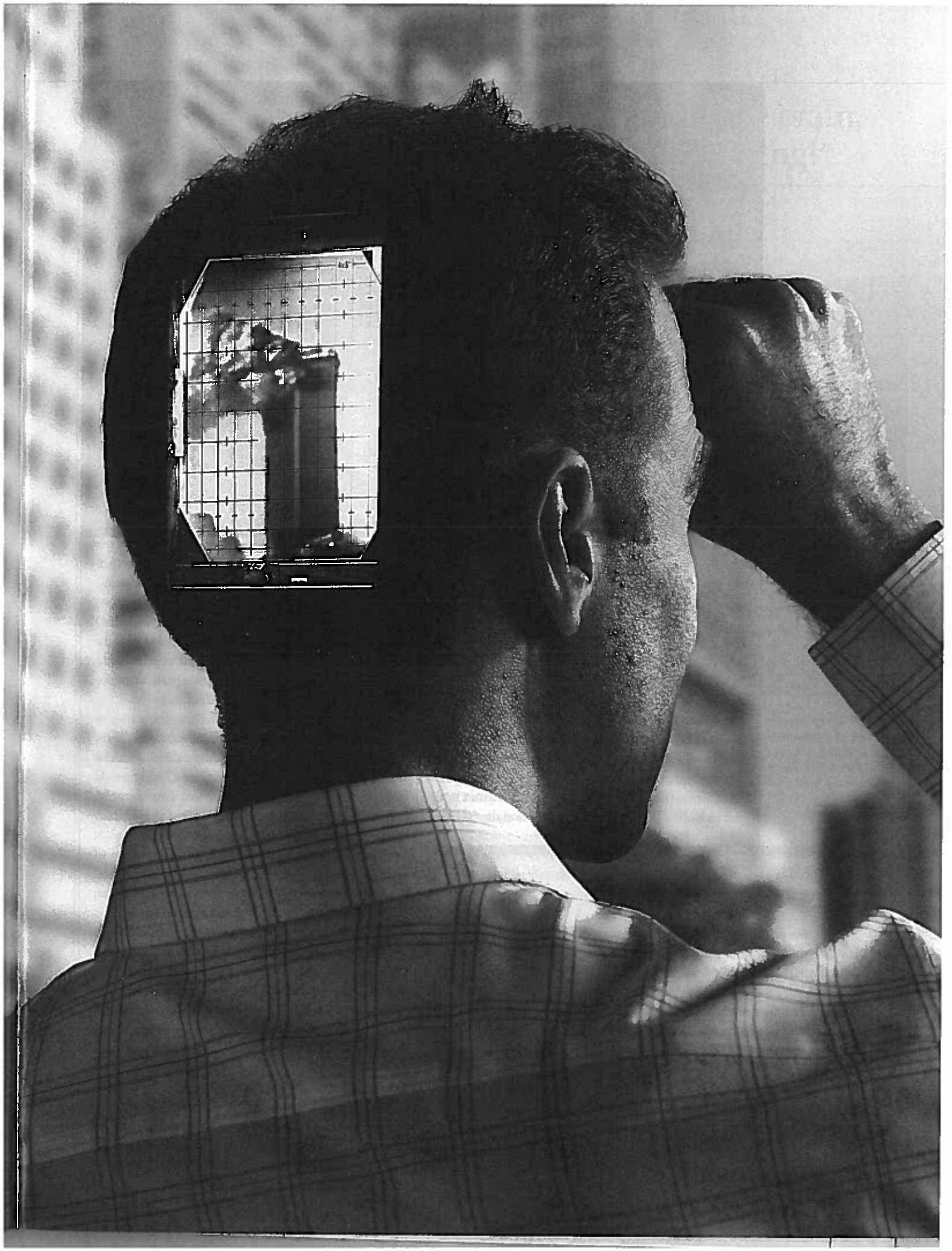
A Feeling for the Past

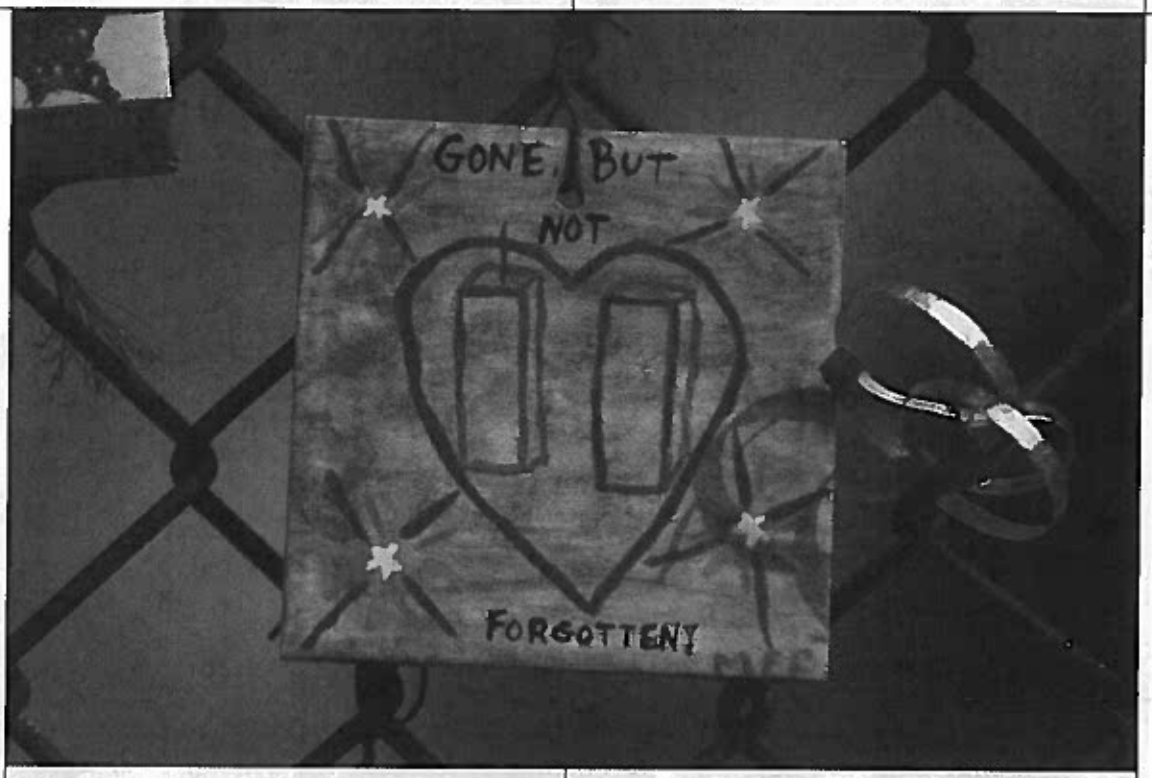
Emotion engraves the brain with vivid recollections but cleverly distorts your brain's record of what really took place

By Ingfei Chen

On September 11, 2001, Elizabeth A. Phelps stepped outside her apartment in lower Manhattan and noticed a man staring toward the World Trade Center, about two miles away. Looking up, "I just saw this big, burning hole," Phelps recalls. The man told her that he had just seen a large airplane crash into one of the skyscrapers. Thinking it was a horrible accident, Phelps started walking to work, a few blocks away, for a 9 A.M. telephone meeting. By the time she reached her eighth-floor office at New York University, a second jet had struck the other tower, which collapsed after an hour. Later, she saw the remaining tower fall.

PHOTOILLUSTRATION BY AARON GOODMAN; ROBERT GIROUX *Getty Images (towers)*





Virtually no one will forget the World Trade Center—or that 9/11 happened. But our brains distort the details of that day.

Like Phelps, many Americans have searing memories of that day. In your mind's eye, you can probably relive the moment you first learned of the terrorist attacks: where you were, what you were doing, the shock or fear you experienced. Yet chances are that although they feel real and true, our memories of 9/11 are riddled with errors. "I remember all those details; I'm certain that I'm right," says Phelps, a psychologist. "But the data suggest I'm not."

Recollections of the moment we found out about surprising, traumatic public events are known as flashbulb memories, first described in 1977 by Harvard University psychologists Roger Brown and James Kulik. The idea was that emotionally intense experiences trigger your brain to perfectly record what you are hearing, seeing and feeling—like a camera snapshot when the flash goes off. Stacks of psychology and neuroscience studies indeed show that the human brain is rigged to react to a flood of feelings by activating the key regions that store memories. The brain's recordings, however, are far from flawless reproductions of the original moment.

Research from the past 25 years, including a long-term nationwide survey of 9/11 memories conducted by Phelps and her colleagues, shows that "flashbulb memory" is a misnomer. Memories forged under strong emotions distort considerably even though, paradoxically, they seem so vivid that we hold a misguided confidence in their fidelity.

Although emotion powerfully bolsters our memories of an event, it also edits and sculpts the particulars of what we recall. Such biases or imperfections might seem like a failing of the human brain, but experts note that our emotional memories serve us well most of the time—by preserving the most crucial knowledge for surviving life's challenges. Most people are oblivious to the fact that we possess a heavily edited record of the experiences that move us most. When it comes to remembering, we are more at the mercy of our emotions than we may realize.

Look Here

Amid the endless stream of everyday experience, emotion is like a blazing neon tag that alerts the brain, "Yoo-hoo, this is a moment worth remembering!"

FAST FACTS

Feeling the Moment

1» **So-called flashbulb memories actually fade considerably even though, paradoxically, they seem so vivid that we hold a misguided confidence in their fidelity.**

2» **Emotion produces a kind of tunnel memory, boosting recall of central objects but allowing people to forget surrounding details.**

3» **Putting a positive spin on a bad situation—a technique called cognitive reappraisal—can both enhance accuracy in emotional memories and diminish their negative overtones.**

BEVIS FUSHA *Redux Pictures*

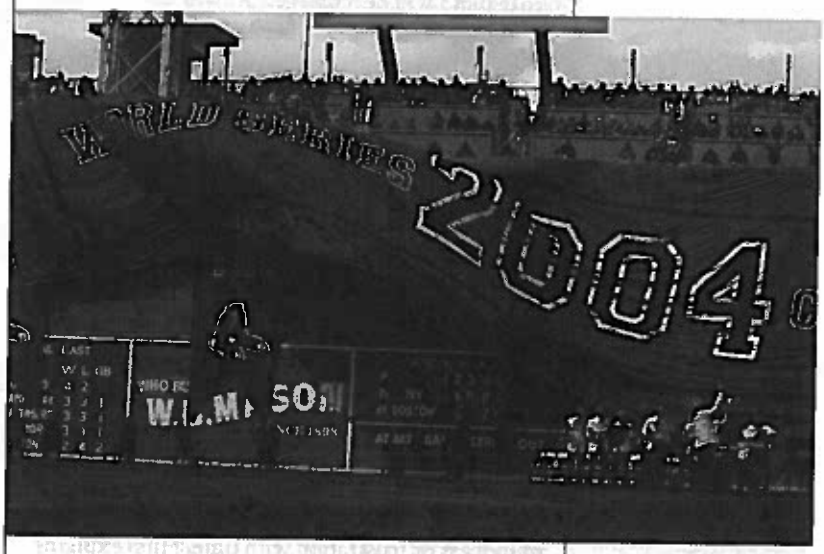
Emotion is like a blazing neon tag that alerts the brain, "Yoo-hoo, this is a moment worth remembering!"

The salience of the humdrum sandwich you ate for lunch pales in comparison, consigning its memory to the dustbin. Yet emotions regulate our recall of not just our most riveting moments. Researchers now recognize that the same neural mechanisms involved in flashbulb memories underlie recollections along the continuum of human emotional experience. When people view a series of pictures or words in the laboratory, any emotionally laden content sticks in their head better than neutral information.

Memory is a three-stage process: First comes the learning or encoding of an experience; then, the storage or consolidation of that information over many hours, days and months; and last, the retrieval of that memory when you later relive it. Insights into how emotion modulates this process emerged from studies of conditioned fear responses in rats in the 1980s and 1990s by neuroscientists Joseph E. LeDoux, now at N.Y.U. [see "Mastery of Emotions," by David Dobbs; SCIENTIFIC AMERICAN MIND, February/March 2006], and James L. McGaugh of the University of California, Irvine, among others. Their work established that the amygdala, a structure buried deep within the brain, orchestrates the memory-boosting effects of fear.

For instance, if you suddenly glimpse a snake while walking in the woods, your amygdala instantly reacts to the snake's threatening features, explains Kevin S. LaBar, a cognitive neuroscientist at Duke University. This region signals your cortex to boost its visual and perceptual processing to confirm that the snake is real, rapidly directing your attention to it. Second, the amygdala triggers the release of stress hormones that set your heart racing and pupils dilating. Those same hormones spur the hippocampus, the memory-encoding center, to start storing or consolidating your perceptions into a neural record. Over the long run, sensory details of the memory are believed to migrate into areas of the cortex for vision, hearing and movement. Later, when you remember that snake, the amygdala and hippocampus are again involved, reigniting the emotional and sensory dimensions of that memory.

The same basic mechanisms also apply for highly arousing, positive events, LaBar explains; activity within the amygdala is associated with many kinds of emotions, not just fear. For instance, in a 2010 study LaBar and his colleagues scanned the brains of diehard college basketball fans and found that the amygdala and hippocampus lit up as the participants remembered exciting plays from a game they watched. In addition, unlike lab studies probing recollections of emotional words or images, the real-world, high-octane basketball memories also engaged social cognition areas involved in recalling situations that include social interactions, LaBar notes. Other studies show that pleasant recollections also activate the brain's reward system. Rather than being limited to a few key brain regions, emotional memory processes are "much more complex than we thought," he says.



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Happy memories are susceptible to distortion, too. We tend to recall fewer perceptual details of pleasant events, however, than of troublesome ones.

Certainly Wrong

Although emotional experiences may initially be etched into memories more strongly than neutral ones, over time they twist away from reality. The first detailed evidence of the inaccurate nature of flashbulb memories emerged from surveys done after the space shuttle *Challenger* exploded in 1986. The recent analyses of 9/11 memories have further clarified what is and is not special about these intense remembrances. On September 12, 2001, Duke psychologists Jennifer M. Talarico and David C. Rubin surveyed students' memories of 9/11 and a more prosaic but notable event from the preceding weekend, such as a birthday party or study group session. In retests during the following year, accuracy of details declined equally in both types of memory. The clarity and confidence they reported in their recollections varied: the students consistently rated their memory of 9/11 as being much more

vivid than it was for the ordinary occurrences.

"They thought it was much more accurate," says Talarico, now at Lafayette College. In other words, she says, what distinguishes flashbulb memories is "this sense of enhanced vividness and inflated confidence that we have in the accuracy, this sense that I will never forget 'X.'"

A similar pattern was seen in the nationwide 9/11 memory project. Phelps and psychologist William Hirst of the New School for Social Research and their colleagues surveyed more than 3,000 volunteers in New York City, Washington, D.C., and five other cities one week after the attacks, in subsequent years and again this past summer. (Ten-year data are still being analyzed.) Compared with their initial reports, Hirst says, participants were only 63 percent correct on the when-where-how types of details about learning of the attack one year after 9/11; after that, the decline slowed. Yet they were "absolutely confident that their memory was correct," he says.

A year later people were only 63 percent correct on the when-where-how details about learning of the attack on 9/11.

Surprisingly, people were worst at describing their emotional state on 9/11, with only 42 percent of them right a year later. Initial shock may give way to sadness or frustration with time, Hirst explains, and we tend to "reconstruct our emotional past in a way that's consistent with the way we currently are emotionally reacting."

Survey takers showed better accuracy for the central facts of the terrorist event, such as the number of hijacked planes and crash sites. "Societal memory practices" such as watching media coverage and talking about 9/11 with others had a major influence. "Our memory is just not independent of the larger social context in which we exist," Hirst says.

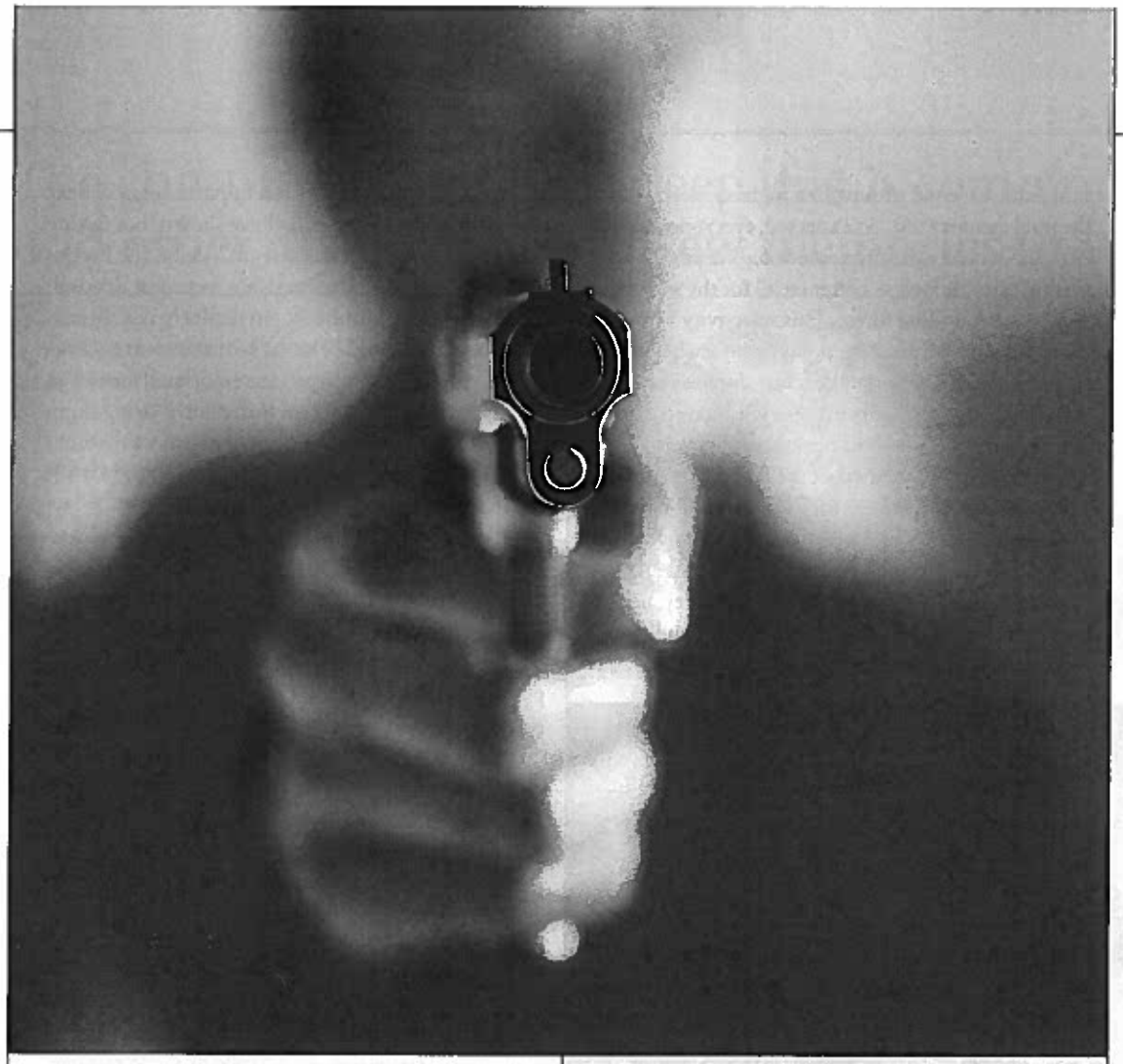
Emotional Tunnel Vision

Our gut reactions to the world affect the brain's cataloguing efforts in several distinct ways. For one thing, emotion is selective in how it enhances memory. Experts noticed long ago the "weapon focus effect"—a witness might confidently testify to seeing the gun held by a robber and yet recall little of his face. Many other lab studies have observed the same kind of tunnel vision: individuals remember a picture of a snake in a forest better than a scene of a chipmunk set in a similar background. Although people vividly recall the snake, they tend to forget the surrounding forest, says cognitive neuroscientist Elizabeth A. Kensinger of Boston College. "Their memory for that emotional item"—the snake—"actually seems to be coming at the cost of their memory for the context."

That trade-off can partly be explained by the way an emotionally arousing object grabs your attention. Countless stimuli vie for your notice, says psychologist Mara Mather of the University of Southern California. What wins out might be something eye-catching or startling, such as a bright object flitting across the grass, or it might be something you are deliberately trying to focus on, such as a phone call, while consciously screening out distractions.

Emotions magnify this effect, intensifying the attention-snagging property of a stimulus, Mather believes. Thus, whatever dominates your mind ends up in the memory banks. That idea may help explain why, in seemingly contradictory studies, scientists have observed participants showing stronger memory for neutral details in an emotional scene. Say you are walking past a man, and a gunshot suddenly rings out from up the street. Under Mather's theory, someone who was nondescript to begin with would be even less memorable after the gunshot. Yet if you had already looked at the gentleman closely because he resembled a friend, "you would actually remember that face even better if there were a gunshot afterward," she says. The emotional nature of the situation would burn this bystander into your mind, as a kind of side effect, even though he had nothing to do with the real action.

Some research suggests that positive, highly arousing events, such as a marriage proposal or winning a prize, trigger a similar trade-off, Kensinger says. Uplifting memories, on the other hand, may differ in the type of information that is preserved, she notes, based on functional MRI studies she and her colleagues published in 2008. Whereas the scary snake-in-the-forest scenario fires up the brain's sensory processing regions, perhaps leading to a crystal-clear memory of the snake's stripes, positive excitement may instead stimulate areas in the frontal lobe that process concepts, Kensinger points out. It may, for example, train your memory toward happy thoughts about how you might spend a wad of cash that was just handed to you, rather than on what the cash looked like. "It seems like a



GETTY IMAGES

Emotion intensifies memory for a central, charged object in a scene at the expense of the context. In the "weapon focus effect," a witness might vividly describe a gun but be unable to picture the face of the person holding it.

lot of those perceptual details just are not retained with the same resolution for positive information as they are for negative information," Kensinger says. Happy memories also appear prone to distortions in accuracy and confidence—in some studies, even more so than negative recollections.

What you remember about an emotional event may also depend on your personality and age. In a 2010 study Kensinger and her colleagues found that people who reported higher everyday anxiety were more likely to exhibit the emotional memory trade-off—better retention of the main emotional features but a weaker grasp of the neutral background information—than those with less anxiety. The memories of older adults are biased in a different way; they swing toward being more positive. Mather and her associates observed in a 2003 study that after viewing a series of images ranging from, say, a cockroach on a pizza slice to the face of a smiling baby, older adults favored the happy images: half of the images the elders correctly recalled were positive and slightly more than a quarter were negative (the rest were neutral), compared with 36 percent positive, 40 percent negative for the younger participants. The effect does not seem to arise from any age-related decline in the amygdala's radar for threatening signals, Mather says. Instead older adults appear to actively manage their emotions by paying less attention to negative things.

Sleep on It

After an emotional event, increasing evidence shows, another factor has a potent hand in pruning and transforming the brain's recollection of it: sleep. "The sleeping brain seems to somehow make calculations about what to remember and what to forget," says cognitive neuroscientist Jessica D. Payne of the University of Notre Dame.

How sleep meddles with memories, however, is complex. In one study, Payne, Kensinger and their colleagues asked volunteers to look closely at chipmunk- or snake-in-the-forest types of scenes and then tested whether they recognized various components of those images after 30 minutes and again 12 hours later. One group did the experiment during the day-

(The Author)

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time, and a second group got a night of sleep before the final memory test. As expected, everyone showed enhanced memory for the emotional scenes over the neutral ones, as well as better recall for the snake but not the surrounding forest. This selectivity was even more pronounced after sleep, Payne says: whereas the memories of the entire snake scene showed some deterioration after 12 hours in those who stayed awake, the sleepers actually had better recollection of the snake and worse retention of the forest. Yet slumber offered no memory benefit for the nonemotional chipmunk scene. As Payne explains, sleep "selectively preserves only the emotional aspect of the scene."

At the University of California, Berkeley, neuroscientist Matthew P. Walker is exploring an intriguing new hypothesis that sleep also helps to soothe the sharp edges of bad memories. In particular, Walker notes that numerous studies have shown that during rapid eye movement, or "dream" sleep, the hippocampus and amygdala reactivate, yet some arousal-inducing stress hormones, particularly noradrenaline, are suppressed. The lack of those stress hormones may let the brain process emotional memories in what seems like a safe environment. During slumber, he theorizes, the brain strengthens its memory of the information within a distressing episode while "stripping away the emotional tone."

If that mechanism fails, the result could be chronic anxiety or the recurring nightmares of post-traumatic stress disorder, Walker says. Experiments by his lab also suggest that the chronic lack of sound sleep that is common in those disorders and in depression may even skew memories toward gloom, possibly perpetuating symptoms.

To keep their minds from zooming in on the most gut-wrenching element in a scene, such as a corpse, detectives keep their emotions in check and look around the area for clues.

Good Enough?

What should we make of the fact that our most cherished memories may not be entirely true? Experts are quick to answer that these recollections typically do bear a hardy kernel of truth. "Our memory is good enough to get through the day," Hirst says, noting that accuracy concerns did not come up in humanity's ancient past, when neither tape recorders nor written accounts could serve as references. Yet human memory may not be sufficiently solid to offer reliable eyewitness testimony in courts, he says. There the devil may be in the details, such as whether an alleged bank robber drove off in a Honda or a Toyota SUV, and those details of a heated moment are especially fluid in memory. The challenge for psychologists, Phelps says, is to clearly define where and when people's memories of emotionally fraught incidents tend to break down. To that end, her group has unpublished results suggesting that people have more accurate recall for the place and the timing of an emotional event than for other aspects, such as who first told them about it.

An even greater mystery is why emotion infuses our memories with such a supreme yet misplaced confidence. "You can't even convince people that their memories are wrong," Phelps says. Usually when you feel certain about many facets of a run-of-the-mill recollection, you are right. With emotional events, however, your vivid memory for a few central, correct facts seems to foster the mistaken impression that it is good for all details, Phelps says.

Why this disconnect? Enhanced confidence lets you react more quickly during a similar crisis in the future, Phelps theorizes. People do not forget the gist of 9/11, and if you saw a plane flying near a sky-

The chronic lack of sound sleep that is common in anxiety and other disorders may skew memories toward gloom.

scraper you were in, she notes, "you would get out, right now."

Experts believe that human memory evolved not to provide a static, high-fidelity record of the past but to help us prepare for an unpredictable future. A malleable memory lends a powerful advantage: "You can add and change things as you need to," Payne says. That flexibility allows our brain to restructure what we have learned, make generalizations across concepts and experiences, and brainstorm new ideas.

Remaking Memories

At times, though, you might prefer an accurate account over the benefits of fluid learning. By realizing that memory naturally zooms in on the most emotionally evocative aspects of an experience, you may be able to broaden your attention to override that bias. "You can make some effort to actually now focus on the nonemotional things that might be important," Phelps says. Police officers are trained in such tactics for assessing crime scenes, she notes: faced with a dead body in a motel room, homicide detectives would not only examine the corpse but also control their emotional responses to it and carefully scan around the bed or bathroom for possible clues.

Another potential way to enhance accuracy in emotional memories while also damping down their negative overtones is to put a positive spin on a bad situation—a technique called cognitive reappraisal. In a study published in 2010 LaBar, Jasmeet Pannu Hayes, a psychologist now at Boston University, and their colleagues asked people—while they were in a brain scanner—to either suppress their emotional reactions as they viewed distressing scenes or appraise them more favorably. If shown an injured man in a hospital bed, the participants could imagine that excellent care would help him heal. Compared with the suppressors, the reappraisers reported less emotional distress on seeing the unpleasant pictures and showed better memory for the images two weeks later. In the reappraisers, the hippocampus got "a double whammy" of stimulation, LaBar says: One boost came from the amygdala reacting to the negative scenes even though its response had been muted by the reappraisal process. A second communiqué came from the left inferior prefrontal cortex, which helps to process information deeply and showed greater activity in the reappraisal group [*see illustration on this page*]. (In the suppression group, the hippocampus communicated less with these other brain regions, resulting in poorer memory for the scenes.)

By using the strategy of positive thinking in a stressful circumstance, "you've lowered the emotional arousal, but you still have a good memory of it," LaBar says. Reappraisal is the basis of cognitive-behavior treatment for various psychological disorders.

The possibilities for refining our emotional memories are intriguing. Yet with the passage of time, human memory is inevitably a fragile, fading thing. Societies compensate for this frailty by holding anniversaries and memorials that revive the memory of loved ones lost—and by inventing gizmos such as tape recorders and cell-phone cameras that help us never forget. M

Thinking positively can reduce distress and sharpen memory. Activity in the amygdala, an emotion hub (*yellow spots at left*), was higher in people who passively viewed upsetting pictures than in those who appraised them positively or stifled their feelings. Part of the left inferior prefrontal cortex, an information processing region (*upper yellow spot at right*), lit up more during reappraisal than suppression. The upshot was better recall of the pictures.

FROM "STAYING COOL WHEN THINGS GET HOT: EMOTION REGULATION MODULATES NEURAL MECHANISMS OF MEMORY ENCODING," BY JASMEET PANNU HAYES ET AL., IN *FRONTIERS IN HUMAN NEUROSCIENCE*, VOL. 4, NO. 230; DECEMBER 22, 2010

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