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PARTIAL RECALL

Can neuroscience help us rewrite our most traumatic memories?

BY MICHAEL SPECTER

Daniela Schiller's research centers on the connection between memory and fear.

One morning every spring, for exactly two minutes, Israel comes to a stop. Pedestrians stand in place, drivers pull over to the side of the road, and nobody speaks, sings, eats, or drinks as the nation pays respect to the victims of the Nazi genocide. From the Mediterranean to the Dead Sea, the only sounds one hears are sirens. "To ignore those sirens is a complete violation of the norms of our country," Daniela Schiller told me recently. Schiller, who directs the laboratory of affective neuroscience at the Mount Sinai School of Medicine, has lived in New York for nine years, but she was brought up in Rishon LeZion, a few miles south of Tel Aviv. "My father doesn't care about the sirens," she says. "The day doesn't exist for him. He moves about as if he hears nothing."

Sigmund Schiller's disregard for Holocaust Remembrance Day is perhaps understandable; he spent the first two years of the Second World War in the Horodenka ghetto (at the time in Poland, but now in Ukraine) and the next two hiding in bunkers scattered across the forests of Galicia. In 1942, at the age of fifteen, he was captured by the Germans and sent to a labor camp near Tluste, where he managed to survive the war. Trauma victims frequently attempt to cordon off their most painful memories. But Sigmund Schiller never seemed to speak about his time in the camp, not even to his wife.

"In sixth grade, our teacher asked us to interview someone who survived the Holocaust," Daniela Schiller said. "So I went home after school. My father was at the kitchen table reading a newspaper, and I asked him to tell me about his memories. He said nothing. I have done this many times since. Always nothing." A wan smile crossed her face. We were sitting in her office, not far from the laboratory she runs at Mount Sinai, on Manhattan's Upper East Side. It was an exceptionally bright winter morning, and the sun streaming through the window made her hard to see even from a few feet away. "I long ago concluded that his silence would last forever," she said. "I grew up wondering which of all the horrifying things we learned about at school the Germans did to him."

Slowly, over the years, that silence closed in on her. "It wasn't so much a conscious thing," she said. "But I grew up with that fear in the background. What was he hiding? Why? How do people even do that?" The last question has, to a large degree, become the focus of her career: Schiller studies the intricate biology of how emotional memories are formed in the brain. Now forty-one, and an assistant professor of neuroscience and psychiatry at Mount Sinai, she specializes in the connection between memory and fear. "We need fear memories to survive," she said. "How else would you know not to touch that burner again? But fear takes over the lives of so many people. And there is not enough that we can do about it."

More than five per cent of Americans have experienced some form of post-traumatic stress disorder; for combat veterans, like those returning from Afghanistan and Iraq, the figure is even higher. Millions of others suffer from profound anxiety, debilitating phobias, and the cravings of addiction; those emotions appear to be formed in the same neural pathways, which means that a successful treatment for one condition might also work for others. Behavioral therapies, even those which work initially, often fail. Relapses are common, and the need for more successful treatments has never been so acute. New approaches are hard to develop, though, because most of what is known about the human brain has come from studying the neurons of other animals. One can't simply stick a needle into somebody's brain, grab a few neurons, drop them in a nutrient bath, and see what happens. PET scans and functional-magnetic-resonance-imaging machines

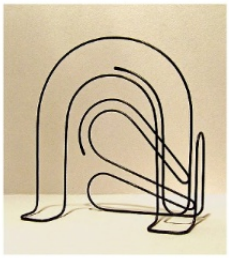
PHOTO ILLUSTRATION BY JOSEF ASTOR

have helped address the problem; they permit neuroscientists to monitor metabolic changes and blood flow in the human brain. But neither of them can measure the activity of neurons directly.

Even so, Schiller entered her field at a fortunate moment. After decades of struggle, scientists had begun to tease out the complex molecular interactions that permit us to form, store, and recall many different types of memories. In 2004, the year Schiller received her doctorate in cognitive neuroscience, from Tel Aviv University, she was awarded a Fulbright fellowship and joined the laboratory of Elizabeth Phelps, at New York University. Phelps and her colleague Joseph LeDoux are among the nation's leading investigators of the neural systems involved in learning, emotion, and memory. By coincidence, that was also the year that the film "Eternal Sunshine of the Spotless Mind" was released; it explores what happens when two people choose to have all their memories of each other erased. In real life, it's not possible to pluck a single recollection from our brains without destroying others, and Schiller has no desire to do that. She and a growing number of her colleagues have a more ambitious goal: to find a way to rewrite our darkest memories.

"I want to disentangle painful emotion from the memory it is associated with," she said. "Then somebody could recall a terrible trauma, like those my father obviously endured, without the terror that makes it so disabling. You would still have the memory, but not the overwhelming fear attached to it. That would be far more exciting than anything that happens in a movie." Before coming to New York, Schiller had heard—incorrectly, as it turned out—that the idea for "Eternal Sunshine" originated in LeDoux's lab. It seemed like science fiction and, for the most part, it was. As many neuroscientists were aware, though, the plot also contained more than a hint of truth.

Concepts of memory tend to reflect the technology of the times. Plato and Aristotle saw memories as thoughts inscribed on wax tablets that could be erased easily and used again. These days, we tend to think of memory as a camera or a video recorder, filming, storing, and recycling the vast troves of data we accumulate throughout our lives. In practice, though, every memory we retain depends upon a chain of chemical interactions that connect millions of neurons to one another. Those neurons never touch; instead, they communicate through tiny gaps, or synapses, that surround each of them. Every neuron has branching filaments, called dendrites, that receive chemical signals from other nerve cells and send the information across the synapse to the body of the next cell. The typical human brain has trillions of these connections. When we learn something, chemicals in the brain strengthen the synapses that connect neurons. Long-term memories, built from new proteins, change those synaptic networks constantly; inevitably, some grow weaker and others, as they absorb new information, grow more powerful.



Memories come in many forms. Implicit, procedural memories—how we ride a bike, tie our shoes, make an omelette—are distributed throughout the brain. Emotional memories, like fear and love, are stored in the amygdala, an almond-shaped set of neurons situated deep in the temporal lobe, behind the eyes. Conscious, visual memories—the date of a doctor's appointment, the names of the Presidents—reside in the hippocampus, which also processes information about context. It takes effort to bring those memories to the surface of awareness. Each of us has memories that we wish we could erase, and memories that we cannot summon no matter how hard we try. At N.Y.U. and other institutions, scientists have begun to identify genes that appear to make proteins that enhance memory, and genes that clearly interfere with it. Both kinds of discovery raise the tantalizing, if preliminary, hope of a new generation of drugs, some of which could help people remember and some that might help them forget.

Until memories are fixed, they are fragile and easily destroyed. Who has not been interrupted while trying to remember a phone number or an address? That memory almost invariably slips away, because it never had time to form. (This also explains why accident victims often have trouble recalling events that occurred just before a car crash or other severe trauma.) It takes a few hours for new experiences to complete the biochemical and electrical process that transforms them from short-term to long-term memories. Over time, they become stronger and less vulnerable to interference, and, as scientists have argued for nearly a century, they eventually become imprinted onto the circuitry of our brains. That process is referred to as consolidation. Until recently, few researchers challenged the paradigm; the only significant question about consolidation seemed to be how long it took for the cement to dry.

For years, though, there have been indications that the process is less straightforward than it seems. In 1968, a team at Rutgers, led by Donald J. Lewis, published the results of an experiment in which rats were conditioned to retrieve memories that had, presumably, been stored permanently. First, the scientists trained the rats to fear a sound. The next day, Lewis played the sound again and followed it immediately with a shock to the head. To his surprise, the rats seemed to have forgotten the negative association; they no longer feared the sound. That seemed odd; if the memory had truly been wired into the rat's brain, a mild shock shouldn't have been able to dislodge it. The experiment wasn't easily repeated by others, though, and few neuroscientists paid much attention to such a singular and contradictory finding.

Not long afterward, in seemingly unrelated research, the psychologist Elizabeth Loftus, now at the University of California at Irvine, embarked upon what has turned into a decades-long examination of the ways in which misleading information can insinuate itself into one's memory. In her most famous study, she gave two dozen subjects a journal filled with details of three events from their childhoods. To make memories as accurate and compelling as possible, Loftus enlisted family members to assemble the information. She then added a fourth, completely fictitious experience that described how, at the age of five, each

child had been lost in a mall and finally rescued by an elderly stranger. Loftus seeded the false memories with plausible information, such as the name of the mall each subject would have visited. When she interviewed the subjects later, a quarter of them recalled having been lost in the mall, and some did so in remarkable detail.

"I was crying and I remember that day . . . I thought I'd never see my family again," one participant said, in a taped interview (available on YouTube). "An older man approached me. . . . He had a flannel shirt on. . . . I remember my mom told me never to do that again." These assertions were delivered with a precision and a certainty that few people could have doubted, except that there was no man in a flannel shirt and no admonition from the subject's mother. Memory "works a little bit more like a Wikipedia page," Loftus said in a recent speech. "You can go in there and change it, but so can other people."

Loftus has been vilified for demonstrating that even the most vivid and detailed eyewitness accounts—a "recovered memory" of sexual abuse, for example—can be inaccurate or completely false. "She changed the world," Elizabeth Phelps told me recently, when we met in her office at N.Y.U., where she is the Silver Professor of Psychology and Neural Science. "The notion of the unreliability of memory has changed courtrooms in America, and it is completely owing to Elizabeth's persistence in the face of a very harsh backlash."

Loftus's results raised a fundamental question about the biology of the brain: if misinformation can be incorporated so seamlessly into a person's recollection of an event, what becomes of the original memory? Is it completely overwritten, or merely adjusted somehow, layered with a new trace?

In the decade following Loftus's experiment, an answer began to emerge, as LeDoux, Phelps, and others slowly mapped the neural circuitry responsible for many types of memory, particularly memories associated with fear. They began to entertain the idea that, in order for an old memory to be recalled, it had to retrace the pathways in which it originated, and that under certain circumstances the memory seems to change. Scientists called that reconsolidation. But reconsolidation, with its eerie implication that our memories are inauthentic or transitory, was highly disputed. To many scientists, while the idea was fascinating, it remained far-fetched.

By 1996, LeDoux's lab had demonstrated that fearful memories were particularly durable, but also that when certain parts of the amygdala were destroyed those fears disappeared. That year, Karim Nader joined the laboratory as a postdoctoral researcher. Not long afterward, he attended a lecture given by Eric Kandel, the Columbia University neuroscientist who, in 2000, received a Nobel Prize for his research into the physiological basis of memory. Kandel spent decades demonstrating how neurochemicals form short-term memories, and how more permanent memories are then consolidated into various parts of the brain. Without his findings, none of the research into emotional memory that followed would have been possible.

In the early nineteen-sixties, Kandel decided to conduct classic Pavlovian conditioning studies on aplysia, or sea slugs, which have relatively few neurons. More important, aplysia possess what Kandel has described as the "largest nerve cells in the animal kingdom. You can see them with your naked eye." That made them easy to manipulate in a laboratory. Kandel removed neurons and placed them in a petri dish. By stimulating the neurons with an electrode, he was able to map the entire neural circuit required to cause a common reflex. (The reflex he chose forces the slug's gills to retract when they are disturbed, in much the same way that a threatened porcupine will raise its quills.)

Scientists were already aware that making a memory requires chemical activity in the brain. But neurons are programmed by our DNA, and they rarely change. On the other hand, synapses, the small gaps between neurons, turn out to be highly mutable. Synaptic networks grow as we learn, often sprouting entirely new branches, based on the way that chemical messengers called neurotransmitters pass between neurons. "The growth and maintenance of new synaptic terminals makes memory persist," Kandel wrote in his book "In Search of Memory: The Emergence of a New Science of Mind" (2006). "Thus, if you remember anything of this book, it will be because your brain is slightly different after you have finished reading it."

Nader was thrilled by the idea that one could watch an organism form a memory. "I was not trained as a neuroscientist in memory or in consolidation," he told me recently on the phone from McGill University, where he is now a professor of psychology. "Kandel talked about the physiology of the neuron on the most basic level, and I was amazed. But I didn't understand why a thing like that—the complete chemical production required to form a memory—would happen just once. I looked at the data and thought, What makes us so certain that, after our memories are formed, they are fixed forever?"

The prospect that a memory might be altered simply by being recalled was heretical; LeDoux urged Nader not to waste his time. But he was determined, and LeDoux didn't interfere. Early in 1999, Nader and his colleagues devised an experiment in which they trained a group of rats to fear a tone. Conditioning, for rats and most species, including ours, is relatively straightforward: a researcher will pair a neutral stimulus like a tone or a color with something unpleasant, usually a shock. The results are quick and definitive; replay the tone, even without the shock, and the rat will freeze in place, crouching as low as it can. Its fur will stand on end, and its blood pressure will soar. The next time the rat (or human) hears the tone, the electrical circuitry in its brain responds as powerfully as if it were also experiencing the shock, and the synapses associated with that memory will grow stronger.

After teaching the rats to fear the tone, Nader waited twenty-four hours, to give their memories time to consolidate. Then he played the tone again and injected the antibiotic anisomycin into the rats' lateral amygdala, the area that houses fearful emotions. Anisomycin has been shown to prevent neurons from producing the proteins necessary to store a memory. If memories are formed just once, Nader reasoned, the drug should have no effect. "The idea," he said, "was that if a new set of proteins was required then the drug should prevent the memory from being recalled." That is exactly

what happened. Rats that received the drug within four hours of recalling the memory forgot their fear. Two weeks later, when Nader again tested the rats, those with blocked memories responded as if they had never heard the tone. Rats in two control groups—one of which received no shot, the other of which received a placebo injection that did nothing to prevent synapses from making new proteins—remained terrified.

Nader's data could not have been clearer, or more unsettling. He had demonstrated that the very act of remembering something makes it vulnerable to change. Like a text recalled from a computer's hard drive, each memory was subject to editing. First, you have to search the computer for the text, and then bring it to the screen, at which point you can alter and save it. Whether the changes are slight or extensive, the new document is never quite the same as the original.

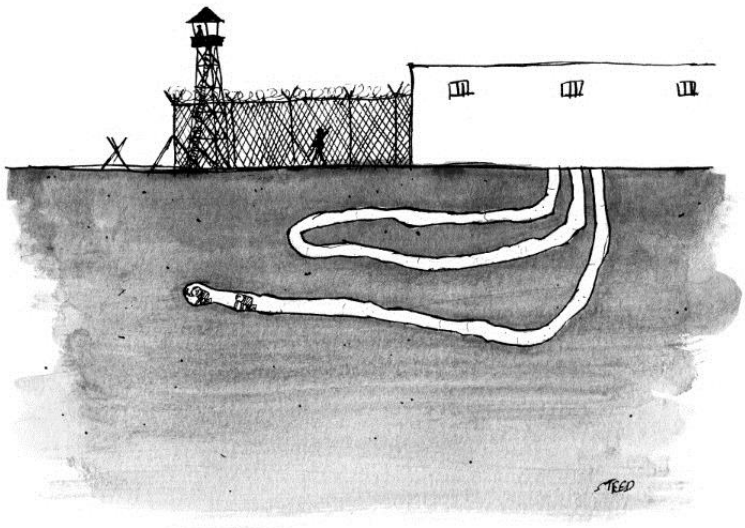
Many people in the field treated Nader's findings with contempt. James L. McGaugh, of the University of California at Irvine's Center for the Neurobiology of Learning and Memory, and one of the nation's leading neuroscientists, argued, like most of his colleagues, that, once long-term memories are established, they are there to stay. "Occasionally, the seduction of simplicity embarrasses the field," McGaugh and two colleagues wrote at the time. He compared work on reconsolidation like Nader's to notoriously inaccurate research, begun in the nineteen-sixties but long since debunked, suggesting that it was possible to transfer intelligence from one animal to another through "memory molecules." "We should be careful not to laugh in retrospect at such ideas," McGaugh wrote, "if we remain attracted to other more contemporary simple explanations of the complex phenomena of learning and memory."

Scientists around the world soon set out to repeat Nader's study, and the results of experiments in dozens of species, from fruit flies to mice, supported his conclusions. The dogma of consolidation made no sense. It is one thing, of course, to erase a fear created in a laboratory and applied to rats, and another to do it with humans. Daniela Schiller was in Israel at the time, finishing her doctorate. Using an animal model, she had studied the relationship between emotion and neural circuitry in schizophrenia. When Schiller learned of Nader's findings, she wondered if it would be possible to reactivate a traumatic memory in humans and then block the fears associated with it, much as Nader had done in rats. With her father's advancing age never far from her mind, she became determined to find out.

Daniela Schiller is tall and trim, with steel-blue eyes and dark-blond hair. When she strides through her laboratory, at Mount Sinai, Schiller—nearly always dressed in understated outfits designed by her sister, Yael, in Tel Aviv—carries herself more like a Middle European aristocrat than like a woman who grew up in a scruffy suburb of Tel Aviv. Schiller's mother is Moroccan, and she says that her father, who suffers from emphysema, sounds like a sort of Polish Darth Vader. "You hear him before you see him," she said. Schiller is the youngest of four children; her two older brothers and her sister stayed in Israel, and her parents still live in the house where she grew up. Science always appealed to Schiller. "I would mix sand from the back yard with all sorts of materials I found at home and turn it into weird solids and liquids," she told me. The concoction "looked like a top-secret chemistry set, in my little mind, so I asked a neighbor to hide it in her back yard. After a few days, she asked me to take it back. She was worried it might blow up or something."

The winter Schiller started working at N.Y.U., she noticed her boss, Joseph LeDoux, playing guitar at a Christmas party with Tyler Volk, a professor of biology. Schiller is a drummer, and she soon found a lab mate who played bass. The four formed the Amygdaloids, which, despite the gimmicky name, is far better than one might suspect of a band born in a brain lab. At N.Y.U., Elizabeth Phelps asked Schiller to work on a study that might determine whether humans would respond the way rats did to Nader's experiments. But the drug used for rats was far too toxic to use on people. Instead, Schiller used propranolol, a common beta blocker that, because it latches on to receptors in a variety of proteins, has been shown to interfere with the formation of memories. She applied to the university for permission to carry out the experiment, and waited for a response; she has not yet received one.

During a laboratory meeting, however, Schiller's colleague Marie Monfils mentioned that, after behavioral training, a group of rats in one of her experiments seemed to lose their fear. The finding was serendipitous; Monfils had originally been studying something else. But the comment provided Schiller with what she describes as her "eureka moment." Until then, memory



"Are you sure you've got everything this time?"

reconsolidation had been blocked only by physical intervention, either drugs or electric shocks. If, as scientists have suggested, reconsolidation evolved so that memory could be augmented with new information, then behavior modification ought to have the same effect as a drug. "I suddenly realized that we had never tested that theory," Schiller told me. Monfils agreed to carry out a behavioral study of rats, and Schiller would do the same with humans.

The theory was borne out by both experiments. Schiller trained sixty-five people to fear a colored square by associating it with a shock. The next day, the sight of the square alone was enough to revive their fearful reactions. Then Schiller divided the subjects into three groups. By presenting the squares many more times, with no shock, she attempted to teach them to overcome their fear. That is called extinction training. The results were dramatic: people who saw the squares within ten minutes of having their memories revived forgot their fear completely. The others, who were not shown the squares again until hours later, remained frightened.

Schiller's study, which was published in *Nature* in 2010, offered the first clear suggestion that it might be possible to provide long-term treatment for people who suffer from P.T.S.D. and other anxiety disorders without drugs. And the effect seemed to last; a year later, when the researchers tested the subjects again, the fear response still had not returned.

Schiller moved to Mount Sinai in 2010. Since then, she has pursued three central goals in her research: tracing the neural mechanism, or signature, that causes memory to update in the human brain; determining whether drugs might work safely in humans; and establishing a protocol that therapists could use to treat patients. (Scientists have already found that behavioral interference during reconsolidation appears to alter glutamate receptors in the amygdala, which might explain how memories are rewritten during the treatment.)

On a particularly harsh winter morning in February, I joined Schiller and one of her postdocs, Dorothee Bentz, at the Mount Sinai School of Medicine's Brain Imaging Core. Despite its impressive, "Matrix"-like name, the Core is a closet-size room filled with computers and electrical machinery. The gauges and ominous-looking dials seem to belong on an old radio set. Bentz attached electrodes and sensors to my arms and to my right wrist, told me to take a deep breath, and then started ramping up the voltage. I watched the meter as the needle jumped.

"Do you feel that?" Schiller asked, somewhat remotely. "It's twenty volts, a small charge." I said no. She moved the lever to thirty. Yes, but only barely, I told her. Finally, at forty volts, I began to feel the shock. It was by no means a dangerous level; nonetheless, it was a sensation that few people would welcome. Schiller was planning to do to me what she had spent so much time doing to others: teach me to fear a meaningless symbol. Colored spheres began to float onto a computer screen in front of me, in no particularly discernible pattern: just a random, rapid-fire procession—purple, yellow, and blue. It didn't take long to realize that nearly every time a blue sphere appeared a shock would follow; by the time I felt the voltage, my pulse and heart rate had already spiked in anticipation. The shock itself quickly became superfluous.

The day after learning to fear the spheres, Schiller's subjects see them again many times—but without the accompanying shock. "If you present a negative memory over and over again, without anything bad happening, it is possible for most people to overcome the fear," Schiller explained. Extinction training has for a long time been one of the principal treatments for many phobias and fears; psychiatrists refer to it as exposure therapy. The more you see something, the less it scares you, and the less it scares you the more able you are to deal with it. There has always been a problem, though, in using extinction to

ROCKLAND

I saw it being built, flat as a Frisbee
in the bowl of those foothills, trees disappearing
month after month, replaced by smooth roads,
empty schools, pork-chop lots, and cul-de-sacs
spotted with unfinished houses, the noise walls curving
the roadway into one long cement smile.

We used to drive up there in our parents'
cars—past the starter castles—to the daisy-wheel
junctions with their stoplights sheathed in muslin
like some beheaded prisoner, the air
so high and tight and piney you could hear
construction hammering from miles away.

It was a ghost town but for that sound. We'd sit
in the unfinished high-school stadium, at the
lip of what would become the bleachers, the half-
built Cineplex in the distance like a prison, and listen
to nothing turning to something, waiting
for the sky to turn purple and the traffic to hush.

Then, curfew looming, we'd race back across
the newly edgeless city, our radios turned up
to drown our pounding hearts, tires screeching on
the silky arterials. We felt it would never end.
The empty sky, the city that didn't matter.
We held our breaths when we clicked off
the headlamps and ran through stoplights.

—John Freeman

treat people who have experienced profound trauma: the process leaves them with a pair of memories: blue sphere predicts shock; blue sphere doesn't predict shock. Over time, the two memories can compete for expression. That is a significant characteristic of anxiety disorder. People will be fine for months or years, but if they encounter a particularly stressful situation the fear memory often overwhelms the calm memory.

Schiller's study demonstrated that the competing memories can become one. "If we zap it at just the right time, there are no new memories," she told me with a look of restrained satisfaction. "There is a different memory. You will still know what happened, and the information will be available to you. But the emotion will be gone."

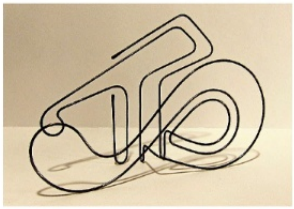
Schiller has applied for funding to continue the research. Deep budget cuts have made it harder to get money than ever before, though, and her initial, three-year grant at Mount Sinai has nearly come to an end. I asked what would happen if she received no money. "I'm back on the street," she said, shrugging. "But I believe we can find a way to make P.T.S.D. less terrible. From the research perspective, you really do get very optimistic. Of course, I am careful not to try and overhype it. Translating research into better human lives is never easy."

Not long after my fear test, I took the train to Philadelphia to speak with Edna Foa, who is the director of the Center for the Treatment and Study of Anxiety, at the University of Pennsylvania Medical School. Foa is one of the nation's leading experts on the psychopathology of anxiety disorders, and she has written widely on P.T.S.D. We met in her office at the medical school, which looks onto the oddly serene urban landscape of Center City. I asked if she thought scientists would ever really be able to write the pain out of a patient's mind.

"That is the critical question," she replied, stressing that she is a clinician, not a neuroscientist. "This is the most exciting prospect I think I have ever seen for treating people with severe anxiety-based disease. It isn't easy to banish demons caused by war, trauma, and rape." Freud argued that repressed memories, blocked unconsciously, were like infections, capable of deepening and festering unless they were brought to the conscious mind and resolved. Many psychiatrists have taken the opposite approach. "There has always been a group that says we could reignite a trauma by asking people to deal with the memory," Foa said. "In this thinking, keeping the memory suppressed was actually better. That was a strong belief in the early era of psychiatry: Put it behind you. Don't deal with it. Go on with your life. The idea behind counselling was to soothe the patient, to find ways to make him as comfortable as possible."

Only in the past decade have researchers determined that, while the original memory may be inhibited, it doesn't vanish. Foa said that the idea of rewriting memories, rather than destroying them, appealed to her. But she added that reconsolidation raises a paradox: in order to update our most painful memories, we have to revisit them. That is never easy to do. Foa described a patient who was raped more than a decade ago, by her boyfriend and several of his friends. She suffered badly from P.T.S.D., found it impossible to maintain relationships, and had recently entered therapy. "Instead of asking herself what actually happened, she would immediately say it was all her fault," Foa said. "She always said the same thing: 'I didn't fight them. If I had, they would have stopped.'

"But she never dealt with it, and that is why she had P.T.S.D.," Foa went on. "We asked her to tell the story of that



New Year's Eve and repeat it many times." As people work through the story again and again, they learn to distinguish between remembering what happened in the past and actually being back there. For people with P.T.S.D., this distinction is not easy to make. The next step was to bring those memories to the surface—and when, finally, the woman did that she realized that her terror and her rape were not her fault.

I asked Foa if she had considered the ethical complexity involved in tampering with a person's memory. "Of course," she replied. "But you do have to look at the whole picture. We are talking about helping people who have been severely traumatized, and in many cases they are unable to function. Nobody is suggesting that we rewrite the memory of someone who had a bad date or a fight with his mother."

In practice, it may be hard to draw an ethical line that would satisfy patients, doctors, and the public. Few people would deny effective treatment to victims of severe brutality. But any treatment available to those who need it will almost certainly be available to others. "Memory erasure remains a possible but unproven hypothesis," Joseph LeDoux has written, adding that editing memories "is definitely possible and has broad implications. We are nothing without our memories, but sometimes they also make us less than we could be. . . . Although some ethicists argue that memory should not be tampered with, every special date and anniversary, every advertisement, every therapy session, every day in school is an effort to create or modify memory. Tampering with memory is a part of daily life. If we take a more realistic view of just how much we mess with memory, the dampening of memories that produce emotional responses in traumatized individuals might seem less malevolent."

Reconsolidation has already been shown, in promising if limited research, to help treat drug addiction. Addicts are compelled by the same persistent emotional memories that drive other disorders. "The biggest problem for most addicts is how to deal with relapse," Schiller told me. "Let's say somebody is drug-free and then goes and hangs out with friends at a park. He might see a cue associated with his drug use, and that will induce a craving that will cause him to seek the drug." Reconsolidation presents a chance to disrupt that process; you don't lose the memory—you just lose the pleasant feeling it creates.

The idea is simple enough: you cannot be addicted to a desire that you don't remember. Jonathan Lee, a behavioral neuroscientist now at the University of Birmingham, in England, has already put that notion to a test. He used Pavlovian conditioning to induce cravings

in rats, by pairing light with a narcotic. The next time he showed the animals the light, they automatically reached for the drug. But, as was the case with Nader's experiments, when Lee interrupted the process of reconsolidation the association disappeared. Researchers in the U.S. and China have had similar success with human addicts. Once again, timing was critical: the effect worked only if extinction training took place within ten minutes of retrieving the old memory. "If you block that association, you can erase the craving," Schiller said. "This is the first time we have seen a treatment like that lead to a cessation of addiction." Even six months later, the addicts showed no sign of relapse, suggesting, as with Schiller's work, that when fearful memories are disturbed at the right moment the fear may be gone for good.

At the age of eighty-eight, Sigmund Schiller, with a mustache, goatee, and nearly bald pate, looks like an aging Lenin. These days, he spends most of his time tending the small, immaculate garden behind the ranch house that he and his wife, Yaffa, have lived in for nearly half a century.

I had come to his house, in this sunny spot between Ben Gurion Airport and the Mediterranean coast, for an unlikely reason: not long ago, after decades of unwavering silence, Schiller spoke about his Holocaust experience. It happened once, and he says that it won't happen again. But his words were filmed for a documentary. I had watched it with Daniela Schiller in Brooklyn, at the home of the director, Liron Unreich; the day I visited Rishon LeZion, Schiller's parents were about to see the film for the first time. Unreich is a multimedia artist and a co-founder of the Ripple Project, which explores the multigenerational effects of the Holocaust through short documentaries. Schiller, who took part in the film, had been astonished when her father began to talk to Unreich and his crew. "To say I never expected it would be an understatement," she told me before we went to Israel. "I still have trouble believing the sequence of events."

Unreich told Schiller that he wanted to make a documentary about the connection between survivors and their children. Schiller had explained that her father would never talk—that it would be a silent movie. Unreich was undeterred, and said that he was planning a trip to Israel, where he grew up, and would be grateful for the chance to film Daniela as she tried to engage with her father. Her father had no objection, so she agreed. "I told him not to worry, they were aware that he would say nothing."

Unreich had brought a young cinematographer who was born in Ukraine; he quickly established a rapport with Sigmund Schiller. His daughter asked him once again, for the film, to discuss his memories. He declined. "So we sat there in silence for a while, and I was happy that Liron was there to capture one of our 'conversations.' " Then the silence ended.

"I was eleven when my little sister was born," her father said, speaking Hebrew in a flat monotone, but with tears in his eyes. "I was very attached to her, and she was closer to me than to my mom. I taught her how to walk. Her first words, her first laughter was with me. I am the one who raised her."

Schiller had never before mentioned a sister, even to his wife. Daniela fought back tears in the film, and was fighting them back again in the family's living room. Her mother, who watched the film in silence, said in a whisper, "I never knew about your sister."

"She never grew up," the elder Schiller told Unreich in the film. "She was amazing."

Unreich asked if he remembered the last time he saw her.

"I remember the last time I didn't see her," he replied. "We had a maid who loved the kids very much, but she lived in a different village. When we ran away to hide in the forest, my mom took my sister to her house. . . . After a while, there was a rumor that she had been executed. Two policemen came, and took her to the fields. One was a 'humanitarian.' He didn't want her to suffer, so he took her toy, threw it away, and said go pick it up. That way, he could shoot her in the back without her knowing."

In the living room, surrounded by book-lined shelves and bright pictures of birds, painted over the years by Yaffa Schiller, we all sat stunned, in silence. Before we left New York, Daniela Schiller had told me that her father finds being called a Holocaust survivor demeaning. "When people talk about the Holocaust, they talk about gas chambers, Auschwitz—the Holocaust is not just about that," she said. "It's about the little humiliations, the loss of dignity."

Her father made much the same point in the film. "People talk about 'Sophie's Choice' as if it were a rare event," he said. "It wasn't. Everybody had to make Sophie's choice—all of us. My mother left behind a four-year-old with the maid. You don't think I was beaten and shot at? There are no violins in my story. It is the most common thing that happened."

Nobody moved in the Schillers' living room while the film continued. At times, Daniela hid her eyes with her hands, and so did her father. For the most part, they were immobile. On camera, she asked him if he had consciously suppressed this information.

"Yes," he said. "You must suppress. Without suppression I wouldn't live."

"I have learned in my research," she told him, "that it should be the other way around. I think it's good to cry—you should bring back memories and relive them. And since you are not in the war anymore, it might be a good experience." At that, Sigmund Schiller shook his head and stopped speaking.

It's not clear if the experience has altered his memory of those events. But it has transformed his daughter's memories of him, and of her own life. She told me that she realized memory is "what you are now, not what you think you were in the past. When you change the story you created, you change your life. I created the story and brought these memories together, and now my past is different from the past I had before. Especially the memories of my father. He was a reserved man, a non-talking person. I know that, but there was this window when he was a different person. A very brief window, but now that is the person who inhabits each of my previous memories."

She sat quietly for a long time. Then she continued, "I picture him from the time I was in kindergarten. But now I only can see him with all the insight I have gained. My memory has been updated. I have spent much of my life trying to find a way to reconsolidate my father's memories, and ended up reconsolidating my own." ♦