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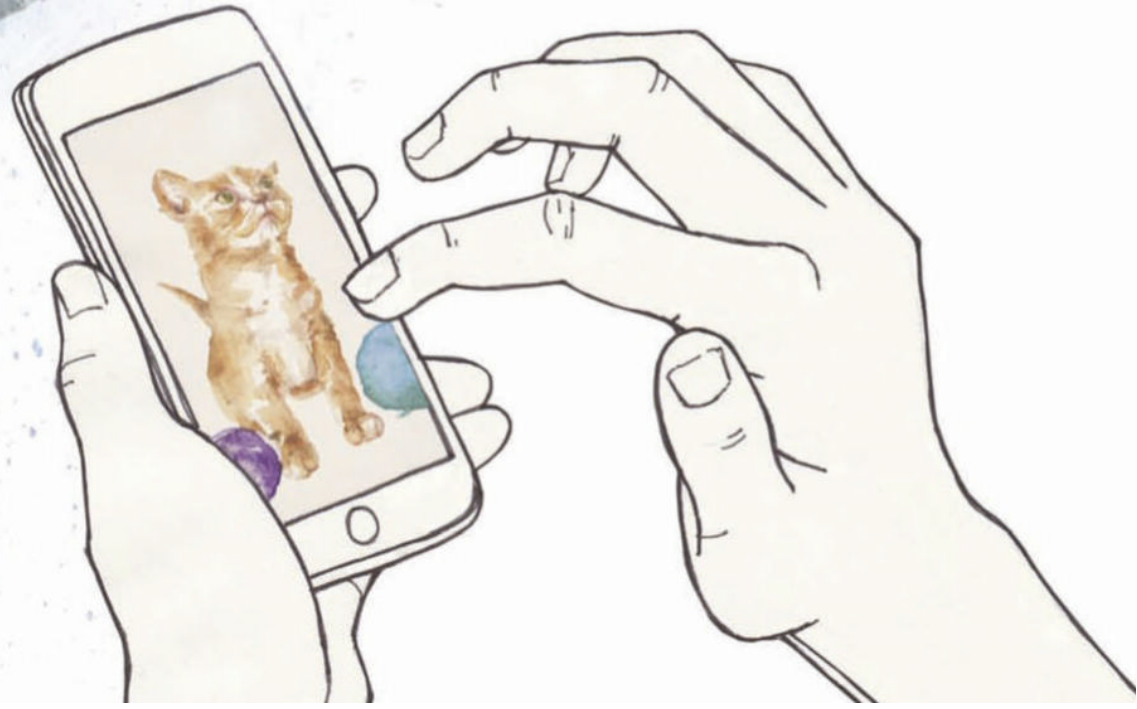
## **Memory Now**

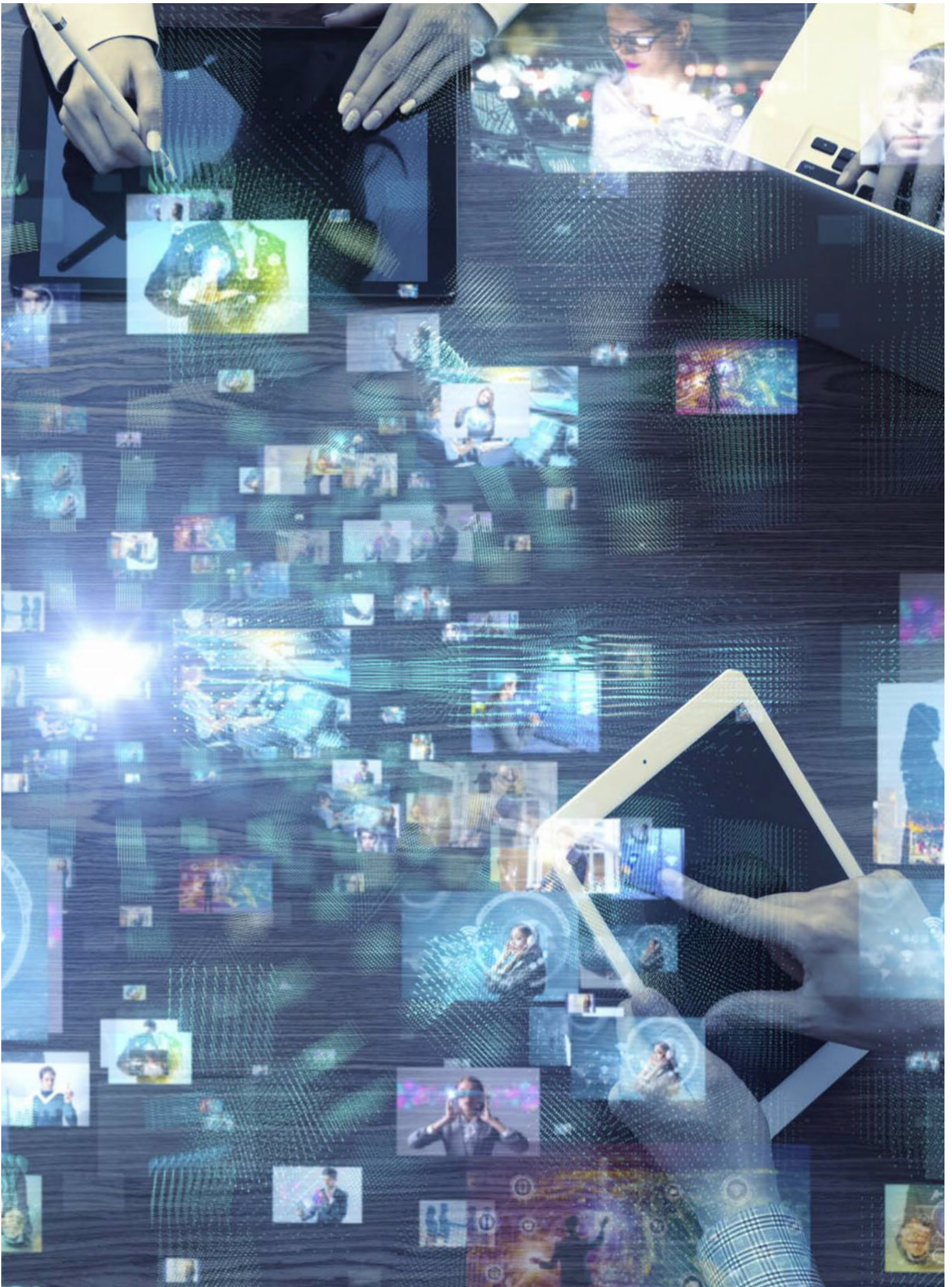
*Buffeted by the internet, stress and insomnia, modern life can feel like an endless round of The Interruption Game. How is it affecting our recall abilities?*





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# THE DIGITAL-ERA BRAIN



*Critics complain the internet is eroding our memory. Supporters say it is opening pathways. Who is right?*

**By J.I. Baker**

**A** REVOLUTIONARY NEW TECHNOLOGY was promising unprecedented access to information but was also sounding alarms: “This invention will produce forgetfulness in the minds of those who learn to use it, because they will not practice their memory,” warned a leading mind of the era. It was 370 B.C., and the speaker was Socrates. The object of his scorn? The dreaded written word.

It was only the beginning of millennia of hand-wringing over technology and memory. In the 1400s, the invention of the printing press prompted concern that monks would become lazy without all that copying to do. In the 18th century, the bogeyman was the newspaper, which French statesman Malesherbes argued isolated readers. Now, several centuries later, the internet is memory’s latest alleged enemy, with psychologists, neurobiologists and educators warning that our recall and attention spans are being decimated. The digital us, the concern goes, is distracted and superficial, on the road to intellectual ruin.

But is the internet really corrupting our memories—or will our skeptical experts, like Socrates before them, eventually be proven wrong? After all, the brain’s attention system and preferences for novel experiences existed long before the digital age, and our ability to remember is nearly inexhaustible—with about a million gigabytes of mental storage capacity. “Your brain—every brain—is a work in progress,” said Michael Merzenich, a neuroscientist and brain-plasticity researcher. “It is ‘plastic.’ From the day we’re born to the day we die, it continuously revises and remodels, improving or slowly declining, as a function of how we use it.”

Though we don’t know exactly how memories are created or retrieved, we know that neurons talk to one another through synapses, which function sort of like bridges. Information crosses those bridges with the help of chemicals called “neurotransmitters.” The more neurotransmitters we have and the more frequent their signals, the stronger the connections between neurons become—until the process begins to happen even without the help of neurotransmitters. This leads to the formation of strong memories, but it only works when our brains are ac-

tively engaged. In short, the brain is like a muscle—the more you use it, the better it functions.

But our brains don't work well when we're distracted, which we are more than ever these days. A 2016 joint study by MIT and Microsoft found that the average employee checks their email 11 times an hour. Another survey, of college students from 26 states, revealed that students spend 20% of their class time texting, playing games and checking social media on digital devices. By constantly interrupting our thought processes, we are interfering with our ability to form both short- and long-term memories, experts say.

Even the fact that many of our online “conversations”—instant messaging on Facebook, for instance—remain unfinished affects our brains' ability to function. This phenomenon is sometimes called “the Waiter Effect,” since studies have shown that waiters tend to remember incomplete business with customers better than visits that end normally. “Social interactions are very demanding for the brain,” says Eric Fransén, who studies memory at Stockholm's Royal Institute of Technology, “and social media is designed to enable interactions with basically unlimited numbers of people.” The mental juggling involved in switching back and forth between platforms and conversations slows down our brains—sometimes for up to half an hour after a switch of topic, Fransén says.

The contemporary onslaught of information affects our ability to remember too. Though our brains are designed to seek new data, too much of it may be causing this evolutionary instinct to run amok. The compulsion to constantly consume information means we often check Instagram when we should be doing what Fransén calls “memory housekeeping” by giving our brains some downtime. “My greatest concern today concerns our use of social media at time points of the day when our brains need to rest,” notes Fransén. “The pauses that once occurred whenever we weren't explicitly focused and active now often get filled with social media.”

Another issue: the passive nature of obtaining information online. Trying to actively recall data is a

good workout for the brain, but today we Google instead—more than 5.5 billion times daily, compared with 3.3 billion times per day in 2012, according to the most recent estimates. As a result, our attention spans have shrunk from 12 seconds in 2000 to eight seconds—one second less than a goldfish's. This leads to what scientists call digital amnesia: we tend to forget information if we think it can be retrieved from a digital device.

Consider a 2018 study published in the *Journal of Experimental Social Psychology*. Researchers instructed 129 subjects to take self-guided tours of the Stanford Memorial Church on the Stanford University campus. Participants were supposed to take note of details such as “the cruciform shape of the church.” Some had camera phones and were told to

take pictures so they could post images on Facebook, while others toured without cameras. A week later, the tourers were given a quiz about what they had seen and learned. Those without a camera got seven out of 10 questions right on average, while those who had a camera got six right. “It could just be that we're using these devices, distracting ourselves from the experience, and because of that distraction, we don't remember the thing we're supposed to be paying attention to,” Emma Templeton, a Dartmouth psychological researcher who was a co-author of the study, told Vox.

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 But the internet may be changing merely what we remember, not our capacity to do so, suggests Columbia University psychology professor and researcher Betsy Sparrow. In 2011, Sparrow led a study in which participants were asked to record 40 factoids in a computer (“an ostrich's eye is bigger than its brain,” for example). Half of the participants were told the information would be erased, while the other half were told it would be saved. Guess what? The latter group made no effort to recall the information when quizzed on it later, because they knew they could find it on their computers. In the same study, a group was asked to remember both the information and the folders it was stored in. They didn't remember the information, but they remembered how to find the folders. In other words, human



*Fans videoed the pop band the Vamps during a performance at Cardiff University in Wales.*

memory is not deteriorating but “adapting to new communications technology,” Sparrow says.

In a very practical way, the internet is becoming an external hard drive for our memories, a process known as “cognitive offloading.” Traditionally, this role was fulfilled by data banks, libraries and other humans. Your father may never remember birthdays because your mother does, for instance. Some worry that this is having a destructive effect on society, but Sparrow sees an upside. Perhaps, she suggests, the trend will change our approach to learning from a focus on individual facts and memorization to an emphasis on more conceptual thinking—something that is not available on the internet. “I personally have never seen all that much intellectual value in memorizing things,” Sparrow says, adding that we haven’t lost our ability to do it.

Still other experts say it’s too soon to understand how the internet affects our brains. There is no experimental evidence showing that it interferes with our ability to focus, for instance, wrote psycholo-

gists Christopher Chabris and Daniel J. Simons in a 2010 *Los Angeles Times* op-ed. And surfing the web exercised the brain more than reading did among computer-savvy older adults in a 2008 study involving 24 participants at the Semel Institute for Neuroscience and Human Behavior at the University of California.

In *How Google Is Changing Your Brain*, Harvard psychologists Daniel M. Wegner and Adrian F. Ward argue that not needing to remember facts might free our minds to focus on more ambitious endeavors and could even help us fix some of the messes we’ve created. “There may be costs associated with our increased reliance on the internet, but I’d have to imagine that overall the benefits are going to outweigh those costs,” observes Benjamin Storm, a psychology professor with the memory lab at the University of California, Santa Cruz. “It seems pretty clear that memory is changing, but is it changing for the better? At this point, we don’t know.” □



*The North German championships  
of Memory XL, a learning and  
memory competition*

# BATTLE OF THE BIG BRAINS



*On a lark, an American journalist with average recall decided to train for the USA Memory Championship. His first stop? A cutthroat match in Oxford, England, to observe the world's top “mental athletes”*

**By Joshua Foer**

# H

AVING BEGUN TO FUTZ AROUND with memory techniques, I didn't yet have any sense of the true scope of the enterprise I was embarking upon. I still thought of my project as a harmlessly casual experiment. All I wanted to

know was whether I really could improve my memory, and, if so, by how much. I certainly hadn't seriously considered the challenge by self-help guru and memory impresario Tony Buzan to try to compete in the USA Memory Championship. After all, there were more than three dozen American mental athletes who trained each year for the event. There was no reason to think a journalist who occasionally forgets his own Social Security number could compete against the U.S.'s top memory geeks.

Americans on the international memory circuit in 2018 are a different breed than they were in 2011, when I published *Moonwalking with Einstein*, an account of my year of memory training. Today the reigning three-time world memory champ is an American who got into mental athletics after reading my book. But back then, American mentalists were like Jamaicans on the bobsledding circuit—easily the most laid-back folks, and possibly even the most stylish, but on the international stage, behind the curve in both technique and training.



Nobody in North America took memory sport seriously enough to stop drinking three months beforehand, like the eight-time world memory champ, Briton Dominic O'Brien, used to do, and from the looks of it, few competitors engaged in the rigorous physical-training regimen that Buzan recommended. (One of his first, unsolicited pieces of advice to me was to get in shape.)

In those days, U.S. records paled in comparison to the Europeans, and though America had run its memory championship for as long as any country in the world, the best American memorizer had only finished in the top five of the world championship once, in 1999. Perhaps it said something about our national character at the time that America had produced none of the world's best competitive memorizers—that we were not as detail-obsessed as the Germans, as punctilious as the Brits or as driven as the Malaysians. Or maybe, as one European soberly suggested to me, Americans have impoverished memories because we are preoccupied with the future, while folks on the other side of the Atlantic are more concerned with the past. Whatever the reason, it became clear that if I wanted to learn more about the art of memory—if I wanted to study with the best—I was going to have to go to Europe.

**THE GRANDDADDY OF** events on the yearlong international memory circuit, the World Memory Championship, was going to be held in Oxford, England, at the end of the summer. I decided I needed to go and called up Ed Cooke, a young grand master from the U.K. I had met at the U.S. competition, to ask if I could crash at his place. Oxford was his home turf—where he'd grown up, gone to college, and now lived with his parents on their country estate located on the town's outskirts, in a 17th-century stone house called the Mill Farm. I arrived a few days early and got the lay of the land.

The favorite to take the title from the reigning world champ, the Brit Ben Pridmore, was Dr. Gunther Karsten, the balding, angular 43-year-old godfather of German memory sport, who had won every German national contest since 1998. Gunther showed up wearing what I learned was his standard uniform: an imposing pair of black earmuffs and metallic sunglasses whose insides had been completely taped over except for two small pinholes. "Extraneous stimuli," as Gunther called them, are the memorizer's *bête noire*. He also wore

a gold belt buckle embossed with his initials, a gold chain over his tight white T-shirt, and black sailor pants. Gunther informed me that in college he was a photo model for Nissan cars, and depending on how you squinted, he looked like the villain in a James Bond movie or an aging figure skater. He was in terrific physical shape, and was, I would soon learn, a fierce competitor. He was carrying around with him a locked, shiny metal suitcase filled with between 20 and 30 decks of playing cards, which he planned to memorize. He wouldn't tell me the exact number for fear it would get back to Ben Pridmore.

Unlike the U.S. championship of the era, which had just five events, none lasting longer than 15 minutes, the World Memory Championships, held at Oxford University, was often referred to as a "mental decathlon." Its 10 events, called "disciplines," spanned three grueling days, and each tested the competitors' memories in a slightly different way. Contestants had to memorize a previously unpublished poem spanning several pages, pages of random words (record: 280 in 15 minutes), lists of binary digits (record: 4,140 in 30 minutes), shuffled decks of playing cards, a list of historical dates, and names and faces. Some disciplines, called "speed events," tested how much the contestants could memorize in five minutes (record: 405 digits). Two marathon disciplines tested how many card decks and random digits they could memorize in an hour (records: 2,080 digits and 27 decks).

The first World Memory Championship was held at the posh Athenaeum Club in London in 1991. "I thought, this is insane," recalled Buzan, who founded the event. "We have crossword championships. We have Scrabble championships. We have chess, bridge, poker, draughts, canasta and Go championships. We have science fair championships. And for the biggest, the most fundamental of all human cognitive processes, memory, there's no championship." He also knew that the idea of a "world memory champion" would be an irresistible draw for the media, and a savvy way to promote his books on mind training.

With the help of his friend Raymond Keene, a British chess grand master, Buzan sent out letters to a handful of people who he knew were involved in memory training, and also ran an ad in the *Times*. Seven people showed up, including a psychiatric nurse named Creighton Carvello who had memorized the telephone number of every Smith in the



*In ancient times, mnemonic aids were crucial to transmitting stories, such as Homer's tale of Helen of Troy.*

Middlesbrough phone book and another person named Bruce Balmer who had set a record for memorizing 2,000 foreign words in a single day. Several of the competitors wore tuxedos.

Today, contestants no longer adhere to such a strict dress code, but everything else about the championship has gotten far more serious. What began as a one-day contest has now expanded to fill an entire weekend. Of all the disciplines in a three-day memory decathlon, the first one of the first day, the poem, is the most universally dreaded. For years, Gunther had lobbied to have the event stricken from the contest, but poetry is where memorization began, and to cut it from the championship because a few of the competitors find it difficult would run counter to the competition's underlying premise that memorization is a creative, humanizing endeavor. So every year, a new, previously unpublished poem is commissioned for the world championship. For the first few years of the competition, in the early '90s, the poem was written by British poet laureate Ted Hughes, whom Buzan describes as "an old friend." Since Hughes's death

in 1998, the poem has been written by Buzan himself. The 108-line free-verse offering of the year I attended was titled "Miserare," and came from a collection titled "Requiem for Ted." It began:

*With most things in the Universe I am happy:  
Supernovas*

*The Horse Head Nebula The Crab*

*The light-years-big clouds That are the Womb of  
Stars*

It went on to list the many things Tony Buzan was happy about, including "God's freezing balls," and ended:

*I am not happy That Ted*

*Is Dead.*

The competitors had 15 minutes to memorize as many lines as possible, and then a half hour to write them on a blank sheet of paper. In order to receive full credit for a line, it had to be rendered perfectly, down to each capital letter and punctuation mark. Competitors who failed to underscore just how "not happy" the author was or who mistakenly thought that Ted was "dead" without a capital D would get only half the total points for that line.

The question of how best to memorize a piece of text, or a speech, has vexed mnemonists for millennia. The earliest memory treatises described two types of recollection: *memoria rerum* and *memoria verborum*, memory for things and memory for words. When approaching a text or a speech, one could try to remember the gist, or one could try to remember verbatim.

Cicero preferred the point by point, not word by word, approach, and employing *memoria rerum*. In his dialogue, *De Oratore*, the Roman statesman suggests that an orator delivering a speech should make one image for each major topic he wants to cover, and place each of those images at a locus. Indeed, the word “topic” comes from the Greek word *topos*, or place. (The phrase “in the first place” is a vestige from the art of memory.) Perfect recall of words is something our brains simply aren’t very good at, a fact famously illustrated in the congressional Watergate hearings of 1973. In his testimony before the Senate Watergate Investigating Committee, President Richard Nixon’s counsel John Dean reported on the contents of dozens of meetings related to the cover-up of the break-in. To the president’s chagrin and the committee’s delight, Dean was able to repeat verbatim many conversations that had taken place in the Oval Office. His recollections were so detailed and seemingly so precise that reporters took to calling him “the human tape recorder.” At the time, it hadn’t yet been revealed that there had been an actual tape recorder in the Oval Office recording the conversations that Dean had reconstructed from memory.

While the rest of the country took note of the political implications of those tape recordings, the psychologist Ulric Neisser saw them as a valuable data trove. Neisser compared the transcripts of the recordings with Dean’s testimony, and analyzed what Dean’s memory got right and wrong. Not only did Dean misremember specific quotes—that is to say, *verborum*—he often didn’t properly remember the gist of what had been discussed—*rerum*. But even when his memories were wrong in isolated episodes,

notes Neisser, “there is a sense in which he was altogether right.” John Dean may have gotten the details wrong, but he got the important stuff right. We all do the same thing when we try to recount conversations, because without special training our memories tend to only pay attention to the big picture.

It makes sense that our brains would work like that. The brain is a costly organ. Though it accounts for only 2% of the body’s mass, it uses up a fifth of all the oxygen we breathe, and it’s where a quarter of all our glucose gets burned. It has been ruthlessly honed by natural selection to be efficient at the tasks for which it evolved. One might say that the whole point of our nervous system is to develop a sense of what is happening in the present and what will happen in the future, so that we can respond

in the best possible way. In the most reductive sense, our brains are fundamentally prediction and planning machines. And to work efficiently, they have to find order in the chaos of possible memories. Much of the disarray that our brains filter out is words, because more often than not, the actual language is just window dressing. What matters is the *res*, the meaning of those words. And that’s what our brains are so good at remembering. In real life, it’s rare that anyone is asked to recall *ad verbum* outside of congressional depositions and the poetry event at

a memory competition.

Ultimately, Gunther ended up losing the poetry event to a 15-year-old Austrian, Corinna Draschl, and losing the championship as well. The top prize went to one of his protégés, a quiet and intensely focused 18-year-old Bavarian law student named Clemens Mayer. After botching the spoken numbers and names-and-faces events, Ben Pridmore landed in fourth place overall, lowered the brim of his black hat and walked out the door alone, vowing that he would begin preparing the next day to reclaim his title one year hence.

Ed fared even worse. Of the three dozen competitors, he was one of only 11 who failed to memorize an entire deck of cards in either of the two speed cards trials, which is like a placekicker miss-

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**Though the brain accounts for only 2% of the body’s mass, it uses up a fifth of all the oxygen we breathe and burns a quarter of our glucose.**

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*Briton Andi Bell prepared to memorize a deck of cards during the World Memory Championships.*

ing an extra point twice in a row. I ran after him and grabbed him to ask what had happened. “Too much ambition” was all he would say, shaking his head. “I’ll see you back at the house.” He walked across the Magdalen Bridge to go find a pub where he could watch some cricket and drink Guinness until he’d forgotten his failure.

Standing at the front of the Oxford examination hall, watching the competitors scratch their heads and twiddle their pens as they struggled to recall “Miserare,” I felt acutely aware of how odd it was that we’d come to this: that the only place left where the ancient art of memory was being practiced, or at least celebrated, was in this rarefied competition. Here in one of the world’s most storied centers of learning were the last vestiges of a glorious Golden Age of Memory.

It is hard not to feel as though a devolution has taken place between that shining era and our own

comparatively leaden one. People used to labor to furnish their minds. They invested in the acquisition of memories the same way we invest in the acquisition of things. But today, beyond the Oxford examination hall’s oaken doors, the vast majority of us don’t trust our memories. We find shortcuts to avoid relying on them. We complain about them endlessly, and see even their smallest lapses as evidence that they’re starting to fail us entirely. How did memory, once so essential, end up so marginalized? Why did these techniques disappear? How, I wondered, did our culture end up forgetting how to remember?

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*Adapted from Moonwalking with Einstein by Joshua Foer, published by Penguin Press, an imprint of Penguin Publishing Group, a division of Penguin Random House LLC. Copyright © 2011 by Joshua Foer.*

# WHY SLEEPING ON IT IS KEY FOR MEMORY



*While you are getting your shut-eye, your brain is deciding which new information to keep and which to discard*

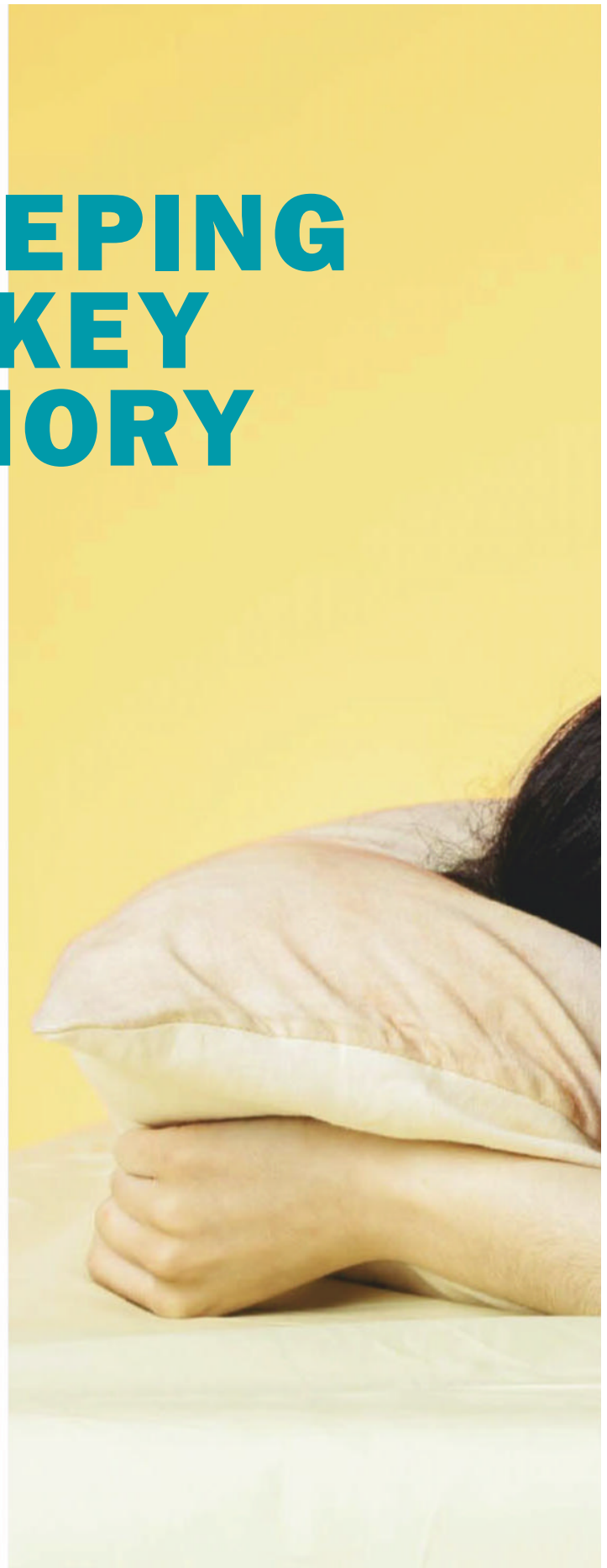
**By Patrick Rogers**

*“To sleep, perchance to dream.”*

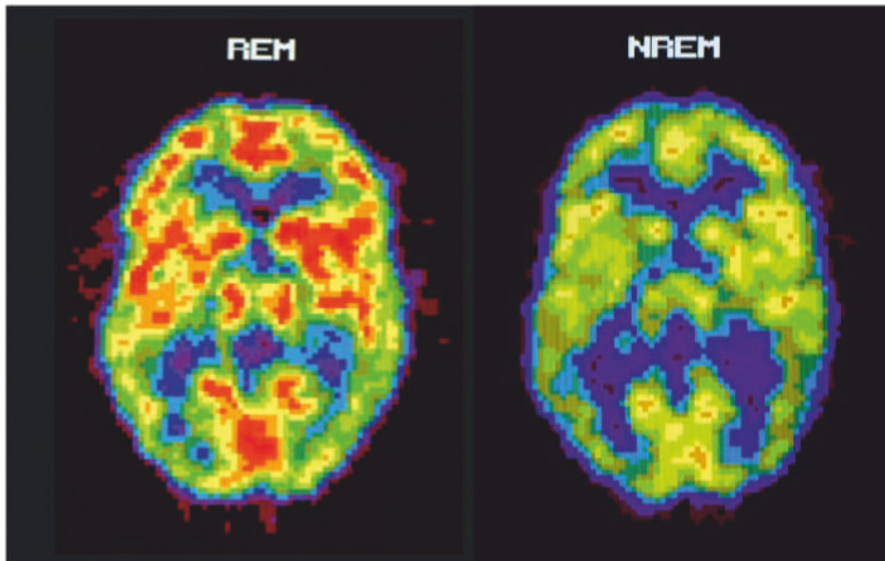
**S**HAKESPEARE, OF COURSE, WAS describing the ultimate slumber, death, in those famous words from *Hamlet*, and the phrase, with its soothing cadence, evokes the common notion of sleep as an escape from worldly toil. Yet recent theories of sleep show that the cells of the sleeping brain are not at rest but surprisingly active, conducting nightly rituals such as shrinking to allow fluid to rinse away toxins and auditing levels of hormones, enzymes and proteins. Meanwhile, the brain’s metronome, just above the bridge of the nose, is making itself heard far into the organ, synchronizing neural activity in near-perfect harmony.

“During the day, the brain is using energy resources to fire neurons,” Allan Pack, director of the Center for Sleep and Circadian Neurobiology at the University of Pennsylvania, told TIME, but “at night, a switch turns on so the sleeping brain can take advantage of the metabolic downtime to do some cleaning up.”

Scientists have long known that the time spent sleeping is ideal for sorting through the torrent of







A PET scan of the brain during REM and NREM sleep. Color coding shows red areas as the most active through to dormant blue.

information taken in during waking hours. By making value judgments about what will prove useful later, the brain consolidates bits of information during sleep, the tastes, smells, thoughts and emotions of daily experience, to produce memories that are worth holding on to. Without these sleep-enhanced memories, learning, language, complex motor skills, decision-making and a slew of friends-and-family interactions would be a long, tough slog.

Consider the foundational gestures of social intercourse—greetings. In a recent study in Boston, a group of people were shown head shots and names of 20 strangers and told they would be asked to identify each subject 12 hours later. “The idea was to recreate the kind of cocktail-party scenario where you meet a lot of people at once and then run into one of them the next day,” says researcher Jeanne Duffy, a neuroscientist in the Division of Sleep and Circadian Disorders at Brigham and Women’s Hospital, a teaching affiliate of Harvard Medical School.

Only half of the subjects were given a chance to sleep, and when it came time to identify the photos, those participants proved an average of 12% more accurate at matching a name to a face than the sleepless cohort. They were also more confident of their ability to say hello to the proper person the next day. The theory goes that during the quiet and unperturbed hours of sleep, the memory-making hippocampus, a seahorse-shaped lobe housed deep in the brain, was better able to bind individual bits of data into paired neural connections along which long-term memo-

ries are ferried to deep storage in the brain’s cortex.

But scientists now believe that a night of rest can do much more than help with simple recall. In his laboratory at the University of California, Berkeley, neuroscientist and psychologist Matthew Walker, author of the 2017 best seller *Why We Sleep: Unlocking the Power of Sleep and Dreams*, has developed an elegant theory that answers one of the key questions in sleep research: Why do we cycle through different modes of sleeping each night? Walker suggests that slow-wave sleep, as well as REM or “dream sleep,” have distinctly beneficial impacts on memory formation and processing. They allow us to update our neural circuits at night and efficiently manage the finite storage capacity of the brain.

**REM TAKES ITS** name from the rapid eye movements that characterize the phase. In a typical sleep cycle, REM is followed by a descent into the deeper unconsciousness of non-REM, or NREM, sleep. Eventually we end up in the state of slow-wave sleep, when brain waves slow to one tenth of typical daytime frequency, before starting the cycle over again. Each cycle lasts about 90 minutes.

There’s no consensus as to why we lurch between stages of sleep in a pattern that, on paper, looks like a cross section of a jagged mountain range, and anything but restful. But Walker argues that these convolutions of the mind are steps in the building of resilient memories. In one experiment, Walker and his colleagues exposed a group of volunteers to new

information, then monitored their brain waves as they nodded off into naps. As the volunteers entered stage 2 NREM sleep (still a light sleep), the researchers witnessed tiny bursts of electricity called sleep spindles traveling between the hippocampus and the brain's cortex. A transfer of information was taking place: the brain was clearing the shelves of its fragile short-term memory banks while moving the most important information to stabler long-term storage. The more sleep spindles the volunteers experienced during their nap, the greater the restoration of their learning when they woke up. The result was a thorough weeding out of the day's earlier lessons that left plenty of room to take in new information.

Even more surprising were the researchers' findings about REM. They asked volunteers to view 150 disturbing images two times, separated by a period of 12 hours. Half of those who slept in the interim were noticeably less stressed out by the images when they viewed them for the second time versus those who hadn't slept. Researchers monitoring their brain waves found decreased electrical activity in the amygdala, a region of the brain that processes emotions, during their REM sleep, when levels of the stress-inducing chemical norepinephrine also drop. In other words, the brain at rest found ways to calm the emotions that adhered to the photos the day before, making the memory of them more manageable. "We sleep to remember and we sleep to forget," Walker says. "I call it overnight therapy."

Just as sleep can take the sting out of painful memories by allowing us to move beyond them, the opposite may also be true, adds Walker. A lack of REM sleep may condemn us to reliving an old trauma as if it were new. "The more nights you sleep, the more soothing the influence of sleep on that memory," he said.

Indeed, other researchers have recently shown that less than five hours of repose at night can lead to forming false memories, and psychologists in San Francisco have uncovered a connection between learning a physical skill by day and increased activity in the motor cortex, the brain's center for executing movements, during certain stages of sleep.

Perhaps Shakespeare's moony Hamlet sought only oblivion at the end of the day, but the poet's fiendish Macbeth knew what he was talking about when he contemplated sleep after murdering a rival: "balm of hurt minds, great nature's second course, chief nourisher in life's feast." □



## The Big Pink: A Soothing Sound That Helps Sleep and Memory

*It's not as well known as white noise but more effective for zzzs*

BY AMANDA MACMILLAN

**Deep sleep is critical** to maintaining a robust memory, but both decline with age. A recent study in *Frontiers in Human Neuroscience* suggests that one easy way for older adults to get deeper sleep and stronger memories is to listen to "pink noise"—a soothing mix of frequencies known for being more natural than the more famous "white noise."

From previous studies, researchers knew that playing pink noise during sleep improved the memory of younger adults, but Northwestern University medical school's Phyllis Zee wanted to see if the same applied to older people, who tend to get less slow-wave sleep and are at greater risk for memory impairment.

Zee and her team had 13 adults ages 60 and older spend two evenings in a sleep lab. Participants took a memory test at night, went to sleep wearing headphones and an electrode cap and repeated the memory test in the morning.

On one night, participants were played a series of short bursts of pink noise during deep sleep. The sounds were timed to match participants' slow-wave oscillations. No noise was played during the other night.

After analyzing everyone's sleep waves, Zee's team found that people's slow-wave oscillations increased on the nights punctuated by pink noise. Come morning, people who had listened to it performed three times better on memory tests than they had the other night. One of the study authors has since co-founded a company that plans to market pink noise commercially. But first, says Zee, larger and longer studies are needed.





# OUT OF MIND




*What do we stand to lose—and gain—when we wipe out a memory?*

**By David Bjerklie**

**A** DISTRAUGHT 23-YEAR-OLD walks into a clinic and pleads with the receptionist: “I’ve got to have a memory erased!” Would you approve of such a procedure? Most people’s gut reaction would probably be along the lines of, “Well, it depends.” If that 23-year-old was crippled by fear because he had been brutally assaulted, for example, or paralyzed by PTSD because she had survived an ambush in which fellow soldiers were captured and executed, then perhaps so. On the other hand, it’s easy to imagine scenarios in which erasing a memory would seem unnecessary, misguided or even frivolous.

To be able to erase memory is as unsettling a prospect as it is riveting. No wonder it’s been a sci-fi plot staple for at least half a century. But now, it appears, researchers may actually be on the cusp of making memory manipulation a reality. The potential applications understandably are getting a lot of attention, as is the question of whether or not people will want to override their memories. But there are also a range of concerns that should give



*Survivors of the Bataclan attacks in Paris were evacuated by bus. Some were treated by Montreal psychiatrist Alain Brunet, who has been testing the effectiveness of propranolol in dampening traumatic memories.*

us pause, cautions Arthur Caplan, a medical ethicist at New York University's School of Medicine. "I think people are looking at memory alteration in ways that trivialize it. My message is that it should be taken seriously."

A growing body of research suggests that memories are reactivated each time we bring them to mind, not retrieved whole, like we might pull something from a file drawer. The act of memory is an act of reassembly. Although the analogy is imperfect, imagine that at the cellular level, where memories exist as connections and paths, we are refreshing a neuronal GPS using the latest information.

The process is called memory reconsolidation, when a window briefly opens and a memory can be updated with new information. It is during reconsolidation, for example, that the emotionally charged memories triggered by PTSD flashbacks can be softened. The challenge is to trigger the memory—to ask the soldier, for example, to recall the details of the ambush—and to then intervene to diminish the emotional reaction to that specific memory. Think of it as tweaking the GPS to generate a new and less stressful route.

Scientists first learned ways to override a simple memory they intentionally created in mice, using an electric shock every time the animals heard a particular sound. Researchers then explored ways to achieve something similar in human subjects. There is now a range of other experimental interventions aimed at interrupting memory reconsolidation. There are drugs that inhibit certain receptors or the synthesis of certain proteins; there are drugs that lower the levels of the stress hormone cortisol; there are techniques such as electroconvulsive therapy and deep brain stimulation; there are also behavioral approaches, including ones based on neurofeedback techniques or subliminal exposure.

Alain Brunet, a professor of psychiatry at McGill University in Montreal, uses propranolol, a drug used to treat high blood pressure by blocking the action of the stress hormone epinephrine. It turns out that propranolol also blocks the action of epinephrine in the amygdala, the almond-shaped structure

in the brain that plays a critical role in mediating the interaction of emotions and memory. Brunet had been testing propranolol in small trials but had the opportunity to bring the nascent treatment to a larger venue in November 2015, when terrorists killed 130 people in an attack on the Bataclan theater and surrounding neighborhoods in Paris. "I went to offer my help," says Brunet, who eventually trained 200 clinicians and treated 320 individuals traumatized in the attack, and in the process they learned how they might begin to "create a model of treatment." Propranolol is especially promising, says Brunet, because "it's cheap, it's safe, we know its side effects, we know who we can give it to and who we shouldn't give it to. It's very close to ideal."

Brunet is quick to explain that the treatment does not wipe out memories. That isn't possible yet, nor is that the intent. "We are taking the pathological sting out of the memory." The patient still remembers the event, but in a way that fades with time. "They might still find it sad. But it's like when you think of an old girlfriend, an ex. You can still think about it, but you are no longer in the terrible grip of the memory."

And it isn't just PTSD that Brunet thinks can be effectively treated with propranolol. Many mental states fueled by highly emotional memories could po-

tentially benefit, including depression, substance abuse, certain phobias, anxiety and adjustment disorders, pathological mourning or, yes, even runaway obsession over romantic betrayal. This is not a magic bullet, of course. Just as we now know there isn't a single memory system, we also know there is no single experience of trauma. There are traumatic events that happen once, and traumas such as sexual abuse and domestic violence that happen repeatedly, over the course of years. Trauma can be part of the environment in cases of poverty or racism.

"We know very little about these complicated situations in terms of what goes on in the brain," says New York University researcher Joseph LeDoux, who studies the connection between memory and emotion, particularly fear and anxiety. What we do

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***"I think people are looking at memory alteration in ways that trivialize it," says an ethicist. "It should be taken seriously."***

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*At a neuroimaging center in France, researchers monitored cerebral activity. Below, veteran Cliff Drake was cured of PTSD at Brainsake, a biofeedback center in Maryland.*





*Vietnam vet Ned Broderick in his Chicago art studio. He was treated with propranolol to deal with war memories.*

know, though, is that the consequences of such experiences and environments can lead to PTSD that is more complex in terms of time frame and volume of memories. It is unclear whether trauma of these varieties will ever be amenable to reconsolidation treatment. “Theoretically you could break down complex trauma stimuli into various trigger components individually targeted for intervention,” says LeDoux, “and kind of chip away at it until the patient is comfortable in some sense.”

The basic question, however, remains. Will people actually want to rewrite their memories, and, if so, under what circumstances? There are good reasons to expect that people would at least want the choice. We love choice. Perhaps too much, as Columbia University researcher Sheena Iyengar points out in her book *The Art of Choosing*: “Choice gives us permission to imagine a better self, and it holds

the promise that we can create that self through our own volition.” And while “choosing helps us create our lives,” we also know that most of us are less than perfectly skillful choosers.

To choose to erase—or even dampen—a memory would be a big decision for most of us. University of California, Irvine, psychologist Elizabeth Loftus and colleagues devised an experiment that aimed to look at the factors that might enter into our choice. They asked nearly 1,000 study participants (half from New Zealand and half from the U.S.) to read one of two scenarios in which the participant was asked to imagine being either a restaurant manager who was stabbed and robbed of money in a vicious assault, or a soldier on a peacekeeping mission in Afghanistan who was stabbed and robbed of supplies in a vicious assault. With that exception, the wording of the scenarios was the same. Participants

also read a statement about the risk of developing PTSD. Some subjects read that scientific studies had established the risk to be 4%, some read that the risk was 40%, and still others read a statement in which the risk was not quantified.

Subjects were then asked if they felt they should be given the choice to take a memory-dampening drug. It turned out that just over half of the subjects believed in having the choice to take the drug and only about a fifth said they would actually take it. The researchers were surprised the numbers were so low. Perhaps people are just generally optimistic that they could surmount such a trauma? Or maybe the trauma wasn't dire enough? Or perhaps they were uncomfortable about tinkering with memory?

**WHILE IT'S IMPOSSIBLE** to say if and when these drugs and techniques will be widely available, we have a pretty good idea of what the debate over their use will look like. "The first concern will be the risk of intervening in the brain when we don't fully understand how memories are formed," says Caplan, the medical ethicist at NYU. "The second will be issues of access and cost." Which, in turn, will lead to issues of fairness and geography. "People may think it's great to have memory therapy in the U.S. and Europe, but what about the people in the Democratic Republic of Congo who have been through mass rape and barbaric civil war? Do we care? Does it matter? Will we pay for it?"

It is the more abstract concerns, however, that generate the most attention. LeDoux remembers the pushback to a key paper from his lab that, when it was published in 2000, demonstrated how a drug could seemingly eliminate a memory in rats. "George Bush's bioethics panel put out a statement, basically saying that memory is sacrosanct, that you can't be messing with memory in people," says LeDoux. "But every human interaction involves messing with memory. Every therapeutic exchange also does." The alarm raised by ethicists was triggered by the specter of people blithely popping pills to forget their traumas. Isn't trauma an important

part of who we are and how we grow?, they asked. But what may have appeared like mindwipe in experiments with rats, however, is in reality far more subtle in humans.

Although current therapies for interrupting reconsolidation can change only the emotional magnitude of memories, not their factual content, researchers acknowledge that, yes, someday memory elimination might be possible. Which makes it easy—and perhaps necessary—to project our concerns into worst-case scenarios. We need to recognize, says Caplan, "that this isn't just about things that give us nightmares. Eliminating memory might be something the individual wants but won't be so great for society. Memory plays a crucial role in our legal system. Do we say you can wipe out that memory,

but not until we bring it to trial? Memory is part of how we hold people accountable." And even if our ability to modify memories is confined to smoothing their jagged emotional edges, Caplan is still concerned. "Anger, fury, indignation, crying, remorse—all of this stuff counts in court." It also counts in our lives. What happens to our personal narrative, our sense of self, if we strip out the emotion attached to the bad stuff?

There will undoubtedly be trade-offs, for individuals as well as societies. But with any of these concerns, says LeDoux,

it's a mistake to consider—let alone dismiss—the concept as a single thing. What we have to do, says LeDoux, is ask: "What happens in this kind of situation with this kind of patient, and what exactly are we trying to treat or change, and is that possible?"

The machinery of memory we rely on has evolved because it is efficient. Walt Whitman's "I contain multitudes" is an apt description of our interlocking memories and the systems in which they reside. Rewriting our memories, forging and forgetting them, even intentionally, is something we do on our own. That's not to shrug our shoulders about the prospects of pills or procedures to enhance those processes, but rather to try to address and more fully understand what it is that we lose—and gain—when we change a memory. □

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***"Eliminating memory might be something the individual wants but won't be so great for society. Memory plays a crucial role in our legal system."***

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