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Under pressure? Stress messes with your memory

Men's and women's brains respond differently to anxiety

By Gretchen Voss



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Everyone has had an experience like this one: You're running late for an important meeting, frantically tearing apart the house on a desperate search for the car keys you just put down... somewhere. Or at the other extreme, you spent weeks freaking out over an upcoming presentation only to deliver all the key points with Oscar-accepting eloquence when the day arrives.

So what is it that makes a person either go completely blank or perform brilliantly on simple tasks involving memory when feeling stressed?

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The answer is complicated, and neuroscientists are finally teasing out some of the bigger mysteries behind how that three-pound mass of electrochemical soup remembers, or forgets, where the damn keys are. An old adage says a little stress is good for memory, and a lot is bad — but it turns out to be true only for men. New research suggests that gender matters when it comes to memory and stress, whether that stress is acute, chronic, or traumatic.

Acute stress

"Your son's test came back, and it's irregular," the doctor told Denise Carleton, then a stay-at-home mom in Mill Valley, California. After hearing those alarming words, the 36-year-old nearly fainted as her body crashed over with waves of stress and fear. For the past month, she'd worried that her 2-year-old was regressing on all of his developmental milestones, such as talking and walking. But she never suspected that he could have a serious medical problem.

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Initially, she could barely hear the rapid-fire questions the physician blasted at her. But then she snapped to, answering in detail about

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when he first walked, talked, and smiled; the dates of his last vaccinations; and every symptom over the past month. "In the midst of this incredible stress, I suddenly remembered everything," she says today. "Stuff that on a normal day I would be hard-pressed to recall."

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Being able to remember things and learn new info depends entirely on the ability of networks of neurons—mostly in the areas of the brain called the prefrontal cortex and the hippocampus—to communicate with one another. Picture each neuron as an old-fashioned telephone, but with multiple wires snaking out from the receiver. Some of those wires are called axons, and they intersect with other wires called dendrites at connections called synapses.

The brain creates and retains memories in part by growing thicker, more efficient communication lines between groups of neurons—basically, by hooking up the phone wires and keeping them on a biological speed dial. When you try to remember when your son first smiled, says Todd Sacktor, M.D., a professor of neurology at the State University of New York Downstate College of Medicine, the phone lines should start buzzing with activity, connecting the neurons that hold those memories. Ah, he was 4-months-old and reaching for his favorite teddy bear.

But then you hear that your child might be really sick. Immediately, the fight-or-flight sympathetic nervous system unleashes stress

hormones, such as epinephrine and cortisol, into the "phone" system, generally making the connections crisper and clearer. The result: "As a safe general rule, a moderate to strong amount of acute stress—stress that happens once and then goes away—tends to be good for memory," says Larry Cahill, Ph.D., a professor of neurobiology and behavior at the University of California at Irvine. Over the years, research has backed something called an inverted U response, meaning that as stress levels increase, so does memory performance—up to a person's own optimal level of stress. Add more than that and memory function fizzles.

Then, on a hunch, Cahill's lab decided to take a closer look at how sex differences might play a role in this long-established "safe general rule" and, surprisingly, discovered in one experiment that the rule did not apply to women. In that experiment, Cahill tested the memories of both men and women after an

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acute stress and found that the stressful event enhanced the memories of the men but did not do so for the women. (Yes, Denise Carleton's killer recall seems to contradict this, but stay with us.) It was a puzzling finding: The levels of stress hormones were elevated equally in both males and females—so why didn't it have the same affect on their memories?

Thinking that perhaps stress hormones were interacting with sex hormones, they ran the experiment again, this time using only women and controlling for various phases of the menstrual cycle. They discovered that when women had high levels of estrogen (before and during their periods), stress fuzzed up their recollection, but when they had high levels of progesterone, following their cycle, stress boosted recall—just like it did for guys. In other words, women received the memory lift that acute stress provides only when their estrogen levels were normal.

Cahill's work was groundbreaking—and goes a long way toward explaining Denise's peak performance in the doctor's office (she was in that high-progesterone part of her cycle). It also explains why, on other days when she's been pelted with curveballs, she's been known to forget that she tossed her cell phone on the bumper of her truck or left a takeout pizza on the roof.

"Most of the research on stress and memory has been done in adult male humans, rats, and monkeys," says Victoria Luine, Ph.D., a neuroendocrinologist at Hunter College in New York City, whose own work has since revealed

similar findings. "Scientists have taken the male model and just assumed that females are the same. It's a big assumption, and it's wrong." Especially, it turns out, when it comes to the impact of chronic stress.

[6 Strategies for all-day calm.](#)

Chronic stress

Sarah Wieland, 40, of Concord, Massachusetts, couldn't find her breath. She was already anxious about quitting an executive job in order to start teaching yoga, and was nervously trying to put together her first class. Then suddenly, all the moving parts in her personal life jammed up. She was diagnosed with shingles (a painful virus); her twin 6-year-old daughters had to have their tonsils removed and required round-the-clock care; and she was scrambling to pull together the final touches of a long-planned blowout birthday dinner party for herself, with 45 friends invited, and a much-anticipated 10-

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day trip to Bermuda.

Yet, shockingly, instead of drowning in details, she found herself kicking butt. She remembered doctor's appointments and medication dosages, and had a perfect handle on the party and trip details. "My first yoga class went amazingly well too," she says. "I really think all the overwhelming stress actually helped me calm down and focus." She was lucky that her husband was traveling and the craziness fell on her shoulders: New research shows that men generally flounder in the face of chronic stress, and women excel.

While the increased levels of stress hormones washing over your brain during acute stress quickly recede once life returns to normal—and any resulting memory enhancements disappear—chronic stress (i.e., stress that lasts a least a few weeks) keeps the spigot turned on. Too much of the stuff is toxic and essentially disconnects those phone-wire dendrites, says Luine. The result: The brain is prevented from laying down new memories and accessing old ones, making it difficult to think clearly and remember crucial details.

"Very few neuroscientists know this," says Cahill. "The conclusion that everybody knows—that chronic stress damages hippocampal cells—just isn't the same in females. It's quite different. And that's remarkable. The sex difference is a big, unfolding story. The idea that sex doesn't matter in neuroscience is crumbling rapidly."

While the fact that female brains are better

able to handle chronic stress might be news to neuroscientists, it sure isn't to any woman with a male significant other. In a study last year, Zhen Yan, Ph.D., a professor of physiology and neuroscience at the State University of New York at Buffalo, found that chronic stress in male rodents suppressed the communication ability in neurons in the prefrontal cortex, impairing the working memory—the kind of short-term information storage that remembers, say, what you gave your mother-in-law for her birthday last year. This did not happen with females (It was a coral sweater, duh), thanks to the sex hormone estrogen. It somehow keeps the phone lines humming along even under crazed conditions.

Luine reached similar conclusions when looking at the hippocampus, the area of the brain crucial to memory storage. In her study, stress caused male rats to fail miserably on all memory tests, while it helped females ace

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some tests (those that involved spatial memory—the kind that knows the location of your purse, for instance) and didn't affect the outcome of others. "If you chronically stress males, they get worse, absolutely. Females actually get better," she says. "It's pretty astounding."

It all makes sense, says Luine, if you put it in the context of evolution. While cavemen were out chasing ferocious animals to eat—and trying not to be eaten themselves—women were back in the cave toiling away at endless child-care tasks. "The men became adapted to acute stress," says Luine, "while the women became adapted to chronic stress. This is clearly a hypothesis, but it could account for why the responses are different, why females won't show this loss of dendrites in the hippocampus to the extent that males do."

The good news for men is that the scatterbrained effects of chronic stress disappear once things calm down. In other words, the severed phone wires grow back. Still, it's not a condition men or women want to endure over the long haul, because it might permanently impair their memory, says Luine, although this hasn't been tested.

Traumatic stress

In December 2004, Alexis Moore was driving on the freeway near her home in northern California when she spaced out. "My mind was a complete blank," the 36-year-old says today. "I had no idea where I'd been headed." Other days, she'd find herself standing in the grocery store, staring at the rainbow of choices in the

produce section, unsure of what she'd gone there to buy.

For six years before that, Alexis had been the victim of domestic abuse and stalking at the hands of her now ex-boyfriend. "The trauma, the nonstop, red-alert stress was unbelievable," she says of those days when she always wore running shoes in case she needed to, literally, run for her life. After nearly being beaten to death that November, she finally escaped, though the scars from the traumatic stress still linger even now. "I noticed right away that I began having difficulties with memory when thinking of dates and times to share with police and the courts," she says. Though she had always prided herself on her razor-sharp recall, she entered law school in 2008 with her memory in tatters. "Simple tasks, such as memorizing laws, take much longer for me than for other students," she says. Alexis works hard to compensate, using flash cards twice a day, but

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any memory improvements are very slow in coming.

Traumatic stress (defined as a threat to one's life or integrity, or to someone close, and characterized by intense fear and helplessness) unleashes a deadly assault on the hippocampus, the memory bank of the brain—actually causing it to shrink measurably in size. According to J. Douglas Bremner, M.D., a professor of psychiatry and radiology at Emory University School of Medicine in Atlanta, who specializes in post-traumatic stress disorder (PTSD), this kind of stress can spring from such psychological traumas as childhood sexual abuse, car accidents, military combat, or assault. The massive brain mess left in its wake includes deficits in declarative memory (remembering facts or lists), fragmentation of memories (remembering only bits of an event), and dissociative amnesia (gaps in memory lasting from minutes to days).

Even worse: The damage to the hippocampus from extreme stress not only destroys memories already in the bank but also impairs the creation of new ones. It's as if the whole telephone system—now consisting of severed wires and disconnected calls—shuts down. And the damage, even with new drugs and therapies, is not always reversible. Alexis's experience with a patchwork memory, says Bremner, is fairly typical.

As with acute and chronic stress, sex hormones probably play a role in PTSD's effects on memory, but this hasn't been

studied in clinical populations. "PTSD affects two to three times as many women as men," says Cahill. "Nobody knows why. Almost no one is studying it, but they should be." If they did, perhaps effective treatments would be developed, which could be a huge help at a time when women are on the front lines of two wars and rates of reported domestic abuse are rising.

In the meantime, researchers say, these breakthroughs in stress and memory can help women think about—and manage—their own lives. And more information is coming. "This is a whole new world," says Cahill. "My eyes have been opened."

The optimal level of stress

Somewhere between mellow and meltdown is an anxiety sweet spot that sharpens memory. Find yours.

Research shows that, for women, acute stress

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can enhance memory. "But we don't want you to say, 'Stress is good, so I should seek it out,' " says Zhen Yan, Ph.D. "To boost memory, stress needs to be at some kind of an optimal level." And that optimal level is different for each woman.

So how do you go about sussing out your stress sweet spot? The answer will require some sleuthing.

Keep in mind the inverted U function, in which memory sharpens as stress piles up until it reaches an in-the-zone peak before traveling downhill. That's the balance you need to gauge for yourself. "If you are giving a speech and can still do it even when you're having major symptoms—like nausea and loss of appetite—then that's encouraging, and the anxiety should lessen with practice," says Margaret A. Itemus, M.D., an associate professor of psychiatry at Weill Cornell Medical College. "But if you're trying to manage multiple tasks at once, such as filling out a form online, giving directions over the phone, and talking to a child, this amount of distraction is stressful and will likely impair your memory. The sweet spot is an optimal level of alertness, without feeling overwhelmed or anxious. That's the rule to use in finding your stress balance: Look to see if the stress is impairing your functioning, including your job performance and your ability to enjoy life. If it is, try to reduce the stress with lifestyle changes, and if necessary, psychodynamic or cognitive behavioral therapy, or lastly, taking psychiatric medication."

The great news, she says, is that with this kind of help, the intensity of perceived stress can be reduced. "I wouldn't advise people to avoid stressful situations because they are worried about their memory performance," she says. "These situations provide an opportunity to find better ways to cope."

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