Stress breaks loops that hold short-term memory together: study

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Stress has long been pegged as the enemy of attention, disrupting focus and doing substantial damage to working memory—the short-term juggling of information that allows us to do all the little things that make us productive.

By watching individual neurons at work, a group of psychologists at the University of Wisconsin–Madison has revealed just how stress can addle the mind, as well as how neurons in the brain's prefrontal cortex help "remember" information in the first place.

Working memory is short-term and flexible, allowing the brain to hold a large amount of information close at hand to perform complex tasks. Without it, you would have forgotten the first half of this sentence while reading the second half. The prefrontal cortex is vital to working memory.

"In many respects, you'd look pretty normal without a prefrontal cortex," said Craig Berridge, UW–Madison psychology professor. "You don't need that part of the brain to hear or talk, to keep long-term memories, or to remember what you did as a child or what you read in the newspaper three days ago."

But without your prefrontal cortex you'd be unable to stay on task or modulate your emotions well.

"People without a prefrontal cortex are very distractible," Berridge said.

"They're very impulsive. They can be very argumentative."

The neurons of the prefrontal cortex help store information for short periods. Like a chalkboard, these neurons can be written with information, erased when that information is no longer needed, and rewritten with something new.

It's how the neurons maintain access to that short-term information that leaves them vulnerable to stress. David Devilbiss, a scientist working with Berridge and lead author on a study published today in the journal PLOS Computational Biology, applied a new statistical modeling approach to show that rat prefrontal neurons were firing and re-firing to keep recently stored information fresh.

"Even though these neurons communicate on a scale of every thousandth of a second, they know what they did one second to one-and-a-half seconds ago," Devilbiss said. "But if the neuron doesn't stimulate itself again within a little more than a second, it's lost that information."

Apply some stress—in the researchers' case, a loud blast of white noise in the presence of rats working on a maze designed to test working memory—and many neurons are distracted from reminding themselves of … what was it we were doing again?

"We're simultaneously watching dozens of individual neurons firing in the rats' brains, and under stress those neurons get even more active," said Devilbiss, whose work was supported by the National Science Foundation and National Institutes for Health. "But what they're doing is not retaining information important to completing the maze. They're reacting to other things, less useful things."

Without the roar of white noise, which has been shown to impair rats in the same way it does monkeys and humans, the maze-runners were reaching their goal about 90 percent of the time. Under stress, the animals completed the test at a 65 percent clip, with many struggling enough to fall to blind chance.

Recordings of the electrical activity of prefrontal cortex neurons in the maze-running rats showed these neurons were unable to hold information key to finding the next chocolate chip reward. Instead, the neurons were frenetic, reacting to distractions such as noises and smells in the room.

The effects of stress-related distraction are well-known and dangerous.

"The literature tells us that stress plays a role in more than half of all workplace accidents, and a lot of people have to work under what we would consider a great deal of stress," Devilbiss said. "Air traffic controllers need to concentrate and focus with a lot riding on their actions. People in the military have to carry out these thought processes in conditions that would be very distracting, and now we know that this distraction is happening at the level of individual cells in the brain."

The researchers' work may suggest new directions for treatment of prefrontal cortex dysfunction.

"Based on drug studies, it had been believed stress simply suppressed prefrontal cortex activity," Berridge said. "These studies demonstrate that rather than suppressing activity, stress modifies the nature of that activity. Treatments that keep neurons on their self-stimulating task while shutting out distractions may help protect working memory."

Provided by University of Wisconsin-Madison

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