Fear boosts activation of young, immature brain cells

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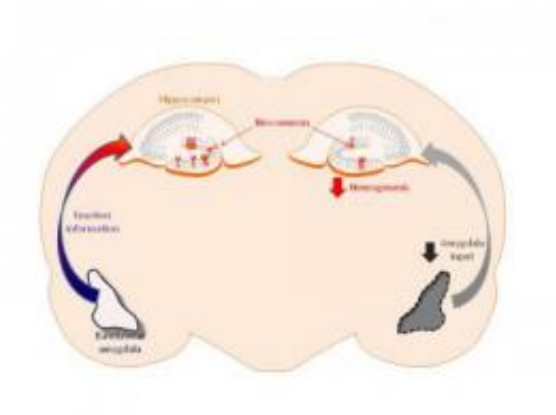

Emotional information from the amygdala promotes maturation of adult neural stem cells into new neurons in the hippocampus. These neurons can be activated by fear during a critical 2-4 week period after birth, helping to imprint a memory of the fearful situation. Without input from the amygdala (right), the hippocampus produces fewer new neurons. Credit: Daniela Kaufer lab, UC Berkeley

(PhysOrg.com) -- Fear burns memories into our brain, and new research by University of California, Berkeley, neuroscientists explains how.

Scientists have long known that fear and other highly emotional experiences lead to incredibly strong memories. In a study appearing online today (Tuesday, June 14) in advance of publication in the journal Molecular Psychiatry, UC Berkeley's Daniela Kaufer and colleagues

report a new way for emotions to affect memory: The brain's emotional center, the amygdala, induces the hippocampus, a relay hub for memory, to generate new neurons.

In a fearful situation, these newborn neurons get activated by the amygdala and may provide a "blank slate" to strongly imprint the new fearful memory, she said. In evolutionary terms, it means new neurons are likely helping you to remember the lion that nearly killed you.

"We remember emotional events much more strongly than daily experiences, and for a long time we have known that connections between the amygdala and hippocampus help to encode this emotional information," said Kaufer, an assistant professor of integrative biology and a member of UC Berkeley's Wills Neuroscience Institute. "Our research shows that amygdala input actually pushes the hippocampus to make new neurons from a unique population of neural stem cells. This provides completely new cells that get activated in response to emotional input."

The finding has implications for post traumatic stress disorder (PTSD) and other problems caused by faulty regulation of emotional memory.

"Many affective disorders involve disordered emotional memories like PTSD, depression and anxiety. We think that newborn neurons may play a role in creating these emotional memories," she said.

The finding comes a year after brain researcher Fred Gage at the Salk Institute for Biological Studies in La Jolla, Calif., showed that the formation of new memories is associated with increased activation of two-week-old newborn nerve cells in the hippocampus that are derived from adult neural stem cells. Adult stem cells appear to differentiate continually into new nerve cells – nearly 100 each day – yet half of those newborn neurons are slated for death within four weeks after their birth.

If they are highly activated, however – such as in learning new complex information – many more of them will survive and presumably help in establishing new memories in the brain.

Kaufer, who conducts research on the effects of stress on the brain, knew that many types of positive and negative experiences, such as exercise and stress, affect the rate of neurogenesis in the hippocampus. Along with graduate students Elizabeth Kirby, the lead author of the study, and Aaron Friedman, she was intrigued by the idea that emotions might affect neurogenesis in the hippocampus, since the brain's clearinghouse for emotions, the amygdala, is connected to the hippocampus via multiple neural circuits. To test this, Kirby focused on the basolateral amygdala, the region of the almond-shaped structure that handles negative emotions, including stress, anxiety and fear.

Using rats, Kirby surgically destroyed the basolateral amygdala and discovered that the production of new nerve cells in the hippocampus decreased. To make sure that the cell damage created when the amygdala was surgically destroyed was not affecting the experiment, the researchers borrowed a gene therapy technique from Robert Sapolsky's lab at Stanford University to genetically introduce potassium channels into the amygdala, which shut down the activity of the nerve cells without causing injury. This also decreased neurogenesis in the hippocampus.

They next tested Gage's theory that new neurons are especially sensitive to input two weeks after they form. Kirby and Kaufer labeled hippocampal cells created over a three-day period in a group of rats, and then conditioned a fear response in these rats two weeks later. They then confronted the rats with the same fearful situation or a neutral yet novel context the next day. When they examined the brains, they found that the newborn neurons had been specifically activated by the fearful situation. However, when they destroyed the basolateral amygdala, new

neurons were no longer activated in response to the fearful memory.

"The research suggests that newborn neurons play a role not only in the formation of memory, but also in helping to create the emotional context of memory," Kirby said. It also suggests that the basolateral amygdala drives the ability of new neurons to be part of an emotional memory.

The team now plans to see whether other negative stimuli, such as stress and anxiety, similarly cooperate with amygdala activity to alter neurogenesis in the hippocampus.

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