Studies relate life experiences to brain structure

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Recent studies from the lab of neuroscientist Elizabeth Gould are helping to show how major experiences -- such as early-life traumas -- can have a long-term effect on the structure of the brain.
In one study published last year, researchers in Gould's lab found that baby rats that were separated from a care-giving adult for several hours a day formed fewer new neurons in their brains later in life. Another study showed that adult rats that grew up normally produced elevated numbers of new neurons if they achieved social dominance in a small community of rats.

"These are different examples of how life experience changes the brain," said Gould, a professor of psychology at Princeton.

Until the last decade, scientists did not believe that the brain changes that Gould and colleagues study were even possible. The conventional view in neuroscience was that once animals, including humans, reach adulthood, they acquire no new neurons, or nerve cells. Gould is a pioneer in showing that several important areas of the brain continue to create neurons throughout life, a process called adult neurogenesis. In recent years, Gould has investigated factors that influence the rate of adult neurogenesis and the roles played by the new brain cells.

The recent studies examined neurogenesis in a part of the brain called the hippocampus, which is involved in learning and memory as well as in responding to stress. Previous studies had shown that stress can significantly reduce neurogenesis.

Reporting their results in the journal Nature Neuroscience, Gould and postdoctoral researcher Christian Mirescu found that the stress involved in an early-life trauma can affect the hippocampus in adulthood. Animals that had experienced maternal separation turned out to have low levels of neurogenesis even when they were grown and living in low-stress conditions. Their neurogenesis rates resembled those of normal adult rats that are being actively stressed.

"Rats -- and humans -- have low levels of stress hormones circulating through their bodies all the time," said Mirescu. "Normally they're not high enough to have damaging effects. But in maternally separated rats, even these low levels seem to restrain neurogenesis. These animals seem to be especially sensitive to stress hormones." To test this idea, the researchers artificially lowered the rats' stress hormone levels to well below normal; only then did the rate of neurogenesis return to a normal level.

Mirescu said the finding supports previous research, which showed that maternally separated animals have exaggerated responses when exposed to stress later in life. Reduced neurogenesis may be one underlying cause, he said. Early-life stress has been shown to have long-term effects in humans too, but it is too early to tell whether neurogenesis plays a role in those effects, the researchers warned.

In addition, the researchers emphasized that their experimental procedure should not be equated with typical day-to-day separations between mothers and infants, such as in the case of daycare. Even the normal rats in the study were raised by "foster" rats rather than their biological mothers, but the separated ones received no adult care at all. "It was just a way to induce an early-life stress," said Gould. "But it might be a good parallel to understanding extreme cases of abuse or neglect in humans."

In the social dominance study, published in the Journal of Neuroscience, Gould and graduate student Yevgenia Kozorovitskiy also expected stress to play a role, but were surprised to find it did not. Kozorovitskiy placed a strain of particularly docile, nonaggressive male rats along with female rats into a larger-than-usual burrow system that allowed for relatively normal social interactions. Within three days, the male rats established dominance hierarchies. Subsequent tests showed that the dominant ones had greater numbers of new neurons in the hippocampus, but there was no difference in stress levels between the dominant and subordinate groups.

Another intriguing finding is that the dominant rats did not produce new neurons at a faster rate, but the new cells lived longer, causing the dominant animals to have greater numbers of new neurons over time. The researchers are now conducting further experiments to pinpoint what causes this effect. One theory is that it has to do with testosterone. The dominant animals probably engage in more fighting and mating, which increases testosterone, said Kozorovitskiy. Testosterone may improve the survival of the new neurons.

Kozorovitskiy said the study also raises a note of caution about drawing comparisons between laboratory animals and humans. Rats such as those used in this study are often kept in spaces that are not enough like the natural world for them to form social hierarchies. The study suggests that this limitation has a bigger effect on the structure of the brain than previously thought. "We often use lab animals to try to understand how the human brain works," Kozorovitskiy said. "But if they're not having a natural experience, we could be misguided, at worst, in ways that are relevant to understanding brain structure."

Source: Princeton University

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