Newborn neurons in the adult brain may help us adapt to the environment

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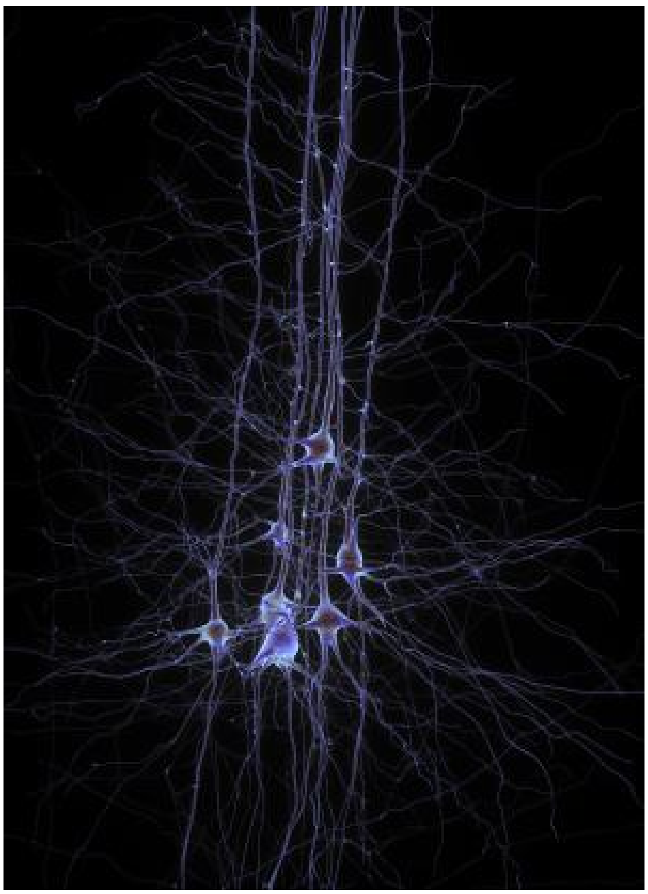

This is a group of neurons. Credit: EPFL/Human Brain Project

The discovery that the human brain continues to produce new neurons in adulthood challenged a major dogma in the field of neuroscience, but the role of these neurons in behavior and cognition is still not clear. In a review article published by Cell Press February 21st in *Trends in Cognitive Sciences*, Maya Opendak and Elizabeth Gould of Princeton University synthesize the vast literature on this topic, reviewing environmental factors that influence the birth of new neurons in the adult hippocampus, a region of the brain that plays an important role in memory and learning.

The authors discuss how the birth of such neurons may help animals and humans adapt to their current environment and circumstances in a complex and changing world. They advocate for testing these ideas using naturalistic designs, such as allowing laboratory rodents to live in more natural social burrow settings and observing how circumstances such as social status influence the rate at which new neurons are born.

"New neurons may serve as a means to fine-tune the hippocampus to the predicted environment," Opendak says. "In particular, seeking out rewarding experiences or avoiding stressful experiences may help each individual optimize his or her own brain. However, more naturalistic experimental conditions may be a necessary step toward understanding the adaptive significance of neurons born in the adult brain."

In recent years, it has become increasingly clear that environmental influences have a profound effect on the adult brain in a wide range of mammalian species. Stressful experiences, such as restraint, social defeat, exposure to predator odors, inescapable foot shock, and sleep deprivation, have been shown to decrease the number of new neurons in the hippocampus. By contrast, more rewarding experiences, such as physical exercise and mating, tend to increase the production of new neurons in the hippocampus.

The birth of new neurons in adulthood may have important behavioral and cognitive consequences. Stress-induced suppression of adult neurogenesis has been associated with impaired performance on hippocampus-dependent cognitive tasks, such as spatial navigation learning and object memory. Stressful experiences have also been shown to increase anxiety-like behaviors that are associated with the hippocampus. In contrast, rewarding experiences are associated with reduced anxiety-like behavior and improved performance on cognitive tasks involving the hippocampus.

Although scientists generally agree that our day-to-day actions change our brains even in adulthood, there is some disagreement on the adaptive significance of new neurons. For instance, the literature presents mixed findings on whether new neurons generated under a specific experimental condition are geared toward the recognition of that particular experience or if they provide a more naive pool of new neurons that enable environmental adaptation in the future.

Gould and her collaborators recently proposed that stress-induced decreases in new neuron formation might improve the chances of survival by increasing anxiety and inhibiting exploration, thereby prioritizing safety and avoidant behavior at the expense of performing optimally on cognitive tasks. On the other hand, reward-induced increases in new neuron number may reduce anxiety and facilitate exploration and learning, leading to greater reproductive success.

"Because the past is often the best predictor of the future, a stress-modeled brain may facilitate adaptive responses to life in a stressful environment, whereas a reward-modeled brain may do the same but for life in a low-stress, high-reward environment," says Gould, a professor of psychology and neuroscience at Princeton University.

However, when aversive experiences far outnumber rewarding ones in both quantity and intensity, the system may reach a breaking point and produce a maladaptive outcome. For example, repeated stress produces continued reduction in the birth of new neurons, and ultimately the emergence of heightened anxiety and depressive-like symptoms.

"Such a scenario could represent processes that are engaged under pathological conditions and may be somewhat akin to what humans experience when exposed to repeated traumatic stress," Opendak says.

Because many studies that investigate adult neurogenesis use controlled laboratory conditions, the relevance of the findings to real-world circumstances remains unclear. The use of a visible burrow system—a structure consisting of tubes, chambers, and an open field—has allowed researchers to recreate the conditions that allow for the production of dominance hierarchies that rats naturally form in the wild, replicating the stressors, rewards, and cognitive processes that accompany this social lifestyle.

"This more realistic setting has revealed individual differences in adult neurogenesis, with more new neurons produced in dominant versus subordinate male rats," Gould says. "Taking findings from laboratory animals to the next level by exploring complex social interactions in settings that maximize individual variability, a hallmark of the human experience, is likely to be especially illuminating."

More information: *Trends in Cognitive Sciences*, Opendak, M. and Gould, E.: "Adult neurogenesis: a substrate for experience-dependent change" (2015)

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