Newborn brain cells 'time-stamp' memories

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"Remember when...?" is how many a wistful trip down memory lane begins. But just how the brain keeps tabs on what happened and when is still a matter of speculation. A computational model developed by scientists at the Salk Institute for Biological Studies now suggests that newborn brain cells—generated by the thousands each day—add a time-related code, which is unique to memories formed around the same time.

"By labeling contemporary events as similar, new neurons allow us to recall events from a certain period," speculates Fred H. Gage, Ph.D., a professor in the Laboratory for Genetics, who led the study published in the Jan. 29, 2009, issue of the journal *Neuron*. Unlike the kind of time stamp found on digital photographs, however, the neuronal time code only provides relative time.

Ironically, Gage and his team had not set out to explain how the brain stores temporal information. Instead they were interested in why adult brains continually spawn new brain cells in the dentate gyrus, the entryway to the hippocampus. The hippocampus, a small seahorse-shaped area of the brain, distributes memory to appropriate storage sections in the brain after readying the information for efficient recall.

"At least one percent of all cells in the dentate gyrus are immature at any given time," explains lead author Brad Aimone, a graduate student in the Computational Neuroscience Program at the University of California, San Diego. "Intuitively we feel that those new brain cells have to be good for something, but nobody really knows what it is."

Each of these newborn neurons undergoes a prolonged maturation process, during which it changes from hyper-excitable to composed and reaches out to mature brain cells that are already well-connected within the established circuitry. Exercise, learning, and environmental enrichment increase proliferation and survival of new neurons, while pathological (chronic) stress and age send their numbers plummeting. Despite an increasing understanding of how new neurons become part of the existing dentate gyrus network, it is still unclear what their exact function is.

Trying to ascertain the newcomers' job in adult brains, the Salk researchers took every piece of available biological information and fed it into a computer program designed to simulate the neuronal circuits in the dentate gyrus. "Most modelers test a specific hypothesis and build a model around it," says Aimone. "We tried not to make any big assumptions about the function of new neurons. Instead we asked, 'What is the biology, and what does the math suggest?'"

It quickly became clear that overly excitable youngsters respond indiscriminately to incoming information. "The circuit in the dentate gyrus is designed to separate incoming memories into distinct events, a process called pattern separation, but immature cells get into the way by blurring the lines," says Aimone. "And if they keep muddling the picture, there's almost no point."

But nothing lasts forever. Even the most highly strung nerve cells that used to get excited by just about anything will eventually quiet down. As they mature into fully functional granule cells, they take their place in the existing circuitry while the next generation of newborn neurons takes their place firing away at new events.

Yet, independent events that had nothing in common but the fact that they occurred around the same time will now be connected forever in our minds—explaining why discussing the movie we saw a couple of months ago might bring back the name of the café we visited afterward but whose name has been eluding us.

"Current thinking holds that when we bring up a certain memory, it passes back to the dentate gyrus, which pulls all related bits of information from their offsite storage," says Gage. "Our hypothesis suggests that cells that were easily excitable bystanders when the memory was formed are engaged as well, providing a hyperlink between all events that happened during their hyperactive youth."

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Janet Wiles, Ph.D, a professor at the School of Information Technology and Electrical Engineering, University of Brisbane, Australia, also contributed to the study.

Source: Salk Institute