Researchers see evidence of memory in the songbird brain

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University of Illinois cell and developmental biology professor David Clayton and his colleagues saw an unusual pattern of gene activity in the brains of zebra finches after the birds heard an unfamiliar song. Credit: Photo by L. Brian Stauffer, U. of I. News Bureau.

When a zebra finch hears a new song from a member of its own species, the experience changes gene expression in its brain in unexpected ways, researchers report. The sequential switching on and off of thousands of genes after a bird hears a new tune offers a new picture of memory in the songbird brain.

The finding, detailed this month in the Proceedings of the National Academy of Sciences, was a surprise, said principal investigator David Clayton, a professor of cell and developmental biology at the University of Illinois. He and his colleagues had not expected to see so many genes

involved, and thought that any changes in gene activity after a bird heard a new song would quickly dissipate.

The new experiments uncovered three distinct profiles of gene expression in the brain. One is typical of a bird sitting alone in silence. A second profile appears quickly just after a bird hears a recorded song - but only if the song is new to the bird. A third profile then emerges 24 hours later, after the song has become familiar.

"I can tell you whether the bird has heard a particular song before or not just by looking at the molecular assay," Clayton said.

In the study, each bird was kept in quiet isolation overnight before it heard a recording of a new song. The recording was then repeated every 10 seconds for up to three hours.

"The most important thing in its whole life is the sound of another bird of its species singing," Clayton said.

"And what we found is that 24 hours after the experience its brain is still trying to make sense of what it heard."

The new study took a broad snapshot of gene activity in the brain. Using DNA microarray analysis, the researchers measured changes in levels of messenger RNAs in the auditory forebrain of finches exposed to a new song. These mRNAs are templates that allow the cell to translate individual genes into the proteins that do the work of the cells. Any surge or drop in the number of mRNAs in brain cells after a stimulus offers clues to how the brain is responding.

Some genes were upregulated within 30 minutes of exposure to a new song, the researchers found, and these included a lot of transcription factors that modulate the activity of other genes. Many other genes were

downregulated, including those that code for ion channel proteins, which allow ions to flow into the cell. This could be one way that the brain dampens its response to a powerful stimulus, protecting itself from too much disturbance, Clayton said.

"Whenever something unexpected and different comes along, such as the song of a new bird in the neighborhood, it's going to deform the listening bird's neural network," Clayton said. "And so the system has to basically absorb some of that, make some changes and not be overwhelmed by it. If you push the system around too much, cells die."

On the other hand, if the system were completely resistant to disturbance, no memory would form, he said.

Twenty-four hours after the initial stimulus, the pattern of activated genes was entirely different from that of the initial response, regardless of whether the bird heard the song again on day two or not, Clayton said. Those genes that were originally upregulated or downregulated had returned to baseline, and a new network of genes was engaged. A major focus of this new network appears to be the regulation of energy metabolism. This suggests a lot is still going on in the brain, Clayton said.

"It's like we've lifted the hood and we're seeing that these things are just chugging away," Clayton said. "The bird had this one day of experience and a day later the brain is in a different state. It's still in high gear. It's still processing stuff. It's still reverberating and echoing."

Source: University of Illinois at Urbana-Champaign (news : web)