Brain uses both neural 'teacher' and 'tinkerer' networks in learning

June 4 2007

While most people need peace and quiet to cram for a test, the brain itself may need noise to learn, a recent MIT study suggests. In experiments with monkeys, the researchers found that neural activities in the brain gradually change, even when nothing new is being learned. Challenging the monkeys to adjust their task triggered systematic changes in their neural activities on top of this background "noise."

The researchers said their findings suggest a new theory of how the brain learns.

"What surprised us most was that the neural representation of movement seems to change even when behavior doesn't seem to change at all," said Sebastian Seung, professor of physics and computational neuroscience and a Howard Hughes Medical Institute investigator. "This was a surprising degree of instability in the brain's representation of the world."

Seung and Institute Professor Emilio Bizzi led the study, which was published in the May 24 issue of the journal *Neuron*. Lead author on the study was Uri Rokni, a postdoctoral fellow in Seung's laboratory.

In earlier work, Bizzi and colleagues measured neural activities in the motor cortex while monkeys manipulated a handle to move a cursor to targets on a screen. In control experiments, the monkeys had to move the cursor to targets in the same way they had been trained. In learning experiments, the monkeys had to adapt their movements to compensate for novel forces applied to the handle.

The scientists found that even when the monkeys were performing the familiar control task, their neural activities gradually changed over the course of the session.

To explore the significance of these background changes, Rokni analyzed the data from the learning component of Bizzi's experiments. He found he could distinguish learning-related neural changes from the background changes that occurred during the control experiments. From this analysis, Rokni developed a working theory that combined the concepts of a redundant neural network and that of a "noisy" brain.

"A good analogy to redundant circuitry, which accomplishes the same behavior by different wiring configurations, would be a piece of text, in which you can say the same thing with different words," Rokni explained. "Our theory holds that the learning brain has the equivalent of a 'teacher' and a 'tinkerer'--a learning signal and noise in the learning process, respectively.

"In producing a specific piece of text, the tinkerer just randomly changes the words, while the teacher continually corrects the text to make it have the right meaning. The teacher only cares about the meaning and not the precise wording. When the teacher and tinkerer work together, the text keeps changing but the meaning remains the same. For example, the tinkerer may change the sentence 'John is married' to 'John is single,' and the teacher may correct it to 'John is not single.'

"In the same way, learning in the brain has two components--error-correction and noise--so that even though the neural representation keeps changing, the behavior remains fixed. We think the tinkerer, that is the noise, is not merely a nuisance to the teacher but is actually helping the teacher explore new possibilities it wouldn't have considered otherwise."

To test this idea, Rokni constructed a mathematical model of a redundant cortical network that controls movement and used it to simulate the learning experiment with the monkeys. In this model, learning of the connections between neurons was assumed to be a considerably noisy process. "When we ran the simulation long enough, the performance became good, but the neural representation kept changing, very similar to the experiments," Rokni said.

According to Rokni, the concepts of redundant networks and "noisy learning" have important implications for neurobiology. "I don't think this concept of redundancy--that the brain can say the same thing in different ways--has really been fully appreciated until now," he said.

"More practically, people who are constructing devices that translate brain signals to operate such external devices as neural prostheses will have to take such constantly changing neural representations into account," said Rokni.

Source: MIT

Citation: Brain uses both neural 'teacher' and 'tinkerer' networks in learning (2007, June 4) retrieved 23 April 2024 from https://medicalxpress.com/news/2007-06-brain-neural-teacher-tinkerer-networks.html