Researchers use computational models to study fear

September 30 2009

The brain is a complex system made of billions of neurons and thousands of connections that relate to every human feeling, including one of the strongest emotions, fear. Most neurological fear studies have been rooted in fear-conditioning experiments. Now, University of Missouri researchers have started using computational models of the brain, making it easier to study the brain's connections. Guoshi Li, an electrical and computer engineering doctoral student, has discovered new evidence on how the brain reacts to fear, including important findings that could help victims of post-traumatic stress disorder (PTSD).

"Computational models make it much easier to study the brain because they can effectively integrate different types of information related to a problem into a computational framework and analyze possible neural mechanisms from a systems perspective. We simulate activity and test a variety of "what if" scenarios without having to use human subjects in a rapid and inexpensive way," Li said.

From previous experiments, scientists have found that fear can subside when overcome with fear extinction memory, but it is not permanently lost. Fear extinction is a process in which a conditioned response to a stimulant that produces fear gradually diminishes over time as subjects, such as rats in auditory fear experiments, learn to disassociate a response from a stimulus. One theory has concluded that fear extinction memory deletes fear memory, and another concluded that fear memory is not lost, but is inhibited by extinction memory as fear can recover with the passage of time after extinction.

"Fear extinction memory is not well understood, and our computational model can capture the neuron response well in rat during auditory fear conditioning with a mixture of mathematics and biophysical data," said Li. "Our main contribution is that our model predicts that fear memory is only partially erased by extinction, and inhibition is necessary for a complete extinction, which is a reconciliation of the erasure and inhibition theories. Furthermore, our model shows that the inhibitory connection from interneurons to pyramidal cells serve as an important site for the storage of extinction memory."

For PTSD victims, the fear circuit is disrupted and they cannot retrieve the fear extinction memory. However, the fear extinction memory exists, so the fear memory dominates every time victims get a fear cue. Li and his collaborators are targeting the inhibitory connection in the brain that makes it possible to retrieve the extinction memory. Li hopes that his research can contribute to new drugs that can help PTSD victims.

"Treatment for PTSD patients depends on which connection stores the fear extinction memory and which circuit misfires," Li said. "With our model, we can figure out what specific connections store fear/extinction memory and how such connections are disrupted in the pathology of PTSD, which may lead to the suggestions of new drugs to treat the disease."

The study has been published in the *Journal of Neurophysiology* and *Psychiatric Annals*.

Source: University of Missouri-Columbia (news : web)