Neuroscientists Show How Brain Stores Memories of Specific Fears

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(PhysOrg.com) -- The brain is capable of holding and retrieving memories for specific fears, revealing a more sophisticated storage and recall capacity than previously thought, neuroscientists have found. The study, which appears in the journal *Nature Neuroscience*, may have implications for treating post-traumatic stress syndrome -- as scientists begin to understand how different fears are stored in the brain, they can move toward addressing specific fear memories.

The research was conducted by researchers at New York University's Center for Neural Science, the Department of Psychiatry at NYU School of Medicine-Bellevue Hospital Center, the Copernicus Center for Interdisciplinary Studies in Krakow, Poland, Université Paris-Sud, and the Emotional Brain Institute at the Nathan S. Kline Institute for Psychiatric Research.

The research focused on the brain's amygdala, which has previously been shown to store fear memories. However, prior studies have indicated that the amygdala does not discriminate among the different threats it holds and processes. In other words, whether you are afraid of dogs because you were once bitten by a dog or you are afraid of pizza because you once nearly choked to death eating it, all the amygdala remembers is that both of these experiences were scary. By contrast, other brain areas, such as cortex, ensures that all other aspects of these fearful events in your life are remembered.

The scientists on the Nature Neuroscience study sought to determine if

there were differences in how the amygdala processes and remembers fears. To do so, they focused on a process called memory consolidation in which an experience is captured, or encoded, then stored. Once consolidation occurs, memories may be long lasting—one experience may create memories that last a lifetime. However, whenever recalled, memories become labile—that is, susceptible to changes. This process is called reconsolidation. In life, reconsolidation allows updating existing memories. But this process also serves as a valuable methodological tool as it lets researchers control the modification of memories.

When it comes to developing fear memories, one model posits that during a fear experience, a neutral stimulus (e.g., a musical passage) becomes associated with a negative encounter (e.g., a dog bite). Therefore, future occurrences of this neutral stimulus, or conditioned stimulus (CS), forewarns the onset of the negative encounter, or unconditioned stimulus (US). Previous research shows that the association between a CS and a US is processed and stored in the amygdala.

To replicate this process, the researchers devised an experiment using laboratory rats. In it, they paired two distinct audio tones, which served as the neutral stimulus, or conditioned stimulus (CS), with mild electric shocks to different parts of the rats' bodies. As a result, the rats linked a mild shock to a certain part of their bodies with a certain tone.

Under the memory reconsolidation model, exposing an organism to any aspect of the learned experience brings this memory back to mind and makes it susceptible to changes. Thus, if two distinct tones were each paired with two distinct electric shocks and if the amygdala does not discriminate among different threats, then re-exposing a rat to any of these shocks should cause lability of all fear memories stored in the amygdala.

However, the *Nature Neuroscience* study yielded quite different results. The researchers found that re-exposing a rat to a particular shock (that is, one applied to a certain part of the body), followed by an injection of an antibiotic known to disrupt reconsolidation processes, impaired only these associations that were linked to this particular shock. Despite the disruption of one type of fear memory, rats were still able to express fear behavior to the tone which had been paired with a shock applied to another part of the body.

The finding demonstrates that the amygdala makes distinctions among the fear memories it holds and retrieves.

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