How the brain handles surprise, good and bad

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Whether it's a mugger or a friend who jumps out of the bushes, you're still surprised. But your response—to flee or to hug—must be very different. Now, researchers have begun to distinguish the circuitry in the brain's emotion center that processes surprise from the circuitry that processes the aversive or reward "valence" of a stimulus.

C. Daniel Salzman and colleagues published their findings in the September 20, 2007 issue of the journal *Neuron*, published by Cell Press.

"Animals and humans learn to approach and acquire pleasant stimuli and to avoid or defend against aversive ones," wrote the researchers. "However, both pleasant and aversive stimuli can elicit arousal and attention, and their salience or intensity increases when they occur by surprise. Thus, adaptive behavior may require that neural circuits compute both stimulus valence—or value—and intensity."

The researchers concentrated their study on the amygdala, known to be the brain center that processes the emotional substance of sensory input and helps shape behavioral response to that input.

In their studies, which used monkeys, the researchers performed two types of experiments as they recorded the electrical activity of neurons in the animals' amygdala. In one experiment, they taught the monkeys to associate a pattern on a TV monitor with either the rewarding experience of a sip of water or an unpleasant puff of air to the face. The researchers

measured how well the monkeys learned the association by recording how frequently the animals anticipated the water sip or the air puff by, respectively, licking the water spout or blinking. This experiment was intended to establish whether there were specific amygdala neurons activated by rewarding or aversive stimuli.

In the other experiment, the researchers surprised the monkeys by randomly delivering either the water sip or the air puff—which aimed to establish whether the amygdala harbored specific surprise-processing circuitry.

The researchers' analyses of the activity of the amygdala neurons did reveal different types of neurons. Some neurons responded to either the reward or the aversive stimulus, but not both. However, the activity of distinctly different sets of neurons was affected by expectation of either a reward or an aversive experience.

"These different neuronal populations may subserve two sorts of processes mediated by the amygdala: those activated by surprising reinforcements of both valences—such as enhanced arousal and attention—and those that are valence-specific, such as fear or reward-seeking behavior," wrote the researchers.

They concluded that "These different types of response properties may underlie the role of the amygdala in multiple processes related to emotion, including reinforcement learning, attention, and arousal. Future work must develop experimental approaches for unraveling the complex anatomical circuitry and mechanisms by which amygdala neurons influence learning and the many emotional processes related to the valence and intensity of reinforcing stimuli."

Source: Cell Press