# 'It's all in the eyes': The role of the amygdala in the experience and perception of fear

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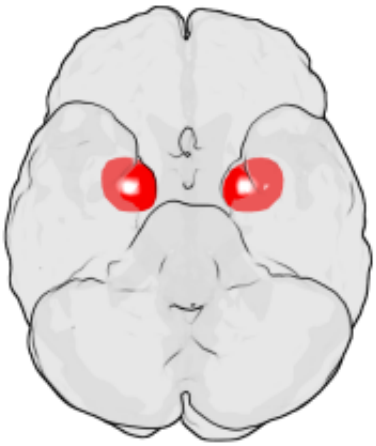

Location of the amygdala in the human brain. Image: Wikipedia.

Researchers have long believed that the amygdala, an almond-shaped structure in the brain, is central to the experience and perception of fear. Studies initiated in the 1990s of a patient with a rare condition affecting the amygdala initially seemed to support this conclusion. However, as Lisa Feldman Barrett, Ph.D., of the Massachusetts General Hospital (MGH) Department of Psychiatry writes in a new paper, the role of the amygdala has turned out to be more complex than originally thought. Barrett, a research scientist at the Athinoula A. Martinos Center for Biomedical Imaging at MGH and a University Distinguished Professor of Psychology at Northeastern University, was invited to write the paper

for the 40th anniversary issue of the journal *Trends in Neurosciences*.

"Scientists originally hypothesized that the amygdala contained the circuitry necessary for fear and its related behaviors," says Barrett. "They continually broadened their hypotheses for the amygdala's role with accumulating research in both humans and non-human animals. The amygdala was then thought to contain the circuitry for negative emotions, for emotions in general, and eventually, for anything broadly affective, such as threat. Through the natural process of systematic scientific investigation, it's become clearer that the amygdala plays a role in signaling the rest of the brain to information that is important to learn because it is relevant to allostasis—the brain's process of anticipating the needs of the body and attempting to meet those needs before they arise. Whether threatening, rewarding or novel, this to-be-learned information will help the brain better predict future occasions."

The amygdala has been linked to fear since the publication of a 1930s paper by University of Chicago researchers Heinrich Klüver and Paul C. Bucy, who described profound behavioral changes—including a newfound willingness to approach snakes and other dangerous animals—in rhesus monkeys whose temporal lobes, including the amygdala, had been removed. This work spurred decades of continuing research in non-human animal models into the role of the amygdala in creating states of fear. By the early 1990s, Barrett writes in the current paper, investigators had concluded the structure was integral to a central fear system in the brain.

However, understanding of the amygdala's role started to change around that time when a team at the University of Iowa College of Medicine began to publish a series of studies of a woman known in the literature as S.M. with rare bilateral lesions of the amygdala resulting from a condition known as Urbach-Wiethe disease. A 1994 study published in *Nature*, showed that S.M. was unable to recognize facial expressions of

fear, underscoring the earlier conclusions about the role of the amygdala; but a more complex picture began to emerge in the following years. Further studies with the patient revealed that she had difficulty perceiving facial expressions of other emotions when those expressions involve a widening of eyes, and even then, only in particular contexts.

As described in Barrett's paper, these findings spurred the development of new hypotheses about the role of the amygdala in the experience and perception of fear. Instead of directly mediating fear, it now appears that the amygdala is involved in a person's ability to attend to the whites of another person's widened eyes, something that is more generally important to social functioning. "The amygdala is not necessary to experience or perceive fear," Barrett says. "Amygdala neurons very likely contribute to fear in some instances, but the neurons can't be said to actually compute fear. More likely, amygdala neurons act as a context-sensitive sentinel for learning threat and reward."

She adds that the work with S.M. over the years offers an excellent example of "science's self-correcting process," in which new findings are used to challenge and, if necessary, revise current hypotheses. "The original hypotheses about the amygdala's role in fear turned out not to be supported after careful study across decades," Barrett says. "This is a good example of how the scientific method, at its best, works."

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