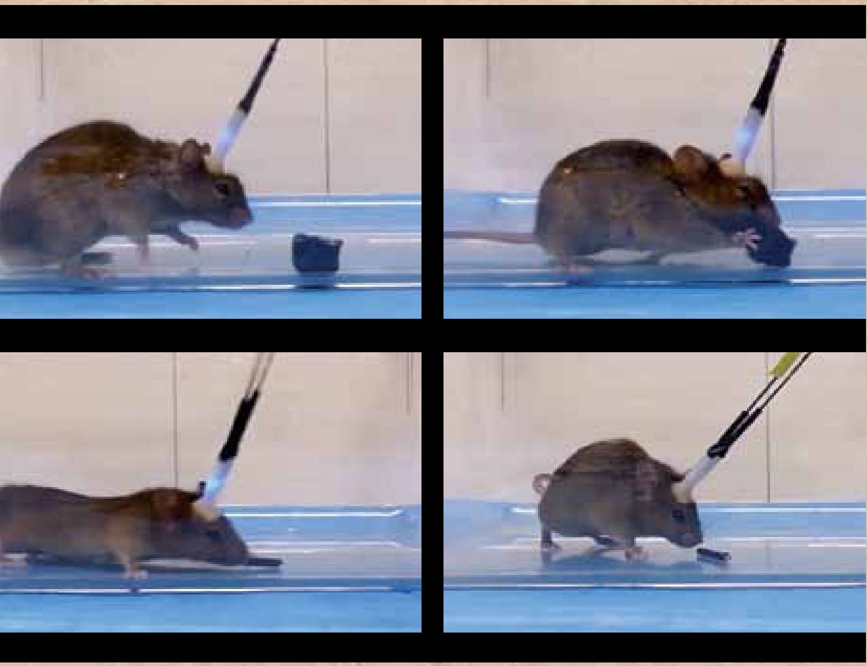

Optical fibers transmit laser beams to mice brains. When the light goes on, the mouse is stimulated to hunt. When the light goes off, the behavior stops

NEUROSCIENCE

# Hunting circuits

## Two neural pathways that originate in the brain's amygdala control the aggressive behavior of predators

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PUBLISHED IN FEBRUARY 2017

A small, almond-shaped brain structure situated in the temporal lobe, the amygdala is commonly described as a group of neurons associated with the processing of emotions, in particular, fear. The classic scenario of a rat paralyzed by terror in the face of imminent attack by its natural predator, the cat, is usually the example chosen to illustrate the result of the activation of this center in the nervous system. However, a study published in the journal *Cell* on January 12, 2017, demonstrates that stimulation of a sub-region of this structure unleashes the cat's predatory behavior rather than the rodent's defensive response. Using a technique called optogenetics, which uses laser to turn specific brain circuits on and off, neuroscientists at Yale University (United States) and the Institute of Biomedical Sciences at the University of São Paulo (ICB-USP) are demonstrating that the amygdala's central nucleus controls the predator's decision to search for prey, capture it and then attack and bite it.

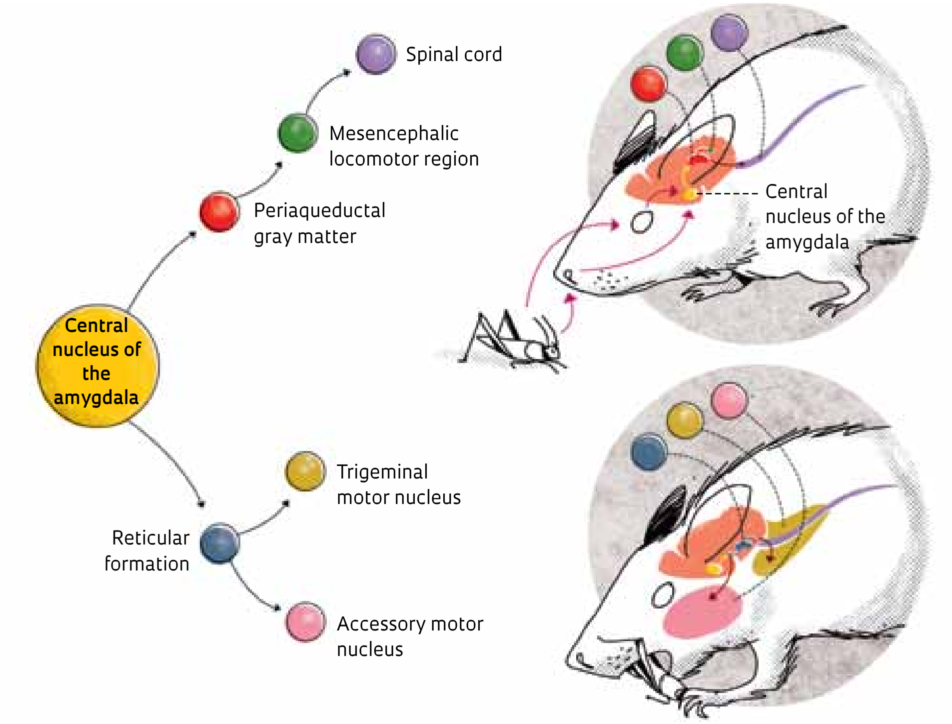
In the study, researchers show that the activation of two independent neural pathways that originate in the amygdala is critical to unleashing the predator's hunt for food (*see box*). When this occurs, rodents chase and then attack almost anything in their path, from actual insects to artificial prey, even bottle caps. "We observed that activating these two groups of neurons is both necessary and sufficient to compel mice to adopt typical hunting behaviors," said Brazilian neuroscientist Ivan de Araújo at Yale University, in whose lab the animal experiments were conducted. Although the neuroscientists do not rule out the possibility that other brain structures may also modulate predatory behaviors, the study's design indicates that stimulating these two circuits is all it takes for the mice to adopt predatory behaviors (*see video at bit.ly/VCircuitoCaca*).

The first pathway stimulated is that related to the pursuit of prey. In nature, this situation occurs when a predator identifies its prey with the help of at least one of the senses (smell, sight or hearing) and begins to move closer to the prey. In experiments with rodents, neuroscientists noted that this behavior is mediated by a projection of neurons present in the amygdala's central nucleus. This circuit relays signals to a structure called the periaqueductal gray matter, which transmits information to the mesencephalic locomotor region. This region then activates the spinal cord, which prompts the animal to mobilize for a hunt.

The second neural circuit controls the very capture and destruction of the prey. This is the moment the hunt is consummated, when the predator attacks the captured prey. The pathway

# Stimuli of predatory behavior

Activating two independent neural pathways that originate in a region of the brain known as the amygdala's central nucleus, which is associated with the processing of emotions, prompts rats to pursue, capture and bite prey




**PATHWAY OF PURSUIT**

Activation of a structure known as the periaqueductal gray matter sends impulses to the mesencephalic locomotor region, which activates the spinal cord. When it sees or smells its prey, the predator initiates a pursuit

**PATHWAY OF CAPTURE**

Arousal of a diffuse set of neurons, known as the reticular formation, sends electrical impulses to the accessory motor nucleus, which controls the movement of the neck, and to the trigeminal motor nucleus, responsible for opening and closing the jaw. The predator grabs the prey and bites down hard on it

**SOURCE** IVAN DE ARAÚJO AND NEWTON CANTERAS

that modulates this action also originates in the amygdala's central nucleus, but it takes a different path. The activation of a diffuse set of neurons, known as the reticular formation, carries electronic impulses to the accessory motor nucleus, which controls the movement of the neck, and to the trigeminal motor nucleus, which is responsible for opening and closing the jaw. "When we stimulate only the first pathway and not the second, the rodents pursue their prey, but they don't attack it," explains one of the study's other authors, ICB-USP neuroanatomist Newton Canteras, a specialist in the study of the neural basis of fear and aggression. If, in contrast, the only circuit activated is the second one and not the first, the mice stop what they are doing and simply grab and bite at the air, as if they had an imaginary prey to tear to pieces.

According to the neuroscientists, optogenetics is a technique that can test the functioning of brain circuits in a subtler way than other approaches, such as causing mechanical or chemical lesions in certain areas of the brain to observe their behavioral or clinical effects. By injecting a virus from a genetically modified population, researchers heighten the sensitivity to light of the neural pathway to be studied. In this way, an optical key that turns the circuit "on" and "off" is created and controlled by the researchers. In the case of the mice in the hunting study, small optical fibers connected to the animals' brains transmit blue laser beams to the amygdala and enable modulation of the two circuits. "In addition to the color, we can control the intensity and frequency of the laser pulse," says morphologist Simone Motta, also a professor at ICB-USP who participated in the study and spent some time at Araújo's lab at Yale learning the technique.

## AMYGDALA IN MAMMALS

Work done by Canteras more than 10 years ago inspired the effort to confirm the possible role of circuits tested in the experiment on predatory hunting behaviors. Those studies had already suggested that some neural pathways that originate in the amygdala's central nucleus were more closely associated with predatory stimuli than the expression of fear. Since the amygdala is a structure in the brain that is well preserved in mammals, it may also be involved in regulating hunting behaviors in other vertebrates. The new study brings to the table once again the idea that the amygdala's central nucleus plays an essential role in the organization of responses unleashed by fear. ■


### Projects

**1.** Neuroendocrine and autonomic responses in rats with dorsal premammilary nucleus lesion after social defeat (No. 10/05905-3); **Grant Mechanism** Postdoctoral research fellowship; **Principal Investigator** Newton Canteras (USP); **Grant Recipient** Simone Motta; **Investment** R$197,050.51 and R$176,479.88 (Research internship abroad).
**2.** Role of anterior thalamus and its cortical targets in conditioned defensive behavior to the social defeat context (No. 12/13804-8); **Grant Mechanism** Doctoral research fellowship; **Principal Investigator** Newton Canteras (USP); **Grant Recipient** Miguel José Rangel Junior; **Investment** R$188,066.58 and R$96,354.03 (Research internship abroad).


### Scientific article


HAN, W. *et al.* Integrated control of predatory hunting by the central nucleus of the amygdala. ***Cell.*** v.168, i. 1-2, p.17-9. 12 Jan. 2017.