YOUR BRAIN ON TERROR

CHEMOSIGNALS OF FEAR AND THEIR EFFECTS ON BEHAVIOR

By Fernando Racimo

"The smell of fear" is a very popular phrase. We use it in alarming situations, to indicate that something is wrong or when we think our date is secretly panicking. But does fear really have a smell? According to recent studies, it does, and it may be more powerful than we think.

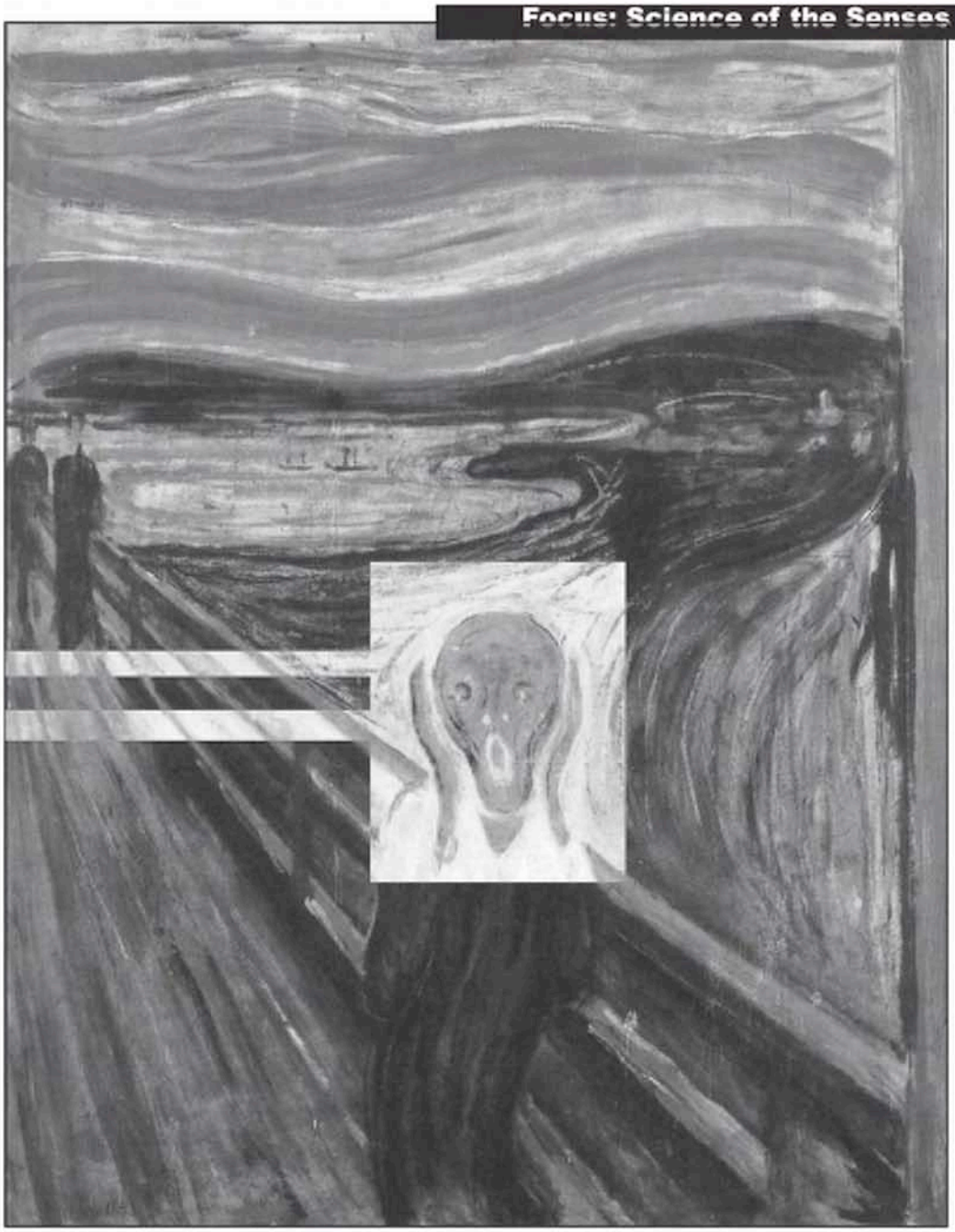
Our bodies are keenly perceptive systems. Whenever we feel alarmed, frightened or under threat, the body responds accordingly – making other bodies respond as well. Just as love pheromones affect insects' sexual cycles, the chemical signals emitted by terrified individuals can have dramatic effects on the brains of nearby organisms. We are, after all, a very social species…for better or for worse.

Why animals smell when they get scared

Fear chemosignals have a wide range of effects on a variety of species. Deer, mice and even roundworms excrete these chemicals during states of alarm and induce other members of the species to act in a particular way [1] [2]. Some chemosignals may alert them to run from a potential threat, others may help coordinate a collective attack against territorial intruders. These types of alarm create physiological changes in the nervous system, which in turn generate specific emotional states. Studies revealed that the pituitary gland mediates the production of these chemicals in alarmed rats [3], which suggests a similar origin for similar molecules in other animals.

An experiment on aphids under predation helped uncover some of the intricacies of chemosignaling. When an attack by a predator or parasitoid seems imminent, aphids emit a volatile chemical alarm called EBF ((E)-ß-farnesene) that lets other aphids know of the presence of danger [4]. The insects emit multiple bursts of the chemical after perceiving an attack, but the volatility of the substance seems to decline exponentially after the initial burst, which

credit: Clipart courtesy FCIT. http://etc.usf.edu/clipart



The central figure in Edvard Munch's famous painting depicting fear, *The Scream*, may be releasing fear pheromones.

credit: Edvard Munch's *The Scream*, public domain.

suggests that the first alarm signals are also the most precious ones.

There also exists evidence which suggests that chemosignals may alter the production of certain antibodies in the immunological system of mice. Animals exposed to stress odors for 24 hours appeared to have a diminished production of natural cytotoxic tumor killers in comparison to those that are not exposed to the smell. This response may posses a certain adaptive value in encounters with predators, which require an animal's physiology to function differently than it normally does [5].

The scent of horror makes for a keener mind

Curiously enough, fear signals are also present in humans. The question remains as to which molecule is in charge of delivering such "terrifying" messages. Ackerl disproved the theory that cortisol – a hormone released by our adrenal glands when we are scared – is the inducer of the scent that communicates the alarm [6]. The true inducer, however, remains to be found.

"Just as love pheromones affect insects' sexual cycles, the chemical signals emitted by terrified individuals can have dramatic effects on the brains of nearby organisms."

Scientists have also devised experimental tests to find out exactly what one responses person's fear may trigger in another. By making young college males watch scary movie segments, for example, Chen et al. obtained sweat odor samples rich in pheromones. They then taped sweat-stained pads onto a different group of individuals and tested their cognitive abilities in word-association exercises [7].

"Research on mice, our distant mammal cousins, has revealed that pheromones can be significantly helpful in generating specific behaviors in individuals of the same species."

The results demonstrated heightened cognition, though in a very specific way: the individuals "under the influence" of fear chemosignals became more cautious and vigilant when pairing up words with threatening meanings but had slower responses at pairing words that were only ambiguous in their threat content. This suggests that the improved cognitive effect may be related to a threat-response mechanism encoded early in our evolutionary history, when linguistic warning signals had yet to evolve.

Influence of anxiety signals on emotion perception

Problem-solving cognition is not the only faculty affected by pheromones produced in times of danger. Studies conducted by Pause et al. used a simple test to prove these chemicals' surprising effects on emotion recognition. Instead of using frightening videos, however, they collected sweat samples from male students about to take an exam, with the aim of obtaining an even higher level of stress in the chemosignal donors. The samples were then presented to a different group of individuals, who were shown a series of photographs with happy and sad faces. When people were primed with a happy face for a short time interval and then presented with another face, they judged the second face in a more positive light than if the second face had been presented in isolation. This did not occur in individuals under the effect of anxiety odor. Furthermore, this alteration of face perception was only detected in female subjects, suggesting a chemosensory difference between men and women [8]. These findings suggests that females may posses a more acute ability to perceive fear chemosignals.

Further research into the neurological responses to alarm pheromones may prove valuable in the study of intelligence, cognition, inter-species communication and predator-prey interactions in the early history of our species. However, the extent to which outside chemicals may affect our emotions at present still remains unknown.

Evolutionary origin: a cue for potential threats

Like other common forms of animal communication, chemosignals evolved under the pressure of natural selection. In social animals, like insects and humans, the ability to communicate alarm signals to other members of the family, herd or colony, is of inestimable advantage to those organisms capable of such signaling. When danger looms, chemical warning can help animals avoid disaster.

Research on mice, our distant mammal cousins, has revealed that pheromones can be significantly helpful in generating specific behaviors in individuals of the same species. In fact, rodents respond to fear chemosignals by withdrawing from the source of the smell and increasing their motor activity (in case an attack becomes unavoidable) [9].

Nowadays, of course, it may not be very helpful to make everyone aware of the fact that your midterm is one hour away and you are terrified. But early on in the evolution of the human species, fear chemosignals could have provided a valuable resource in threat assessment. While language has became our primary form of communication, but in the past, perhaps all we had in the face of danger was a pair of eyes and a very keen sense of smell. ■

—Fernando Racimo '11 is a prospective Organismic and Evolutionary Biology concentrator in Currier House.

References

1. Muller-Schwarze, D. et al. "Alert odor from skin gland in deer." Journal of Chemical Ecology 10 (1984): 1707-1729.
2. Rottman, S.J. and Snowdon, C.T. (1972) Demonstration and analysis of an alarm pheromone in mice. Journal of comparative and physiological psychology 81 (1972): 483-490.
3. Abel, Ernst. "The Pituitary Mediates Production or Release of an Alarm Chemosignal in Rats." Hormones and Behavior 28 (1994): 139-145.
4. Shwartzberg, Ezra G. et al. "Real-Time Analysis of Alarm Pheromone Emission by the Pea Aphid (Acyrthosiphon Pisum) Under Predation." Journal of Chemical Ecology 34 (2008): 76-81.
5. Cocke, Robert. "Exposure to Conspecific Alarm Chemosignals Alters Immune Responses in BALB/c Mice." Brain, Behavior and Immunity 7 (1993): 36-46.
6. Ackerl, Kerstin et al. "The scent of fear." Neuroendocrinology Letters 23 (2002): 79-84.
7. Chen, Denise et al. "Chemosignals of Fear Enhance Cognitive Performance in Humans". Chemical Senses 31 (2006): 415 - 423.
8. Pause, Bettina M et al. "Positive Emotional Priming of Facial Affect Perception in Females is Diminished by Chemosensory Anxiety Signals." Chemical Senses 29 (2004): 797 - 805.
9. Zalaquett, C. and Thiessen, D. "The effects of odors from stressed mice on conspecific behavior." Physiology and Behavior 50 (1991): 221-227.