Inside the brain of a crayfish

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Voyage to the bottom of the sea, or simply look along the bottom of a clear stream and you may spy lobsters or crayfish waving their antennae. Look closer, and you will see them feeling around with their legs and flicking their antennules – the small, paired sets of miniature feelers at the top of their heads between the long antennae. Both are used for sensing the environment.

The long antennae are used for getting a physical feel of an area, such as the contours of a crevice. The smaller antennules are there to both help the creature smell for food or mates or dangerous predators and also to sense motion in the water that also could indicate the presence of food, a fling or danger. The legs also have receptors that detect chemical signatures, preferably those emanating from a nice hunk of dead fish.

"They constantly flick their antennules," says DeForest Mellon, a University of Virginia biology professor, as he watches a Southern swamp crayfish in a bucket doing just that. "It is doing two things that are processed simultaneously in the brain as he flicks: smelling the water, and also sensing motion in the water, which can indicate the presence of food or other things of interest. "I'm interested in understanding how these senses are combined and interpreted in the brain of these animals. My question is, how does the brain detect, integrate and use co-joined but dissimilar sensory inputs?" It's much like humans tasting food by a combination of senses that detect taste, aroma, texture and how good that dish of pasta looks. It's a complex process of brain processing that serves us well in a world of smells, textures, flavors and visual stimuli. It's not much different with crustaceans, though their brains are much simpler, which makes them a great study model, Mellon says.

Mellon, and other neurophysiology researchers commonly use crustaceans to try to gain basic understanding of the nervous systems of creatures in general, and, wherever possible, for extrapolating what they find to a basic understanding of the much more complex human brain. All animals, from single-celled amoebas to humans, use similar cellular processes to interpret their olfactory environment.

“Due to the large-sized nerve cells of invertebrates, we can conveniently and practically examine these systems that are largely the same among all creatures,” Mellon says. “And antennule flicking can serve as a practical model that helps us understand how two or more senses work together in the brain.” Mellon has been investigating sensory systems for half a century, since his grad school days at Johns Hopkins University. He’s still learning. “We can say we know that animals use their senses to make maps of their environment that direct their behaviors,” he says.

Recently Mellon perused the research in the field – his own and that of many other scientists – of the past 45 years or so and has published a review of the literature in the August 2007 issue of The Biological Bulletin. What he’s found is that there is still a lot not understood. “It’s fertile ground for ongoing research,” he said. “The size of an area of the brain devoted to a particular sense gives us a good idea of how an animal perceives the world. It provides insight as to how the world is interpreted by that animal.”

About 40 percent of a crustacean’s brain is devoted to the sense of smell. “This shows how important detecting odors is to the animal,” Mellon says. Crayfish and lobsters are generally solitary creatures, inhabiting an aquatic environment that is often dark, and they need that highly acute sense of smell. Humans, by contrast, have a very small portion of the brain devoted to interpreting smells, less than one percent by volume. But about 30 percent of the human brain is concerned with visual processing, interpreting images from the eye, Mellon says. As social animals, humans rely heavily on sight and color for identifying food, as well as friends and foe.

"I have always been fascinated by the diversity of animal types and their equally diverse behaviors," Mellon says. "Both are genetically based. And through often very subtle adoption of genetic variations in different animals, evolution has arrived at different solutions to common survival problems. This behavioral diversity and the variants in nervous system organization account for why I remain fascinated with biology."

Source: University of Virginia

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