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Deciding to stay or go is a deep-seated brain function

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Birds do it. Bees do it. Even little kids picking strawberries do it.

Every creature that forages for food decides at some point that the food source they're working on is no richer than the rest of the patch and that it's time to move on and find something better.

This kind of foraging decision is a fundamental problem that goes far back in evolutionary history and is dealt with by creatures that don't even have proper brains, said Michael Platt, a professor of neurobiology and director of the Center for Cognitive Neuroscience at Duke University.

Platt and his colleagues now say they've identified a function in the primate brain that appears to be handling this stay-or-go problem. They have found that the dorsal anterior cingulate cortex (ACC), an area of the brain known to operate while weighing conflicts, steadily increases its activity during foraging decisions until a threshold level of activity is reached, whereupon the individual decides it's time to move on.

In lab experiments with rhesus macaque monkeys, Platt and postdoctoral fellows Benjamin Hayden and John Pearson put the animals through a series of trials in which they repeatedly had to decide whether to stay with a source that was giving ever-smaller squirts of fruit juice, or move to another, possibly better, source. The animals were merely gazing at a preferred target on a display screen, not moving from one tree to the next, but the decision-making process should be the same, Platt said.

For the other variable in this basic equation, travel time, the researchers added delays when monkeys chose to leave one resource and move to another, simulating short and long travel times.

As the monkeys repeatedly chose to stay with their current source or move to another, the researchers watched a small set of neurons within the anterior cingulate cortex fire with increasing activity for each decision. The rate of firing in this group of neurons grew until a threshold was reached, at which time the monkey immediately decided to move on, Platt said. "It is as if there is a threshold for deciding it's time to leave set in the brain," he said.

When the researchers raised the "travel time" to the next foraging spot in the experiment, it raised the decision-making threshold, Platt said.

This all fits with a 1976 theory by evolutionary ecologist Eric Charnov, called the Marginal Value Theorem, Platt said. It says that all foragers make calculations of reward and cost that tell them to leave a patch when their intake diminishes to the average intake rate for the overall environment. That is, one doesn't pick a blueberry bush until it's bare, only until it looks about as abundant as the bushes on either side of it. Shorter travel time to the next patch means it costs less to move, and foragers should move more easily. This theorem has been found to hold in organisms as diverse as worms, bees, wasps, spiders, fish, birds, seals and even plants, Platt said.

"This is a really fundamental solution to a fundamental problem," Platt said.

Platt said the work also relates to recent papers on the Web-browsing habits of humans. In the case of Internet users, the cost of travel time translates to download speed. The faster the downloads, the quicker browsers are willing to forage elsewhere, Platt said.

They aren't sure yet where the brain's signaling goes after the stay-or-go threshold in the ACC is reached. Platt believes this kind of "integrate-to-threshold" mechanism would be a good way to handle a lot of functions in the brain and may be found in other kinds of systems. This particular threshold in the ACC might also be a way to explain maladaptive behaviors like attention deficit, in which a person decides to move on constantly, or compulsive behavior, in which a person can't seem to move on at all, he said.

More information: "Neuronal basis of sequential foraging decisions in a patchy environment," Benjamin Y. Hayden, John M. Pearson, Michael L. Platt. Nature Neuroscience, Advance Online, June 5, 2011. doi: 10.1038/nn.2856

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