Bats Use Guided Missile Strategy to Capture Prey

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When it comes to rocket science, it looks like bats had it worked out before the scientists did. A new University of Maryland study finds that echolocating bats use a strategy to track and catch erratically moving insects that is much like the system used by some guided missiles to intercept evasive targets and different from the way humans and some animals track moving objects.

Using infrared video cameras and an array of microphones in their bat lab, the University of Maryland research team discovered that the big brown bat solves a rather complex geometrical problem to minimize the time it takes to intercept flying insects. The pursuit strategy is different from that reported in earlier studies of target pursuit in humans and other animals.

This study also demonstrates, for the first time, that bats work out ahead of time how they will catch an insect. Evolutionary pressure to catch flying insects as fast as possible, the researchers speculate, may have pushed the bat to adopt this technique to catch a meal on the go as quickly as possible. Their paper appears in the May issue of *PLoS Biology*.

This study is one of several published by the Moss lab in recent months that have uncovered new information about how bats use sound to probe their environment and process information.

"This finding contributes to our growing discoveries about the bat's exquisite adaptive behaviors in response to rapidly changing echo 'pictures' of the world," says psychology professor Cynthia Moss, a co-author of the study and director of the lab. "These adaptive behaviors include agile flight and head-aim control, as well as adjustments in the timing patterns of sonar vocalizations, all finely coordinated to allow the bat to capture a free-flying insect in complete darkness and in the snap of a finger."

Interception

One way to intercept a target moving at fixed speed in a straight line is with constant bearing, a technique used by humans and other animals such as fish and dogs. When a centerfielder runs for a fly ball, for instance, he uses constant bearing, keeping the angle between him and the ball constant, and moving in a straight line as he closes in on his target. He uses his eyesight to track the ball's movement, moving, essentially, in a collision course with the ball.

"Constant bearing is a simple, intuitive way of doing complicated mathematical calculations," says lead author Kaushik Ghose, Ph.D. "It's the quickest way to get to a predictably moving target."

Enter the bat, which uses sound rather than sight, to track its prey. The bat emits a series of ultrasonic pulses through its mouth to search its environment. When the pulses hit upon an insect that could be dinner, they bounce back to the bat to alert it to the insect's presence. But insects don't move in a predictable straight trajectory like a baseball. They fly about erratically and may be in the open for only seconds at a time.

"The bat has a fleeting time window to detect, localize, and capture highly maneuverable and unpredictable prey," says Ghose. "A complete insect chase, from detection to capture, typically takes the bat less than a second."

Like a Guided Missile

To see just what methods a bat uses to make the lightning fast interception, the team took infrared video and sound recordings of eight big brown bats intercepting both free flying and tethered insects in Moss's specially designed bat lab. By slowing the video, the team reconstructed the bats' flight and tracking maneuvers to reveal that bats don't use the constant bearing method the baseball player does.

Instead, the bat constantly changed its bearing angle and speed in response to the insect's rapid movements. The bat locks its head on its target, much like the baseball player who keeps his eyes on the ball, and maintains the lock-on throughout the interception maneuver, even as its flight direction changes.

"The bat keeps the compass direction to the target a constant, but it changes its flight direction at the same time," says Ghose. "So, when the bat chases an insect, if the insect is initially located to the northwest, the bat maneuvers to always keep the target to the northwest while closing distance.

"This strategy is called parallel navigation after the parallel nature of the bearing lines. Interestingly, in the late 1940s engineers working on the problem of how to program guided missiles to hit their targets implemented a similar strategy."

Fast Food

On first glance, the bat's strategy doesn't appear to be the easiest. "After all it's easiest to just head straight for a target. As long as you've moving faster, you will catch it," Ghose says.

"The next easier thing is to maintain a fixed angle between yourself and the target. But the bat has done one better. It's worked out ahead of time where it thinks the insect will end up and leads its flight to do that. It turns out the bat's strategy is time-optimal for catching erratically moving targets.

"It suggests that the bat adopted this strategy in response to evolutionary pressures of having to capture erratic and fast moving insects. I guess you could say that the need to intercept unpredictably moving targets as quickly as possible has driven both nature and engineers who design missiles to adopt the same strategy."

Other researchers on the study were Maryland faculty Timothy Horiuchi, and P.S. Krishnaprasad, professors of electrical and computer engineering. They, along with Ghose, also work in the university's Program in Neuroscience and Cognitive Science. The study was funded by grants from the National Science Foundation and the National Institutes of Health.

Source: University of Maryland