Johns Hopkins study overturns long-held assumption about bat vision

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It was a scientific “fact” that went untested for nearly a century: bats don’t move their eyes. By capturing the first empirical evidence of bat eye movement, a new Johns Hopkins study reveals a sophisticated gaze-stabilization system, proving that vision plays a vital role in how these animals move through the world.

For more than 80 years, scientists largely accepted that bat eyes were static, with echolocation doing most of the navigational work. This belief was based on a single book published in 1942 by optometrist Gordon Walls, who claimed that small nocturnal mammals possess eyes that “never move even reflexively.”

Because Walls was a leading authority on vision, his assertion became conventional wisdom for decades, despite never being tested experimentally. Now, Johns Hopkins researchers have set the record straight. By studying Seba’s short-tailed bats, the team captured the first direct evidence of bats moving their eyes to stabilize their vision. This discovery, published recently in *Current Biology*, reveals that vision plays a far more important role in bat navigation than previously thought.

“This study shows that the brain’s solutions to navigation are more flexible than we assumed,” says Kathleen Cullen, the Raj and Neera Singh Professor of Biomedical Engineering at Johns Hopkins University and the study’s principal investigator. “Even in an animal as specialized as the bat, multiple senses are integrated in ways that depend on behavior and environment—and that’s likely a general principle across many species, including humans.”

To investigate, the researchers measured how Seba’s short-tailed bats move their eyes in response to visual cues. When the team moved visual patterns in front of them, the bats tracked the motion across a range of ±10°. This response, called the optokinetic reflex (OKR), was similar to mice and other mammals: the eyes slowly followed the cue, then quickly snapped back to the center to reset and begin tracking again.

The study took a surprising turn when the team tested how bats react to physical movement. In most mammals, the inner ear triggers a reflex to keep the eyes steady when the head turns. Interestingly, when the researchers passively rotated the bats' heads—side to side—their eyes barely moved.

Micro-CT scans confirmed this difference wasn't anatomical; bats have inner ear structures nearly identical to mice, which showed strong eye movement responses during the same tests.

So why don't bats respond the same way? The findings suggest that the difference isn't in the sensors but in how the brain uses these signals. The researchers propose that this system is specialized for active flight—relatively quiet at rest but likely engaging during the rapid, acrobatic maneuvers bats use to navigate in the dark.

The research challenges the long-held view that bats rely almost exclusively on sound. Instead, it shows they integrate vision and sonar to support split-second decisions in complex environments. The findings also point to a broader neurological principle that will be the focus of future studies: how the brain flexibly combines sensory streams—vision, balance, and more—to guide behavior in 3D space.

"In bats, we see that this integration is dynamically tuned depending on context," says Cullen. "The same is true for humans. Understanding how the brain optimizes this integration process has vital implications for treating balance disorders and for designing more effective rehabilitation and assistive technologies."

In addition to Cullen, the Johns Hopkins research team included Grace Capshaw, Dimitri Skandalis, and Cynthia F. Moss from the Department of Psychological and Brain Sciences. The study was a collaborative effort with Hui Ho Vanessa Chang of the Research Institute for Aerospace Medicine at Inha University, who carried out this work as a PhD student in Cullen's laboratory.

Image Credit: Brock Fenton

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Associated Faculty: Kathleen Cullen