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Wiring bats for neuroscience research

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Mysterious creatures that thrive in the dark, bats have long been associated with witchcraft, vampires, and black magic. But according to Dr. Yossi Yovel of Tel Aviv University's Department of Zoology at Tel Aviv University, we have much to learn from these highly intelligent winged mammals. Now he is developing the world's first bat colony born and raised in captivity to unlock the secrets of behavior and cognition, including social hierarchy and structure, communication abilities, and memory.

The bats, which will be born in captivity but free to forage outside, are outfitted with high-tech sensors including GPS and ultra-sonic microphones to track their activities and interactions. In addition, Dr. Yovel's new state-of-the-art "flightrooms," acoustic rooms within the lab, are specially equipped to better analyze bat sonar.

This research, which has appeared in a number of journals including *Science* and *PLoS Biology*, is already unlocking secrets of the ways that the brain processes time and sound. It could also inspire future developments in robotics, sensors, and sonar technology, among other applications.

Taking neuroscience to the field

Along with high cognitive skills, bats have a sixth sense called echolocation. They and other biosonar animals such as dolphins send ultrasonic "pings" into the environment to identify the type and location of objects by the "shape" of the returning sound. Though man-made sonar and radar technology is inspired by nature, the bat-brain's ability to measure time within hundreds of nanoseconds and distances within less than a millimetre remains a riddle.

Until now, says Dr. Yovel, scientists were ill equipped to learn more about the behavior and functioning of bats. No sensors were light or small enough to attach to the animals, which often weigh only 30 grams or less. But with new sensors weighing less than five grams and novel GPS systems, bats can be observed in their natural condition as part of a research field that he calls "neuroecology."

Though most work in neuroscience is conducted in the lab, this environment is unnatural, says Dr. Yovel. TAU's bat colony is called an "imprinted colony" because despite being born in lab facilities and returning to their artificial "home" roosts daily, the bats are free to forage outside and behave as wild bats do. The GPS sensors relay information on where the bat has been, and sonic microphones record their social communication and echolocation practices. In the future, he hopes to mount cameras on the bats and even measure their brain activity with portable EEG devices.

High-speed perception

Equipped with over 100 sonic microphones and high-speed video cameras to the record bats' signals and behavior, Dr. Yovel's "flightrooms" seek to unlock mysteries of the working of the mammal's brain — which processes information at a speed that no machine can match."Bats must make super-quick decisions when chasing tiny insects while flying at speeds of up to 50 kilometers per hour," he says.

The accuracy of biosonar is well known. Bats can identify different plant types by the shape of the ultrasonic sound that returns from them. And Dr. Yovel is researching the possibility the animals can identify each other as well by the different "sound pictures" that their unique features create. But another factor to consider is how quickly this information is processed.

"Time coding in the brain is something that we don't understand well," Dr. Yovel says. "We don't know how neurons that work on a time scale of milliseconds can measure time with an accuracy of hundreds of nanoseconds. Since humans rely on vision, we can't accurately measure when something is perceived. But because bats emit sonar calls that can be recorded and analyzed, we have a window into the bat's brain," says Dr. Yovel. With ultra-sonic microphones designed to measure the incoming and outgoing of sonar signals, he can gather accurate information on the bats' decision-making processes. This could answer the question of whether a specific network in the brain governs time coding.

Besides having applications in sonar and radar technologies, the research also contributes to understanding the limits and functioning of the brain, he says, noting that he is also attempting to use Functional Magnetic Resonance Imaging (fMRI) to measure bats' brain activity for the first time.

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