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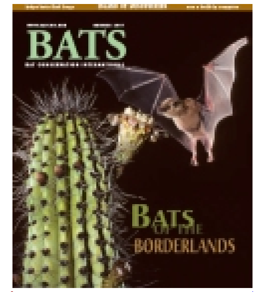

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Social Learning
How fringe-lipped bats identify tasty frogs
Rachel Page

In trying to decide what to order at a new restaurant, have you ever scanned nearby tables to see what other diners were having? Thatâ€™s about what some foraging bats seem to do when faced with the smorgasbord of potential prey provided by a tropical rainforest, except the bats donâ€™t so much look as listen. In our study of fringe-lipped bats in Panama, we found that they can learn whatâ€™s good to eat by eavesdropping on successful bat diners.
The fringe-lipped bat (*Trachops cirrhosus*) feeds on a variety of prey, from large insects to small vertebrates, and sometimes even on other bats. But this bat is most noted for feeding on frogs. Male frogs produce loud, conspicuous advertisement calls at night to attract potential mates. Fringe-lipped bats use these calls to find and assess prey. On the basis of the advertisement calls alone, this bat can tell whether a specific frog is poisonous or edible.
But how do the bats learn these associations? Are they born knowing which frog calls mean dinner â€“ and which signal danger? Or do they learn how to decode the signals over the course of their lifetimes? Previous experiments, which I conducted with Michael Ryan of the University of Texas at Austin, show that these bats are extremely flexible and can quickly learn and relearn associations between prey cues and prey quality. What we wanted to know next was: Can these associations be transferred from bat to bat by social learning?
To answer this question, we set mist nets near streams and ponds at the Smithsonian Tropical Research Institute on Barro Colorado Island, Panama, and brought fringe-lipped bats back to a large outdoor flight cage for behavioral tests.
We wanted to use a call that the bats would probably never approach in the wild. We chose the calls of the cane toad (*Bufo marinus*). Cane toads, abundant on Barro Colorado Island, are highly toxic and can weigh ten times as much as a fringe-lipped bat. So it is extremely unlikely that bats in the wild would be attracted by the calls of a cane toad.
We first tested each bat for its baseline response to cane toad calls. None responded.
Then we took a single bat and offered food rewards to calls that sounded initially like those of the tÃºngara frog, a preferred prey species, and then progressively morphed, in subsequent versions, into the calls of a cane toad. To create these â€œhybrid calls,â€ we started with the tÃºngara frog call, then recorded a low-amplitude cane toad call on top of it. We increased the amplitude of the toad call in regular increments while decreasing that of the frog call. In a very short time, the bat learned to respond to pure toad calls.
Next, we put this newly trained bat and an untrained test bat together in a flight room. We placed a food reward on an audio speaker and played the toad call. The trained â€œtutorâ€ bat flew down to the speaker and retrieved its food reward. Would the untrained bat follow suit? And if so, how quickly?
To ensure that the bats were not just learning to associate speaker boxes with food, we concealed them beneath a screen covered with leaf litter and moved them to a different, random location for each trial. Then we counted the number of times the tutor bat retrieved its reward before the test bat learned that, in this environment, cane toad calls signal palatable prey.
Learning was extremely rapid. On average, it took a test bat 5.3 trials of observing a tutor bat before it, too, responded to the toad calls by flying to the speaker and collecting the food. At that point, we removed the tutor bat from the room to determine whether the test

bat had, in fact, learned to associate the call with prey or was just responding when the tutor did. When we retested each test bat by itself, we found that they did indeed associate the calls of a toxic toad with palatable food.

To further confirm these results, we tested two control groups of fringe-lipped bats. We wanted to be sure that what we interpreted as rapid social learning was not simply the result of individual trial and error. To test this possibility, we placed a single bat in the flight room, positioned a speaker as before, placed a food reward on it and broadcast toad calls. We repeated this over the course of five nights for a total of 100 trials or until the bat learned, whichever came first.

We were also concerned that perhaps the presence of more than one bat might somehow change the batsâ€™ motivation to explore the area and accelerate their learning rates. To control for this, we placed two inexperienced bats together in the flight room, placed a reward on the speaker and broadcast toad calls. Again, we presented the toad call up to 100 times.

The results were striking. While the social-learning group had associated the toad call to food in an average of 5.3 trials, most of the bats in the control groups never made the association, even after 100 trials. Surprisingly, however, a single bat in each of the control groups did eventually learn the association, but only after more than 80 trials. Once we finished our tests, we carefully reconditioned the bats to avoid toad calls in the wild, then released each one where we had caught it.

These experiments clearly show that bats can learn socially from other bats. All that is required is that one bat observe another foraging. Fringe-lipped bats are social animals that roost in groups of four to fifty or more individuals. Multiple bats are often found at foraging sites, such as ponds that host chorusing frogs. So it is very possible that individuals can eavesdrop on the foraging activity of other bats, leading to the transfer of novel behavior from bat to bat.

The fact that one bat learned in each of the control groups points to the role of exploratory behavior in nature. We clearly show that novel associations between prey cues (the frog calls) and prey quality (palatability) can spread rapidly from bat to bat, but these associations must originate somewhere. Exploratory behavior could be how such novel associations between cues and prey quality originate in nature.

Our experiments do not tell us how these cues are learned. Does the test bat actually observe the tutor bat, using echolocation or even vision to follow the batâ€™s foraging behavior? Is the test bat alerted to the foraging event by the crashing sound of the tutor bat landing in the leaf litter to retrieve its prey? Or does the test bat eavesdrop on the echolocation calls that the tutor bat produces as it nears its target?

While we did not explicitly test these hypotheses, our observations point to another possibility. In each of the initial trials, the test bat did not begin paying attention to the actions of the tutor bat until it had retrieved the prey, returned to its perch and started eating. Only after the tutor bat was actually consuming its prey did the test bat respond with interested ear motions and head orientation. After that initial response, the test bat would respond in subsequent trials to the entire sequence of the tutor batâ€™s foraging activity.

What specific sensory cues might elicit this initial attention? When a fringe-lipped bat eats a frog, it consumes the entire creature, bones and all. The chewing noises are loud enough to be heard several meters away, even over the background sounds of a night in the rainforest. Could it be that bats key in on the chewing noises of other bats to learn what they can safely eat? While experiments testing this question are still under way, preliminary evidence suggests this may be the case.

So letâ€™s return to our restaurant scene. Perhaps a better analogy is this: Youâ€™re still not sure what to order, but the lights are too dim to see what others are eating. So instead of peeking at their plates, you listen to the noises they make. If they are â€œoohingâ€ and

â€œaahingâ€ over their food, you mimic their foraging behavior: â€œWaiter, Iâ€™ll have whatever theyâ€™re having.â€ Now imagine that your choices are not between mediocre and delicious food, but between dishes that taste good and those that are poisonous. Those are the conditions facing the fringe-lipped bat. Survival depends on learning what other bats are eating with gusto.

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