What role does mouth shape play for echolocating bats?

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Echolocating bats are able to manipulate the acoustic projection pattern of their sonar pulse emissions—but how they do it remains a largely unexplored mystery.

The Mexican free-tailed bat, Tadarida brasiliensis, appears to do it by adjusting the shape of its mouth cavity, aka beam forming, similar to the way humans purse their lips to create an "O" sound. While this is usual for humans, it is unusual for animals. Flying Tadarida lift their nose and lips before each echolocation pulse with a set of specialized facial muscles.

In a moment of serendipity while working on another project, Samantha Trent, a doctoral candidate working with Michael Smotherman at the Texas A&M Institute for Neuroscience, noticed a large group of muscles running straight down the middle of the top of the bat's skull. A set of muscles like this is quite unusual in size and location for a small mammal, so she questioned their purpose.

During the 172nd Meeting of the Acoustical Society of America and the 5th Joint Meeting with Acoustical Society of Japan, being held Nov. 28-Dec. 2, 2016, in Honolulu, Hawaii, Smotherman will present his work with Trent exploring the muscle's complex activity patterns during sonar performance, whether the muscle tissue displays necessary fast-twitch specializations to accommodate echolocation, and how manipulations of mouth shape altered 3-D beam patterns.

"It seems evident that this particular set of muscles is involved in changing the shape of the bat's mouth—especially during echolocation," Trent said. "We think this aids the bat's ability to change the shape of its outgoing echolocation pulse beam."

To put this to the test, they used a microphone array to capture recordings from all around the bat's head to build a picture of the beam shape of sound coming out its mouth. They also recorded electrical activity from these muscles while the bats were freely echolocating to determine how these muscles are involved in producing echolocation pulse streams.

More specifically, electromyography (EMG) recordings from awake echolocating bats confirmed that the muscles in question were activated in precise temporal coordination with pulse emissions. The researchers also found that raising the bats' nose tip alone creates a small aperture and wide-angle beam, while simultaneously raising the front and side lips creates a wider aperture with a narrower beam. These results indicate that Tadarida possess a specialized neuromuscular tool for sonar beam forming.

"This type of vocal control is unique within the animal kingdom," Trent said. "It's exciting to study animals that have such special abilities and to show the public that bats really are cool, as our lab has always known them to be."

This project has several intriguing sonar applications. "[I'm] especially excited to bring engineers on board to collaborate and explore how this behavioral ability may be useful for building or improving sonar devices," Trent said.

Trent is doing her dissertation on this work, delving deeper into the neural mechanism underlying the bats' flexible vocal ability.

"We're eager to see where and how this behavior may be controlled within the brain," she noted.

More information: Presentation 1aAB3, "Specialized facial muscles support sonar beam-forming by free-tailed bats," by Michael Smotherman is at 11:15 a.m. HAST, November 28, 2016 in Room South Pacific 4.

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