Research team finds species share perceptual capabilities that affect how communication evolves

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A research team that included Hamilton E. Farris, PhD, Research Assistant Professor of Neuroscience and Otorhinolaryngology at LSU Health Sciences Center New Orleans, reveals that two entirely different species show similar perception of auditory cues that drive basic biological functions; that these perceptions may be universally shared among animals; and that such perception may also limit the evolution of communication signals. The work is published in the August 5, 2011 issue of *Science*.

Using the labs at the Smithsonian Tropical Research Institute in Panama, the team tested whether psychophysical laws explain how female túngara frogs and frog-eating bats compare male frog calls and whether the rules for perception constrain how communication signals evolve.

Animals, including humans, continuously make decisions based on comparing external stimuli from the environment. However, the decisions are not based on the actual, but rather the perceived physical magnitude of the stimuli. A perceptual rule called Weber's Law proposes that stimuli are compared based on ratios, not absolute differences. For example, distinguishing between a 1-lb. object and a 2- lb. object is easier than comparing a 50-lb. object vs a 51-lb. object. The comparison does not depend on the absolute difference (1 lb. in each case), but the relative difference (100% vs. 2%).

The researchers tested whether Weber's law or alternative hypotheses explain túngara frog mate choice. Male túngara frogs produce a vowel-like "whine," followed by 0-7 consonant-like "chucks." They placed wild-caught females in a sound chamber and alternately broadcast two call types with varying numbers of chucks from two speakers on opposite sides of the chamber. Choice was quantified as walking to within 10 cm of either speaker.

"By giving females a choice between calls with different numbers of chucks, we found that the female frogs prefer calls with the most chucks, but based on the ratio of the number of chucks.," notes LSUHSC's Dr. Farris. "This means that as males elaborate their signals by adding more chucks, their relative attractiveness decreases due to the perceptual constraint on the part of females."

To more fully understand how females' perception influences the evolution of the males' calls, the research team then tested fringe-lipped bats, a natural predator of túngara frogs who select their prey based on the calls of the male frogs. Using this rare case in which two very different species, amphibian and mammal, have evolved the same behavioral approach to the same communication signal, the research team asked whether hunting bats choose their prey based on chuck number ratio as well. Testing bats in a behavioral test similar to that used with female frogs, the team showed that bats compared calls using chuck number ratio as well.

"It is astounding that two disparate animals use the same perceptual scale, suggesting a generality in how animals compare stimuli," says Dr. Farris.

As males increase chucks, so do their neighbors. With a fixed difference of one chuck between neighbors, both the risks and benefits of adding chucks decrease with increasing elaboration. Adding one chuck to many

chucks adds less risk than adding one chuck to few chucks. Adding multiple chucks to outcompete neighbors will not succeed because males maintain a fixed difference.

"Natural selection and bat predation are not limiting male call evolution, This supports our conclusion that it is the females' cognition that is limiting the evolution of chuck number," says Dr Farris. "The results are significant because we show that certain types of perception may be universal. Furthermore, with respect to the evolution of communication signals, we propose that by limiting signal elaboration, ratio-based coding could favor the evolution of signal innovation. That is, Weber's law would favor the evolution of a signal along a completely different perceptual axis."

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