Making Sense of Animal Sounds


Pat Vosburgh

Scientists studying animal sounds are finding common threads to the barks, growls and whines of different species

By DAWN D. BENNETT

Tales of talking animals abound throughout history and literature. From the serpent in the Garden of Eden to the characters in Aesop's fables, people have been fascinated with animal talk. But can anyone imagine a bird that barks or a lizard that growls?

Ornithologist Eugene Morton can. In 1977, Morton came up with a theory of animal language that says, in effect, that almost all animals bark and growl. Although Morton has studied mostly birds, other researchers have applied his findings to mammals. Recent research on animal communication has both corroborated Morton's theory and uncovered exceptions to it.

Morton, who is with the Smithsonian Institution's National Zoological Park in Washington, D.C., calls his theory of animal communication the motivation-structural (MS) rules model. He talked about the model and other research in animal communication at a recent Smithsonian seminar on the subject.

The model holds that differences in the physical structure of animal sounds reflect differences in animals' motivational states. A frightened animal, for instance, makes a noise that not only sounds but also "looks" different from the sound made by an animal ready to attack.

Morton uses a sonagraph to study how sounds look. This device, about the size of a sewing machine, is composed of filters tuned to certain frequencies and piled on top of each other. The energy of a sound at a particular frequency creates a charge, and a stylus records a black mark indicating that frequency on a sheet of special paper.

The resulting sonagrams provide two-dimensional pictures of individual sounds. That's where a bird's bark and a lizard's growl come in. In certain motivational states, a bird makes a sound that looks like a bark on a sonagram. It even sounds like a bark when slowed down and played back on a tape recorder. Likewise, a lizard's low, rumbling noise before an attack looks like a growl on a sonagram.

Morton discovered two extremes of vocalization in his studies of animal sounds. He developed hypothetical sonagrams to describe these and other sounds. An aggressive animal makes a low, harsh sound (the "growl") that looks like a low-frequency, broad band on a hypothetical sonagram (see diagram). A friendly or fearful animal makes a high, tonal sound that looks like a thin line.

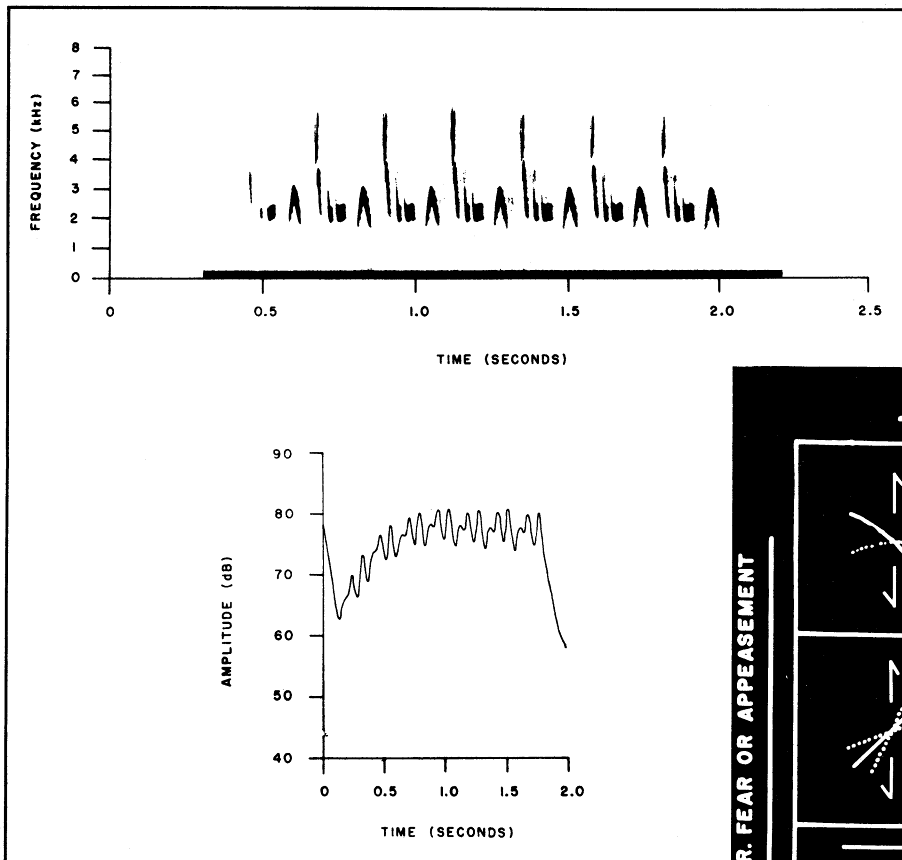
The bark is between the two extremes (center block in diagram). According to Morton, the bark's continuous rise and fall in frequency indicates that the animal is neither aggressive nor fearful or appeasing, but is "interested" in what is going on. A dog's bark when it hears a person approaching is perhaps the best example. The bark indicates that the dog is not yet committed to a motivational state. If the approaching person turns out to be the mailman, the bark quickly changes to a growl; if the person is the dog's owner, it becomes a whine of acceptance.

Human study of animal sounds is difficult, Morton says, because humans rely on assumptions about their own language that may not be true for animals. When two people converse, the speaker informs the listener. Known as the information theory, this basic scheme, speaker→message→listener, has dominated communication studies for 25 years. Animals, however, can communicate even when no receiver is there, Morton says.

For instance, when a bird is caught by a hawk, it gives a distress call, not because it is trying to attract a potential savior (although it may do just that) but because after many similar episodes among the bird's ancestors, natural selection determined that the call is the best behavior under the circumstances. Although the bird is unlikely to escape, a small percentage of birds who give distress calls do escape. The hawk may be startled and let the bird escape; a larger hawk, attracted by the sound, might come along, and the bird might escape in the competition over the prey; or members of the bird's species may try to mob the predator, letting the bird escape.

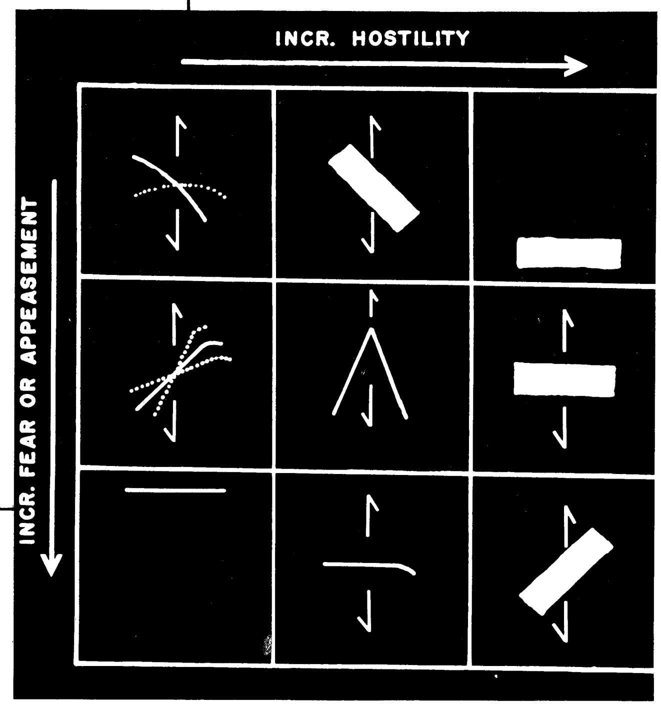
Information theory does not allow for such an evolutionary perspective of animal communication, Morton says. "Information theory is a little too far advanced, too far from evolutionary-based communication," he says. "It doesn't deal with structure and function." Yet the tenet that structure can predict function is a fundamental concept of biology. Sonagrams of animal sounds, he says, show that the concept holds for animal communication as well.

Human speech relies on arbitrary words to convey meaning, Morton says, leading us to assume that animal sounds are arbitrary as well. But the physical structures of animal sounds are not arbitrary. In fact,



Morton

At left, sonagrams of a song by Carolina wrens, the species Morton has most studied, show repetitive "barking." Below, hypothetical sonagrams illustrate the motivation-structural rules. Thin lines depict tonal sounds; thick lines depict harsh sounds. Half-arrows indicate that the frequency of sounds may vary up or down, approaching either low- or high-frequency endpoints. The upper right block depicts the aggressive endpoint; the lower left block, the fear endpoint; and the middle block, the "bark."



sonagraphic study of human speech reveals that it has a similar nonabitrary component: the pitch of a human voice. When a person is expressing a demand or aggression, pitch tends to decrease, but when a person is speaking to a baby, it increases. So, when words are disregarded, human speech patterns follow the rules of animal communication, Morton says.

Biologist Peter August, who has also done research on the motivation-structural rules, agrees. "When you think of the MS rules in human terms, you find several fundamental noises they make that seem to jibe with them," he says. "When you open a cabinet and see a spider, you shriek with fear, a high-frequency, very tonal sound. The aggressive noises of football players on a football field are very different."

August and graduate student John Anderson, both of the University of Rhode Island in Kingston, tested Morton's theory in 1984. From the theory they predicted that aggressive sounds should have a statistically significant lower frequency and broader bandwidth than fear or appeasement sounds. They examined the literature on animal communication in 50 kinds of animals, from shrews to elephants, and found this to be true in most cases. "The motivation-structural rules," August says, "are one robust theory that seems to explain the vocalizations of many different kinds of animals."

But the literature review uncovered one important variation on the motivation-structural rules theory. The researchers found that mammals' fear and appeasement sounds vary more in bandwidth and frequency than predicted by Morton's rules. August says the discrepancy may be because fear and appeasement are two different motivations in mammals, whereas they are fused into one motivational state in the motivation-structural rules.

Edwin Gould, curator of the department of mammalogy at the National Zoo, has discovered another exception to the motivation-structural rules. In his studies of nocturnal animals and other animals that do not rely on vision as a primary means of communication, Gould found that repetition rate is more important than frequency range in expressing motivational state.

Many animals, including baby mice, bats, porpoises, shrews and the shrewlike tenrecs of Madagascar, are almost constantly producing sounds. The sounds provide a continuous set of signals for listening animals, who can gauge the animal's excitation indicator, as Gould calls it, by changes in the repetition rate.

A baby mouse, for instance, makes pulsing noises. If touched in an experimental setting, it pulses faster, showing that it has become more excited, Gould says. A baby bat lost from its nest increases the rate of repetition of its screeching calls. When the mother returns it to the nest, the bat decreases its rate of repetition.

Gould's excitation indicator is similar to Morton's motivational state. Take the barking dog example. The dog increases its rate of barking when someone is approaching, showing that it is more excited. "The dog is fearful and aggressive at the same time," Gould says. "This fits in quite well with Morton's rules."

Just as Morton's motivation-structural rules have human applications, so do Gould's repetition rules. Humans have pauses during their speech, and animals—even ones that generally produce sounds continuously — have pauses in their communication. Psychologists who study speech patterns often look at the pause patterns of human speech. They have shown that the pattern and timing of pauses often reflect an individual's emotional state. Gould believes pause patterns in the repetition of animal sounds likewise reflect animals' excitation states.

But certain animal sounds have no equivalent in human communication. Among these are nonvocal sounds like the hiss, which are

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throughout North and South China, report Wu and Dong Xingren in Olsen's translation. The deposits range from 1 million to 200,000 years old.

H. erectus fossils continue to be found at the famous Beijing Man, or Peking Man, site, which was first excavated in the 1920s, they add. The remains of more than 40 individuals from all age classes have been recovered from this one site. "This will allow us to study the evolution of *Homo erectus* in one area over several hundred thousand years," observes Olsen. There are important isolated *H. erectus* finds in the West, he points out — notably the recent discovery of a 1.6-million-year-old adolescent in Africa (SN: 10/27/84, p. 260) — but no population sample comparable to the Chinese collection has been unearthed.

Another important *H. erectus* find occurred late last year in northeastern China. Archaeologists from Beijing found the skull and partial skeleton of an individual who lived from 200,000 to 600,000 years ago. "China may well serve as a sort of laboratory for documenting the transition of *Homo erectus* to *Homo sapiens*," notes Etler. Late *H. erectus* and early *H. sapiens* deposits in China are often located in the same vicinity, he says.

For now, however, the Chinese literature suggests that *H. erectus's* jaw and tooth size varies much more than previously thought, explains Zhang Yinyun in Olsen's translation. He argues that four large primate molars found in central China may belong to an atypical population of *H. erectus*, not to the earlier ape-man *Australopithecus*, as some scientists have held.

If this is true, it provides further evidence that east Asia was not a separate "cradle of humanity," says Olsen. Instead, *H. erectus* may have migrated to China from Africa.

The data increasingly indicate, adds Yinyun, that in South China *H. erectus* shared the same environment and even came into contact with *Gigantopithecus*, an ancient primate that probably stood about 9 feet tall and weighed about 1,000 pounds. The most likely modern comparison to *Gigantopithecus* is the mountain gorilla, notes Olsen, which predominantly eats fruit.

Fossil evidence of *Gigantopithecus* is scanty, consisting of several hundred teeth and a few jaw fragments discovered in China, India and Pakistan. But in South China, and in a recently excavated deposit in North Vietnam, *Gigantopithecus* and *H. erectus* remains are found together in the same layers of earth. "It is possible, although unproven," writes Yinyun, "that intense competition between these two forms resulted in the demise of *Gigantopithecus* stemming from the superior abilities of *H. erectus* to exploit their shared environment through the manufacture and use of tools."

One advantage Chinese archaeologists have in locating the teeth of creatures

Sivapithecus *cranium from China.*

Photos from *Palaeoanthropology and Palaeolithic Archaeology in the People's Republic of China.* © 1985 Academic Press

such as *Gigantopithecus* is that these remains often turn up in the shops of apothecaries. The teeth are collected by peasants who quarry fossil-containing caves on what are called "dragon bone hills." They then trade them to druggists, who grind the paleontological treasures into a powder or paste long considered by Chinese folklore to have medicinal properties. This practice was recently banned by the Chinese government, says Olsen, but over the years scientists have had some success in recovering undamaged fossil teeth from druggists' shops and tracing the materials back to their original sites.

But even with an apothecary ace up their sleeves, Chinese archaeologists, like Western investigators, have spirited disagreements over the interpretation of the same sets of fossils, says Olsen. "Chinese science is not a monolithic entity, the product of a policy statement handed down from the Party," he explains. "It's characterized by a diversity of opinions and lively scientific debates." □

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produced without using the vocal cords. The vocal cords are coupled to the brain, Morton explains, and thus vocal sounds reflect an animal's motivational state. A nonvocal hiss, however, is made by an animal that is frightened but wishes to stay where it is until more information about the situation is available. "The hiss provides a way to mask motivation but still look potentially threatening," Morton says. "If vocalized, the hiss would look like a fear sound on a sonagram."

Is a hissing cat playing a game of deception? Not at all, Morton says. "Natural selection has selected for the behavior," he says, "because on the average, it has beneficial consequences." That is, sometimes the cat scares the potential attacker away.

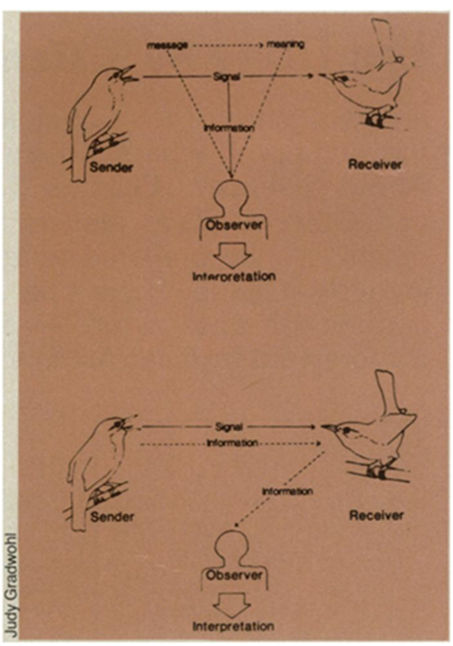
A cat's arched back and raised fur add to the effect of its hiss, as any cat owner knows. These behaviors make the cat look bigger and more threatening. They constitute a general evolutionary trend, Morton says: In the face of incipient attack, the bigger you appear, the better off you are.

The trend is apparent not only in visual displays, such as a cat's arched back or the frilled neck collar of a lizard, but also in animal sounds. The larger an animal is in comparison with others of its species, the lower, harsher and more threatening it sounds.

Amphibians like frogs and toads have it made: They grow all their lives, so the sounds they make constantly get lower and harsher, providing a true reflection of their size. A mating male frog, for example, can tell the size of an encroacher by comparing the encroacher's croak with its own. If the encroacher's pitch is higher, the mating frog is safe from attack because the other frog is likely smaller. If it is lower, the mating frog gets its chance to escape from a frog that is probably larger. Either way, the big frog wins.

Mammals and birds, which evolved later than amphibians, do not grow all their lives, so they are about the same size as others of their species when competing for mates. They evolved voice variability to compensate, Morton says. An animal that makes a low, harsh sound can ward off a potential intruder because the low voice makes it seem bigger. On the other hand, an animal that makes high, tonal sounds can express friendliness or fear.

Mammals and birds, then, appear to be quite clever in their uses of acoustic communication. But Morton is quick to point out that it probably has nothing to do with conscious intent. "Natural selection can come up with clever things," he says. "It's not the animal who's trying to be clever." □



Judy Gradwohl

Traditional concepts of communication emphasize the actions of senders and receivers. Bottom diagram depicts the information theory, while top diagram depicts a related theory called information as knowledge. These models differ from the motivation-structural rules, which emphasize signal structure rather than information communicated.