frontiers FOR YOUNG MINDS

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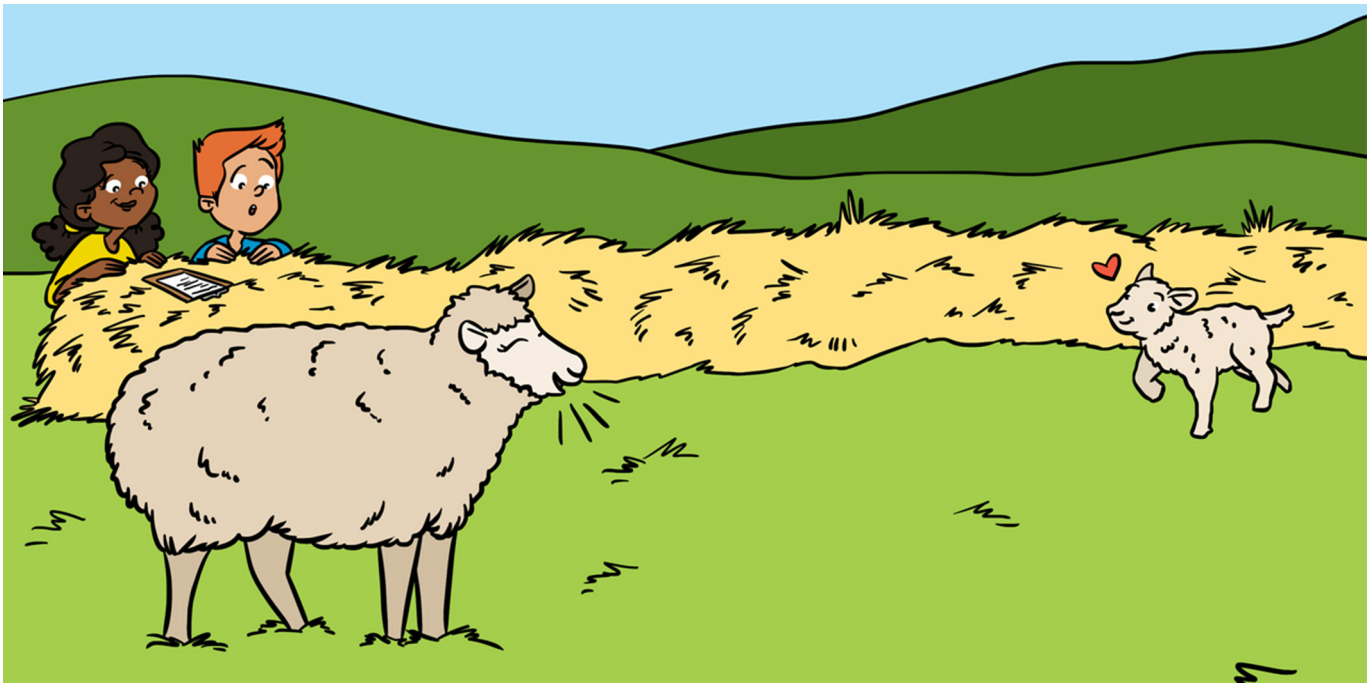

"BAA, BAA": CAN SHEEP TALK TO EACH OTHER?

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If you have ever been out to the countryside in the spring, you might have heard sheep bleating to their lambs. Sheep also bleat when they are separated from the flock or stressed in some other way. To us, all these bleats sound very similar. But do you think they also sound similar to the lambs? Or do you think the lambs know whose mother is calling and what they are saying? Scientists try to interpret the bleats of sheep by observing their behavior when they hear these sounds. They study the sound waves of recorded bleats to identify each sheep's unique voice and even determine which emotions the sheep are feeling. They also investigate the brain to find out what is going on inside the heads of sheep when they hear and understand the sounds of other sheep. Studies show that sheep really can recognize each other's voices and communicate vocally.

COMMUNICATING WITH SOUND

Do you think that animals other than people can communicate by talking to each other? Or what about communicating in ways besides talking? If you have ever lived with a pet, you probably know that

animals are certainly capable of communicating with us. A dog can ask you to throw a stick just by dropping it at your feet. A cat can ask for food by rubbing against your leg. These animals are using behavior to communicate information. If you do not do what they are asking, the dog might bark and the cat might meow, to insist that they really want you to do it, now! Barking and meowing are examples of animals using sounds produced by the mouth (like talking) to communicate. By observing animals in farms, in zoos, or in nature, scientists called **ethologists** (who study animal behavior) have discovered that many animals can communicate using sounds, called **vocalizations**.

ETHOLOGIST

A scientist who studies animal behavior in their natural environments.

VOCALIZATION

A sound emitted by the vocal organ of animals.

INTERPRETING SHEEP SOUNDS FROM THEIR BEHAVIOR

The vocalizations of sheep are called bleats. To interpret the meaning of sheep vocalizations, ethologists often study their bleats and their behavior at the same time, using video cameras and microphones. Observing sheep this way, ethologists showed that lambs and their mothers (ewes) can communicate using what the ethologists called low- and high-bleats. Low-bleats are emitted with a closed mouth, when a ewe and her lamb are close to each other, during caregiving moments such as suckling or licking. High-bleats are emitted with the mouth wide open, when a ewe and her lamb are separated. It is a bit like when parents call their children who are too far away! These high-bleats are also emitted by adult sheep when they are separated from the herd, when they are stressed, and even when their food arrives late! From these observations we interpret low-bleats as comforting vocalizations and high-bleats as distress calls. But scientists do not only *observe* animals, they also create experiments using behavioral tests to investigate how sheep use bleats to communicate.

TWO-CHOICE BEHAVIORAL TEST

A test in which an individual makes a choice between two options.

The **two-choice behavioral test** helps us to understand whether animals can tell the difference between two sounds. If you heard a dog bark and a cat meow, you could easily say which was the dog. If you heard a ewe bleat and a lamb bleat, could you correctly say which was the ewe? These are both examples of two-choice tests, in which you would answer by speaking. But sheep cannot *tell* us the answer, so how do they respond in a two-choice test?

One method that scientists use is to present the bleats in different locations, one on the left and one on the right (Figure 1). When the sheep hear the bleats, they can behave in various ways. Scientists count how many times a sheep chooses to walk toward and stay near the location of each sound. In one study, 48-h-old lambs had to choose between the bleat of their mother in one location and the bleat of an unfamiliar ewe in a different location [1]. The lambs could

not see or smell the ewes, they could only hear them. The lambs chose the sound of their mothers much more often than the sounds of the unfamiliar ewes. So, we know that lambs prefer the bleats of their own mothers *and* that they can tell the difference between the bleats of different sheep. From a similar test, we also know that sheep prefer the bleats of their friends who live in the same barn over the bleats of unknown sheep.

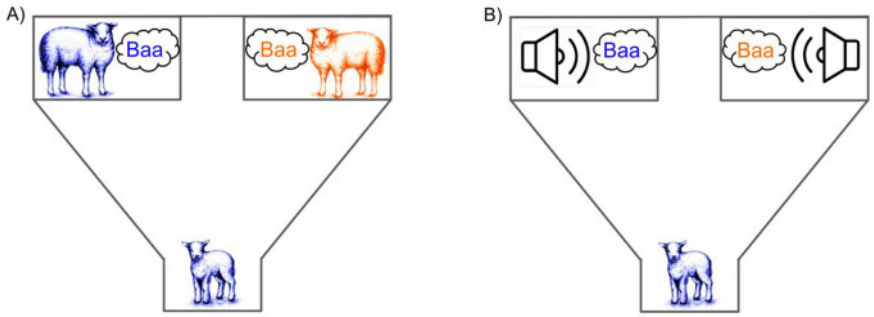

Figure 1

Figure 1

A two-choice behavioral test in which lambs hear two bleats coming from different locations and can show preference for one of the bleats by walking toward it and staying near it. **(A)** A lamb (bottom) hears the bleats of two ewes it cannot see. One ewe is its mother (on the left in blue) and the other is an unfamiliar ewe (on the right in orange). **(B)** The bleats of the mother (left) and unfamiliar ewe (right) are presented from speakers in separate locations, and scientists count the number of times the lamb walks toward each bleat location.

The ewes' vocalizations can be presented to the lambs in two ways. First, the bleats can be made by the actual sheep, which are hidden from the lambs during the test. Alternatively, the bleats can be recorded before the test and presented through speakers (Figure 1). One of the problems with the bleats being made by actual sheep is that the sheep can "say" whatever they want. Scientists cannot control whether the sheep vocalize using high-bleats or low-bleats. So, to test whether lambs preferred high- or low-bleats, it was necessary to use speakers. Speakers were used to play back high-bleats from one location and low-bleats from a different location [1]. The results showed that lambs did not have a preference—it seemed that they liked both. Another good reason to use recorded bleats is that we can also get interesting information from analyzing the sound waves of the bleats.

ANALYZING THE BLEAT SOUND WAVE

Sound waves have physical properties that can be measured and analyzed. One important physical property of a sound is its **amplitude**. High-amplitude sounds are loud, while low-amplitude sounds are quieter. Similarly, high-bleats are louder than low-bleats because they have a higher amplitude. These bleats also have different **frequencies**, which is another important physical property of sound waves. High-bleats have a higher frequency than low-bleats. To understand what different frequencies actually sound like, imagine the sound of a whistle (high frequency) and the sound of thunder (low frequency). **Bioacousticians**, who are sound scientists, study

AMPLITUDE

The amplitude of a sound wave is a measure of its energy, it determines the sound's loudness or volume.

FREQUENCY

The number of waves per second.

BIOACOUSTICIAN

A scientist who studies the sounds produced by animals and the body parts used to produce (mouth), hear (ear), and interpret (brain) those sounds.

amplitude, frequency, and other physical properties to identify the unique signatures of a sound.

When you talk on the telephone, you can recognize the person you are talking to from their voice. You can do this because each person's voice has a **vocal signature**. Like a fingerprint, a person's vocal signature is unique, made up of a unique combination of physical sound properties. By studying the physical properties of sheep vocalizations, bioacousticians have shown that sheep also have vocal signatures that can be used to tell them apart [2].

VOCAL SIGNATURE

The physical properties of the voice that are unique to each individual and which allow them to be recognized.

Can the combination of sound properties in a vocalization also tell us which emotions an animal is feeling? Bioacousticians are currently studying this. If they are successful, they could develop a computer program that could detect various types of bleats by analyzing the combination of sound properties. For example, they might be able to automatically detect when a farm animal is in pain [3], so the farmer could be alerted to help the animal.

But how are these sound properties normally analyzed, interpreted, and identified by other individuals who hear the vocalizations? Well, it turns out that bioacousticians are not the only ones who analyze the physical properties of sounds—brains are also experts at it.

RECOGNIZING A SOUND AS A VOCALIZATION

Before a sound can be recognized as a vocalization, the sound must reach the brain. Sounds first arrive at the outer ear, then the physical properties of the sound (such as its frequency) are sent *via* the eardrum to the middle and inner parts of the ear (Figure 2). In the inner ear, the hair cells of an organ called the cochlea translate the sound into an electrical signal. These hair cells are very thin and fragile and can be broken if you listen to music too loud. The electrical signal flows through the cochlear nerve to the brain. The role of the brain is very important in hearing—brains hear sounds, ears do not. For the animal to identify and understand a sound, many parts of its brain are required.

Each brain part has a different role and it is only the combination of these brain parts working together that allows ewes to hear a sound, to recognize it as a vocalization of their lamb, and interpret how the lamb is feeling. These different parts of the brain have funny and complicated names such as, the geniculate nucleus, the amygdala or the hippocampus. To better understand how the sheep brain recognizes a sound, brain scientists can use techniques, such as functional magnetic resonance imaging [4], that are only just beginning to be used with farm animals.

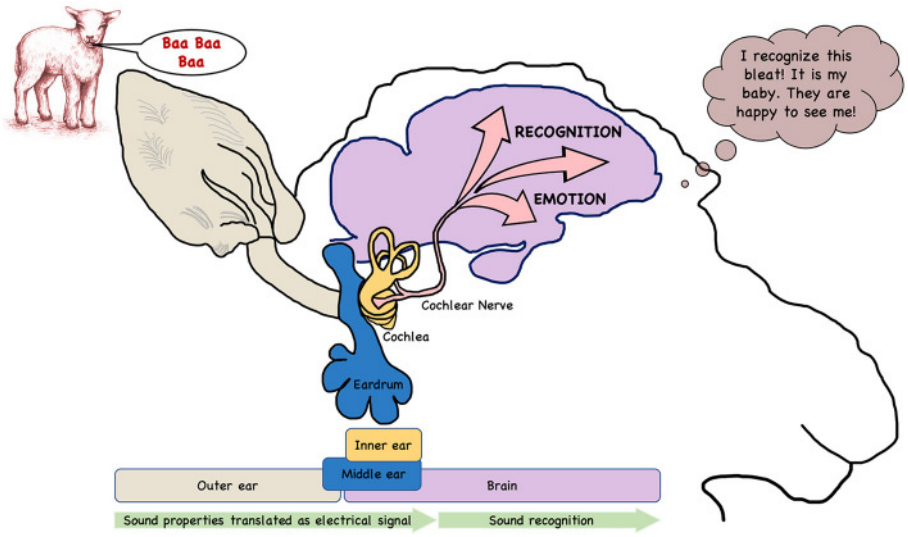

Figure 2

How a sound becomes a voice. When a lamb bleats, it produces a sound wave that travels through the air to its mother's ears. Inside the ear, the sound makes the eardrum (blue) vibrate. These vibrations then travel to the hair cells of the cochlea (yellow), which translate the sound vibrations into an electrical signal. The signal then flows through the cochlear nerve (pink) to the brain (purple). Various parts of the brain analyze, interpret, and identify the electrical signal, so that the ewe knows that the sound she hears is her lamb bleating happily.

CONCLUSION

Sheep, like other animals, can communicate using sounds. By studying their behaviors, ethologists have shown that sheep can tell individual sheep apart from each other just by listening to their bleats. Sheep can do this because each sheep's bleat has its own vocal signature. A bleat's sound waves can also contain information about how a sheep is feeling. Bioacousticians are trying to understand this information to help farmers detect when their animals are in pain, for example. Brain scientists investigate the structure and function of the brain to understand the role the brain plays in vocal communication. To fully understand sheep communication, it is important for ethologists, bioacousticians, and brain scientists to work together. The more we know about the lives of sheep, the better our chances of improving the lives of this farm animal.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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TORBEN, AGE: 13
Torben is motivated, talented, and intelligent. In school, he likes science, math, history, and geography. He loves to read books and is learning Spanish, French, and German. He plays piano and sings in several choirs and has won several local and national music awards. He has a special interest in neuroscience-related topics. His English teacher selected him to report on the COVID-19 crisis. To do so, he wrote a Spotify segment and interviewed his teachers about how the pandemic impacted teaching and learning. He enjoys biking, soccer, hiking, swimming, horseback riding, and other activities that he carries out with his boyscout troop.

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I am a researcher at the French National Research Institute for Agriculture, Food, and Environment (INRAE). I am studying how the structure of the sheep brain relates to a sheep's emotional behaviors. For more than 10 years, I have organized scientific events for children. I love to share my knowledge with young people and to explain the sheep brain, especially helping children to discover the neurons.