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Signals, Signs, and Words: From Animal Communication to Language

William Kemp and Roy Smith

For many years, and for many reasons, human beings have studied a variety of animal communication systems. Just as the possibility of life somewhere in space has long fascinated people, so too has the possibility of finding that some animal here on earth can learn a form of language. People have studied "talking" horses, dolphins, bees, whales, monkeys, and chimpanzees, all in an effort to discover if only humans possess language. Other researchers, especially ethologists, have studied animal communication systems because of their intrinsic interest and because such study helps us to understand both the similarities and differences between animal communication and human language. This research has revealed a great deal about the complexity of animal communication systems; it has also shown that human beings "share with other species an impressive degree of nonlingual communication." In the following selection, Professors William Kemp and Roy Smith, both of Mary Washington College, survey the research on animal communication. They explain the difficulties of such research, as well as its importance. They also describe the elaborate communication systems of bees, birds, and mammals, especially the nonhuman primates. Discussing the extensive work with chimpanzees and gorillas that was done in the 1970s, 1980s, and 1990s, they argue convincingly that these experiments have demonstrated that apes can learn to use semantically a large number of arbitrary symbols. That achievement is more than the most hostile critics will allow. But it is also considerably less than human semantic abilities.

> The sound of the waterfall
> has for a long time
> ceased,
> yet with its name
> we can hear it still.
> –Fujiwaro No Kinto, d. 1041

Haiku is human language at its peak: stunning images from a few carefully chosen syllables. Despite claims for remarkable communication

and even language among the many animals around us, no one has offered an example of haiku by a humpback whale or a chimpanzee. This is not to say that animals do not communicate effectively; they certainly do. Still, most humans use language as something qualitatively different from other forms of communication, at least some of the time.

Because language is so important to the experience of being human, most who study language reserve to humans the ability to use and understand language. As a result, the possibility of animal language has become a challenge to our unique position in the natural world. But evolutionary theory, the organizing framework of the biological and social sciences, warns that we must examine any behavior in its context. Behaviors develop from the interaction over many generations of subtle and not-so-subtle alterations in the physical and physiological conformation of an organism. If these changes allow their bearers to develop behaviors to exploit better the world they live in, they are more fit than other individuals and reproduce more successfully. The new behaviors then become the baseline for further changes. These adaptive changes cumulatively alter the nature of a group of organisms and the way it fits into the environment.

Given the essential dependence of human personal, social, and cultural experience on language, its mastery clearly changes the way we deal with our world. And most linguists agree that language is based on just the sorts of inherited physical capacities that an evolutionary understanding of language requires. But then where are the precursors of human language? Can we recognize in the communication systems of other animals analogies to the pieces that gave birth to human language? Do other animals have communication systems with characteristics parallel to our own? Are there examples of animal language?

An easy answer might be that humans use language to communicate while nonhumans use animal signaling. Unfortunately, this view implies that a loving glance from your mother is part of language while a loving glance from your dog is not. Humans use language layered atop other forms of communication, such as body language, and the nonlanguage signals often contain the more important messages. At the very least, we share with other species an impressive degree of nonlingual communication. Examining animal communication reveals important ways in which language differs from communication in other animals. It also suggests that language is not an aberration that appeared suddenly, without evolutionary precursors.

Ethologists treat animal communication under three headings. The first is *form*. For an animal's behavior to have value as a signal, it must be in a constant form that others can recognize and connect reliably to some future behavior by the signaler. Ethologists call such stereotyped behavior a *display*. The second part of animal communication is *context*; it includes the general environment in which an animal is displaying as well as simultaneous displays it sends through sensory modes or channels. Thus, a dog's bark may convey one message about future behavior when its tail is wagging, another when its tail is stiff. Context usually resolves such ambiguities. The third part of animal communication is the *response* to the signal. Communication is valuable because it increases the likelihood of one animal's choosing behavior that fits with the behavior of others. The choice by the receiving animal must be clear to be sure it has actually communicated. Otherwise, we can't tell the difference between ruffling feathers to get them straight and ruffling feathers to signal an impending conflict.

Consider one of the elaborate prairie dog cities on the western plains. Alarm calls announce a stranger's approach and send nearby animals scurrying to holes from which they cautiously peer. Can there be any doubt that sentries are telling their comrades about the intruder? Patient observation and careful analysis suggest that this alarm, like other prairie-dog vocalizations, is a display. Prairie dogs apparently give this signal whenever they become aroused enough to stop what they are doing and scan the environment, but not scared enough to run for cover immediately. They give the same call during territorial disputes when the caller is unsure whether to attack or retreat. Other prairie dogs, upset by the signaler, give their own version of the display, spreading agitation through the colony. The alarm system works very effectively; knowing that your neighbor is aroused is important. But the prairie dog's display contains information about the caller, not about the source of the alarm. Each prairie dog must sit up and look for himself.

Distinctive behavior that reliably indicates what an animal will do promotes cooperation and reduces conflict, because it allows neighbors to adjust their actions according to what the display predicts. Few animals seriously injure one another in disputes over territory, food, or mates, because displays allow rivals to establish which one is dominant without resorting to combat. Crudely put, the meaning of an agonistic display is, "I feel like attacking you ferociously very soon." The individual whose display is more convincing usually wins. We need not imagine animals computing the combat odds or planning their displays. Sending and comprehending displays are parts of each animal's (and human's) automatic behavior. In human interactions, smiling usually elicits a responding smile and a frown prompts a frown, without any planning by anyone.

In discussing human language, linguists use concepts similar to the ethologist's form, context, and response. Linguists work with *syntax*, which emphasizes form; *semantics*, which emphasizes meaning (defined partly by context); and *pragmatics*, which emphasizes how context modifies or replaces the meaning of an utterance. Linguists also analyze human speech into meaning units called *morphemes* and sound units called *phonemes*—units that seem unique to spoken language. But particular manifestations of phonemes (called *allophones*) share with displays an invariant surface form guided by a stable program in the central nervous system. Both allophones and displays are examples of unvarying sets of motor movements that ethologists call *fixed action patterns*.

As displays become language, several things change. The form of communication shifts from a limited number of lengthy, stereotyped displays to a very large number of very short displays (allophones) that can be combined in many ways according to hierarchical rules. The importance of context also changes. Displays begin as indications of an animal's response to its environment; they are more about the animal itself than about the world. In contrast, humans frequently use language to describe environment(s), while their displays signal much of the accompanying affective content. Although the context of a sentence usually colors its meaning, the sentence has meaning independent of context. Displays have only contextual meaning.

While the response to a display is how we know its meaning, the response of others to language may be unimportant. Although Fujiwaro wrote his haiku for others to read, and probably would be delighted to know that people appreciate it nine hundred years after his death, he must have written it partly or perhaps chiefly for the delight of capturing his experience in words. We have no clear evidence that nonhumans play with their communication systems simply to revel in the workings of the system itself.

Language is also capable of abstraction, a power that seems to have few natural parallels in animal communication. Of course, many animals can create general concepts; some dogs understand that *all* cars are to be chased. And some higher primates, having learned artificial sign systems from humans, clearly use and understand some abstract signs. But even in the cleverest animals, natural displays have no way of presenting abstract propositions about either the animal or its world. The human abilities conferred by language to plan for the future and control our environment are without parallel in other species. Language is far removed from the simple fixed action patterns of affective displays. A hierarchy of rule systems, from phonetics to semantics, transforms language from a set of environmental responses to a self-contained, generative symbol system operating simultaneously on several independently structured levels. Thus our thoughts are at least partly dissociated from our feelings.

Despite clear differences, animal communication systems have a lot to tell us about language. For one thing, displays have evolved in every species out of environmental demands and adaptations to meet those demands. The more carefully we study how other animals exchange signals, the more clearly we see how closely communication systems connect to other elements of behavior. We also find that many creatures are a good deal more clever than we suppose.

For example, we usually regard insects as just barely sentient, doing their business by instinct and incapable of significant mental activity, yet we marvel at the architectural achievements of social insects (ants, bees, termites, and wasps). In fact, the architecture of a termite mound or an ant nest is genetically designed. Each insect responds to the chemical and tactile signals around it with a set of fixed action patterns programmed into its simple brain. In a real sense no member of this miniature corps of engineers has any plan at all; the genetic repository of the whole community contains the blueprint for building the nest, and for other activity besides. More marvelous still are the systems of communication by which social insects manage their collective lives, using emitted chemicals (called *pheromones*), sound, and physical activity to exchange information and coordinate their behavior.

The best understood insect communication system is the dance of the honeybee (*Apis mellifera*). Humans have been interested for centuries in honeybees, but until the 1920s no one noticed that bees returning from a successful foray convey to hivemates important information, which concentrates hive activity on the best sources of nectar. In 1919 Karl von Frisch set out to discover how hundreds of foraging bees could arrive as if by magic at a rich food source recently discovered by a single bee. The result of his experiment was striking:

> I attracted a few bees to a dish of sugar water, marked them with red paint and then stopped feeding for a while. As soon as all was quiet, I filled the dish again and watched a scout which had drunk from it . . . after her return to the hive. I could scarcely believe my eyes. She performed a round dance on the honeycomb which greatly excited the marked foragers around her and caused them to fly back to the feeding place.
>
> (von Frisch 1967, 72–73)

In a series of elegant experiments over the next twenty years, von Frisch established that the round dance conveys three pieces of information: the presence of a food source, its richness, and the type of food available (see Figure 49.1). The scent clinging to the dancer's body, along with droplets of nectar regurgitated from her honey stomach, tell nearby bees of her find. If she dances vigorously, other recruits follow her dance, then promptly leave the hive and search busily for the odors she carries, completely ignoring all other food sources. They may also be guided by a "Here it is!" pheromone the scout releases as she visits the source a second time. Returning to the hive, the recruits will also dance vigorously and spread the odor. Soon, hundreds of hivemates will be exploiting the recently discovered trove.

In 1944 von Frisch began exploring how honeybees deal with food sources far from their hive. He discovered that bees use a "tail-wagging" dance to communicate the distance and direction of remote food sources (see Figure 49.2). "In the tail-wagging dance," he reported (1967), "they run in a straight line wagging their abdomen to and fro, then return to the starting point in a semicircle, repeat the tail-wagging run, return in a semicircle on the other side, and so on." Bees responding to this dance would completely ignore food sources near the hive—even those with identical odors—in their flight to the distant goal.

Von Frisch also discovered that the tail-wagging dance tells the recruit bees which direction to fly and how far to go before starting their search. The scout bee does her dance on a vertical comb inside the dark hive. The angle between an imaginary vertical line running up the comb

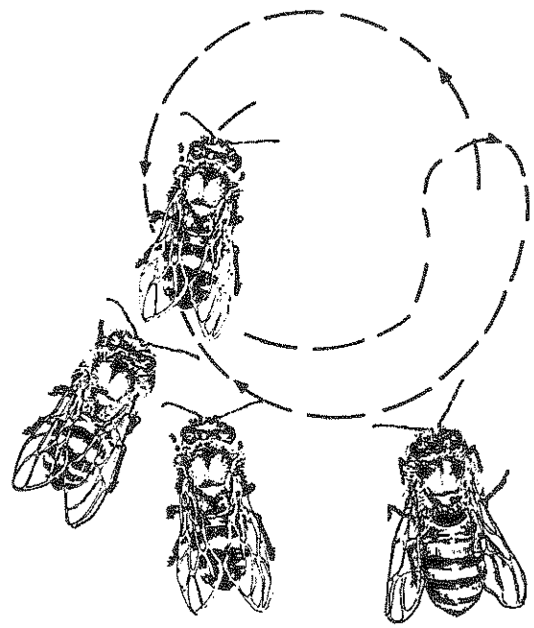

FIGURE 49.1 Round dance.

surface and the tail-wagging run of her dance corresponds to the angle between the sun and the food source (see Figure 49.3). So if the food source is twenty degrees to the left or right of the sun as seen from the opening of the hive, her waggle run will be offset twenty degrees to the left or right of the vertical. If the food source is directly away from the sun, she will start at the top of the comb, dancing straight down, and so on. Later experiments established that this directional information is extremely accurate. In a typical trial lasting fifty minutes, 42 of 54 bees (78%) found the target food source, 7 missed by an angle of fifteen degrees to the right or left, 4 by thirty degrees, and 1 directionally challenged bee by forty-five degrees. The scout bees also compensate for detours, directing hivemates to fly straight toward the goal. Having reasonably accurate internal clocks, they can even adjust their waggle dance for the sun's movement across the sky. While the angle of the waggle run indicates the direction of the goal, its tempo indicates the distance; the farther the source, the more waggle runs the dancer makes per unit of time.

Not all honeybees use exactly the same set of dances. Von Frisch's students have established that different honeybee strains set the boundaries between the round and tail-wagging dances at different distances, and encode like distances by different tempos. For example, Italian bees (*Apis m. ligustica*) dance slower for any given distance than did von Frisch's Austrian bees (*Apis m. carnica*). When Boch, a student of von Frisch, put both kinds of bees into one hive, miscommunication ran ram-

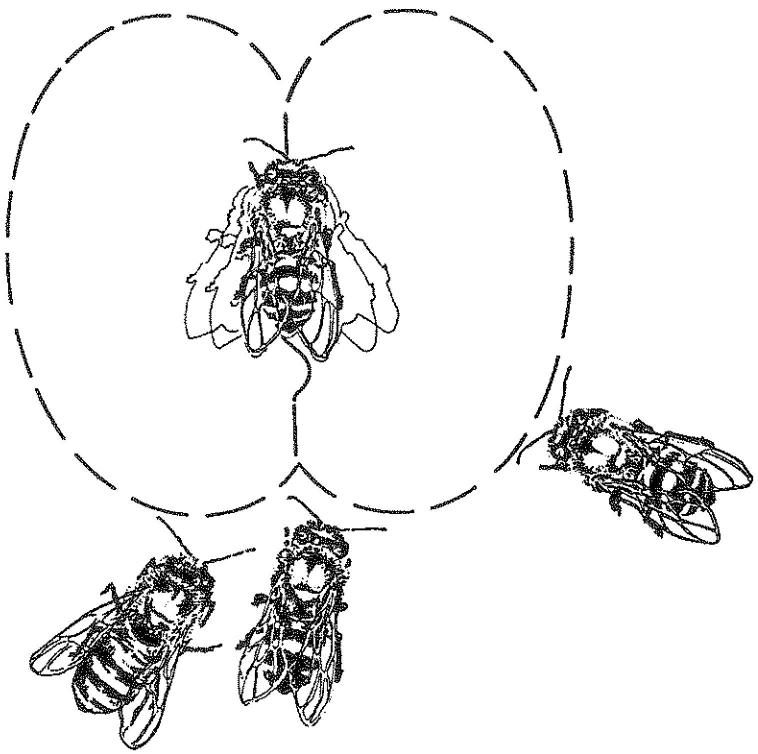

FIGURE 49.2 Tail-wagging dance.

pant. In response to Italian bees, the Austrians flew too far; in response to the Austrian scouts, Italians did not fly far enough. One can accurately say that the bee "language" has genetic dialects.

But is the bee dance really language? It certainly conveys information in an arbitrary code about parts of the world outside the bee herself and remote from where she dances. The dance thus satisfies several of the design features by which Hockett and Altmann (see page 64) attempted to distinguish between animal communication and human language. But von Frisch himself found significant limits to the bee's communication system. He put a hive beneath a radio tower, placed a very rich sugar-water solution high up in the tower, and showed several scouts where it was. After they returned to the hive and danced heroically, their mates searched busily all around the hive—but not up the tower. Evolved for foraging across horizontal landscapes, the powerful communication system of honeybees has no way of indicating up or down. Unlike human language, bee displays are not productive; they do not recombine bits of the code to produce novel messages. Bee messages are essentially the same message, differing only in a few details, uttered almost mechanically, over and over again in response to a narrow band of stimuli. This rigidity prevents the bees in mixed hives from learning each others' dialects, despite repeated attempts to communicate.

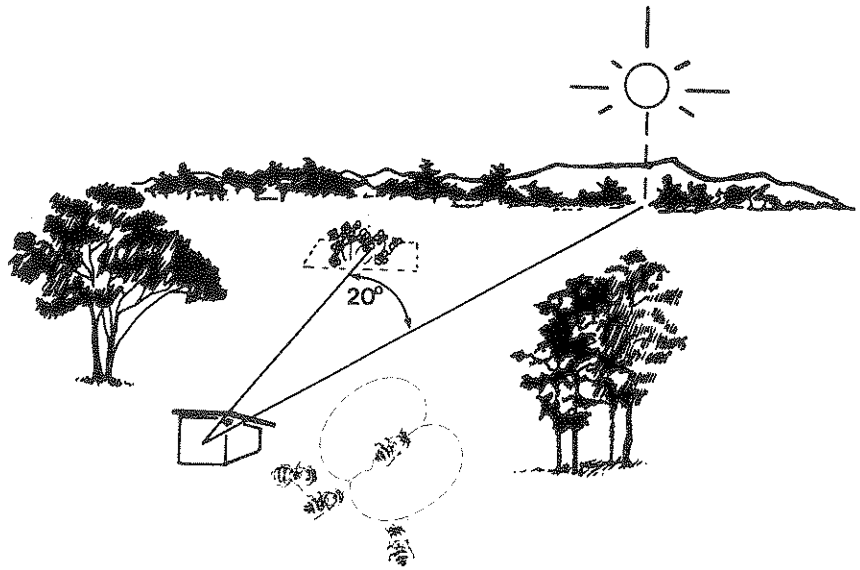

FIGURE 49.3 Angle of wagging dance showing the sun's position.

Because birds are larger than bees and interact over longer distances, one might suppose they use even more complicated communication systems. Their behavior certainly seems more varied than that of insects, and more vocal. Calls and songs are embedded in a rich context of elaborate visual displays. Their messages to mates, rivals, or neighbors arise from a coordinated package of activities, not any single element within the package. Still, to linguists the sounds birds make are the most interesting part of their behavior because, like humans, birds are physiologically and behaviorally specialized to produce and respond to streams of meaningful sound.

Ornithologists divide bird vocalizations into two categories: *calls* and *songs*. Calls tend to be brief, simple in structure, and confined to a particular context. As a result, some calls elicit sharp reactions from nearly every bird hearing them. The contrasting *alarm* and *mobbing* calls that many birds produce when they spot a predator are often shared across species; many birds make similar acoustic distinctions between the two calls. Alarms, given when the predator is airborne and thus able to strike promptly, have acoustic properties that make it difficult for the predator to find the bird emitting them. In contrast, mobbing calls, which summon neighbors to attack a stationary predator, have acoustic features that make the sound easy to locate, so that every bird responding will know where to attack. The survival value of differing calls is obvious.

But only a predator, rival, or prospective mate shows interest in the information contained in birdsong. Song is usually loud, sustained, complex in structure, seasonal, confined to males, and prompted by mating or territorial concerns. Some species, of course, sing no songs at all, using calls instead for territorial and breeding information; in strictest terms a song is simply an especially elaborate call. Still, the distinction between the two has a practical value to us because song seems musical to us and calls do not. Certainly, if a male songbird is to breed, he must learn to sing the right tune: it attracts females and keeps rival males away. And if a female is to breed, she must recognize the tune of an appropriate male.

A major function of birdsong is to establish and maintain breeding territories. Each resident male spends much of his time patrolling his boundaries and declaring his presence in song. The "message" of the song indicates the singer's probable behavior. Roughly translated, a territorial song says that the singer will attack any adult male of the same species who enters his territory. But as the singer's probable behavior changes across the spring, so does the meaning of the song. Early in the season, when pairs are still forming, a male chaffinch (*Fringilla coelebs*) will not attack adult females entering his territory. At that time of year, his song is all invitation. But later on, when eggs are incubating, he will attack strange females. The song does not change, but its meaning does. Other birds know the meaning from the time of year.

Of even greater interest to linguists than the purpose of birdsong is that they learn to repeat sometimes long and complex songs with great precision. In fact, most do not *learn* their songs in the strict meaning of the word. Only four of the twenty-nine avian orders have complex song repertoires or dialects and clearly must acquire their songs after birth. In the other twenty-five orders, the appropriate calls or songs appear to be part of each bird's genetic heritage.

Even within the largest family of songbirds, learning strategies differ sharply from one species to the next. Young song sparrows (*Melospiza melodia*), for example, must hear themselves sing to produce their full repertoire; song sparrows deafened when young fail to develop normal song, unlike individuals merely isolated when young. In contrast, young finches of several species learn the song of the adult male who helps care for them, even if he is of another species. White-crowned sparrows (*Zonotrichia leucophyrs*) and chaffinches must hear adults of their own species sing during the first spring of their lives; white-crowned sparrows raised in isolation until their second spring never perform properly, even after hearing adult song. In such species, it appears that each male is born with a generalized template for his species song. The length and timing of his critical learning period differ according to species, but the pattern is similar. The point of crystallization, when the template has become rich enough to support full adult song during the coming year, varies with the species, but the necessity of a passive learning period does not. This template is analogous to Chomsky's hypothesis of a genetic template supporting universal grammar in humans.

Although genetics establishes dialects of bees, learning appears to produce regional dialects in birds, as it does in human speech. In many species, birds of one area develop shared variations of the species song.

These variations persist for several generations at least, and are clearly differences in learning rather than in the genetic template; fledglings from one area transported to another sing the new dialect, not that of their parents.

Because birds are more like humans than bees, are they closer in communicative ability as well? Probably not. Insect communication and behavior are in many ways as complex as our own. The impressive achievements of insect communities depend on reliable communication systems to coordinate the behavior of thousands, even millions. In contrast, bird vocalizations seem ambiguous. It may even be useful to see birdsong as a simpler form of communication than either the stereotyped, meaning-packed movements and chemical signals of bees or the more variable multichannel displays of some mammals.

But the complexity and variability of mammalian signaling may disguise the rather limited range of subjects of their signal. If most mammals communicate about the same limited set of subjects, and if those subjects are part of an environment shared by humans, it is not surprising that humans understand their mammalian pets—or that the pets appear to understand humans.

Four activities account for almost all the displays of mammals: mating, rearing young, resolving conflict, and maintaining group organization. In many species, from insects to birds, elaborate courtship rituals supplement the basic chemical signals of sexual readiness. Still, the rituals give only redundant information about the sexual condition and identity of the displaying animal. Mammals are no different, although their sexual displays are rather ordinary compared to the courtship of other animals. In contrast, the other three display categories show extensive expansion, reflecting specific mammalian adaptations.

Communication between mother and offspring is unimportant in sea turtles, which abandon their newly laid eggs and return to the sea. Even birds, many of which are good and faithful parents, communicate with their young through a simple set of calls and several kinds of specialized physical contact until the young are ready to fly. Then the fledgling is on its own to find food, avoid predators, and maybe migrate. Young turtles are genetically programmed to run for the sea as soon as they hatch. In ways we do not fully understand, migratory birds are programmed to find their way accurately across immense distances. Neither turtles nor birds learn much from their parents. So it is hardly surprising that all turtles and most birds produce multiple offspring as insurance that the species will continue. Although the casualty rate may be high, some offspring are bound to survive and keep the species going.

In contrast, most mammalian parents invest a remarkable amount of energy and time in a few offspring. Maternal care over a long period involves elaborate and sustained interaction between mothers and their young. The displays guiding this interaction are no more complex than those controlling mating. In fact, to a casual human observer they may not seem to be displays at all, because we behave very similarly in caring for our own infants: feeding, cleaning, restraining, warning, punishing, and petting.

Still, the fundamental feature of animal communication persists in even the most social mammals: the value of displays does not depend on a desire to tell another animal something. And even the most highly social mammals send messages with great redundancy. Such redundancy, together with a fairly limited number of messages, perhaps only a couple of dozen, is important because it means that pulling one sensory channel from the display for some other purpose need not seriously disrupt the message. In developing language, humans appear to have reserved the acoustic channel for complex spoken language. But the original display system still functions in human behavior, as the expanding literature on kinesics testifies.

Representatives of another group of mammals, the cetaceans, have also adapted the auditory channel for special communication. Water as a medium for chemical, visual, or acoustic signals is considerably different from air. Because a liquid veil shields the individual and social lives of water-based vertebrates from casual observation, we lack much of the behavioral context to understand their communication systems. For years scientists studied the sonar signals of dolphins as a model for artificial sonar systems. Various explanations for dolphin sonar have included stunning or killing prey, forming acoustic images of their surroundings, identifying individuals, and, according to one author, deliberately communicating with each other and with humans. A decade of intensive work with captive dolphins showed both the refinement of dolphin sonar and the flexibility with which the animals apply it to solving problems. Early behavioral studies using trained animals also suggested that dolphin problem-solving ability stems from a high level of intelligence but failed to find a useful way of measuring their cognitive skills.

More recently, Louis Herman and his colleagues have shown that dolphins are capable of responding to unique sequences of learned signals that identify various objects and actions; his subjects can execute accurately an interesting range of instructions. While the resulting claims for dolphin syntax and sentence comprehension are based on linguistically questionable definitions, this carefully described work illustrates again the remarkable cognitive capacities of the animals.

The humpback whales, another group of cetaceans (*Megaptera novaeangliae*), have been extensively studied in their breeding grounds off Hawaii and Baja California, and in their Alaskan hunting grounds. The animals seem to live in social aggregations without discernible structure. During their summer feeding season off Alaska, stable groups (most often chiefly female) sometimes hunt together in clearly coordinated ways, and even in the same areas from one year to the next. But during the winter breeding season, when the animals do little if any hunting, the only stable social groups are pairs of cows and calves, often followed by an interested adult male or three.

Like other cetaceans, humpback whales make a variety of sounds, but they are famous for singing. (Shortly after the discovery of this behavior in the 1960s, an album of whale songs was briefly popular.) In several ways whale and birdsongs are similar: males do the singing only during the breeding season, and the whale song is learned. Each song consists of several discrete *themes*, usually sung in the same sequence. The themes in turn contain *phrases*, the phrases contain *subphrases*, and the subphrases contain *units*. Complex birdsong can be analyzed using the same concepts. Whale song is also dialectical; Atlantic and Pacific humpbacks sing clearly different songs.

The most interesting feature of whale song is that within a given breeding population it changes rapidly over time. Analyzing the singing of Pacific whales for two breeding seasons, Payne, Tyack, and Payne (1983) found "dramatic monthly evolution following set rules of change. Substitution, omission, and addition occur at different rates in different times, but at any one time all songs are similar." We know almost nothing about what constitutes "good" whale singing; since no one has been able to identify the offspring of any male humpback, we cannot correlate a specific performance of a whale song with success at breeding. But it appears that a singing male must do two things simultaneously: produce the complex song and listen to the songs of his competitors. Nothing else can explain the fact that although the song changes steadily, nearly all males sing the same song all the time. The acoustic transactions among humpback whales exemplify a special kind of reciprocity in which the singing of each animal simultaneously shapes and is shaped by the singing of his neighbors.

Unfortunately, we do not know the meaning of this behavior. Since nearly all males seem to be singing the same song, females may choose mates on the basis of their troubadorial gifts. Possibly the songs are addressed entirely to other males as a way of spacing out individuals in the breeding territory. Given our ignorance about how aquatic creatures spend their time, we might construct several models to explain whale singing, based on the behavior of various land creatures.

To understand the basis of human language in animal communication, it seems wise to study our closest surviving biological relatives, the other primates. Although the similarities hold obvious promise for advancing understanding of humans, they make valid, objective research with primates difficult. Anne Premack writes:

> Aside from a human baby, I can think of no creature which can arouse stronger feelings of tenderness than an infant chimpanzee. It has huge round eyes and a delicate head and is far more alert than a human infant of the same age. When you pick up a young chimp, it encircles your body with its long, trembling arms and legs, and the effect is devastating—you want to take it home! (1967, 17).

Early studies, some using human infants as controls, investigated whether raising chimpanzees in a completely human environment (*cross-fostering*) would produce humanlike behavior, including spoken language. Although the chimps learned rapidly to respond to a variety of spoken commands, none acquired speech or even clearly intelligible word sounds. This result is hardly surprising; other primates do not share the subtle genetic adaptations of the human vocal track that enable speech. So, beginning in the mid sixties, several research teams began exploring other means of communicating with the animals.

Although these studies used different methodologies, they had two important goals in common. First, they focused on teaching the animals to produce symbols. Whether making signs, placing plastic tokens, or pushing computer keys, the animals were to create recognizable utterances to obtain reinforcement from their human trainers. Second, researchers hoped that the animals would produce strings of signs that would show meaning not only in the individual symbols but also in the order of the signs. Linguists have always emphasized the importance of syntax in human language, and sequence, or word order, is certainly important in the grammars of many languages—including English, the native language of these researchers. So ape language projects followed the lead of linguists.

Allen and Beatrice Gardner (1969) chose American Sign Language (ASL) and began teaching it to a female chimp whom they named Washoe. ASL is a complex, flexible system of hand signs developed for the deaf. A language in its own right rather than a facsimile of English, ASL uses the shape of the hand(s), their relative position, and their movement to convey ideas. Since home-raised chimps had shown excellent motor control at an earlier age than human infants, the Gardners felt confident that chimps could master ASL. Certain that a chimpanzee could readily learn arbitrary signs to obtain food, drink, and other things, they set a larger goal: "We wanted Washoe not only to ask for objects but to answer questions about them and also to ask us questions. We wanted to develop behavior that could be described as conversation" (Gardner and Gardner 1969). Just under two years into the project, Washoe had acquired 34 signs. By the end of the third year, she knew 85 signs. Her mature vocabulary reached approximately 180 signs (see Figure 49.4).

In later years the Gardners acquired other animals and offered them similar training, with similar results. Changes in funding transported this small colony of signing chimpanzees from Nevada to the University of Oklahoma for several years and finally to Central Washington University, where Roger Fouts, who began working with the animals as a graduate student of the Gardners, presides over a number of chimps living in a laboratory approximation of a social group. In the seventies, Herbert Terrace directed a Gardner-like program with one animal, Nim Chimsky. Penny Patterson carries on a similar project with two gorillas, Koko and Michael, and Lynn Miles did similar work with an orangutan named Chantek.

FIGURE 49.4 Washoe signing "tickle."

Not all investigators used adaptations of ASL. Even before the Gardners' first reports, Anne and David Premack (1983) had begun training a chimp named Sarah to answer simple questions using plastic tokens affixed to a sticky board, and their first publications nearly coincided with the Gardners'. Sarah's tokens were completely arbitrary shapes and colors (a blue triangle meant "apple," for instance), and the Premacks gave her very elaborate, step-by-step training in both definitions and sequence of tokens within a statement (see Figure 49.5).

Inspired by both the Gardners and the Premacks, Duane Rumbaugh developed an arbitrary language called Yerkish (after the Yerkes Primate Center in Atlanta) to communicate first with a female chimp named Lana, then with two males named Sherman and Austin. Its symbols, called lexigrams, are arbitrary designs displayed on the backlit keys of a large computer-controlled keyboard (see Figure 49.6). They are moved randomly from key to key so the animals will learn to select the designs rather than locations on the board. The lexigrams of the current message appear on a screen above the board, and the computer records all input.

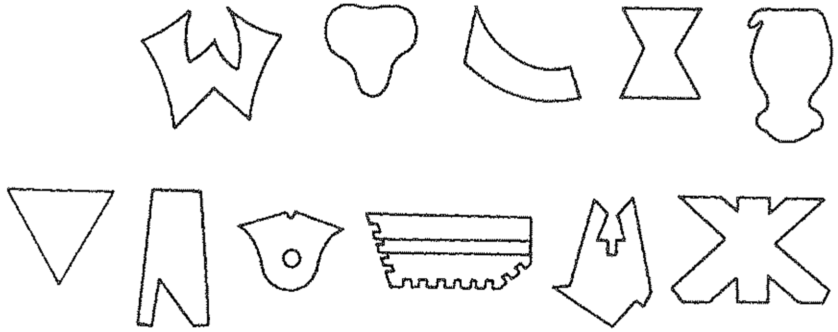

FIGURE 49.5 **Sarah's symbols.**

The Gardners themselves no longer work with chimps. The Premacks' project continued, focusing on the cognitive rather than linguistic abilities of their animals. Rumbaugh and his wife Sue Savage-Rumbaugh have extended their lexigram system to work with profoundly retarded humans and with bonobos, another species of ape. Fouts and Patterson continue their ASL research programs. Fouts has given Washoe an adopted son, Loulis, and studies the transfer of signing from one generation to the next.

Through the seventies and eighties, these projects attracted some popular attention—Washoe, for example, appeared in two different programs of the PBS science series *NOVA*. The projects also provoked considerable controversy about methodology, the nature of the animals' capabilities, and what it means to be "human." Thirty years ago, humans were often defined as "the tool-making animal." But then Jane Goodall (1986) and other field scientists demonstrated that wild chimpanzees make and use a variety of tools, which constitutes a kind of protoculture for particular groups of animals. Not all groups make or use the same tools, and within a given group toolmaking and use are passed from one generation to the next. By the early seventies, only language conspicuously separated humans from other higher primates. However, the images of Washoe, Sarah, and Lana apparently engaging in communicative transactions with humans through arbitrary symbolic signs called into question even that distinction. No one denied that the animals were performing arbitrary and "unnatural" behavior. At issue was the meaning of that behavior. What was going on in the animals' minds? Was it language? Was it a kind of protolanguage, which could give a shadowy glimpse into our own evolutionary past? Or were the primate communication researchers overinterpreting their data? Criticism took two main forms: attacks on the accuracy of data, and alternative analyses of what the accumulating data means.

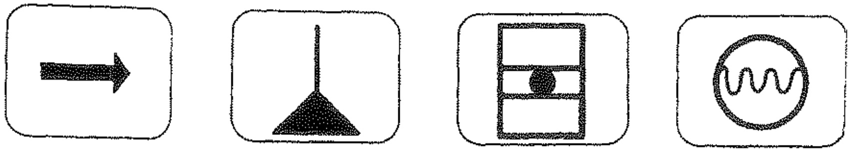

FIGURE 49.6 **Yerkish: sample lexigrams.**

The most severe critics charged that the researchers were either dishonest or unable to avoid providing behavioral cues to their animals, which could explain away any instance of symbol use. Led by Thomas Sebeok, these critics campaigned to discredit all the ape language projects and deny funding to the investigators. Interestingly, even the first studies by the Gardners had used a standard technique to avoid just the sort of cuing their critics attributed to them. They used the double-blind design developed by social psychologists to control the influence of extraneous information on the behavior of human subjects in experiments.

In a double-blind design, no one in the direct contact with the subjects knows which experimental condition is in effect at any time. Consider, for example, a study to test for the effects of hypnosis on suggestibility. The chief experimenter decides on the design of the experiment but does not interact with the subjects. In turn, the hypnotist, having been told perhaps that the experiment is about pain perception, is blind to the hypotheses, so neither the hypnotized nor the control subjects can gather relevant cues from the person they actually work with. The experimenter gathering data, not knowing which of the subjects have been hypnotized and which are in the control group, is blind to the experimental manipulation and cannot provide distorting cues either.

The Gardners early established a reliable double-blind system for testing Washoe's vocabulary. They report that in a typical double-blind testing session Washoe correctly named 91 or 92 of 128 items. The obvious meaning of these experiments, confirmed by the Premacks and Rumbaughs using different symbol systems, is that chimpanzees can learn to use arbitrary signs within the problem/reward structure of a behavioral experiment. The animals earned their treats honestly, by learning the symbols the experimenters asked them to learn.

Still, critics have rejected the significance of this achievement, offering a limited interpretation of the data: that the animals are simply using a learned maneuver—whether making a gesture, selecting a plastic token, or punching a computer key—to get something they want. The claim, in other words, is that the animals are not performing a cognitive function even vaguely analogous to naming familiar objects and actions; they are simply doing tricks for reward, just as a pet mynah bird will say "come in" when it hears a knock on the door. This area of controversy developed into a discussion of whether strings of symbols produced by the animals constitute syntax. To demonstrate the point, pigeons were trained to peck four colors in rigid sequence to obtain food. Labeling the four colors with words to produce English sentences like "please give me corn," "start give corn stop," or "dammit, where's the corn" does not mean that pigeons have learned language. The "messages" they produce are artifacts of the experimental apparatus, not constructions of the pigeons' minds. Although the process is laborious, careful conditioning of sequenced responses can produce such behavior in a variety of animals.

In the late eighties, Sue Savage-Rumbaugh realized that a fundamental feature in the design of all the projects had simultaneously fed the controversy and made it unresolvable: all projects had concentrated on training animals to produce signs, using their comprehension of signs only as evidence of reliable mastery of production. This emphasis gave all the projects similar features:

- long training periods before significant results appeared
- communicative transactions that interested the experimenters more than the animals

Emphasis on positive reinforcement—getting a treat for the right answer—meant that critics could always claim the animals were simply doing tricks to get rewards. Transactions interesting chiefly to the experimenters meant that the animals sometimes performed erratically, throwing the reliability of their mastery into question. It also meant that the animals' interests were not the focus of using signs.

Benefitting from the results and problems of earlier ape studies, Savage-Rumbaugh has carefully built a program of research into the basic language capacities of chimps and their cousins, bonobos. These two species certainly are the most closely related to humans genetically, and an evolutionary understanding of human nature suggests studying them for insight into the underpinnings of human language. Based on work in parallel programs for encouraging language development in apes and mentally retarded individuals, Savage-Rumbaugh has presented important and challenging results on just how both groups acquire the use of signs.

Starting with the program for teaching Lana to use Yerkish for acquiring rewards, Savage-Rumbaugh began a series of experiments with Sherman and Austin designed to make symbolic communication functional for them as well as for her. In one experiment, for example, she required Sherman and Austin to exchange information through lexigrams so they could use appropriate tools to extricate food from various containers. The animals were placed in different rooms, and one was allowed to watch a human put food into one of six kinds of container. After the human left, whichever animal knew where the food was hidden could use the keyboard to ask his comrade for the appropriate tool. If they completed the transaction successfully, they could share the prize. Allowed to use lexigrams, each would readily ask for or provide the appropriate tool; deprived of lexigrams, each would present the available tools in random order, or persistently offer the same tool. Having or not having access to the arbitrary symbols of Yerkish completely changed how they solved their problem. Having reframed the problem to be studied from production of syntactic utterances to comprehension of symbols for objects of value and use to a chimp, Savage-Rumbaugh clearly

demonstrated that chimps and bonobos both possess cognitive capacities to comprehend and use arbitrary symbols for communication.

This new orientation, combined with access to another species of ape, has led to the most interesting results from ape language research. Kanzi, a bonobo raised from infancy in a symbol-rich environment, spontaneously acquired a small set of symbols. Constantly present in tutoring sessions with his mother, the young bonobo was never the focus of training; he acquired his first symbols through observation, much as a young human learns early words through constant exposure and observation. Kanzi's ability became obvious only when he started using the Yerkish keyboards to get desired objects (food or toys) and initiate desired play activities. Thereafter, Kanzi learned a large set of symbols quite rapidly.

Savage-Rumbaugh has shown convincingly that after intensive language exposure Kanzi can also understand spoken words and has the ability to respond to at least some aspects of word order. As she notes: "Such an ape can also understand the intentions of others as expressed through language, though the nonlinguistic expression of intent must match the linguistic one or the words will be ignored" (1994, xi–xii). Analysis by a developmental linguist, Patricia Greenfield, suggests that Kanzi may well be using Yerkish lexigram combinations in a systematic way—one similar to the simple grammar that governs the two-word stage in young humans. Further, the replication of these results with two other bonobos and a common chimpanzee imply that this basic ability is generally available to both species, though bonobos seem more proficient at this kind of learning.

These results justify Savage-Rumbaugh's shift in experimental focus from production to comprehension. Certainly neither Kanzi nor any other ape has *produced* utterances or sign strings that match the complexities of human grammar. And although Kanzi responds appropriately to requests, commands, and even embedded identifiers, verb modifiers and conditionals leave him completely confused. Still, the basic ability to comprehend ordered symbol strings and extract the information about the world they convey appears in nonhuman as well as human primates. Chimps, bonobos, and possibly gorillas and orangutans have the basic cognitive ability that humans use in language comprehension. The unique ability is the control humans exert over modified vocal, breathing, and swallowing structures.

Although primate studies have not uncovered systems that closely parallel human language, they have certainly provided insight into the variety of ways that animals exchange meaningful and useful information about their environments and their actions and intentions in relation to them. Attempts to elicit ordered communication by signs in apes may have failed in their original objective, but they have given us evidence of cognitive capacities in apes that are far beyond our expectations. And we are closer to understanding the basic abilities from which our ancestors developed the language capacity that shapes the world we inhabit.

What are we to take away from a quarter century of ape language work? A combination of classic experimental research, informed observation, and quasi-ethological research on the relationship between symbol use and environmental consequences reveals that apes comprehend even when their spontaneous production of signs is limited. But of course this is also true for young children. Indeed, examined objectively, the corpus of evidence for early language usage in Kanzi is more convincing than that in many linguistic development studies of children. Like young humans, apes are capable of using arbitrary symbol systems to manipulate their environment and relationships with others. Unlike bees and most birds, apes are not limited to a neurologically programmed set of behavioral signals.

What does this tell us about apes and about ourselves? The basic cognitive and neurological abilities that underlie language exist in our closest biological relatives. But full comprehension of syntax and the production of syntactic utterances appear limited to humans. This difference correlates interestingly with human brain lateralization. Among all nonhuman higher primates, handedness is evenly distributed—approximately fifty percent of chimpanzees are right-handed and fifty percent left-handed. In contrast, something like ninety percent of human beings are right-handed—that is, left hemisphere dominant. It begins to seem increasingly significant that the brain areas most concerned with the intricate processes of speech and syntax production are typically located in the left hemisphere. If this level of syntactic competence is beyond the mastery of nonhuman primates, then syntax production becomes a promising candidate for one dimension of language capability that only humans as a species have developed.

The expanding body of information on animal communication in general and the acquisition of symbol systems by primates in particular is valuable to students of human language in several ways. First, it helps us to understand, however vaguely, the mental worlds of animals we often consider mindless if not senseless. And for linguists particularly, the study of ape communication provides a rare contrast to normal human language competence. Parallels between teaching the Yerkish lexigram system to severely mentally retarded humans as well as chimps and bonobos have already proved instructive. Last, because language does not leave fossils, we are unlikely to resolve all our questions about its evolution. We might resolve some of them by examining the closest thing to language fossils: the communicative and cognitive capacities of our nearest biological relatives. Although the other higher primates are not in any sense our linguistic ancestors, their evolutionary history may have conserved the cognitive abilities shared by our common prelingual ancestors.

Careful study has shown the degree of human communication that takes place on the level of affective displays using fixed action patterns. The same studies, however, have shown how great a gap separates animal and human use of symbols. Human language is an additional symbolic layer, extremely rich in hierarchical rule systems, superimposed on an existing pattern of communication that we share with other animals. This new layer has led to rapid alteration of every facet of human social structure and even to changes in human perception of the world.

To continue to acquire information about communication systems in a broad range of animals, investigators need to rethink older data, integrate new studies, and reexamine some operating assumptions. Communication within social groups is a fundamental part of animal life, and particular features of a species' communication system have long been seen as defining that species' unique social and even biological nature. The human capacity to appreciate multiple levels of meaning in a set of auditory or written signals clearly separates the cognitive worlds of humans and other primates. Advances in fields such as neurophysiology, linguistics, cognitive science, and comparative psychology seem to be converging on new and exciting conceptions that will challenge much of our understanding of the role language plays in human cognition and behavior. While current information does not show that any other animals have even a close approximation of formal language systems, such formal language (as opposed to other verbal and nonverbal communication systems) plays a relatively small role in the majority of our everyday lives.

By changing the focus of primate research from the study of formal language skills to cognitive strategies, several investigators have shown that chimps have cognitive mapping skills very similar to those of humans. The differences in the basic perceptual skills of higher primates may be slight indeed; genetic data suggest that the physical differences are minimal. The similarity of the cognitive world of great apes and humans, in contrast to their seemingly absolute difference in syntactic ability, suggests the decisiveness of the world-constructing power of language. The linguistic differences between human and animal may, in the case of higher primates, represent only small cognitive differences. Yet the power of language, once unleashed, has magnified them into an unbridgeable gulf.

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SUGGESTED READINGS

General

Griffin, D. R. *The Question of Animal Awareness: Evolutionary Continuity of Mental Experience.* Los Altos, CA: William Kaufmann, 1981. [In this important book Griffin opened the way to a reconsideration of cognitive capacities and functions in animals.]

Peters, R. *Mammalian Communication: A Behavioral Analysis of Meaning.* Monterey, CA: Brooks/Cole, 1980. [A well-written, clearly organized analysis of nonverbal communication from moles to man.]

Smith, W. John. *The Behavior of Communicating.* Cambridge: Harvard University Press, 1977. [A good general introduction to communication as a kind of behavior that fits into other behavior and environment.]

Bees

Gould, J. L., and C. G. Gould. "Can a Bee Behave Intelligently?" *New Scientist* 98 (1983), 84–87. [An interesting update on bee language research.]

Von Frisch, K. *Bees: Their Vision, Chemical Senses, and Language.* Rev. ed. Ithaca, NY: Cornell University Press, 1971. [The classic story of von Frisch's seminal work on honeybee communication.]

Whales

Payne, R., ed. *Communication and Behavior of Whales.* AAAS Selected Symposia Series. Boulder: Westview Press, 1983. [A compendium of papers that explore the communicative behavior of whales.]

Schusterman, R. J., J. A. Thomas, and F. G. Wood, eds. *Dolphin Cognition and Behavior: A Comparative Approach.* Hillsdale, NJ: Lawrence Erlbaum Associates, 1986. [The editors collected an array of reports on dolphin communication and placed it in the larger context of communicative behavior in other species.]

Birds

Catchpole, C. K., and P. J. B. Slater. *Bird Song: Biological Themes and Variations.* Cambridge: Cambridge University Press, 1995. [A comprehensive survey of research on birdsong.]

Apes

de Luce, J., and H. T. Wilder, eds. *Language in Primates: Perspectives and Implications.* New York: Springer-Verlag, 1983. [This third compendium is somewhat more balanced, definitely more philosophical, and less polemic than the first two.]

Goodall, J. *The Chimpanzees of the Gombi: Patterns of Behavior.* Cambridge: Belknap, 1986. [Among the observations in this summary of decades of meticulous work are several on the nature of chimp vocalization and its role in their social organization.]

Premack, D., and A. Premack. *The Mind of an Ape.* New York: W. W. Norton, 1983. [An entertaining and informative summary of a more cognition-oriented line of research with chimps.]

Savage-Rumbaugh, E. Sue, and Roger Lewin. *Kanzi: The Ape at the Brink of the Human Mind.* New York: John Wiley and Sons, 1994. [The most recent book on the subject, it offers a clear overview and details the shift in emphasis from language production to cognitive capacities of primates.]

Sebeok, T. A., and J. Umiker-Sebeok, eds. *Speaking of Apes: A Critical Anthology of Two-Way Communication with Man.* New York: Plenum Press, 1980. [This anthology is largely an outgrowth of a conference spearheaded by Sebeok and Terrace to publicize their doubts about ape language research.]

Sebeok, T. A., and R. Rosenthal, eds. *The Clever Hans Phenomenon: Communication with Horses, Whales, Apes, and People.* Annals of the New York Academy of Sciences, vol. 364. New York: New York Academy of Sciences, 1981. [A second anthology covers areas and commentators left out of the first volume, but with the same intent and purpose.]

Terrace, H. *Nim: A Chimp Who Learned Sign Language.* New York: Alfred Knopf, 1979. [Terrace presents in detail his work with Nim and the basis for his reinterpretation of his results.

FOR DISCUSSION AND REVIEW

1. Explain why ethologists and linguists believe that studying different kinds of animal communication is important.
2. In analyzing animal communication, ethologists use the terms *form*, *context*, and *response*. Define and give an original example of each term.
3. Kemp and Smith state that "distinctive behavior that reliably indicates what an animal will do promotes cooperation and reduces conflict, because it allows neighbors to adjust their actions according to what the display predicts." Drawing on your own experience, write brief descriptions of three situations involving animals that illustrate this principle.
4. Explain the relationship between the *allophones* of human speech and animal *displays*.
5. Review Hockett's "design features" discussed by W. F. Bolton (pp. 61–72) in "Language: An Introduction." To what extent does animal communication embody these features? Be specific; you may wish to consider only bees, or birds, or mammals.
6. Explain the differences between bird calls and songs; be sure to consider the functions of each.
7. Explain the implications for comparisons of human language and animal communication of Kemp and Smith's statement that "the

fundamental feature of animal communication persists in even the most social mammals: the value of displays does not depend on a desire to tell another animal something."

8. Why are specialists from many disciplines interested in studying nonhuman primate communication?
9. In all human languages, sentences have both hierarchical and linear structure. What is the significance of this fact in research with nonhuman primates?
10. What did Savage-Rumbaugh do to change the orientation of primate research? What impact has this change had?
11. What have researchers learned from working with Kanzi, a bonobo primate?
12. How do Kemp and Smith answer their own question: "What are we to take away from a quarter century of ape language work?"

50

The Continuity Paradox

Derek Bickerton

Where and how did humans acquire language? What events took place among people that stimulated the development of language? What role has language played in the development of our species? Scientists and linguists have long been trying to answer these questions. In this selection from his book Language and Species, *Derek Bickerton, professor of linguistics at the University of Hawaii, examines what he refers to as a "paradox" in the evolution of and examination of human language: the Paradox of Continuity. Bickerton asserts that if the theory of evolution is accepted, then language must be no more than an evolutionary adaptation. The paradox exists because language is far too complicated to have been the result of a genetic mutation or shift. Bickerton discusses innate differences between human and animal communication systems as he focuses on such specifics as "creativity" and the differences between "calls" and "words." He also examines "formalist" versus "antiformalist" views in his attempt to solve the paradox of the evolution of language. In his search for solutions, Bickerton clearly demonstrates how our ability to use language distinguishes us from all other species, and how language is an invaluable asset to human beings.*

Anyone who sets out to describe the role played by language in the development of our species is at once confronted by an apparent paradox, the Paradox of Continuity. If such a person accepts the theory of evolution, that person must accept also that language is no more than an evolutionary adaptation—one of an unusual kind, perhaps, yet formed by the same processes that have formed countless other adaptations. If that is the case, then language cannot be as novel as it seems, for evolutionary adaptations do not emerge out of the blue.

There are two other ways in which evolution can produce novel elements: by the recombination of existing genes in the course of normal breeding, or by mutations that affect genes directly. Even in the second case, absolute novelties are impossible. What happens in mutation is that the instructions for producing part of a particular type of creature are altered. Instructions for producing a new part cannot simply be added to the old recipe. There must already exist specific instructions that are capable of being altered, to a greater or lesser extent. What this means is that language cannot be wholly without antecedents of some kind.