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Chomsky[1] once remarked that if animal communication has any fundamental properties in common with human language, the place to look for these properties is not at the level of ethological displays (i.e., the motor aspects of performance) or linguistic analysis, but rather at the level of perceptual and cognitive organization (see also Count;[2] Eisenberg;[3] Osgood.[4]) In this paper we shall consider those aspects of human and nonhuman communication which seem most interesting from a functionally oriented, cognitive, and comparative point of view.

A Functional Point of View

First of all, all communication systems may be viewed as means to an end. They are mechanisms whereby humans or nonhumans solve the basic problems of coordinating and regulating their societies: discriminating each other's specieshood, sex, age, social background, group membership, emotional and motivational states, and the state of other objects and events in the environment; transmitting the capacity for similar accomplishments to subsequent generations; and thus ultimately securing all of the requisites for the survival and reproduction of the phenotype. Inasmuch as all living species are, almost by definition, capable of achieving their basic goals under natural conditions, it seems chauvinistic to ask whose communication systems are the "best," or to attempt to train animals in our languages before learning theirs.

Communication is Part of the General Information Processing Activities of an Organism

Communication is embedded in the general perceptual and cognitive activities of the organism, and these activities have the primary characteristic of being adaptive and purposeful. To separate communication from the overall information pickup and transmission capabilities of the individual would be a tour de force on the part of the human observer. Obtaining information from language or other specialized signal systems must share common features with obtaining information from any source.

Meanings Have Multiple Signs and There Are Multiple Meanings for Signs

Communication is symbolic, but the symbols do not correspond to meanings in any simple one-to-one fashion. An animal moving through the woods might hear a

single vocalization or the sound of several footsteps, or see a footprint in the sand, or smell the slight trace of urine or body odor in the air. Any number of these "sign stimuli" might stop him in his tracks, cause him to hypothesize or conclude that "something is out there," and that "it is probably over there rather than elsewhere," and "it is an X animal rather than a Y," and so forth. It is not the stimulus as such, but what that stimulus might *represent* which makes the stimulus biologically or cognitively significant. There is probably no one "innate releasing stimulus" for any particular hypothesis, and the same general conclusion can be reached in a host of different ways. Conversely, the "same" nominal stimulus can often represent a number of objects or events. What is a *snake*? It depends on whether you are talking to a student of biology, a fundamentalist preacher who is about to baptize you, a two-year-old child who is about to set foot in a Louisiana swamp, your psychoanalyst, a dance leader, a crapshooter. Neither the calls of monkeys nor the words of people *directly* stand for things. As Olson[5] and others have suggested, words serve to provide information relative to a given set of alternatives. This reduces the likelihood that a dictionary approach —assigning signs to meanings in a direct one-to-one fashion—will be adequate for characterizing any communication system.

The Importance of "Triangulation"

In the everyday world information comes from multiple sources, and except perhaps for organisms with split brains[6] or those in highly specialized laboratory experiments,[7] various channels function together as a coordinated, if not in some sense a unified, information-getting system. As Hornbostel (quoted by Gibson,[8] p. 54) put it, "it matters little through which sense I realize that . . . I have fallen into a pigsty." Many different forms of stimulus energy can all carry the same information: and information about the world can be obtained with any cue system alone or with many combinations of cues working together. D. T. Campbell[9] gives the latter process a very apt name: "triangulation." The most obvious form of triangulation is intramodal binocular vision or the ability to integrate the information received by each eye separately into a single percept. Other forms of triangulation would include the integration of information from verbalizations and gestures, visual and auditory cues, and so on.

The Importance of Cognitive Structures

A fundamental characteristic of information processing in general, as well as of language, is that two or more individuals do not reach the same understanding without similar cognitive structures. This is, of course, because the meaning of a message depends on the cognitive structure or schema to which it is referred (e.g. Bransford & Johnson.)[10] *Move out of the way* means one thing if someone is trying to run a vacuum cleaner around you and another if a large truck is coming toward you. Similarly, the sound of leaves rustling probably means one thing if you know a friend is near the source of the noise and another if you have reason to believe that a predator might be near. Thus, not only is there "triangulation" of information from various sources, but also there is considerable "filling in" or redintegration on the basis of the cognitive structures which are active at any given moment. Probable inferences based on past experience and reasonable hypotheses in any given situation are an integral part of information utilization (e.g., Kintsch;[11] Johnson *et al.*;[12] Johnson).[13]

Taking into Account the Cognitive Structure of Someone Else

In ordinary human discourse, the appropriate cognitive organization may be given by the immediate environment, as in the *Move out of the way* example. Or it may be given by experience and conventions; to use John Searle's example, *Could you pass the salt?* does not ordinarily mean *are you able to pass the salt?* but rather *Please pass the salt.* However, environmental cues and the habits of conventions are often only partial cues to meaning. Frequently, much of the appropriate cognitive structure must be established during the interaction of speaker and listener.

One of the most interesting aspects of practical communication situations is that people continually assess and take into account the cognitive competencies and cognitive structures of others and tailor their communications accordingly. If you were looking for the TWA gate at Kennedy Airport, you would be more likely to ask a person in an airport uniform than a randomly selected passerby. If you wanted to buy marbles, you would be more likely to ask a child where to go than to ask an adult. Similarly, if the airport guard or child were giving you directions, he or she would very likely start by determining something about your current state of knowledge about the environment. "Well, do you know where the airport restaurant is? Good. Turn left there and it's about three gates down."

An ongoing series of studies by David Goldstein and some of his colleagues indicates that children communicate more effectively the more familiar they are with the environment they are communicating about (Goldstein & Kose, personal communication). More importantly, children are more likely to use gestures in interactions with younger children than in interactions with adults (Goldstein *et al.*, personal communication); and the length of children's verbalizations is affected by the age of the listener (Shatz & Gelman [4]). Apparently, by the age of four or five, if not sooner, children are beginning to tailor their communication to fit the presumed cognitive outlook of their listeners. As adults, many specific features of our communications (e.g., word choice, gestures, length of sentences, tone of voice, our rate of speech) are determined partially by the presumed capacities and actions of someone else.

Successful Communication Is Based on the Above Characteristics of the Process

In general, successful communication depends on accurate assumptions about the cognitive organization of others and creative ways of using the entire communication process—making gestures, facial and body expressions, drawing pictures, making analogies, in addition to "straight" verbalization. This point is important not only in people-to-people exchanges, but also in people-to-animal exchanges. Most behavioral work with animals (like that with human infants) is largely a communication problem. Since we cannot verbally question an octopus about whether he can tell the difference between black and white, we have had to find some other ways to ask such questions. The most successful behavioral researchers are probably those who have particularly good intuitions about the way the world might look from someone else's point of view. As Konrad Lorenz put it, the first requirement of good research is that you be thoroughly familiar with your animal.

Since successful communication depends on accurately assessing the available cognitive structures of other beings, and animals integrate information from various sources, it is misleading to think of communication as one individual transmitting information to another who knows absolutely nothing about the intended message.

The more two individuals share common structures, assumptions, knowledge, and values, the more efficient their communication. This is one reason why it is easier to teach a human language to a chimpanzee than to a rhesus monkey. Perhaps this is partly why animal communication systems appear less elaborate than our own. In their societies, more information is shared information. Thus there is less variability in psychological organization to overcome.

In any event, if successful people-to-people and people-to-animal communication depends on accurate assumptions about the cognitive structure of other beings, it is probably not too far-fetched to assume that communication between animals involves similar assumptions about how the world looks to someone else.

Looking at Animals Collecting and Transmitting Information

With this background of assumptions, consider a "simple" interaction between an animal and an unknown object or being. Suppose that a normal, free-ranging monkey is strolling through the woods and suddenly comes into sensory contact with an object. How would he go about sizing up the situation? How would he know whether he was dealing with another living being, and if so, how would he determine its intent? If it were a conspecific, how would he determine whether it knows better than he does the lay of the land, the whereabouts of food, predators, and the rest of the social group?

Intentional Triangulation and Testing Hypotheses

Even if our monkey could conceivably be viewed as a "passive receiver" at the instant he perceives the first signal or cue (a glimpse, an odor, etc.), he does not remain passive for long. In nature, few situations can be sized up with certainty on the basis of a single distal cue; and in most cases the monkey will accordingly not "automatically" race toward or away from the source of the signal, but rather he will seek out additional information, or indulge what Pavlov called the "what is it?" reflex. He might turn his head this way and that, send out an answering call, sniff the air further, possibly climb a tree to scan the area visually. In this way, whatever "hypothesis" or "question" was posed initially can be further probed or checked out. We doubt very much that monkeys, like theorists (e.g., Marler[15]), sort various signals or cues into different categories according to what sensory modality is involved. They are, in other words, probably even less aware of and interested in their raw sensations as such than are human beings.

The Problem of Context

The extent to which our monkey will continue to indulge his curiosity depends upon many factors in addition to his initial hypothesis about the object. It depends, for example, upon his general familiarity with this particular portion of woods, whether or not the area includes large vertical structures that might provide cover or escape, how far away he is from his companion, how hungry he is, and so on. Those scientists who relegate such considerations to a garbage-pail category of "contextual factors" and focus their attention on "signals as such" should ask themselves: How do we, as observers, know which stimuli are "context," *psychologically speaking*, and

quite different reactions according to whether it is standing upright or lying on its side, and the upright position usually produces greater caution. It is striking that so many of the visually-mediated "aggressive displays" of so many different species are based on the simple principle of "making oneself look bigger" (via sitting up vs. lying down, standing bipedally vs. standing quadrupedally, showing piloerection, and so on). Conversely, one way to get a timid animal or child to approach is to stoop down or otherwise make yourself look smaller. A puzzling problem is why even presumably intelligent animals such as monkeys and men, who show excellent size constancy in other situations, often do not see through such tricks.

Visual Capacity.

Of all the static visual cues that lead a monkey to respond to an object as if it were a living being, one of the most important is anything that looks like eyes. Two buttons attached to a rectangular piece of fur, for example, will produce a much more pronounced reaction than the fur alone. To be really effective the buttons should be located together on one end of the rectangle. A monkey will characteristically circle the object and then make his first close approach from the "tail end" of the object—that is, the end opposite from the eyes. Using a doll as the test object, one can in fact often cause the direction of the monkey's approach to vary simply by having the doll's eyes either opened or closed. A radio-controlled doll which would open its eyes and rotate its head toward the monkey as he was sneaking in cautiously from the rear would probably produce a striking effect. It should go without saying that similar behaviors occur if the test objects are other living beings, particularly other monkeys; the phenomenon of "gaze aversion" is by now very well known. One of us (Menzel) kept a record for about two months of all the times that he was approached and threatened by free-ranging rhesus monkeys as he was sitting passively in the woods. The data of principal interest were the direction of approach and the monkey's location when he sounded his first threat vocalization. A large majority of the monkeys (especially the smaller ones) made their approach from the rear, and in addition, many of these came in from overhead. They approached much closer, too, than those who did not come in from outside the test person's field of vision.

We could add many more examples of such behaviors, but perhaps their major point is already clear. Not only does the monkey seem to know the layout of the environment and his own behavioral and information-processing potentials, but also, he seems to be making hypotheses or somehow taking into account what behavioral and perceptual capacities *the other being* might possess. Was this indeed not true almost from the start, when our imaginary monkey received its first cue about the presence of the object? From a phenomenological point of view we might be stretching the data in putting forth such a claim: but from an evolutionary and functional point of view the claim is most plausible. In other words, we would argue that *most* species-specific behaviors, if not most morphological characteristics of living things (such as the eye-spots of a moth which frighten off predatory birds, and the bright colors of flowers which attract bees) in some way "take into account" the perceptual and cognitive organization of other living beings. Just where in the foregoing description of the monkey's behavior one is actually warranted in positing phenomenological knowledge or understanding on the monkey's part is a matter that future research will have to settle, but we are convinced that the question is not a trivial one (Bastian & Bermant[20]).

Behavior Potentials

Up to now we have said nothing about motion, and this is undoubtedly the most important single visual feature that gets and holds an animal's attention and assists him in distinguishing between a living being, a dead animal, and an inanimate object. Indeed, the general attention-getting value of movement most likely evolved in the first place because moving things are so apt to be either living beings or objects that are being acting upon by living beings; that is, certain types of movement are a fairly reliable sign of life, and hence of food, danger, or something else that might be of biological significance. A pile of leaves or a series of bushes that rustle and stir in a regular progression (as if they were being moved by a live animal burrowing or walking through them) will frequently be investigated, and the monkey does not investigate all points along this line of movement, but only the *last* point.

Even more pertinent to our present discussion, monkeys are capable of learning very quickly to discriminate between two static objects, one of which will move in one way (suddenly and rapidly toward you) when it is approached and another of which will move in a different way (slowly and away from you). In other words, the animals seem to learn a particular object's *potential ability* to move in a particular way; the object does not have to be moving at any given instant to produce its differential effect. It would be very surprising to us if normally raised monkeys could not, like people, take into account the following sorts of facts when they confront "new" animals: if the beast has wings and feathers, it is probably capable of traveling through the air; if it has no appendages at all, it probably cannot travel through the air; if it has big teeth, it can probably bite; and, in general, the more it looks like me, the more likely it can do whatever I can do.

While the general nonrandomness of an object's movement and the suddenness and directionality of this movement are highly effective determinants of a monkey's response, these animals seem also to be highly sensitive to whether or not the object's movement (and, of course, its other behaviors) are nonrandom *specifically with respect to their own behavior*. For example, a radio-controlled doll that moves its head up and down on a randomly determined schedule would probably be much less apt to inhibit a monkey from taking food that lay at the doll's feet than another doll that performs precisely the same movements but "looks down" only when the monkey is about to put his hand on the food.

Many aspects of the stalking behavior and play of mammals have some of the characteristics we have discussed so far. Consider, for example, how a monkey tries to sneak up on another animal for a "surprise attack." Not only will he move slowly, silently, and low to the ground, circle in from the rear if possible, and keep trees, rocks, bushes, or any available visual barrier between himself and the victim, but also, he will continually keep a watch on what the victim is doing. If he steps on a dry leaf he will freeze and watch the victim, and if the victim pricks up its ears, he will probably take greater care not to make any noise. If the victim starts visually to scan the area in the monkey's direction, the monkey might move quickly and duck behind a tree. If the victim plops down on the ground and closes its eyes, the monkey moves in faster than before, and so on.

Certainly it is not farfetched to say that the monkey perceives the correlation or the lack of correlation between his own behavior and that of the other animal (*and vice versa*) and varies his behavior appropriately. Is it possible that he also tries to guess what the other animal is hypothesizing, or even, conceivably, to control the other animal into hypothesizing one thing rather than another? Such a question might at first glance seem absurdly anthropomorphic. However, as Norbert Wiener

suggested many years ago in his classical description of a fight between a mongoose and a snake, a principal advantage that the "higher" animal has is that he can use higher orders of information and feedback than the "lower" animal. In a fight he can correct his own moves in midcourse according to cues received from the other animal, rather than responding on an all-or-none basis; he can feint in one way to draw the other animal out, and then utilize this "opening"; he can keep himself in a favored location and gradually maneuver the other animal into a corner; he can learn what the other animal's potentials for certain types of movement will be as it gets more and more tired, and so proceed on the principle of first wearing the other animal down before the killing move is made. By the objective criteria that authors such as Tolman,[21] Sommerhoff,[22] and Rosenblueth *et al.*[23] have proposed, not only monkeys and mongooses but possibly even the snake could be said to know something about other animals' behavior potentials, hypotheses, and intentions.

Communicating about Others, Objects, Intentions, and the Environment

A still more complicated form of interaction is that which involves a third party in addition to the sender and the receiver. Can animal A perceive the fact that animal B's behavior is nonrandom with respect to animal C or with respect to an object? Since such behavior may be said to involve communication about the environment, and since it has been an accepted dogma for many years that animals other than man do little if any communicating about the environment, there are many authors who would be understandably skeptical about the ability of monkeys on this score. Consider, however, the following examples, which we are sure almost every field observer of primates has seen:

1. A human observer stares hard at an infant, then leans down to pick up a rock. The infant's mother, who is 20 yards off, starts to threaten the observer.

2. Monkey A, Monkey B, and a big ripe banana are all located 20 feet from each other, like three points of an equilateral triangle. Monkey A happens to see the banana first and starts for it. Monkey L, who is dominant to A, looks up at A, then immediately spots the banana too, and gives a gruff vocalization and gets up and starts for the same goal. A stops short at B's vocalization, glances once or twice between B and the banana, and sits down and grimaces at B.

3. Monkey A and Monkey B are sitting a few yards apart. Monkey A spots something behind a bush and cocks his head and stares toward the bush. Monkey B immediately stares in the same direction, then gets up and walks over and looks behind the bush.

We could, of course, extend this sort of analysis to four-party, five-party, or N-party interactions, and ask how many independent factors a monkey is capable of taking into account simultaneously before responding, but unfortunately there is very little empirical data available on such "higher order" situations. A majority of the available studies of primate behavior focus attention on simple dyadic relations (see Kummer *et al.*[24] for a cogent critique). It is, however, safe to predict that although probably all species of primates are capable of taking into account two or three independent factors, various species of primates would differ greatly in the sheer number of independent factors they could handle simultaneously.[25]

Perhaps the major point that we are trying to make here is that any statement to the effect that "animals other than man are capable only of communicating their internal emotional states and cannot convey information about objects" is predicated upon a false dichotomy and a very narrow view, even of emotional and expressive

behavior. As Michotte[26] pointed out some years ago, human beings, if not other animals also, characteristically perceive "emotion" as a modification of a signaler's behavior *in regard to* oneself or *in regard to* some object or event. That is, we judge the character and meaning of another being's internal state not merely from his motor patterns and vocalizations and other molecular reactions, but also from the relation of these reactions to the rest of the environment.

When we see an individual acting excited or even just walking rapidly in a straight line, we tend to assume that the individual is not performing some isolated activity, but rather that his behavior has some external referent or cause, if not some goal or purpose. A whole group of monkeys startles and leaps for the trees when one member does so, not because of what the leader's behavior portends about his internal state, but because of what such behavior might portend (or has in the past portended) about the environment and the receiver's odds of survival. A chimpanzee heads over in the direction of another chimpanzee who is giving loud "food calls" not because the calls indicate how happy the signaler is (and happiness is contagious), but because of what the calls suggest about the receiver's odds of getting something for himself.

Chimpanzees that have seen a member of their group orient toward an object which they themselves cannot see will often search the field in the indicated direction. It is not necessary that the signaler accompany them or even that he be in the situation at the time of group response. Moreover, there can be a considerable temporal delay between the leader's signal and the followers' response. Further, the followers react quite differently if the hidden object is a snake than if it is a pile of food, and they can similarly discriminate the difference between a large vs. a small pile of food or a preferred vs. a less preferred type of food.[28]

To give one more example, consider a group of semidesert-dwelling hamadryas baboons that sleep every night on one of several cliffs but that forage up to several miles from these cliffs during the day.[29] Assume that on a given day the group is at a position from which each cliff lies in a different direction, and that the leader of the group starts to glance alternately toward the setting sun, the cliffs, and the other animals, and then strides off in the direction of one of the cliffs. Would it really be so remarkable if the other adult group members could predict the leader's (and the group's) destination an hour or so and a few miles in advance? Does the leader actually need a vocal or gestural language to get across to the human observer or to his followers that it is late in the day and time to move out, and that he intends to spend the night at the same place the group put up a few nights ago?

It seems to us that one function of communication is to reduce the others' uncertainty in situations that are not already clear, and that the more information the sender and receiver already have in common and the better they can evaluate each other's knowledge and momentary predispositions, and the greater the number of alternative ways they have for filling in the few remaining blanks of information, the less necessary is any particular "signal."

According to Suzanne Langer,[30] two of the clearest suggestions of symbolization in nonhuman species, and hence two of the clearest precursors of language-like processes are (1) the "mere sense of significance" that animals attach to strange-looking objects and new situations and (2) expressive movements and "dances." Maybe she did not go far enough. Almost any motor behavior, even simple locomotion, is "symbolic" in the sense that it usually has some external referent or "refers to" objects and events that the animal has either encountered in the past or expects to encounter in the future. Actions may also be said to possess most of the formal design features by means of which other investigators have tried to characterize language. The ability of nonverbal animals to "tell" each other the nature and location of objects and events is limited only by the richness of a signaler's behavioral

organization and a receiver's knowledge of the signaler and the common environment in which they are operating.

Summary and Conclusions

Our major goal has been to indicate some primary features of a cognitively oriented, functional account of communication. In summary, we have argued that communication is part of the general perceptual and cognitive activities of an organism. Before we can predict how a "word" or a "signal" will be comprehended in a particular situation by a particular receiver, we must presuppose a good bit about the psychological organization of the receiver. Specialized signals supplement and complement the information that is available from other sources, including internal schemata and hypotheses. Some of the most interesting of these hypotheses involve assumptions about the perceptual and cognitive capacities of someone else. Sometimes these assumptions may be wrong, but many animals, and especially primates (including us) seem to be able to correct them even in the midcourse of an action on the basis of feedback from another individual. Where language leaves off and nonlanguage begins, or where "cues" leave off and "context" begins, is an open question, and in our opinion it is not a very central one.

These considerations suggest that it is time to question, if not lay to rest, many of the assumptions that still linger on in the area of animal communication, especially the assumptions that there are one-to-one correspondences between particular signals and particular meanings (the principle of the dictionary and the ethogram), that the relative communicative ability of species can be measured in terms of how many different signals they make (vocabulary size), that nearly all nonhuman communication patterns are involuntary and nonintentional, that the hallmark of human language is the ability to indicate objects rather than purely internal states, that without language animals can convey nothing about the past or the future or about objects that are not present to the senses. In particular, we would argue that any theory of communication that ignores the ability of animals to use many different interchangeable means for getting across the same general message (which ability has been called "paraphrasing" and "translation" in linguistics, "means-ends-readiness" in the area of problem solving, and "equifinality" in biology) is of little value for understanding primate communication or its biological roots or its cognitive base.

Some investigators have argued that sentences or propositions rather than words or phonemes are the appropriate units for a structural analysis of verbal language. For a functional analysis of language and communication in general, the more appropriate units are the larger events in which sentences *and* nonverbal cues occur. The amount of information conveyed by a signaler to a receiver cannot be specified from any more molecular form of analysis.

The more we think about the fact that communication is part of the general information-processing activities of an organism, the more obvious it becomes that beneath the "deep structure" of human language and human thought there are indeed "deep-deep" structures that we share with other species, and that it is on these structures that our linguistic abilities are predicated.

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