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Chapter 12

COMMUNICATION AND NATURAL DESIGN

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ABSTRACT

The basic value of the natural design perspective is that it provides a rich language for the description of social interactions that is neither covertly mentalistic nor barrenly behavioristic. A natural design analysis begins by clearly defining and identifying those properties of behavior that require special explanatory principles. Communication is design to mediate a design. Behavior between two animals is communicative only if one of the two animals has a behavioral design, *and* the other animal displays structures or behaviors that mediate this behavioral design *and* these structures or behaviors are evidently designed for their mediating role. Many phenomena in animal behavior are communications by this definition. Two classic cases are analyzed from the natural design perspective, the alarm calls of the vervet monkey and the song of the white-throated sparrow. This analysis makes clear that these two cases differ not in the referentiality of the communication, as is often supposed, but in the kinds of designs that are mediated.

INTRODUCTION

Confusions between description and explanation often seem to occur in conversations concerning communication. If we say that a bird's song or a baby's

cry is a communication, are we saying how the behavior came to be? Or are we merely providing a way to classify the behavior, leaving for later the work of explaining it. The view presented in this paper is that communication is a descriptive category and that our first job in doing research on communication must be to identify the formal properties that define it.

For the last two decades I have been developing an approach to the study of animal behavior that I call the natural design perspective. The natural design perspective holds that before we engage in evolutionary, physiological, or developmental *explanation* we must first engage in teleonomic *description*: we must first identify those properties of behavior that demand special explanatory principles. If you drop a dead bird out of a tenth story window, simple physics will suffice to describe the corpse's trajectory. But if you drop a living bird out of the same window, what happens will move you to evolutionary, motivational, physiological, and developmental explanations. Providing a means to describe the special properties of organisms—a *priori* to the *explanation of these properties*—is what the natural design perspective seeks to do (Sommerhoff, 1950).

My basic strategy in developing this perspective has been to turn it loose on problems in the field of animal behavior and show how it helps to rationalize our practices as ethologists, sociobiologists and comparative psychologists. Often in ethology a thread of reasonableness connects our practices but the reasons we give for these practices are incoherent. Looking at the world from a natural design perspective helps to make intelligible many anomalies in the study of animal behavior and evolution. It makes clear why evolutionary explanations of behavior seem so often to be circular (Thompson, 1981) and how these explanations, while rarely strictly speaking circular, are often abused (Lipton and Thompson, 1988). It explains why the idea of a teleonomic science of biology went awry (Thompson, 1987) and it rationalizes the central concerns of ethology (Thompson, 1986) and comparative psychology (Thompson, 1987) as well as peculiarities in their historical development. It points to a defect in how Hempelian explanations are applied to behavior (Derr and Thompson, 1992), even by the master himself (Hempel and Oppenheim, 1948), and shows a way around Brentano's irreducibility thesis in the study of intentionality (Thompson and Derr, 1993). It elucidates what is uniquely puzzling about the natural phenomenon called deception and assists in developing an account of animal/human play (Mitchell and Thompson, 1986). It helps to demonstrate what is and what is not useful about "manipulation" as an evolutionary concept (Thompson and Derr, in press).

Broadly speaking, each of these situations is characterized by a confusion between description and explanation. Many of the key concepts of ethology are ambiguous: do they identify a phenomenon that needs to be explained or do they identify the causes of a phenomenon that has been already identified? For instance, when we say that a structure is "adapted" or a behavior "motivated," are we saying something about its *form* or are we saying something about its

causal history? Knowing the difference is crucial because if we think we have explained—when we have in fact only described—we are left thinking that we know more than we actually know about the phenomenon in question. One of the advantages of the natural design perspective is that it clearly separates as descriptive such concepts as motivation and adaptation and separates them from their associated explanatory concepts, reinforcement and natural selection. Thus, the perspective should be useful in clarifying any theoretical area of ethology where descriptive and explanatory concepts tend to be confounded.

A BRIEF REVIEW OF THE NATURAL DESIGN PERSPECTIVE

In its most general form, *design* is an association between two arrays, an array of structures and an array of uses. The most easily communicated examples are structures of material in space. For instance, consider the design of the tools in a mechanic's toolbox. The box contains specialized instruments, each tool appropriate to one of the circumstances the mechanic encounters, each fitted to the form of a particular type of bolt, screw, socket or fitting. When the mechanic wishes to turn a number 8 Phillips head screw, he reaches for a Phillips head screwdriver of the appropriate size; when he wishes to loosen a 15 mm bolt, he reaches for a 15 mm wrench, and so forth. Watching the mechanic at his work, one might say that a particular wrench is well designed for turning a particular bolt. As design is here understood, attribution of design in this situation means more than saying that the wrench turns the bolt: one can, after all, turn the bolt with pliers. It means that there is in general a relationship between the form of the tools in the box and the circumstances in which they are employed and that the wrench is exemplary of that relationship.

Although the most common uses of the concept of design are to describe a property of human artifacts, not all designed objects are made by humans. Organisms, their behavior, and their artifacts are also designed. *Natural design* is an association between an array of forms of organisms, behaviors, or artifacts and the array of their circumstances. Natural design comes in at least four forms, forms that I have called *adaptation*, *development*, *motivation*, and now, *communication*.

Adaptation is correlation between the form of organisms and their circumstances. If we, like Darwin and Wallace, travel from place to place, studying the form of organisms in relation to their circumstances, we will find correlations between the structure and behavior of organisms and the circumstances under which they live. We speak of an organism as being "adapted," when it is an example of such a correlation. So, for instance, we speak of a polar bear's coat being adapted to Arctic life not just because the polar bear is white and the Arctic is white, but because in general there is a correlation among mammals between

CIRCUMSTANCES	TRAIT
Snow on ground most of year->	White fur year round
Snow of ground part of year->	varying fur color
	<div style="border: 1px dashed black; padding: 5px; margin: 5px 0;"> <div style="display: flex; justify-content: space-between;"> winter -----> white </div> <div style="display: flex; justify-content: space-between;"> summer-----> brown </div> </div>
Snow rarely on ground----->	Brown fur year round

Fig. 1. The adaptation of fur color to environment color.

coat color and environment color, and the polar bear's coat exemplifies that correlation. This correlation we can plainly observe without counting the number of cubs in the polar bear's den, and it is, I insist, what we actually MEAN by adaptation.

Development is correlation between age-specific behaviors and age-specific circumstances in which those behaviors typically occur. Before we say that development is occurring in any individual, we must first have observed in the species of which the individual is a member a typical sequence of behavior traits that are deployed by a growing organism as well as a typical sequence of contexts in which the organisms grow. Development consists in a meshing between these sequences such that a particular behavior is regularly deployed at the time of life when a particular environment is present.

For instance, as a kitten increases in size, it typically deploys different clusters of behaviors: first rooting and groping, then crawling, then walking, then straying short distance from the nest, then approaching strange objects, then wandering farther and farther from the mother and finally hunting entirely on its own. These behavior patterns occur in the face of a gradually altering environment provided by the mother. Early on, she frequently nurses and licks the kittens, assists them in elimination and restrains their attempts at independent locomotion. Gradually, however, she attends to them less frequently, approaches and restrains them less. Ultimately, she begins actually to fend them off when they try to nurse and leads them on extended sorties away from the nest. Each stage in the kitten's behavior is fitted to a corresponding stage in the mother's behavior. What makes the kittens' growth an instance of development is not only that the kittens display stereotyped sequence of behaviors as they get larger or that the environment displays a regular sequence of changes, but that there is a correlation between events in behavior and events in environment such that a particular cluster of behaviors is regularly deployed in each particular environ-

mental circumstance. Notice that as we distinguished between adaptation and its consequences above we here distinguish between development and its consequences. Effectiveness of the behavior in the circumstance is not part of the definition. Young animals often deploy behaviors such as sexual behaviors in circumstances in which they are not obviously effective: they do not bring about their adult consequences. Still, if these behaviors typically occur as part of an age-related sequence of behavior changes that are related to changes in the young animal's environment, they are constituents of development, by definition.

Motivation consists in two nested levels of design. If we study the individual animal in its natural habitat as it conducts its daily and yearly round, we can develop its "ethogram," the catalogue of its behaviors and the circumstances under which those behaviors are deployed. We will discover, in general, at least two levels of correlation in an ethogram. At the first level, is the correlation between the animal's motives and its circumstances. In the prolonged absence of water, the animal seeks water; in the prolonged absence of food, it seeks food; during the appropriate seasonal conditions, it seeks a sexual partner. At the next level of design, each of these motives consists of correlations between the animal's immediate circumstances and the behavior it deploys, each combination of circumstance and behavior increasing the likelihood of the achievement of the animal's purpose. So, in an animal that is seeking food, there is a variety of circumstances, food present, the odor of food present, the presence of stimuli which have been related to food in the past, to which the animal will respond in characteristic ways, ways that all share the property of increasing the likelihood that food will be consumed.

In this usage, the term "motivated" is synonymous with the word "purposeful." In earlier publications, I have avoided the term "motive" because it invites circular reasoning. As the term is often used, the term appears to refer indifferently to the purposive organization of behavior and to the physiological and neural mechanisms that underlie that organization. But it cannot refer to both, because if it does, then the statement that motivation organizes behavior is empirically empty. Thus I have often used the word "purpose" to refer to the formal property of goal directedness that I wish to discuss. Unfortunately, for some, the term "purpose" carries its own unfortunate baggage of referring to conscious intent. Since I have terminological trouble whichever word I choose, I have decided to lay claim to "motive" for my own purposes; i.e., to refer *ONLY* to the goal-directed organization of behavior, and *NOT* to the causes of that goal directedness, whatever they may be.

My conception of motivation is based on Sommerhoff's analogy to a self-aiming gun (Sommerhoff, 1950). Imagine a gun mounted on the prow of a ship. Further imagine that the gun is *designed* to shoot at the target: i.e., there is an array of target positions and an array of gun positions and a function between these two arrays such that the projectile from the gun is likely to strike the target.

Fig. 2. MOTIVATION: A complex two-level design.

Second, imagine a gun that is designed to shoot at surface targets. Once again there is an array of target positions and an array of gun positions and a correlation between them. But the function that connects the two arrays will be different in the two kinds of gun because a surface target is capable of different sorts of motion from an aerial target. For one thing, the trajectory of an aerial object is much more ballistic than that of a surface object. A surface object is much more able to twist and turn because of the greater mass of the material it is attached to.

Third, imagine a self-aiming gun that shoots at subsurface targets, such as torpedoes. As before, there is an array of target position and an array of gun

positions and a function that relates them, and as before, this function must be different because of the medium in which the target is moving. In this case, the function must not only take account of the greater possibilities for evasive maneuver due to the target's contact with the water, but it must also take account of the water surface's capacity to refract light and its capacity to deflect a projectile that approaches at too shallow an angle.

Finally imagine that a military engineer has the bright idea of mounting a single gun on the prow of the ship that can shoot at all three kinds of targets. Guided by a complex computer program, this single weapon could behave in accordance with three different designs: one for aerial targets, one for surface targets, and one for subsurface targets. Each design would relate particular trajectories of the target to particular firings of the gun; and each of these designs would, in turn be related to the type of target. So, the gun would display two levels of design, the lower level that relates trajectory to firing and the higher level that relates the lower level design to target type.

The motivational structure of behavior is analogous to such a multifunction gun. To say that an animal is thirsty is to say that the animal "shoots at water": there is an array of circumstances relevant to water, an array of behaviors relevant to water-seeking, and a function that connects the two arrays such that the animal has a high probability of finding water. To say that an animal is hungry is to say that the animal "shoots at food": there is an array of circumstances relevant to food, an array of behaviors relevant to food-seeking, and a function that connects the two arrays such that the animal has a high probability of finding food. To say that an animal is sexually motivated is to say that the animal "shoots at sex": there is an array of circumstances relevant to sex, an array of behaviors relevant to sex-seeking, and a function that connects the two arrays such that the animal has a high probability of finding a sexual partner.

Of the three, hunger, thirst, and sex, sex is the only motive that is essentially social. Social motives characteristically involve a meshing of the design arrays of the participants: i.e., the behaviors of one participant's design arrays become the circumstances for the others'.

Like the multifunctioned gun, the animal displays a second, higher level of design. At this higher level, the design of the purposive system relates circumstances to the deployment of the lower level designs. Each of its designs, its design for water-seeking, its design for food-seeking and its design for seeking a partner of the opposite sex, is itself matched to a set of circumstances, the absence of water, the absence of food, and the seasonal circumstances appropriate to mating.

This conception of multiple hierarchical layers of design is a useful way to describe many of the phenomena that ethologists and sociobiologists are required to explain.

WHAT SORT OF A DESIGN IS COMMUNICATION?

Communication is a form of design to mediate a design.¹ Thus, for a given act to be a communication between two animals, at least three conditions must be met: (1) One of the animals must have a behavioral design; (2) the second animal must have a structure or behavior that mediates that design; and (3) the mediating structure or behavior must show evidence of design for that role. Cries for help are examples of human communications. When a drowning man cries for help he mediates a design between his circumstances and the behavior of his rescuers. Lifeguards are people whose behavior is designed for the protection of swimmers: that is, they have an array of behaviors that are matched to circumstances in such a way as to protect from drowning the swimmers under their responsibility. They scan the water constantly, they intervene and prevent horseplay and other activities that carry a risk of drowning, they call swimmers from the water who seem to be beyond their depth or endurance, and, if necessary, they enter the water to rescue a swimmer who seems likely to drown. The function of a successful cry for help is to switch the behavior of the lifeguard to behavior appropriate to a drowning emergency, even though the lifeguard herself may not be able to see that such an emergency is in progress. The effect of the call is to invoke the design of her behavior so that her behavior becomes appropriate to the actual circumstances of the swimmer, even if those circumstances are not otherwise perceived. Even though the lifeguard may not be able to see the caller, she still begins to behave as a person in the presence of a drowning emergency.

Because the cry for help mediates a design, it meets the first two criteria for communication. It also meets the third: it is designed to mediate. Crying "Help!" is part of an array of behaviors that a swimmer might deploy upon finding himself in trouble. He might stop thrashing and try to float, he might look around for some sort of floating debris, he might pace himself and try to swim slowly toward a nearby shore. Or he might cry for help. Each technique will be deployed depending on the circumstances of the swimmer. If shore is near, he might swim for it; if a floating buoy is nearby, he might cling to it, or if a lifeguard is nearby, he might call for help. Thus, evidence in the behavior of drowning men supports the conclusion that crying help is behavior that is designed to mediate lifesaving.

By definition, communications always promote the appropriateness of behavior to the situation that obtains. The effect of the cry for help is to correct

a mismatch in the array of the lifeguard. Before the cry for help, the lifeguard was deploying general scanning behaviors, behaviors that were appropriate for a nonemergency situation. But, in fact, an emergency was in progress. Unbeknownst to the lifeguard, a man was drowning. To that extent, the lifeguard's behavior was momentarily ill-designed. After the cry for help, the lifeguard deploys lifesaving behaviors, behaviors which are appropriate for the actual state of affairs.

But not all uses of "Help!" are communications; some are deceptions. A deception is a design to defeat a design (Thompson, 1986).² Imagine that the hollering swimmer is a distant admirer of the lifeguard who wishes to meet her. What if he was only pretending to be drowning in the hope of getting her to swim out to him? In this case, the swimmer's design array would be quite different, an array of techniques for making new acquaintances of which crying "help" in a crowded swimming pool might be one. But the lifeguard's design array would be the same. The only difference for her would be that—prior to the cry for help—her behavior would be in keeping with the actual situation in the water before her. Thus, the effect of his cry for help would be to make her behavior incompatible with the actual situation before her. In this sense, his deceptive behavior is behavior designed to defeat the water-safety design of her behavior, not to mediate it.

Communications can be complex or simple depending on the complexity of the designs they mediate. The example of the swimmer is simple because it involves only two designs: first, the matching between the array of water-safety techniques and the array of water situations that constitutes the lifeguard's design for lifesaving; second, the matching between the array of swimmer's self-preservative techniques and the array of emergency situations that constitutes the swimmer's design for drowning-avoidance. One of the lifeguard's techniques is to respond to cries for help and one of the swimmer's techniques is to call for help. But imagine that our swimmer, instead of just crying out "Help" had called out, "I may be in a little bit of trouble, please keep an eye on me." This example reveals that nested within the technique of calling for help is a possible range of vocalizations, each related to the situation of the swimmer: "Throw me a line" might be appropriate for a swimmer who was experiencing leg cramps but whose arms were OK. "I'm going down," might be the thing to say to elicit an immediate rescue attempt. Choice among these alternative vocalizations has the effect of eliciting a second level of design from the lifeguard: selecting the appropriate rescue technique from among the array of rescue techniques in her repertoire.

¹ By mediate is not meant "negotiate" but something closer to what physiological psychologists invoke when they speak of "mediating mechanisms." An example of a mediating mechanism in this sense is the transmission of an automobile, which stands between the engine of the car and the wheels and mediates the relationship between engine speed and wheel speed.

² Defeat is here used in the sense of "subvert": "I defeated the design of the lawn mower safety power cutoff by tying the dead-man release bar to the handle of the mower with a bit of twine."

DO ANIMALS COMMUNICATE?

From a natural design perspective, animals communicate if their behavior manifests design to mediate design. Their behavior displays design to mediate design if:

- One of the two animals has a behavioral design; and
- The other animal manifests structures or behaviors that mediate this behavioral design; and
- These structures or behaviors are evidently designed for their mediation role.

Many phenomena in animal behavior are communications by this definition. Designs to mediate designs can come in the form of development, adaptation, or motivation. For instance, an example of adaptations that mediate designs are species-specific colorations or behaviors that mediate courtship behaviors in conspecifics. They are adaptations in the sense that each species displays structures or behaviors that are matched to the sensitivities of courtship partners of the same species. They are mediators in the sense that they facilitate a matching between the behavior of the partner and the species identity of the "communicator." They are designed for mediation in the sense that they are suited to the perceptual capacities of the receiver.

An example of developments that mediate designs are age-specific structures or behaviors that facilitate designs of full-grown conspecifics. For instance, many young primates have pelage colorations that change dramatically at the end of infancy. Adults in the troop are designed to behave discriminatively to young animals when they are infants and less so thereafter. The coat change is a developmental communication in the sense that it facilitates a matching between the age of the young primate and the behavior of its fellow group members. It is designed for mediation in that the infant color coat sharply contrasts the infant with the coat colors of the adults around it.

The most interesting and controversial examples of designs to mediate design are those that mediate motivational designs. With the rest of this essay, I would like to consider two sorts of mediated motivational designs: those where the mediated design is to events external to the mediator and those where the mediated design is itself a design of the mediator.

Designs Mediated to Events in the Environment of the Mediator ("Referential Communication")

One broad case of mediated motivational designs are those that manifest a receiver's behavior well-designed for some state of affairs in the world.

CIRCUMSTANCES	TRAIT
Leopard----->	Run for trees
Eagle----->	Look up, run for brush
Snake----->	Stand tall, look around feet.

Fig. 3. Vervet monkey's direct predator aversion design.

the sender or the receiver. This kind of design mediation is best illustrated by the alarm calls of the vervet monkey (Cheney and Seyfarth, 1990). The vervet monkey makes three acoustically distinct alarm calls, one to large predatory mammals such as leopards, one to eagles, and one to snakes. And each call is responded to in a manner appropriate to the predator. Vervets seeing a snake or hearing a snake call, stand tall and look in the grass about their feet; vervets seeing a leopard or hearing a leopard call, run to trees, and vervets seeing an eagle or hearing an eagle call look up and/or run into brush.

There are three designs immediately evident in this situation: between the evasive behavior of the caller and the type of predator (Figure 3), between the communicative behavior of the caller and the type of predator (Figure 4), and finally between the communicative behavior of the caller and the behavior of the hearer (Figure 5). None of these designs seem to constitute communication *per se*.

The effect of these three designs is to mediate a fourth. Together they assure that the call hearer's *behavior* is well-designed for the caller's *circumstances*. (Please see Figure 6.) When the caller sees a snake, the hearer deploys snake-appropriate behavior; when the caller sees an eagle, the hearer deploys eagle-appropriate behavior; and when the caller sees a leopard, the hearer deploys leopard-appropriate behavior. The caller's vocalizations link the hearer's responses with the caller's circumstances. In effect, they "stand in" for the caller's circumstances in producing an appropriate response on the part of the hearer.

CIRCUMSTANCES	TRAIT
Leopard in sight----->	Give "Leopard" call
Eagle in sight----->	Give "Eagle" call
Snake in sight----->	Give "Snake" call

Fig. 4. Vervet monkey's *indirect* signaling design.

CIRCUMSTANCES	TRAIT
"Leopard" call ----->	Run for trees.
"Eagle" call ----->	Look up, run for brush
"Snake" call ----->	Stand tall, look around feet.

Fig. 5. Vervet monkey's call response design.

Thus, the vervet's system is a particularly clear case of "design that mediates design."

But is it design *to* mediate design? Observations on vervets provide two kinds of evidence that its calls are designed for their effects. The first is evidence that "design mediation" is one of a variety of techniques that the vervet monkey uses under various circumstances that have a common outcome. As a social species the vervet has many behaviors that are beneficial to fellow group members and induce them to behavior cooperatively (Figure 7). For instance, vervets not only warn one another, they groom one another, and they collectively mob predators when group members are attacked. That warning behaviors are part of a higher-order design reassures us that they are not simply behaviors that mediate design but are behaviors that are designed to mediate design.

The second kind of evidence that vervets' calls are designed for their effects is evidence that the signalling behavior itself belongs to a class of behaviors that are pitched to the receptor- and response-capacities of their hearers. In other words, we should find that design mediators as a class share properties and are different, as a class, from behaviors designed for their effects on rocks, water, and other inanimate objects. Such differentiation is evident in the calls of the vervet and not in the direct evasive actions of the vervet (Figure 8). The characteristics of displays in general and vocal displays in particular are predictable from the receptor characteristics and perceptual sensitivities of the receiving organism. Because alarm calls share this "hearer friendly" property with other vervet vocal displays, we are led to say that the vervet's calls not only

CIRCUMSTANCES	TRAIT
Leopard present, not visible>	Run for trees
Eagle present, not visible-->	Look up, run for brush
Snake present, not visible-->	Stand tall, look around feet

Fig. 6. Vervet's mediated predator aversion design.

CIRCUMSTANCES	TRAIT
parasites on skin----->	groom
predator at distance----->	deploy design to mediate design (predator calls)
<div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> Leopard in sight -----> Give "Leopard" call Eagle in sight -----> Give "Eagle" call Snake in sight -----> Give "Snake" call </div>	
predator attacks----->	mob

Fig. 7. Vervet monkey's co-group member protection design.

have the effect of mediating a design between the behavior of the hearer and the circumstances of the caller but that they are designed to do so. This second level of design is essential. A deaf monkey might avoid predators appropriately by using the evasive actions of other vervets as cues, but we would not say that the evading monkeys were communicating unless they also provide evidence of design for mediation in their behavior.

This discussion of the alarm calls of the vervet monkey illustrates the basic approach of the natural design perspective to communication. Communication is described in terms of the design arrays of the participants and the manner in which communicative behavior serves to place those design arrays in harmony each other and with the environment.

Designs that Mediate Designs between Social Partners

Many instances of "communication" are behaviors that mediate designs between the behavioral designs of two or more social partners. A simple and familiar example is the song of the white-throated sparrow. The white-throated

CIRCUMSTANCES	TRAIT
Design mediators----->	"receiver friendly": showy bright, loud, tuned.
Other behaviors----->	Not showy, not bright, not loud.

Fig. 8. Design properties of designs to mediate design.

sparrow is said to communicate three sorts of information with its simple song: species identity, individual identity, and motivation. The simplicity and tonality of the song are related to the species identity of the singer, the particular arrangement of tones to the individual identity of the singer, and the length of the song to the motivation to defend the territory (Falls, 1969).

The details of white-throated sparrow territorial defense were unknown to me at the time of writing, so what follows must be understood as a plausible hypothetical. If white-throated sparrows are similar to many other territorial songbirds, they deploy two behavioral designs with respect to territories: one is the design to defend territory and the other is the design to avoid territorial conflict. The design to defend territory consists of a graded series of defensive behaviors each matched to the behavior of the intruder (Figures 9 and 10). The design to avoid territorial conflict consists of a graded series of evasive behaviors, each matched to the behavior of the territory holder. They are matched to clues of the location of the territory holder, including those provided by song. They permit a nonterritorial bird to survive and feed in the interstices of established territories or territorial birds to trespass on the territories of neighbors in search of food, extra pair copulations or other resources without attracting the attention of territory holders. How an encounter goes between a territory holder and an intruder will depend on the designs of the two birds when they encounter one another. If one bird's behavior is designed for territorial defense and the other for territorial conflict avoidance, then the territory holder will chase off the intruder and the interaction will be of short duration. If, on the other hand, both birds' behavior is designed for territorial defense, then there will be a fight and one of the birds will switch over into territorial conflict avoidance design and be

CIRCUMSTANCES	TRAIT
No sign of intruder	Deploy song: i.e., design to mediate territorial conflict coordinate design.
	<div style="border: 1px solid black; padding: 5px;"> attacked -----> avoid approached ----> retreat attacked -----> flee hear song -----> avoid no song -----> forage </div>
Intruder seen near boundary -->	Approach, sing more
Intruder crosses boundary -->	Attack, sing more
Intruder reciprocates attack -->	Escalate attack

Fig. 9. Territorial defense design.

CIRCUMSTANCES	TRAIT
attacked ----->	flee
approached ----->	retreat
hear song ----->	avoid
no song ----->	forage, explore

Fig. 10. Design to avoid territorial conflict.

chased off. Thus, the effect of the fight between the two animals will be to alter the design of one of the two from territorial defense to conflict avoidance design. Imagine a territorial intruder feeding undiscovered on a territory of a resident bird. Unless the intruder is challenging the owner for the territory, his behavior will be designed for avoiding confrontation. The song of the territory holder mediates that avoidance. In the absence of song, the territory intruder might inadvertently create a mismatch between his conflict avoidance design and his actual circumstances by blundering into the territory holder in the thick ever-green forests that the sparrows frequent. Song facilitates a correction of the mismatch by making it possible for the intruder to relate his behavior to the position of the territory holder even when he cannot see him.

RELATION OF THE NATURAL DESIGN PERSPECTIVE TO SOME OTHER CONTEMPORARY PERSPECTIVES ON ANIMAL COMMUNICATION

This redescription of two instances of animal "communication" is meant to demonstrate the potential of the natural design perspective to provide constructive ways of describing complex animal interactions that are not illicitly explanatory. What special advantages can be claimed for the natural design perspective? Here is not the place to provide a thoroughgoing comparison and contrast of the natural design perspective on communication in relation to its alternatives. But before closing I would like to provide a brief sketch of the direction that such an analysis might take.

The natural design perspective will have advantage over its alternatives just to the extent that it helps solve problems in the field of animal communication. What are those problems? They seem largely to be conceptual. Research on animal communication proceeds apace, but the researchers seem unable to

agree on how to characterize the phenomenon they are studying. There are three prevalent characterizations, the information (Smith, 1977), manipulation (Dawkins, 1982), and management views.³ Each has intuitive appeals and each has been heuristic in the sense that it has helped one or more researchers in the pursuit of a vigorous and productive research program.

But all three rely fatally on causal mentalism. The reliance on causal mentalism is not always as obvious as the kind some animal behaviorists have promoted (Griffin, 1976) and others would abjure (Davis, in press). I am not necessarily accusing animal communication theorists of thinking that animals are aware of their own intentions in the way that vernacular psychology suggests that humans are. But I do think all three views invoke a communicator's privileged knowledge of his own mental states as a crucial explanatory link, and that notion is faulted in two fundamental ways (Thompson, 1995).

The first way in which causal mentalism is faulted is that mental states are not the sort of entities that can cause behavior. In principle, causes must be distinguishable from the events they cause. If mental states are to be the causes of behavior then they must be specifiable independent of behavior, and there is no way to specify mental states independently of the relationships between circumstances and behavior that causal mentalists would have them explain. Thus, behaviors are constituents of mental states, not results of mental states, and a state cannot logically be said to cause its constituents (Derr and Thompson, 1992).

The second way in which causal mentalism is faulted is that it requires some sort of inherent privilege in the communicator's knowledge of "own" mental states, and there is no way to be sure that such a privilege exists (Thompson, 1995). The difficulties with the idea of privileged access to own mental states become clear when one thinks about what would be involved in any information-processing system knowing itself. Whatever system one invented to answer questions like, "What am I like?", the system could not answer

questions strictly speaking about itself. It could answer questions about the larger system of which it was part, but these answers would not be infallible.

Reversing the traditional sociobiological flow, I tend to think of individual humans as analogous to organizations, such as, say, The Administration In Washington. Everyday questions like, "What does the Administration think about the situation in the Middle East?" are asked and answered, but such exchanges are shot through with category errors. It is never the "Administration" that actually answers questions about itself but a specialist who is delegated to answer such questions. He reports his own view based on the partial information made available to him. He is not reporting about himself, nor does he have infallible information about the subject of his report. His answer is privileged only in that he is practiced at answering such questions and in that he may—or may not—have better sources of information than those "outside" the administration. Similarly, when you ask an individual to speak for him- or herself, it cannot logically be the individual that you hear from but a specialist subsystem that is designed to speak for the individual. That subsystem does not report about itself nor does it have infallible information about the subject of its report.

The three alternative views on communication vary in the degree to which they take as their point of departure the commonsense view of communication that is embedded in our ordinary language use of the term. The vernacular view of communication holds that the message is something apart from the communication of the message. In some sense we know the message before we communicate it. So, of the vervet monkey, a vernacular psychologist would say, the monkey sees the danger and communicates it with the appropriate call apart from his own reaction to it. Or the white-throated sparrow knows its own territorial motivation and consciously tries to communicate it with the appropriate number of triplets tagged onto the end of its song.

Closest to the vernacular view of communication is the informational view. It holds that the communicating animal is selected or reinforced for transferring information to the receiver about itself. According to this view, the vervet's bark reveals her disposition to flee ("There is a fair probability that I am about to take strong snake evasive action") and the sparrow's song his disposition to attack ("If you fly one more wing beat toward my territory I will come over there and beat the feathers off you"). What distinguishes the informational from the vernacular view is that its adherents can disclaim any implication of conscious intent in communication. They can say that the sender has been reinforced or selected for making this information available, but that it has no conscious intent to do so.

But the implication of privileged access still remains. For information-transfer views of communication to work, the communicator has to know his own dispositions apart from his enactment of them. While information-transfer theorists need not share the vernacular psychologist's view that there is conscious awareness of the information communicated by vervets and white-throated

³ One peril of writing an essay while interacting with such an illustrious company as the authors of this volume is that one may change one's views faster than one can write them down. One case in point is my view of W. John Smith's informational perspective on communication. While I am confident that I have heard many colleagues use the concept of information in the way I describe here, I am less confident than I was two months ago that W. John Smith is one of them. On the one hand, he has specifically and vehemently rejected the mentalistic and commodity transfer implications that I attribute to those who make use of an information account. On the other hand, in my own reading of his work, I cannot myself make sense of it without supplying those implications. Since deadlines made it impossible for Professor Smith and I to meet to sort this issue out before publication of this essay, it is my deep and abiding hope that some philanthropist will invite us (along with all the authors of this volume and any of our devoted readers who would care to come along) to some gracious Italian lakeside, some stark Austrian eyrie, or some luxurious Caribbean villa so that we may have appropriate surroundings in which to take on the painful labor of coming to an agreement on the many issues raised by this volume.

sparrows, they do imply that the communicator has accurate knowledge of self that may be communicated. This is essentially the doctrine of privileged access.

Dawkins' manipulation view starts out as an attack on the information-transfer view of communication. It takes as its model a dung beetle's pushing around of its bit of dung (Krebs and Davies, 1978). When animals interact, said Krebs and Dawkins, they are no more "communicating" with one another than a dung beetle is communicating with a dungball it rolls into its burrow. Just as the dung beetle uses the properties of the dungball to its own advantage, so communicating animals use each other's properties to their own advantage. The only difference is that in the case of the dung beetle the properties used are physical properties whereas in the case of the communicating animals, the properties used are properties of the nervous system.

But the dung beetle image is one of those aggressively reductive images that fails to stop the argument because it fails to address the issue the argument is about. When we are talking about communication we are trying to distinguish those properties of the behavior we are calling communicative that distinguish that behavior from rolling dungballs. The fact is that the rules of rolling a dungball and manipulating a nervous system are different and no account of the behavior we call communicative that does not characterize those differences will be very useful. Characterizing those difficulties requires considering how organisms differ from dungballs and such a consideration leads directly to the issues of design raised in this paper. One way out of this quandary is to assert that the crucial difference that a nervous system makes between a dungball and an organism is just that nervous systems are information processing systems and, therefore, if one would manipulate a nervous system, one would best do it by providing INFORMATION. But this "way out" leads directly to the information-transfer view that I have just discussed and that the manipulation theorists currently under discussion have ridiculed.

Dawkins and Krebs became aware of this problem and extended (1984) their notion of manipulation to include a special kind of manipulation relevant to the communication situation—manipulation by failing to disclose information. They treat the signaler as analogous to a poker player deciding to deploy a poker face (p. 397). But to make this idea meaningful we have to imagine that the animal has privileged access to his own intentions. And as I argued above, and elsewhere there is no particular reason to believe that the sender has information about what he is disposed to do that is *in principle* better than information possessed by his antagonist.

Of the three views of communication, the assessment/management perspective (Owings and Hennessey, 1984; Owings, Swaisgood, and Rowe, 1994; Rowe and Owings, 1990; Owings and Morton, this volume) is the natural design perspective's most formidable competitor because it comes closest to avoiding explanatory mentalism. It does so by employing an extension of the idea of homeostasis. Both participants in an interaction are viewed as creatures attempt-

ing to maintain critical variables within acceptable limits. The feedback loops that accomplish these ends may be narrower or wider. They may extend only to the reserves of the creature, or they may extend out into physical world around the creature, or they may extend still further into the social world of the creature. So, for instance, a hungry infant animal may manage its blood sugar account by metabolizing some starches, or by eating some foodstuffs that are to hand or by crying out until an adult animal brings it food. The signals of the crying infant work only because adults in its vicinity are constantly assessing its degree of need. Because the effectiveness of a communication presupposes another individual who is attempting to assess variables revealed by the communication, the view is called the management/assessment view. Of the three competing models, I am most attracted to the assessment/management perspective, perhaps because it is the only one of the three that is rooted primarily in physical imagery rather than in psychological imagery. But its weakness, from my point of view, also arises directly from this strength. Organisms differ from physical systems precisely in their possession of higher-order properties that I have called design. While many physical buffering processes serve to control variables in nature within limits, these physical processes aren't designed to do so: they just do. In the example of the baby above, the baby's cry does not simply control its parents, it is designed to do so; and the parents do not simply assess the baby's food state, they are designed to do so. And no account of the relation between them will be complete until this mutual design is described (Watson, 1995).

Moreover, the proponents of the M/A view have flirted with explanatory mentalism in the development of their perspective. Owings and Morton (present volume) reintroduce the concept of information in the course of their characterization of assessment because they feel that gathering information about states is the essence of assessment. But this extra grammatical level—"about states"—is entirely unnecessary. These authors would not feel that they had to introduce that extra step into an account of the monitoring of blood acidity by the carotid sinus: they would not feel that they needed to say that the carotid sinus gathers information "about" blood acidity; they would say only that the carotid sinus assesses blood acidity. So why do they feel they need to say, for instance, that the displayee monkey monitors information "about" the displaying monkey's probability of attack? Why can't they say that one monkey assesses another's probability of attack?

In response to these criticisms, Don Owings (personal communication) has argued that the natural design perspective on communication has its own weakness. In a commentary on an earlier draft of this manuscript, Owings suggested that there are many instances of designs to mediate design that I would have to recognize are *not* communications and therefore that my criterion is inadequate to pick out accurately only instances of what I would call communication. The example that he offered was of a parent carrying a child to the dinner table. The child is presumably designed to respond to the sight and smell of food by eating

and the parent's act is designed to create the conditions to realize that design. The problem is not limited to one guilefully contrived human example. I can add many ethological examples, such as a mother stroking her baby's cheek with her nipple in order to induce nursing or a lamb's butting his mother's teats in order to induce milk letdown.

The objection is troubling, but I think it can be dealt with by insisting on a precise understanding of what it is for a process to mediate between two other processes. The word "mediate" is often wrongly used to mean "facilitate" or even simply "elicit." Its precise meaning is "to set up a relation between." The parent who moves the highchair or the mother who strokes the baby's cheek or the kid that butts his mother's flanks are all examples of behaviors that elicit a design, but except as these acts may be considered to be communications, they do not *mediate* designs. The intuition that all three examples capitalize on is that it is possible to elicit designed behaviors from another creature without communicating with it. But there is an important difference between eliciting designed behaviors and mediating a design. To be a mediator, a process must "stand in" for another process, in the way that the vervet's snake vocalization "stands in" for the snake in producing snake avoidant responses in hearers of the "snake call."

WHY THE NATURAL DESIGN PERSPECTIVE IS PREFERABLE

The basic value of the natural design perspective is that it provides a rich language for the description of social interactions that will substitute for and make unnecessary the use of intentional idioms in the study of animal behavior. Intentional idioms are expressions that contain a proposition about the world as the object of a mental verb such as wanting, knowing, believing, thinking and informing. Intentional idioms are an essential feature of causal mentalism since the mental terms that govern these idioms appear as causes in mentalistic accounts of behavior. The difficulty with intentional idioms is that the propositions they contain display two odd properties: existential inexistence and referential opacity (Thompson and Derr, 1993). If we say that Jones is human, we are prepared to commit ourselves both to the proposition that Jones exists and to the proposition that Jones has all the properties of a human being. But if we say that Smith thinks that Jones is human, we are not prepared to make either of those commitments because Smith may have imagined Jones and/or Smith may not know all the properties of a human being. In short, the line between intentional and unintentional idioms is important because the possibilities of inference that arise from the propositions that appear within intentional idioms are very different from the possibilities of inference that arise from propositions made outside such idioms.

The differences in the possibilities of inference are crucial because science can only work with propositions that make possible substitution with truth. To take a clear contemporary example of scientific progress, one way of understanding the progress that has been made in our understanding of AIDS in the last decade is that we have been able to substitute more accurate descriptions of the agent that causes the disease. In the first place, when the disease first thrust itself upon our consciousness, we weren't sure what sort of an agent it was: environmental, bacterial, or viral. Once we knew it was a virus, we had to learn what sort of a virus it was. Nowadays, we are able to describe it as a very specific virus with a unique reproductive strategy. All the way through this latter process of specification, we have been able to make substitutions of the new information into our causal account while preserving the truth that HIV causes AIDS. How much more difficult to do science around the proposition that the American public believes that HIV causes AIDS! While we might hope that the American public would change its behavior as scientific knowledge about the virus changes, we can never predict that outcome in the scientific sense because we cannot confidently substitute into the statement "the American public believes that HIV causes AIDS" all the new descriptions of the AIDS virus that science has achieved. We cannot, for instance, infer that the American public knows that AIDS is caused "by an RNA virus with a conserved reverse transcriptase enzyme" because we have no way of inferring how much the American public knows about the new discoveries. Thus, as they are usually construed, intentional idioms such as "beliefs that," "knowledge that," or "information that" have no place in the scientific explanation of behavior.

These problems are difficulties not only for contrived human examples but also for describing the behavior of real animals in real situations. For instance, if a vervet gives an "eagle bark" and the other vervets leap for the bushes, then in the absence of the natural design perspective, we would have to choose between two undesirable descriptions. Avoiding intentional idioms, we could say that "eagle barks" are sounds that occur with high relative frequency in situations where a vervet begins to orient toward an eagle and are followed by a high frequency of eagle escape behaviors both in the caller and in animals near enough to hear the bark. Or adopting intentional idioms, we could say that "eagle barks" are given by vervets to inform other vervets that there is an eagle present. The first description fails to communicate the organization of what is taking place and the second opens us up to all the perils of explanatory mentalism. The whole trick of the communication debate seems to be to discover if there is anything of scientific value in the second account that is not in the first, or, perhaps more specifically, which of the things that the second account adds are scientifically valid.

Two things that the second account clearly adds are referential opacity and intentional inexistence: Nothing in the vervet's eagle bark assures either that an eagle exists or that the calling vervet is trying to inform other vervets that a

member of the species *Stephanoaetus coronatus* is approaching. After all, the caller may be a juvenile misapplying the call or an adult abusing it and, in any case, we cannot expect that the caller has read up on his avian taxonomy.

Consider another example. If a macaque gives an open mouth threat, other macaques in the troop may attack or retreat depending on their relative dominance and who else is within reach that might help or oppose them in the altercation. A nonintentional account of these facts is that open mouth displays in macaque monkeys are followed with high relative frequency by attacks or retreats from monkeys toward which the threat was directed depending on their relative dominance. An informational account might be that the displaying monkey is informing the displayee that if the displayee takes another step forward the displayer has a high probability of beating the tar out of the displayee. The informational account once again adds the perils of intentionality: nothing guarantees that any such probability exists and nothing guarantees that the caller will beat the tar out of an animal that is the most recent grooming partner of the alpha male in the troop because the displayer may be wrong about his own probability of attack or so ignorant of the recent grooming history of the displayee as to know that that animal is the "most recent grooming partner of the alpha male of the troop."

The effect of introducing intentional language is to introduce a whole set of pseudoproblems about a commodity called "information" that is moved around when animals interact. People who talk about information transfer in animal interactions are not the first people to be accused of commoditizing interactions. In the late 1970s, the anthropologist Roy Wagner, *The Invention of Culture*, ridiculed the concept of culture as a commoditization of human interactions. He argued that culture was invented when 19th-century Western anthropologists encountered preliterate peoples and attempted to describe what they saw. Because of the societies from which they came, these anthropologists fell back on the imagery of the industrial life. They saw the preindustrial people as engaged in developing, manufacturing, and ultimately trading a product. That product was "culture." But of course, that product was an invention of the anthropologists. The peoples they studied, Wagner argued, were not engaged in any way in the project of developing, manufacturing, or trading their culture. The culture was simply a way of viewing the patterns of interaction among them. And the focus of anthropologists on culture caused them to neglect the description of human interaction for arguments concerning the origins of the structures that underlie the culture.

Similarly, the concept of interaction transfer can be seen as a commoditization of animal interactions. When we ethologists encounter nonhuman animals and attempt to explain what we see, we fall back on the imagery of economic life. We see the animals as acquiring, transmitting, and receiving a product. That product is information. But, of course, that product is an invention of ethologists. The creatures we study are not engaged in acquiring, transmitting, and receiving

information. Communication is simply a way of characterizing the patterns of interaction among them. And the focus of ethologists on communication as a commodity transfer has caused them to neglect the description of animal interaction for arguments concerning the nature of the information that is transmitted in communication, where that information is before it is communicated, and other forms of silliness.

Given the downside to the information account, why do people use it? What are the benefits of introducing intentional language? Why is the correlational account inadequate? One inadequacy is that the correlation account leaves out a level of organization in the behavior. It's not simply that the calling vervet is responding in the presence of the eagle and the hearing vervet is responding to the calling vervet; the whole system seems to be organized to assure that the hearing vervet avoids eagles that the calling vervet sees. Similarly, it's not just that the displaying monkey responds to the displayee's proximity by giving the open mouth display and the displayee responds to the display by retreating or advancing, depending on the dominance situation; the whole system seems to be organized to assure that the displayee avoids an attack that the displayer's behavior foreshadows.

The informational account captures this higher level of organization by representing the caller vervet or the displaying macaque as attempting to inform and the hearing vervet or the displayee monkey attempting to gather information. But it pays, as I have argued, a terrible price of introducing a whole clutter of phantom issues.

So, the challenge for the future of the study of animal communication is to provide an account that captures that higher level of organization in animal interactions without the disabilities of the informational account. That the natural design perspective can accomplish this trick is what makes it preferable to other contemporary perspectives. Two heuristic consequences will flow from thinking of communication as a form of natural design: i.e., as a formal property of behavior, not as an event that explains behavior. First and foremost, it will turn attention away from phantom causes and commodities—away from what the animal is thinking or what information is being conveyed—and toward describing the patterns in the behavior that we can actually see. Second, it will postpone for the time being questions of selection. For most ethological purposes, selection on communication is a largely a hypothetical entity that is revealed only through its proposed effects on the patterns of behavior we observe in nature. Most of what we know about selection on communicative behavior is inferred from how that behavior is designed. Until the designs we call communicative are well described, invocation of selection to explain them is largely premature. How can we hope to bring natural selection to bear to explain a phenomenon before we have thoroughly described and identified the phenomenon we are explaining?

If the natural design perspective were to be widely and self-consciously adopted then all research on animal communication would have to be grounded in comparative study of ethograms—the sort of work that Niko Tinbergen did, for instance. Laboratory work would have to be closely coordinated with observation in the natural habitat. And less effort would be expended on models (they can, after all, always be made to work) and in the search for the crucial experiment or anecdotes (all experiments and anecdotes can, after all, be reinterpreted). Our understanding of animal behavior would arise only from the broadest possible description of the varieties of behavior that animals deploy and the circumstances under which they are deployed, and the relationships between them—i.e., in the study of the varieties of behavioral design.

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