edited by
Carolyn A. Ristau

cognitive ethology

the minds of other animals

essays in honor of
Donald R. Griffin

COGNITIVE ETHOLOGY

COMPARATIVE COGNITION
AND NEUROSCIENCE

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COGNITIVE ETHOLOGY
THE MINDS OF OTHER ANIMALS

Essays in Honor of
Donald R. Griffin

EDITED BY
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PREFACE

This book is dedicated to Donald R. Griffin. He has been a teacher, a colleague, and a most perceptive friend to those of us who have had the very fortunate opportunity of working with him. His creativity and infectious enthusiasm coupled with his wary critical faculties, have made him a formidable scientist.

He is the scientist who demonstrated that bats navigate, even find minute prey, by very high pitched sound waves (sonar)—a seemingly mysterious sense, insensible to humans that Don Griffin investigated with diligence, intuition, and new technology. He likewise probed bird navigation through heavy cloud conditions in which the normal visual cues that might guide the birds are not available. By using tracking radar, he determined that migrating birds, although they usually attempt to avoid flying blind, can nevertheless orient correctly in clouds. The sensory basis for this ability still remains in large part an unsolved mystery.

It should not, therefore, be considered out of character for him to have explored and inspired others to explore yet another realm, out of the ken of the usual—animal cognition and mental experience. He created the field of cognitive ethology, an exploration of the mental experiences of animals, particularly as they behave in their natural environment in the course of their normal lives. The field had its beginnings in areas such as comparative psychology, classical ethology, laboratory experimental psychology, and philosophy of science.

So we present this set of papers in his honor. The collection does not pretend to be a broad sample of the researchers studying animal cognition. It is instead, in part, contributions from scientists who have been associated

with or simply influenced by him. But it is fitting to his character that this collection is not the usual Festschrift. It is a lively array of views, some quite disparate from each other and some especially selected to present approaches at variance from his by scientists not associated with him. The papers derive from a symposium in animal cognition at the Animal Behavior Society (ABS) meetings in Williamstown, Massachusetts in June 1987. It was an extremely lively session with long periods given to interchange between the audience, discussants and presenters of papers.

The mere scheduling of such a symposium was interesting and important. In prior years, the Animal Behavior Society meetings, though presenting many areas of research in animal behavior, rarely covered the area of animal cognition. This symposium was a day-long event. The following year brought yet more presentations dealing with both animal cognition and issues in communication not often tackled by researchers. As a consequence of the ABS meeting, at the International Ethological Conference in Wisconsin during the summer of 1987 a special lunch session in animal cognition was convened to continue spirited discussion.

The contributions have, to the editor's delight, further developed from the presentations at the symposium as the participants continued to wrestle with the issues. The papers are indeed representative of a burgeoning new field and can each be appreciated in a different light. Recognizing that in new areas of research, there is unlikely to be much theoretical structure to guide the way, some urge investigation into unexplored areas, posing new questions of animals, and allowing for the possibilities that animals may have abilities to experience, communicate, reason, and plan beyond those usually scribed to them in a "black box" or "stimulus-response" interpretation. Donald Griffin moves strongly in that direction. However, he and all the other contributors to this volume urge caution in our interpretations. Part of the exploration involves using data that have often been disregarded and/or are unavailable in published form; different researchers may not have gathered them in systematic and similar ways. The reporting of events that only happened once or a few times is a most important example of this, as noted in this volume by both Jolly and Ristau. Alison Jolly cites unique instances of deception and planning collected by researchers such as de Waal studying chimpanzees.

Researchers are also encouraged to look to existing theories and push them as far as possible. Yoerg and Kamil, for example, enjoin cognitive ethologists to utilize the concepts from human cognitive psychology.

New endeavors are underway in the use of what are generally known as folk psychological terms such as *want* and *belief*. In response to these approaches, some urge us to worry about the possible pitfalls that might emerge with their use by researchers in other disciplines. George Michel, for example, discusses difficulties with the folk psychological approach as it has been used in developmental psychology.

Yet another response is to stand firm and retain and continue to use the terms that seemed to suffice in the past and not get lost in mentalism. None of the contributors have quite this view, although others in biology, psychology, and ethology certainly do.

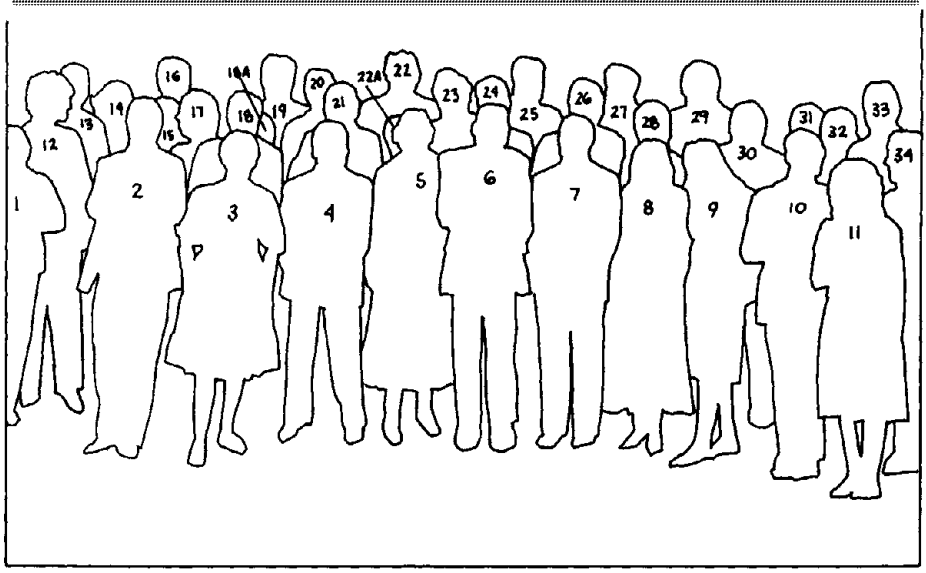
Some, noting the need for conceptual clarification in theory, have contributed to this development. Colin Beer has traced the historical and conceptual evolution of philosophical ideas central to cognitive ethology; the philosopher Jonathan Bennett has further developed the belief-desire-behavior approach of folk psychology to include an emphasis on the context and environment.

Finally, a number of researchers have concentrated on reporting new empirical research findings from laboratory and field work involving animal communication, cognition, and mental states. They also note possible limitations.

In one way or another, each contributor usually emphasizes the need for empirical data. However, each researcher also points out that the others may not be sufficiently concerned about the limitations of their results and the appropriate interpretations to be drawn.

I have probably expressed the concerns and points of view of the authors more mildly than the authors themselves would have. Yet they are all reasonable concerns and contributions. Let us continue the dialogue, remain open-minded, and allow and encourage a diversity of approaches to cognitive ethology.

So we welcome you, the reader, to this most unusual Festschrift. It is not a collection of chapters that praises all of Donald Griffin's ideas, but rather in the true, intellectual, critical, and scientific spirit, this volume presents ideas and experiments that have been stimulated and provoked by Donald Griffin's work. We hope it will stand as a fine tribute to him.



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REMINISCENCES

We planned a surprise celebratory dinner for Don Griffin (DRG) in Williamstown after the Animal Cognition symposium and before the next day's more general symposium in his honor. Several people gathered the names of all the persons we could recall who were students or close associates of Don Griffin. In particular, Ron Larkin, now of the Illinois State Natural History Survey, worked with me, but Timothy and Janet Williams of Swarthmore College helped as did Roger Payne. As I remember, Roger both initially suggested and helped persuade Donald Kennedy, a former student of DRG's and now President of Stanford, to be the Master of Ceremonies for the evening (a great choice!). Don Kennedy's advice: Keep the talks about Don Griffin short, funny, and not too sentimental.

So we were in cahoots—Cheryl Szabo, Don Griffin's secretary; Jocelyn Crane Griffin, his wife; and myself, his research associate. That year Don had already "retired" from Rockefeller University (would that some of us in our prime could get done what he does in his "retirement"), and I was teaching 90 miles away at Vassar College. Don's secretary, whose services I was always permitted to use, had secret files on her word-processing disk with addresses of the dinner guests, menu choices, and so forth. My daughter and her best friend were pressed into service addressing mounds of envelopes in 11-year-old scrawls. Sometimes in the midst of deciding between a banquet menu with Breast of Chicken Divan or Veal Cutlet Cazadora on it I thought of the papers I should be writing, but realized in a sense that all this was far more important. His ever efficient, now retired secretary of 17 years, Roseanne Kelly, was the first to respond, though unfortunately unable to go the long distance and attend.

Don said it *was* a surprise, although he did wonder about a sudden influx of letters wishing him well from old friends (those unable to attend the celebration). During the evening of the event, one incident did suddenly rouse his suspicions. Instead of leaving for the restaurant Jocelyn had arranged for their dinner, he suggested another, which encountered somewhat overheated resistance from Jocelyn—a most peculiar reaction by his wife, he thought. When Don Kennedy arrived at the dinner, having flown in that afternoon from meetings with congressional members in Washington D.C., Don Griffin *was* surprised—he had to sit down for that one. All were placing bets as to arrival of Roger Payne, of humpback whale song fame. He did arrive, having flown in from England and the International Whale meetings, slightly detouring to Williamstown, Massachusetts on his way to Russia.

So we told stories on Don Griffin, all remembering him fondly and recalling with some trepidation those pencil marks and questions that covered the sheets of our manuscripts that he had reviewed for us. The evening *did* produce funny stories. I relate several, adapted from those after-dinner "speeches."

In the late 1960s and early 1970s, many young colleagues were swept up in DRG's project to learn whether birds could maintain oriented flight inside or between clouds, without any visual reference. They wanted to discover the answer by playing with a new toy—a 1-ton, military surplus tracking radar. At that time the operation was based at the Institute for Research in Animal Behavior at the New York Zoological Park in the Bronx. The radar unit and associated paraphernalia were towed on several trailers into nearby rural areas to gather data and then return back to the Bronx Zoo afterward. (DRG called these "forays" or "sorties" more out of natural vigor than because of the heritage of the radar.) Zoo vehicles with the famous ram's head emblem towed two heavy trailers in convoy, while DRG's small green Rambler station wagon usually towed the third trailer. It was a special Griffin-designed mobile hanger for large helium-filled kite balloons, with a huge (Griffin would say "great") volume resting on a lightweight structure and minuscule wheels. On one such trip the graduate student driving the middle vehicle noticed a somewhat bewildered coin-taker at a toll booth leaning out to get a better look at the radar being hauled behind the frontmost zoo vehicle. The temptation was irresistible. The student pulled up in another zoo vehicle and aswered the man's questioning look by pointing back to Griffin towing the bulky balloon trailer, announcing, "he's got the hippopotamus," then driving away. Opportunities for that kind of fun kept DRG's sorties populated with volunteers.[1]

[1]This anecdote is written by Ronald Larkin (Illinois State Natural History Survey), previously a graduate student and then a postdoctural fellow with Donald Griffin.

Those who know him will attest that Don Griffin is a "gadget man." José Torre Bueno, now in San Diego, California, was a graduate student during those times of bird migration studies with the old surplus army radar unit. His wife Susie was helping on the project, wrapping endless quantities of foam balls in aluminum foil ("Susie balls"). These, when attached to huge red helium filled balloons, were used with the radar to determine wind velocity for comparison with the migrating birds' speed.

José remembered one of the more lighthearted occasions of equipment malfunction in the lab. Don was soon due to be checking a recalcitrant piece of gadgetry. "Hmm . . ." noted Beverly Greenspan, another graduate student compatriot, "The black insulation covered BNC cables don't look all that different from licorice strings . . . do they?" So José and Beverly gleefully exchanged a licorice connected cable for a more ordinary one on the equipment. Then they left for lunch in the cafeteria where Don was going to meet them after working in the lab. He arrived to join them at lunch. They waited expectantly. No comments. They rushed back to the lab. The licorice connectors were now neatly labelled "bad cable." Again DRG had the last laugh (A more recent accounting suggests maybe he didn't that time. As DRG recalls the incident, he's not sure he ever realized why it was a bad cable.)

Don Griffin also manages to have the requisite calm and aplomb when the occasion demands. Don was once demonstrating his bat echolocation experiments to distinguished foreign visitors (Marie-Claire and René-Guy Busnel). Part of the visit took place in the backyard of Kenneth Roeder, who was doing electrophysiological studies of moth's hearing, particularly their response to bat vocalizations. Griffin had with him a slingshot, which he used to throw pebbles into the air a couple of meters in front of a bat, so as to elicit insect pursuit maneuvers. So Griffin took careful aim and shot off a pebble. And . . . to the surprise of all, it hit the bat's flight membrane. The Busnels were much impressed by this cowboy American field biologist, who hit a bat at first try from 10 or 15 meters. As DRG notes, he made excuses so as not to have to use the slingshot again. What the humans didn't realize at the time was that bats actively reach out with their wing membranes to catch insects (and flying pebbles).[2]

There was the occasion of live bats on TV, WGBH-TV then being a fledgling one-room studio in Boston. As Charlie Walcott (Cornell University) reports it, Don Griffin, at that time a Harvard Professor, was asked to demonstrate the echolocation ability of bats. He arrived with mounds of

[2]This episode is described in more detail in Griffin, D.R. (1980) The Early History of Research in Echolocation, Busnel, R.G., & J.F. Fish (Eds.), *Animal Sonar Systems*. New York and London: Plenum Press, p. 5–6.

equipment and live bats which were released and, on live TV, flew as they ought around obstacles. But they didn't fly back to their cages and were resolute about not being caught. So the evening news came on next as scheduled and the newscaster Louie Lines reported the world's events surrounded by bats on the wing.

Roger Payne too had tales of bats and equipment. One hot July night he and DRG were loading an incredible amount of equipment for a bat sonar experiment onto a truck, feeling most sweaty, but quite pleased with their efforts and their gadgetry. The botanist William "Cap" Weston was walking by and was called over by them for his comments. Weston looked for a long time and then is reported to have said "I am reminded of the ancient recipe for Welsh hare. First catch ye hare." It did indeed take the next three weeks to find a place to get the proper bats and setting for their research. But all *was* finally successful as it so often turns out to be with DRG.

Success typically results from much preparedness for diverse contingencies. Don's wife Jocelyn Crane Griffin recalled a trip to Italy with Jim Simmons (Brown University) to study bats. None of them spoke Italian, so the task of translating fell to Jocelyn, dictionary in hand, a set of sentences to be used during various emergencies. She particularly remembered contingency plans for use in the case of a farmer becoming irate as he approached his house and saw a long ladder leaning against it with a strange man halfway up the steps. The man on the ladder was to say in Italian, "Oh sir, I have not come to elope with your daughter. I just want to look at your bats."

But there were also occasions when Don Griffin was not adequately prepared. Jocelyn retold Don's recollection of a summer day in Cape Cod when he was a teenager. He had taken out his own sailboat and was teaching a younger boy how to sail, but weather conditions were not ideal. A strong squall blew up with rain, lightning, and much wind. A neighbor saw him as he was sailing in and shouted, "Call your mother; she'll be so worried." Don replied, "No she won't, she doesn't know I'm out. She knows I have too much sense to be sailing in this sort of weather."

Don always managed to be in the right place at the right time. Robert Seyfarth (University of Pennsylvania) noted the time Don Griffin stopped by on his travels to visit him and his wife Dorothy Cheney (University of Pennsylvania) at their vervet monkey site in Kenya. They all had the extremely rare opportunity to have an excellent vantage point to observe simultaneously five lionesses engaged in a finely coordinated cooperative hunt. That observation (of what seemed to be planned by the lionesses according to Don) has since been described in his book *Animal Thinking* and in the New York Times. Immediately afterwards, recalls Robert, Don leapt out of the car and said "This is it! They've got to be aware of what's

going on!" Robert, not quite so oblivious to other possible eating habits of the lionesses yelled, "Get back to the car!" Presumably he did.

I recalled his most apt and genteelly presented advice, often what one *needed* to hear, if not what one *wanted.* It was during my first field season studying piping plovers on a barrier island off the coast of Virginia. I used an inflatable boat which I navigated through the marshes each day, loaded high with all the necessary and possibly necessary equipment for the day. Once as I was leaving the island to avoid an approaching storm, the tide was turning, the boat was full, the wind was rising and the overladen boat took on salt water. But all was safe in the watertight containers . . . except one container turned out not to be. So the video recorder was no longer functioning. Don Griffin, hearing of the event from me, said he'd send on some informational material for me about boating. He'd already piled me high with manuals on the intricacies of battery functioning, and scientific treatises on coastal ecology and flora and fauna, so I expected another technical manual. Instead, the "manual" arriving along with my new assistant, Laura Payne (daughter of Katy and Roger), was Michener's *Chesapeake.* Underlined was a section in which a headstrong, adventurous lady, mother of several children, ignoring advice from those around her about the vicissitudes and fury of the Chesapeake Bay weather, went off in her boat. She was later found dead in the storm-wrecked boat, long brown hair streaming, children now orphaned. Lesson understood—I didn't even go out in the slight drizzle the next day, much to Laura's frustration. (And my children are still not orphaned.)

Many of us recalled frequent conversations over lunch with Don Griffin and remembered his enthusiastic interest in so many topics. Roger Payne, for instance, recalled his first meeting with DRG. "It matters a great deal to me what a person is like," noted Roger. And here in DRG was a person totally interested in what he was doing: Roger volunteered to work for him. Gordon Burghardt recalled his year at Rockefeller shortly after DRG's first book in cognitive ethology, *The Question of Animal Awareness* (1976). Gordon had come to work with both Don and Carl Pfaffmann. At the time Gordon was studying multitudinous aspects of the behavior and olfactory capacity of snakes with a special interest in his two-headed snake. Gordon recalls Don's immersion in all kinds of research literature and papers from a far-flung cadre of correspondents and Don's continuing interest in animal awareness, thinking, communication, and consciousness. All the while Don maintained his research with students on bird migration, infrasound and bee dancing. For Gordon this year was fundamental in his continuing interest in the cognitive revolution in ethology and psychology.

A constantly recurring theme among those who had worked with Don Griffin, expressed spontaneously over and over, was the respect each of us

held for him and the respect he held for us; he encouraged our own individual interests and concerns. To each of us, Don Griffin was a gentleman. And each of us recognized it was a special privilege to have been associated with him. Using Roger Payne's words for us all, our "affection and admiration for Don is quite immoderate."

Compiled by Carolyn A. Ristau

PART I:
THEORETICAL PERSPECTIVES

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1 PROGRESS TOWARD A COGNITIVE ETHOLOGY

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ABSTRACT

The investigation of animal cognition and mental experience is beginning to reveal that animals guide their behavior by surprisingly complex thinking. The versatile adaptability of some animals in the face of unpredictable challenges suggests simple conscious thinking about alternative actions and their probable results. When animals communicate with each other, their communicative signals may provide objective data about their thoughts. Although this "window" on animal thoughts may not be ideally transparent, it can help us to escape from the lingering inhibitions of behaviorism that have impeded research into animal minds. Simple conscious thinking may be an efficient and economical mode of operation by which the central nervous systems enable animals to cope with the multiple problems of finding food, avoiding predators, finding mates, and raising young. If so, it may be most advantageous for animals with small brains.

Cognition and conscious thinking by nonhuman animals present a variety of exciting and significant research challenges for scientists concerned with animal behavior. The extent to which animals think about what they are doing and about the behavioral choices they make is a highly significant attribute that must be understood before we can fully appreciate what it is like to be a certain type of animal. We don't yet know much about this subject, and until quite recently we have been reluctant even to think about it, let alone study it. This is changing, however, and the number of papers devoted to cognitive ethology at the 1987 meeting of the Animal Behavior Society reflected this rekindling of interest. Animal cognition is now a

recognized scientific subject, and several books and symposia have recently been devoted to this topic (e.g., Griffin, 1984; Roitblat, 1987; Roitblat, Bever, & Terrace, 1984; Walker, 1983).

Many students of animal behavior are concerned not only with what animals do, but also with the cognitive processes within their central nervous systems that interact with sensory information to produce the observed behavior. Nevertheless, many of us still hesitate to consider the possibility that some animal cognition may also entail conscious awareness on the animal's part. Contemporary behavioral scientists tend to limit their investigations of animal cognition to patterns of information processing within the central nervous systems of the animals they study and ignore the possibility that subjective mental experiences may occur and may influence behavior. This reluctance to consider subjective mental experiences, so clearly expressed by Yoerg and Kamil in this volume, may result, in part, from unrecognized vestiges of behaviorism that inhibit inquiry—even when we believe we have recovered from the negative dogmatism of strict behaviorism. We tend to find the notion of conscious awareness disturbing and struggle to find ways of analyzing animal behavior without allowing what seem like subversive notions of subjectivity to get a foot in the door. But Radner and Radner (1989) have recently explained how insubstantial a philosophical basis underlies this widespread antipathy to animal consciousness among behavioral scientists. Cognitive ethology should certainly include, but not be limited to, information processing in animal brains.

DEFINITIONS

One reason for avoiding the question of animal consciousness is a feeling that it is too vague a subject for scientific investigation because we lack objective criteria by which to judge whether an animal is conscious. Although we all know in a rough and general way the sorts of things that are meant by thinking and consciousness, these meanings are multiple; they do not refer to homogeneous categories. Given the variety of phenomena and processes that the word *thinking* calls to mind, it seems premature to expect a unitary definition as a prerequisite for scientific investigation. Because we remain almost totally ignorant of the neurophysiological basis of either conscious or unconscious thinking, we cannot define thinking in as concrete terms as molecular geneticists employ when defining genes in terms of DNA. Other widely used terms, such as *learning, motivation,* or *metabolism* are also resistant to rigorous definition; but this has fortunately not prevented effective scientific analysis of the phenomena described by these terms. It is therefore neither necessary nor advisable to become so

bogged down in quibbles about definitions that the investigation of animal cognition and consciousness is neglected altogether.

I suggest that we cope with the difficulty of formulating wholly satisfactory definitions by employing the same basic procedure that has proved fruitful with many other complex and challenging scientific problems. This is to start with some of the least complicated cases, and then, if we can make progress toward understanding them, move on to the more complex and difficult examples. One promising approach of this general type is to inquire whether animals may experience relatively simple thoughts about things that are important to them. When faced with a threatening predator, does an animal think something roughly like: "If that beast gets me, it will hurt?" Or does a hungry animal think about what a particular food will taste like?

This approach suggests the following preliminary working definition of elementary animal consciousness: An animal may be considered to experience a simple level of consciousness if it subjectively thinks about objects and events. Thinking about something in this sense means attending to the animal's internal mental images or representations of objects and events. These may represent current situations confronting the animal, memories, or anticipations of future situations. Such thinking often leads to comparisons between two or more representations and to choices and decisions about behavior that the animal believes is likely to attain desired results or avoid unpleasant ones. It is important to recognize that this working definition leaves open the possibility of more complex sorts of consciousness; it focuses on processes and phenomena that are basic to conscious thinking and which we can hope to identify by gathering objective evidence bearing on their occurrence and nature by employing procedures outlined below. This definition does, however, assume the presence of both internal representations or mental images about which the animal thinks and also of simple beliefs and desires about what it likes and dislikes.

This definition does not include two other attributes that are sometimes proposed as necessary features of consciousness: self-awareness and thinking about the process of thinking itself. Because an animal's own body is a very prominent feature of its situation and contributes enormously to its sensory input, it seems likely that if an animal thinks consciously about anything, it must sometimes think about parts of its own body. But many who tend to deny consciousness to nonhuman animals require for true self-consciousness the capacity to experience such thoughts as: "It is I who see that predator or smell that delicious food." Or they may claim that animals know but are incapable of knowing that they know. In an attempt to keep a preliminary investigation of animal consciousness as manageable as possible, I suggest leaving aside the question whether nonhuman animals are capable of this sort of propositional self-awareness or of thinking about

their own thoughts as well as other more complicated forms of conscious thinking. If and when cognitive ethologists learn how to determine the presence or absence of the simpler sorts of conscious thinking defined above, later stages of investigation can include these and other more complex levels of consciousness.

CRITICAL STANDARDS

Our traditional inhibitions that have discouraged the study of animal minds can be relaxed without lowering critical scientific standards. Indeed, the danger of jumping prematurely to definite convictions is so great that it is desirable to increase scientific caution rather than relax it. There are two pitfalls to be guarded against. The first has been to ignore the problem of animal thoughts and feelings because such phenomena are considered beyond the reach of scientific investigation. That was an easy way out a few years ago, but the progress in identifying cognitive processes in a wide variety of animals has forced a retreat to a second line of defense. This line of defense recognizes the existence and significance of animal cognition but denies that we can tell whether it is ever accompanied by conscious thinking.

The second pitfall is to leap enthusiastically to firm conclusions and to advocate positions that cannot be convincingly supported by the available evidence. Scientists ordinarily make strong and positive assertions only when the supporting evidence is convincing. But when questions of animal mentality arise, we have an unfortunate tendency to do just the opposite; the vigor of assertions tends to be inversely, rather than directly, proportional to the quality of the evidence available. Thus, we sometimes hear vehement arguments that a nonhuman animal cannot possibly have certain kinds of mental experiences. Meanwhile, others are equally certain that some particular beast must want, wish, or believe something related to its current or impending behavior. As critical scientists we must first recognize the extent of our ignorance as a prerequisite for reducing it.

PREMATURE PERFECTIONISM

In many areas of science, we cannot aspire to entirely satisfactory logically watertight evidence when a subject is first studied. But when questions of possible conscious thinking by animals are raised, we tend to demand perfection prematurely. We often conclude a priori that it is not worthwhile to study this sort of phenomenon because we are convinced that we cannot hope to prove anything with absolute certainity. But why are we so much more demanding of perfection in this area than in other scientific areas? It

is helpful to contrast these attitudes with the enthusiastic investigation of the adaptive significance of behavior and how it appears to contribute to inclusive fitness. Underlying this active area of research is an unmentioned implicit assumption that in the remote past the ancestors of living animals reproduced more effectively because they behaved in certain ways. Yet the behavior of extinct animals cannot be studied directly, and we are limited to inferences based on contemporary behavior under current conditions. Such inferences are reasonable and fruitful, but in this popular area of investigation we refrain from demanding the sort of rigorous proof that many scientists require as prerequisite for studying animal consciousness.

EPIPHENOMENALISM

Many scientists find reasons for believing that conscious thinking, even in our own species, has no effect on behavior. This view is known as *epiphenomenalism,* defined by Edwards and Pap (1973) as the belief that "mental states are caused by brain processes, but do not in turn exert any causal influence" (p. 177). This is a very strong claim that one process—conscious thinking—never, under any circumstances, has even the slightest effect on another process—overt behavior. Absolute proof of such a global negative statement is notoriously difficult to obtain, and this one is so counterintuitive that strong evidence would be required to render it convincing. Indeed, it is not accepted by many philosophers. Yet adherence to epiphenomenalism is often taken by scientists as evidence of commendable rigor when, in fact, it may be little more than an excuse for neglecting or ignoring an important scientific problem.

Some biologists tend to feel that it does not matter for questions of evolutionary adaptiveness whether a given behavior pattern is executed with or without conscious awareness on the animal's part. But insofar as an animal can think consciously about its situation and the results of its own behavior, and can make simple rational choices about its problems and prospects, this ability is clearly an advantageous phenotypic trait. Therefore, insofar as conscious thinking occurs, neglecting it will result in an incomplete and inaccurate understanding of the species in question.

IMPLICATIONS OF ASSUMING HUMAN MENTAL UNIQUENESS

It is conceivable that conscious thinking is a uniquely human accomplishment, wholly lacking in all other species. Even if this rather extreme view is correct, it raises an important scientific question: What is different about

human brains that permits them to give rise to consciousness, while the central nervous systems of all other species lack this capacity despite the similarity if not identity of all known basic properties of neurons and synapses? Thus the existence or nature of animal consciousness is a central question of major scientific importance. If it occurs only in our species, or perhaps is shared only by our closest relatives, neuroethologists must look for those properties that allow some central nervous systems, but not others, to produce conscious thinking. Conversely, if conscious thinking is more widespread among nonhuman animals, it is scientifically significant to learn its extent and limits and, in particular, how the content of animal consciousness differs between species or according to the circumstances in which animals find themselves.

COGNITIVE CREATIVITY

The ability to think about the probable results of alternative actions and to choose the one most likely to achieve a desired result is especially valuable when animals face unpredictable problems in carrying out important activities such as obtaining food, avoiding predators or other hazards, seeking mates, or raising young. The traditional view of animal behavior has emphasized prior determination of responses either genetically, through learning, or by some interactive combination of the two. But a fundamental limitation of prescribed responses is that to be effective, the prescriptions must provide for most or all contingencies the animal is likely to encounter. The real world in which animals live under natural conditions is characterized by complex variability. Few if any of the important details lend themselves to simple descriptions or simple rules that can prescribe the most effective way of coping with complicated contingencies. The most appropriate responses vary according to innumerable factors, and the necessary instructions would become astronomically voluminous if they adequately covered the contingencies an animal is likely to encounter.

If, on the other hand, an animal can think about what it wants and how desired objectives can be achieved, many relevant factors can be taken into account and modestly rational decisions can lead to appropriate actions. Even quite simple conscious thinking can be creative in the limited sense that it adaptively integrates a variety of information from current perceptions, memories, and anticipations of probable events—including the anticipated results of the animal's own actions. Of course such thinking, human or animal, is unlikely to achieve perfection. Mistakes will be made, but if they are not fatal, they can often be corrected by learning what does and does not achieve what the animal wants.

SPECIES SOLIPSISM

Skeptical philosophers can argue eloquently that no one can ever prove, with logical rigor, that another person is conscious. We can only make inferences (some would say merely guesses) about the existence or content of another person's thoughts. If a solipsist claims that he is the only conscious organism in the universe, and that all evidence of consciousness in others is inconclusive, we cannot refute his arguments in any rigorously logical fashion. But only in specialized philosophical discussions are such arguments taken seriously. We all go through life assuming that other people do have conscious thoughts, plans, beliefs, intentions, and the like. Indeed it is difficult to imagine how human societies (or perhaps any society) could function effectively if their members acted as consistent solipsists. Of course the difficulties of inferring what animals may be thinking are much greater than with our conspecifics, and many scientists continue to feel that it is not worth the bother of trying. But the extensive and significant discoveries that have resulted from investigations of animal behavior suggest increasingly that these inhibitions may be outdated impediments to research. Species solipsism may be as impractical and arcane an intellectual exercise as its more familiar philosophical counterpart when applied to other people.

DISPARAGEMENT OF "FOLK PSYCHOLOGY"

Three eloquent philosophers (among others) recently advanced another argument that may tend to discourage consideration of animal consciousness. Stich (1983), P. S. Churchland (1986), and Dennett (1987) have argued with varying degrees of vigor that what they disparage as folk psychology relies on inappropriate and misguided concepts. Churchland defines folk psychology as "commonsense psychology—the psychological lore in virtue of which we explain behavior as the outcome of beliefs, desires, perceptions, expectations, goals, sensations, and so forth. . . . the preeminent elements in folk psychological explanations of behavior include the concepts of *belief* and *desire*" (p. 299). Churchland and Stich assert that these terms are as obsolete and misleading as witchcraft or a flat earth, and they anticipate that a complete understanding of brain function will eventually lead to new concepts so superior that they will replace familiar notions such as wishing or fearing that something will happen, expecting some result of a certain kind of behavior, or intending to accomplish a goal. But neither Stich nor Churchland tells us just what the new and superior concepts will be.

Because beliefs and desires are key components of conscious thinking,

consigning them to a trash heap labelled folk psychology tends to discourage ethologists from inquiring whether nonhuman animals are conscious. The principal objection of these philosophers is that folk psychology does not provide a philosophically adequate explanation of human behavior. They seem to expect that a proper theory will neatly account for all human, and perhaps also animal, actions and mental experiences. This surely is a large order, and scientists accustomed to struggling with incompletely understood phenomena will be more easily reconciled to explanations that lack the apparent completeness and tidy finality of nineteenth century deterministic physics. An argument that carries great weight with Churchland is that our concepts of belief and desire have not changed appreciably since the time of the Greek philosophers. Since our basic concepts about physics, chemistry and astronomy have been revolutionized by modern science, she asks why not psychology?

Dennett, on the other hand, recognizes that "if we discard folk psychology as a theory, we would have to replace it with another theory, which, while it did violence to many ordinary intuitions, would explain the predictive power of the residual folk craft" (p. 47). In other words, the concepts of folk psychology are as indispensable in the ordinary day-to-day interactions between people and animals as is folk physics in practical matters of dealing with physical objects, machinery, and the like without worrying about quantum mechanics of the Heisenberg uncertainty principle. An example from obsolete folk astronomy is relevant. Thanks to the Copernican revolution, we now know why the sun appears to sink below the horizon and rise again in the east next morning. We no longer imagine god-driven chariots conveying the sun across the sky or carrying it back eastward below ground, but that understanding has not abolished the concepts of sunset and sunrise, which remain useful for many purposes. Churchland likens folk psychology to Ptolemaic astronomy as an argument for rejecting the former in the confident expectation that neurophysiology will someday discover a true and beautiful analog of Copernican astronomy. But she overlooks a major difference: Copernicus and Galileo rejected Ptolemaic astronomy only because they had in hand a clearly superior replacement.

These arguments for abandoning folk psychology have not convinced a number of philosophers and neuroscientists. Double (1985), Millikan (1984), Marras (1987), Russow (1987), and Sanford (1986) find the major philosophical arguments advanced by Stich to be unconvincing; they doubt that concepts such as belief and desire have outlived their usefulness. And the neuroscientist Stent (1987) is far from persuaded that beliefs and desires will cease to be meaningful and useful concepts in the forseeable future. Millikan (1986) points out that the concepts of folk psychology such

as belief and desire are real and significant attributes of human minds, at least, and that they should be treated as realities to be explained rather than as profound explanatory theories.

Furthermore, the arguments advanced by Stich and Churchland *confuse explanation with abolition.* A pertinent example is the concept of heredity, surely as ancient and basic a notion as belief and desire. Thanks to the magnificent discoveries of molecular genetics, we now understand the basis of heredity, at least in broad outline. But the phenomenon of inheritance has not vanished into obsolescence or oblivion. It may well be that the neurophysiological basis of beliefs and desires, will eventually be understood in the same way that heredity has been largely explained in terms of DNA and RNA, and that will be an equally important triumph of science. But this hoped-for future understanding will not abolish the phenomena thus explained any more than molecular genetics has done away with the concept of heredity.

In terms of cognitive ethology, an explanation of the neural basis of beliefs and desires, if and when it is achieved, will greatly facilitate identification of whatever beliefs and desires may occur in nonhuman central nervous systems. But in the forseeable meantime, there is no reason to take the disparagement of folk psychology as an excuse for abandoning the attempt to understand whatever beliefs and desires may be experienced by nonhuman animals. Indeed it may not be unreasonable to suspect that the disparagement of folk psychology is itself a sort of excuse for turning away from difficult but fundamental problems of cognitive science.

CRITERIA OF ANIMAL AWARENESS

What sort of evidence can we hope to gather that can support or weaken the inference of simple conscious thinking in other species? One general criterion that we tend to employ is enterprising versatility of behavior. When the animal does something that seems appropriate but its behavior is not a stereotyped pattern, we feel more inclined to infer some conscious thinking. Many suggestive examples are discussed by Walker (1983), Roitblat, Bever, and Terrace, (1984), Griffin (1984), and Mitchell and Thompson (1986).

An especially pertinent case is the use of bait to attract fish. Although not an entirely new discovery, this type of innovative behavior has recently been studied in revealing detail by Higuchi (1986, 1987). The heron picks up a small object, drops it in the water, and waits for small fishes to approach the bait. When this happens the heron often manages to catch a fish by the

customary stabbing motion achieved by a rapid extension of the neck. Bait fishing has been observed in only a tiny fraction of green-backed herons, but the herons that engage in this activity do it repeatedly. Yet it has not spread among the population. This sort of fishing with bait was reported many years ago; in fact it was illustrated clearly in a *National Geographic* article (Sisson, 1974). (I must confess that when reviewing this subject [Griffin, 1984] I overlooked this reference constrained by the typical scientist's conceit that serious data will not be found in popular magazines.) Higuchi has observed that green-backed herons show individual differences in their techniques of bait fishing. Some throw the bait out a meter or so from where they are standing and then, when fish come up around it, they fly to the bait and seize a fish. Sometimes the bait is edible material like pieces of bread dropped by children, but in other cases herons use inedible bits of vegetation. Some herons modify the bait, for example, by breaking a twig to get a piece of appropriate size. These individual differences suggest that there is no fixed genetic basis for bait-fishing behavior. Is it reasonable to suppose that a heron develops this kind of behavior and uses it successfully without thinking about what it is doing and looking ahead for at least a short time to what it hopes to achieve?

We can probably all think of other examples where an animal does something that we find it rather difficult to imagine doing without some conscious thinking. Several pertinent cases are described in a recent symposium volume dealing with deceptive behavior (Mitchell & Thompson, 1986). Particularly impressive examples are the deceptive use of alarm calls by certain birds (Munn, 1986) and the observations of social deception in baboons reported by Byrne and Whiten (1985) and Whiten and Bryne (1988). An even better example is the description by de Waal (1986) of the way in which a subordinate male chimpanzee conceals his erect penis when trying to approach a female without attracting the notice of the dominant male who is almost certain to attack if he sees what is going on.

But this sort of inference can always be disputed; inclusive behaviorists are likely to argue that the animal may be carrying out the observed versatile behavior without any conscious thinking. After all, an enormous majority of the processing of information and adaptive changes in behavior that are regulated by our central nervous systems occur without any conscious thinking. Consciousness accompanies only a small but important part of our own behavior. And of course other organs also do a great deal of activity regulating. Kidneys, for example, respond to levels of substances in the blood by reabsorbing or secreting them at different rates to regulate the chemical composition of our body fluids. So, it is often argued that just because an animal's behavior is efficient and adaptive, this is not convincing evidence that the animal is consciously aware of what it is doing.

COMMUNICATION AS EVIDENCE OF THINKING

One avenue of escape from this difficulty is to make use of procedures similar to those we employ with our conspecifics. Although we cannot rigorously prove that they experience thoughts or precisely what the contents of their thoughts may be, we do nevertheless manage to make useful and reasonably reliable inferences about the thoughts and feelings of our human companions. We do so primarily on the basis of their communicative behavior. They often exhibit revealing forms of nonverbal communication, and they sometimes tell us what they are thinking about. Their communication of thoughts is never totally complete or perfectly precise, and only a very small fraction of what their central nervous systems are doing is revealed by their communicative behavior. But certainly that subset of the total activity of their brains is important to them and to us.

Many kinds of animal communication convey to other animals information that affects the recipient's behavior. Signals are often exchanged reciprocally with two or more animals alternating in the roles of sender and receiver or playing both roles at once as in two-way threat displays. But do animals also communicate to others any thoughts and feelings that they may experience? If so, their communicative signals provide cognitive ethologists with objective data about the content of animal thoughts. Recognition that such data are valid evidence of animal thinking could go a long way toward eliminating one of the principal objections that has been advanced against the inference of conscious thinking on the part of nonhuman animals—namely the alleged impossibility of independently verifying or falsifying such inferences. Of course it remains only a hypothesis that some animal communication serves to convey conscious thoughts or feelings. But such hypotheses often serve as fruitful entering wedges to begin the long and complex process of explaining phenomena that would otherwise remain opaque and unapproachable. The assertion that no communicating animal ever thinks consciously about the information it is conveying to others amounts to another global negative as difficult to prove as solipsism or epiphenomenalism. Only quite recently have a few cognitive ethologists begun to ask to what extent communicative behavior might be a source of objective data about any conscious thoughts that animals may experience, and it will take some time to determine whether this approach will prove as fruitful as I expect.

Ethologists are not yet accustomed to think about animal communication in this way. Instead, communication has been considered just one more kind of behavior to be studied with the hope of understanding (a) how it arose, (b) how it increases inclusive fitness, and (c) the degree to which it has been genetically influenced or determined by the experience of the individ-

ual. Communicative signals are generally viewed as a direct result of internal physiological conditions. If an animal's stomach contractions produce sounds that affect the behavior of other animals, this does not mean that it is thinking consciously about food. The cries of anguish from a seriously wounded animal presumably do not result from any conscious attempt to communicate. We have tended to consider that all animal communication falls into this "groans of pain" or GOP category (Griffin, 1985, p. 620). One significant criterion for distinguishing between involuntary GOP communication and intentional communication is the effect of an audience. If the signals are emitted regardless of the presence or absence of potential recipients, intentional communication seems unlikely. Important examples that give every evidence of audience effects are described and analyzed in the chapters by Marler and by Cheney and Seyfarth in this volume.

It is possible that all animal communication is involuntary in the sense that much human nonverbal communication is not readily brought under voluntary control. Of course we are usually aware of the emotions that lead to involuntary nonverbal signals such as blushing, but we cannot ordinarily exert conscious control over these emotional states or the signals that accompany them. Thus it seems best to distinguish the question of voluntary control from the question of whether an animal is consciously aware of its mental states and of the signals by which it may communicate them to others. An aggressive animal might be quite aware of its anger and of the growls by which it threatens a rival even though it had no voluntary control over the onset of the aggressive impulse. In other cases an animal might consciously think about communicating in order to achieve some desired result. For example, one of the birds studied by Munn (1986) might give an alarm call in the complete absence of danger with the conscious intention of causing another bird to break off the pursuit of an insect it was about to capture.

Animal communication has often turned out to be much more complicated and adapted to the animal's needs and situation in more subtle and versatile ways than formerly believed. Semantic information may be conveyed as in the well known case of the three different alarm calls used by vervet monkeys to report the approach of three different categories of predators (Seyfarth, Cheney, & Marler, 1980). The GOP view of animal communication leads to increasing complications when one considers the degree to which many animals exchange communicative signals that serve to coordinate their cooperative interactions. At the very least, we must recognize that the internal physiological state that is supposed to generate the communicative behavior must be strongly influenced by signals received from others—often in reciprocal exchanges. We are thus forced to ascribe more and more complex properties to these internal physiological states,

and this necessary enrichment makes these states more and more like conscious thinking.

For example, it once seemed that the calls given by juvenile rhesus macaques during agonistic interactions, that is, squabbles or preliminaries to fights, were a continuously graded series that varied only in intensity and conveyed only the state of arousal of the calling monkey. But the recent work of Gouzoules, Gouzoules, and Marler (1984) has shown that the screams of juveniles convey information about the social status of the antagonist as well as the degree of arousal of the caller. This does not, of course, prove rigorously (though it does suggest) that the monkeys are really thinking about such things as "That guy is a relative" or "His mother is a dominant," but it does require that our concept of the internal state leading to the communicative signals must include such information in addition to levels of anger, fear, or general arousal.

Thus the communicative signals employed by many animals may well provide objective data that reveal part of what they are consciously thinking and subjectively feeling as I have discussed elsewhere (Griffin, 1984). Acceptance of this view does not constitute rigorous proof of animal consciousness, but it does offer a promising window through which cognitive ethologists can tentatively infer what animals may be thinking and feeling. Thus the hypothesis that vervet monkeys think about three classes of dangerous predators is strengthened by the experiments of Seyfarth, Cheney, and Marler (1980), but it is not conclusively confirmed. With sufficient imagination and ingenuity, cognitive ethologists can probably devise testable predictions based on such hypotheses. For example, if alarm calls are intentional warnings to companions, they should not be given if no companions are present.

Finally, there is a tendency to feel with Walker (1983) and many others that if there is any sort of conscious thinking in nonhuman animals, it is more likely to be found (or perhaps only to be found) in our closest relatives. But as far as we know, the central nervous system of multicellular animals all operate by means of the same basic processes regardless of the species or even the phylum in which they are found. Because we know that at least one species does indulge in conscious thinking, and take it for granted that conscious and unconscious thinking result from the activities of the central nervous system, we have no solid basis for excluding a priori the possibility that conscious thinking takes place in any animal with a reasonably well-organized central nervous system. In fact, as I have suggested elsewhere (Griffin, 1984), conscious thinking may be an efficient way to use the central nervous system for solving the more complex and challenging problems faced by any animal. If so, such economy may be more important in animals with a small central nervous system than it is to us and the Cetaceans. The symbolic communication used by honeybees to