1

Animal Thinking

An Introduction

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The topic of this Strüngmann Forum—animal thinking—was not formulated as a question—"Do animals think?—but rather as a statement. One might question whether we have already gone too far by making such a statement, but this obviously depends on what we mean by "thinking." If one believes that thinking refers only to mental processes accessible through human conscious recollection, then thinking must be strictly reserved for our species alone. The issue of whether animals experience conscious recollections in some similar way dominated the debate at an earlier meeting of the Dahlem Konferenzen, the forerunner to the Ernst Strüngmann Forum. At that meeting, Donald Griffin, who edited the resulting volume, "Animal Mind – Human Mind" (Griffin 1982), was concerned that ignoring or eliminating the possibility of animals experiencing some sort of consciousness might be perceived as being narrow-minded and unscientific. In his words (Griffin 1982:3):

> In areas where data are few and of limited relevance, dogmatic negativity can easily limit what scientists even try to investigate, and thus perhaps delay or prevent important insight and discoveries.

This kind of argument was, and still is, suspected of being anthropocentric, and perhaps even guided by simple-minded "folk psychology." Indeed, comparing animal thinking with the form of thinking that humans consciously experience is, in an epistemological sense, fraught with risk and unfair to any animal species, including humans. Aware of such potential shortcomings, Griffin tried to avoid these pitfalls by motivating participants to focus on experimental paradigms and their conceptual background.

Thirty years later, we continue to struggle with the question of how to judge the mental life of other species. Do we grant animals too much intelligence, or too little? Should we distance ourselves from the idea that animals possess intelligence? Can we reasonably tackle the inner workings of other species' minds, and how can we best conceive an animal mind?

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Since the advent of the cognitive revolution in the 1960s, animals have been viewed as goal-seeking agents that acquire, store, retrieve, and internally process information at many levels of cognitive complexity. This cognitive turn paved the way for an immensely productive research program. While this field benefited from insights into the proximate causes of animal behavior, awareness grew of the importance of taking a species' evolutionary history and ecological adaptation into account, an insight which led to a multitude of field studies with a large range of animal species. Studies in the field and in the lab are now performed in concert to compensate for their respective limitations. It is this combined approach which makes current cognitive behavioral studies so rich. This volume provides multiple and paradigmatic examples for such combined studies.

The conceptual frame of current cognitive behavioral studies acknowledges the multiple levels of neural processing and mental operations but struggles with the borderlines between more behaviorist and more cognitive accounts. Two principles became apparent in the discussions across the four groups:

First, problem-solving strategies that appear similar across animal species do not allow us to conclude that similar neural and/or mental operations are at work, particularly when the comparison crosses the line between animals and humans. However, such comparisons can be highly inspiring and may lead us to working hypotheses that need to be scrutinized, not only with respect to animal but also human cognition. After all, an important aspect of the cognitive turn was the demystification of human cognition, which led to the rejection of an immaterial homunculus inside our heads.

Second, modern science is guided by the parsimony argument. In biology, the doctrine of the simplest and intellectually most economic explanation is complicated by the fact that we do not know what is more or less simple or economical for a particular brain. Elemental forms of cognition, such as stimulus-response connections and a large range of memory items stored in isolation, are interpreted as being more likely to be implemented than composed representations that are handled together in working memory. Sometimes this argument is combined with the notion that small brains or small volumes of parts of the brain favor "simpler" solutions. The scale applied here follows formal principles; for instance, how many parameters or processes might be involved. However, in most cases we do not know whether it involves more or fewer neural processes to encode (e.g., space as a cognitive map or as a combination of seemingly simple rules and picture memories). The same argument can be made for many cognitive faculties; for instance, for decision making, planning, tool manufacturing, intentionality. As the theoretical physicist Jean-Claude Pecker (2004:185) stated:

> The principle [of parsimony or Occam's razor] can both be used to eliminate unnecessary irrelevancies, but also to constrain the development of imaginative theories.

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The issue of where to set the criterion to distinguish imagination from scientific evidence continues to be a matter of debate; some argue that the field of animal cognition suffers from mushrooming "just so" stories and armchair speculation, even in the scientific literature (see Penn, this volume). Anecdotes are powerful because they provide motivation for enquiry. Ideally, they lead to carefully designed experiments that test the conjectures encapsulated in anecdotal observations of animal behavior, but they certainly cannot substitute for rigorous and skeptical enquiry. The reports and discussions presented in this volume provide multiple examples of the ongoing struggle to avoid unfounded complex interpretations as well as to not get stuck in the simplistic assumption that animal minds are just information storage devices bound to external stimuli and sensorimotor associations.

This Strüngmann Forum brought together experts from the fields of animal behavior, neuroscience, computational cognition, cognitive science, and philosophy to discuss the state of the art in animal cognition research. Our goal was to identify key questions at the frontier of present research, and to push the boundaries of knowledge by discussing how these questions could be translated into experiments and observations. Together with the members of the program advisory committee, Sara Shettleworth and Nicky Clayton, we identified four highly active areas of research: navigation, decision making and planning, communication, and social knowledge. These fields differ strikingly in terms of their maturity and integration with other disciplines, as both the sections' chapters and respective group reports document. The former two fields are characterized by emerging integration of behavioral analysis with neuroscience, whereas the latter two are more strongly embedded in the discourse of "what makes us human." Possibly because of this difference, there was great variance in the types of controversies and debates.

In the navigation group (Wiener et al., this volume), discussion focused on how specific sensorimotor connections and cognitive processes are integrated to guide animals to the intended goals, to allow them to localize themselves, and to perform shortcutting travels between locations. Debate centered on the structure and use of a cognitive map. Paradigms were identified in a "navigation toolbox" to allow low- and high-level cognition to be separated in the navigation of different animal species: in walking and flying animals, in middle-range and far-ranging navigation, as well as in laboratory or field studies. The comparison between walking and flying insects (ants and bees) turned out to be particularly informative. An additional component of navigation is pursued in the first chapter by Randolf Menzel, who addresses the question of how navigation and communication about locations is combined in honeybees. Kathryn Jeffery contributes an overview of the neural mechanisms that support navigation in the three-dimensional world of a rat. This chapter is a testimony to the fact that neuroscience is one of the closest partners in addressing questions at the mechanistic level. Verner Bingman makes the case for viewing animal navigation as intelligent behavior. At the meta-level, he

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raises the interesting question: Would animal navigation be less interesting if it were "less intelligent"? The group report on animal navigation (Wiener et al., this volume) delivers the "navigation toolbox"—an analysis of the components important in animal navigation—as well as suggests how and in which way these components are integrated to produce navigational behavior, meaning more controlled by global matching procedures (e.g., of worldwide gradients) rather than a representation of spatial relations.

The second group focused on how we may conceptualize decision making, planning, and knowledge of one's own epistemic states in animals. Tony Dickinson addresses goal-directed behavior, which refers to the fulfillment of an animal's current motivational states, and contrasts it with "future planning," which refers to behaviors that serve the fulfillment of possible future needs. One key issue concerns how experiments need to be designed to uncover planning for the future in animals, and whether such experiments can uncover episodic-like memory indicative of mental time travel. Two theories are presented (the mnemonic-associative theory and the mental time travel theory) to guide future studies. Jeffrey Stevens makes the case for an integration of evolutionary and psychological approaches in animal cognition. Specifically, he argues that the "bounded rationality approach" (i.e., the acknowledgment that simple mechanisms typically suffice to produce adaptive behavior) is also of great relevance for the present field of research. Robert Hampton discusses whether animals know what they know, and how we know whether they know what they know. The key issue here is whether any of the experiments in this field require a meta-representation of an animal's knowledge states, or whether the observed differences in behavior are due to the fact that the animal does one thing when it knows the solution and another when it does not. The group report (Seed et al., this volume) summarizes this controversy as well as other key issues, such as the fundamental question of "what is a decision" to more difficult issues of declarative and implicit knowledge and the repercussion for animal consciousness.

The section on animal communication begins with a foray into the murky waters of "information" by Julia Fischer, who comes to the conclusion that the concept of information is indispensible to understand the receiver's part in the communicative dyad. In addition, she argues that pitting motivational against referential communication effectively sets up a false dichotomy. Christoph Grüter discusses the emerging properties of the collective action of social insects and the importance of communication to achieve such collective action. He attempts to relate collective decision making in insect societies to unsupervised phenomena in other species, including humans, technical communication networks, and neural nets. Michael Corballis straddles boundaries between groups, as he links language to episodic memory. Obviously, information is the key concept in animal cognition research and, indeed, this group spent a great deal of time discussing the value of information for animal communication studies (Wheeler et al., this volume). Perhaps, however, a somewhat fuzzy

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and commonplace understanding of information is more productive than trying to resolve the issue of what constitutes information, as it frees up capacities for more interesting issues, such as the insight that a great deal of signaling behavior can be understood without the need of invoking elaborate cognition. In contrast, cognition is important when it comes to the processing of and response to signals, as well as when animals need to integrate information from different sources.

The fourth section is devoted to social cognition. Redouan Bshary begins with a plea for a broader quantitative research program to gain further insights into the socio-cognitive abilities of a greater range of taxa. Through computational modeling, Charlotte Hemelrijk challenges the notion that complex social behavior requires complex cognition. Her models suggest that relatively simple sets of rules can generate a number of behavioral patterns observed in nonhuman primates. Dorothy Cheney discusses the mechanisms and adaptive value of having long-term bonds, and presents field research that addresses the emergence of contingent cooperation in wild primates. The group report (Jensen et al., this volume) discusses recent advances and problems in the field of theory of mind research.

It is important to understand that controversies about concepts, design of experiments, or interpretations of collected data were not avoided during our discussions, and they often found their way into the reports. In our view, such controversies are of particular value since they reveal the filters in our mind; that is, the often unspoken bias toward a favored idea or concept. Equally, it is important to note that everyone shared a strong desire to understand the species-specific ecological conditions and selective pressures behind the cognitive processes. Our goal was to avoid generalization across species based on superficial similarities, to gain from the insights collected by well-controlled experiments with different animal species, and to be skeptical about single case observations that appeal to a general public audience. This general attitude of the participants reflected the understanding that animals possess a range of representations of the world, and that the ability to make inferences is a key component of animal thinking. Having said that, it is also important to note that the group reports are not consensus documents; presented views are not necessarily shared by all members of the groups. Likewise, the individual chapters may sometimes reveal a somewhat provocative tone, which we have purposely retained to foster further discussion and debate.

The best part about writing this editorial introduction is that it gives us the opportunity to acknowledge the invaluable contributions of several people. First, we would like to thank the moderators of the discussion groups—Sara Shettleworth, Nicky Clayton, Bill Searcy, and Joan Silk—for ensuring that each group worked their way through the sets of questions which they had identified for themselves at the onset. The rapporteurs—Jan Wiener, Amanda Seed, Brandon Wheeler, and Keith Jensen—did a fabulous job in bringing into shape the "train wrecks" of sketches and notes that resulted from the long and

sometimes quite controversial discussions. The staff of the Ernst Strüngmann Forum performed at their usual level of perfection, and we note this because we did not have to worry about anything related to organization; everything was perfectly managed. In addition to the many other things she did, Marina Turner compiled the reference list—no mean feat. Julia Lupp steered us expertly through the process of planning and conducting this meeting. She is the heart and soul of the Forum, and we deeply appreciate her contribution to the success of this meeting. In closing, we wish to thank the Ernst Strüngmann Foundation for their steadfast support of these very special meetings.

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