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BOOK REVIEW

Experimental studies of elementary reasoning: Evolutionary, physiological and genetic aspects of behavior, L. V. Krushinsky. Translated from the edition, 1986, posthumously edited by A. F. Semokhina. English translation edited by Ethel Tobach and Inge I. Poletaeva. Published for the National Library of Medicine, Bethesda, Maryland by Amerind Publishing Co. Pvt. Ltd. New Delhi, India, 1990, XXII + 311 pp.

Closing a chapter on animal cognition, Terrace (1984) referred to a "baffling but fundamental question." "Now that there are strong grounds to question Descartes' contention that animals lack the ability to think, it is appropriate to ask, how does an animal think? . . . Learning the answer to that question will provide an important biological benchmark against which to assess the evolution of human thought." (p. 22)

Experimental studies of elementary reasoning: Evolutionary, physiological and genetic aspects of behavior, by the Russian ethologist, Leonid V. Krushinsky (1911–1984), describes the resolute attempt of himself, his colleagues and students at the Moscow State University, to face the "baffling but fundamental question" of animal thinking in its elementary forms. It belongs to an old tradition in the comparative study of behavior, which goes back to Romanes, Morgan and others, but also to Russian comparative psychologists, such as Wagner, who were all concerned with the stages that paved the evolutionary way to human reason. Written clearly, full of challenging ideas, the book represents the culmination of a long research career dedicated to the study of elementary reasoning, i.e., problem solving in animals. Krushinsky's range of interests was impressive. He approached the question of reasoning from several perspectives: behavioral, neurophysiological, anatomical, genetic. He described behavioral episodes in natural environments, discussed the relationship between reasoning activity and social behavior and speculated about the evolution of brain and behavior.

All this does not result in a potpourri of findings and discussions. There is a fundamental unity in the book, each chapter bringing a new perspective that is integrated with the rest. Because of the scope of the work, all topics are not treated with the same depth, and sometimes one

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would welcome more information and more analysis. While following Krushinsky in his formidable trip, I caught myself several times inventing experiments that would reveal aspects not investigated or trying to tackle conceptual issues, such as redefining reasoning in representational terms. But this is exactly what makes the book stimulating.

ON THE NATURE OF ELEMENTARY REASONING

Krushinsky's proposal starts with an essential assumption: elementary reasoning does not derive from conditioning. Although in concrete acts elementary reasoning may be closely integrated in conditioning or instinct, it cannot be reduced to either. It has to be considered as a behavioral module, with its own causal bases and its own ontogenetic course. Contrasted with learning that requires repetition of trials and is generally marked by a gradual improvement in performance, elementary reasoning involves immediate adjustment to an essentially new situation.

Reasoning goes beyond perception. Its essential property is the capacity to apprehend the empirical laws that connect events and objects in the outer world. Of course, animals are not physicists, and lack the Pavlovian second signal system that would allow them to understand the surrounding world and express theoretical laws. They use empirical regularities, however, in order to anticipate events. Among the simplest regularities are the following: (1) an object continues to exist, even when it disappears from the preceptual field; (2) opaque objects are impermeable to locomotion; (3) an object can be enclosed in another tridimensional, hollow one; (4) such an object moves when the object into which it is placed moves.

EXTRAPOLATION AND DIMENSIONALITY TASKS

Extrapolation is the ability of an individual animal to predict the future location of some part of the environment, on the basis of contemporaneously perceived change. Several tests were devised to assess extrapolation ability. The screen technique involved offering food to a deprived animal, in one of two bowls placed in a gap between two vertical, opaque screens. After some ingestion had occurred, both bowls were displaced, one of them to one side so that the animal could see the trajectory of its movement, the other to the opposite side; the animal could hear the movement, but not watch as it moved behind the screens. To correctly solve the problem, the animal had to go around the screen behind which the bowl with food disappeared. Displacement of the empty bowl served as a control for sound.

According to Krushinsky, the initial perceived movement of the food bowl provides information on the parameters of movement that is transferred (extrapolation) and that makes selection of the correct response possible. Control for learning is obtained only by taking into account the initial performance in the problem solving situation. Later performance is contaminated by reinforcement effects and does not represent true reasoning.

Krushinsky and his co-workers compared the performance of a number of animals on extrapolation tasks: fishes, frogs, turtles, tortoises, lizards, birds, rats, rabbits, foxes, wolves, etc. It is refreshing to see such a range of species invading the traditional territory of white rats and pigeons. In some animals (fishes, frogs, rabbits, fowl), reasoning ability was quite poor: animals would search a long time near the place where the food disappeared, sometimes gaining access to reward through trial and error; lizards, tortoises and turtles (who would predict turtles could solve problems?) showed significant proportions of correct choices; crows and magpies confirmed the good reputation of the Corvidae; cats and dogs reached food with "quick, purposeful movements."

In dimensionality tasks, which were more abstract and demanding than extrapolation ones, animals had to infer the principle of containing or being contained. A typical procedure with dogs was to let the animal feed from a container, placed near two objects, one of them tridimensional, such as a pyramid and the other one two-dimensional (flat), such as a triangle. The bait was then hidden in the tridimensional object, out of the view of the dog. Both objects were subsequently displayed to the animal and put in different locations. The immediate choice of the tridimensional object indicated knowledge of the basic regularity: a tridimensional object cannot be contained in a flat one.

Dogs and wolves, although very good at extrapolating, were not able to solve the dimensionality problem. In order to test dolphins, an aquatic version of the setup was used with two female dolphins, Vasilisa and Malyshka. Instead of food, a ball with which the animals liked to play was used as a reward. At first dolphins showed that they had chosen a stimulus by a very interesting and indirect way: splashing water at it. Afterwards, experimenters decided that a more conventional operandum, a pedal attached to the object, should be used. The dolphins significantly selected the correct (hollow) object, from the very beginning. *Maccaca, Cebus* and *Cercopithecus* species of monkeys and bears (bringing a Russian flavor into the experiments) also gave excellent performances. Control experiments showed that such results were not due to a baseline preference for tridimensional objects.

What about human beings? A longitudinal study with children from 1 year 6 months to 4 years of age, by Moldkina, Kadrybaeva and Obukhova showed an increase, with age, in the proportion of correct responses to a modified screen experiment but, curiously enough, only under a multi-trial procedure. When asked about the toy, younger children would give a nonexistence answer such as: "Not here; gone away; I don't know where it is now." (p. 86) They would insist on staying near the place where the toy was last seen. At four, most children displayed active search and correct responses.

Behavioral disturbances and physiological arousal occurred, during problem solving, a very interesting observation. Some crows, after several correct extrapolation responses, acquired an intense fear of the apparatus, a kind of phobia. They would avoid eating altogether near the screens. Dolphins, when tested more than two times a day, showed a decline in performance, stereotypically choosing the same side of the screen. Krushinsky's opinion is that reasoning tasks can cause strain, especially when difficult. The paradoxical aspect is that emotional disturbances mostly occurred after successful performance. How can our learned helplessness theories account for that?

THE "MATERIAL BASIS" OF REASONING

In several chapters of the book, behavior is related to neurones and neurones to genetic factors, in a way that verges on reductionism. Evolution of reasoning is based on the progressive development in size and complexity of association areas of the brain. Krushinsky claims that the "excess of potential capacity of the brain" is a condition both for adaptation to environmental diversity and for the emergence of higher level behavioral capacities. Evolution would thus have preadapted organisms by selecting "useless" amounts and complexities of neural tissue. This issue is controversial. It took me back to an argument by Kaplan (1987) in support of "extra-units" in the nervous system. According to Kaplan, "extra-units make possible patterns of activity that can function in an 'as if' mode without restricting the organism to the immediately present environment and without necessarily leading to motor output." (p. 672) In other words, extra-units are a prerequisite for representation and for thinking.

Some interesting neurophysiological research is reported, which gives supplementary support to the learning/reasoning modularity. The dorsal cortex, the reptile brain structure most probably involved in cognitive processing, was eliminated in groups of pond tortoises which solved the extrapolation task successfully, but had different levels of training (Ochinskaya). Ablation had a very significant effect in animals with little training, bringing performance to chance level. In groups with extensive training, on the contrary, the number of correct responses remained high after the operation. Such results can be accounted for by supposing that extrapolatory and learning performances depend on different neural circuits. Dorsal cortex is essential for the initial responses to a new problem situation, but its integrity does not matter, once control is assumed by conditioning.

Similar results were obtained with crows: destruction of cortical structures involving the hyperstriatum reduced extrapolation ability in animals without previous training, but not in those previously trained. Dogs and cats that had prefrontal regions of the cortex removed required much longer time than sham operated animals to show correct extrapolation performance. Such results point to homologies in brain structure and function, and deal with the important question of the neural circuit as endowed with a "generation of predictions function." (Gray, 1984)

GENERAL ASPECTS

Lockhard's (1971) criticism of comparative psychology included the argument that white rats were poor, degenerated copies of wild rats. A number of experiments, done afterwards, showed that white rats were not such poor copies after all and that they retained both the essential species-typical responses, and the ability to master complex learning situations. Results of Krushinsky's genetic experiments bring back part of the old interpretation. While laboratory rats of several strains were unable to solve an extrapolation problem, brown rats reached the respectable score of 82% correct solutions. Hybrids of brown and laboratory strains had an intermediate performance.

On the basis of such results, and of similar ones obtained with foxes of different strains, Krushinsky draws a Lorenzian conclusion about the bad effects of domestication. By increasing the probability of phenotypically extreme types and by promoting genetic drift effects, domestication would induce degeneration in genetic systems. "In wild animals, the level of their elementary reasoning is developed so that it is most adapted to the conditions of their existence. Naturally, the process of disintegration of the integrated genotype in the course of domestication results in the reverse, in the lowering level of reasoning." (p. 147) Many of those who study cognitive processes in albino rats may disagree with such a conclusion.

OBSERVATIONS IN NATURAL CONTEXTS

I enjoyed the part of the book dedicated to field observations and to the spontaneous, natural occurrence of reasoning behavior (cognition is not only something psychologists reveal under the very special conditions of the laboratory) regretting only the small amount of systematic original findings.

The case I found most interesting is that of woodpeckers which insert pinecones in existing holes in trees, in order to extract the seeds. The holes can be used for a long time, day after day, so their use as clamps or vises is not an accidental one, but a matter of habit. Pinecones are transported, fitted into the crevice and seeds dug out. All this is indicative of "tool using" and reminds one of the nutcracking behavior of chimpanzees at Tai, Ivory Coast, or at Bossu, Guinea, also characterized by the choice and transport of both "tools" and nuts (Boesch & Boesch, 1984; Sakura & Matsuzawa, 1991).

Do birds use several trees simultaneously, shifting from one to another according to spatial distribution of resources or size of the cones? Can they perceive the relationship between size of the cone and size of the hole? Krushinsky used a wooden wedge several times to close a slit that was used by a great spotted woodpecker. The animal would take out the wooden wedge or would make and widen new holes by pecking at it. More than such casual observations are of course needed to support Krushinsky's conclusion that "the great spotted woodpecker can 'construct' a vise for pecking cones and arrange it in such a way that the clamp's shape corresponds to the shape of cones to be inserted." (172–173)

SOCIAL BEHAVIOR

The richness and variability of social behavior depends on the development of elementary reasoning ability. According to Krushinsky, both aspects showed a parallel, mutually invigorating increase, during evolution, while instinctive signal systems receded and were substituted by individual knowledge of others among members of a community. This relationship between cognition and social life is one that arouses enormous interest in the new generation of ethologists and comparative psychologists.

In crows, the following instances suggest cognitive involvement: exploratory behavior, manipulation of sticks and other objects, play episodes in which one animal chases another one, stealing an attractive object from its beak; vocalizing episodes such as the "roll-call" during which crows alternate singing episodes, learning perhaps to identify individual calls; the establishment of a dominance hierarchy, etc.

In the description of animal communities, Krushinsky puts a greater emphasis on cooperative aspects than on agonistic ones. Typical of this emphasis are statements such as "community (of African hunting dogs) is organized on the basis of extremely 'friendly' relationships" (p. 202), "aggression does not play a decisive role in maintaining the structure of communities of jays" (p. 196), "rather than aggression, personal 'sympathy' between individuals of the same as well as of the opposite sex represented a more essential factor in the life of a community of wolves." (p. 201) Aggression's basic function is a dispersal promoting one, it puts distance between groups and gives origin to exiles that transmit genes from one community to the other. Elementary reasoning, on the contrary, is one of the bases for mutual assistance and cohesiveness, and, thus, a very powerful instrument of evolutionary change.

The importance given to cohesive social tendencies derives from Krushinsky's belief that evolution proceeds principally through group selection. Individual or collective behavior that result in benefit for the community are inevitably selected, through group selection: selfish behaviors can only spread under individual selection. Both principles are perfectly true, but also, only true in principle. Modern views give high priority to individual selection, and offer a very different, somewhat harsher and more Hobbesian picture of social organization.

COMPARISON AND THE ESTABLISHMENT OF SCALES

Using the scores of elementary reasoning tests as a criterion, Krushinsky ordered the species he studied in scales of progressive ability, taking separately each great taxonomic group (mammals, birds, reptiles, amphibians and fishes). Among mammals, for instance, we have, at progressively higher levels of ability: (1) rats and rabbits; (2) cats; (3) silver-black and arctic foxes; (4) red foxes, wolves, dogs, Corsac foxes and raccoon-dogs; and (5) monkeys, dolphins and bears.

Phylogenetic evolution of brain and behavior, according to Krushinsky, did not proceed in the same way in different taxonomic group. Inside each of them, however, animals can be ordered along a scale, according to the level of reasoning. Implicit is the anagenetic (Campbell & Hodos, 1991) idea that evolution is directional and progressive: "Progressive evolution involved the growing capacity of animals to apprehend a greater number of natural empiric laws."

The possibility of establishing hierarchical series of species, on the basis of cognitive ability, is not a consensual matter. Some extreme positions, such as MacPhail's (1987), according to which there are no fundamental qualitative differences among animals in intelligence (at least, among nonhuman vertebrates), are not convincing. But once one accepts the fact that frogs differ from dogs, how is one expected to analyze and interpret the differences?

I personally am not very comfortable with classification of species along scales, when such classification implies strict phylogenetic evolution. I prefer an ecological perspective, which consists in taking learning and cognitive abilities as adaptations to specific habitats. General processes are of course real, and indicate the fact that very different species had to cope with similar general constraints of the environment. The comparative method, however, can lead us to explore and respect diversity (including diversity in learning and cognition) and to relate it to the tasks and circumstances with which animals normally have to cope.

REASONING ABOUT THE ELEMENTARY REASONING CONCEPT

To what extent is the elementary reasoning concept reasonable? I think Krushinsky has pinpointed a real and very relevant aspect of behavior that deserves experimental and theoretical consideration in its own right. One key element of his position is the idea that some animals at least are able to apprehend empirical laws, that is, causal regularities of the environment, and use such knowledge in response to selection. He is not explicit about the mechanisms that could mediate reasoning, and does not indulge in "representational model building," but his ideas are convergent with several recent cognitive proposals, such as Gallistel's (1989) views about functioning isomorphism between environment and brain processes.

I am concerned, however, with some limitations of the elementary reasoning concept and of its operational definition: (1) extrapolation and dimensionality tasks can, at best, assess one or a few aspects of cognitive abilities of animals: they cannot be taken as a primary test of reasoning. As Sherry argues (1987), intelligence may not be a single capacity, but a collection of capacities.

(2) Scores in any single task are not necessarily representative of the animal or species level of cognitive ability. Motivational, species-specific "misbehavior," and, most importantly, the structure of the experimental situation can influence performance, favoring or impeding correct responses. Pigeons, which are quite unable to solve food-behind-the-screen problems, may be quite clever at solving other complex tasks, depending on the current contingencies. Designing tasks that are ecologically relevant, meaningful from the point of view of the natural environment and of the animals' normal way of life could reveal unexpected performances: animals will function most readily in environments that resemble the ones to which they are adapted.

(3) A modular conception of elementary reasoning should not hinder an analysis of the influence of past experience and of learning on intelligent acts. New solutions are frequently the result of a reordering of old, learned behaviors, and some problem solving strategies can be enhanced through training. Exposing chimpanzees to language training, for instance, makes them more proficient in special cognitive tasks such as same/different judgments, solving analogies, etc. (Premack, 1983).

OMISSIONS

A final observation: I sought and did not find mentioned in the book the names of two psychologists, one who published relevant studies from the point of view of extrapolation. The first one is Piaget (1937) who investigated the way young children learn about several essential properties of objects, exteriority, substantiality, individual identity and permanence. Permanence is exactly what Krushinsky means by "the law of nondisappearance of objects." Piaget showed that the infant's search for a hidden object followed orderly stages, going from total indifference as the object ceases to exist when it leaves the perceptual field, up to the stage when the child is able to reconstruct, through ideation, the invisible course of the object.

The second omission is Etienne's (1973) study of object permanence in chicks. Etienne, who knew about Krushinsky's works and was probably influenced by him, used a situation with two parallel, vertical screens, with a glass tube in between, in which chicks could see and follow a mealworm until it disappeared. In this setup, which is very similar to the tunnel or screen setups invented by Krushinsky, Etienne found that during the first trials the animals stayed near the place where the mealworm was seen for the last time, most of them giving distress calls. Later on they started going around the screens and learned how to find the bait. Performance was stimulus-bound: it dropped to chance when relevant aspects of the situation were changed. Such findings confirm Krushinsky's results and give support to his distinction between learning and elementary reasoning.

The fact that Krushinsky did not mention either Piaget or Etienne, (probably not knowing about their publications), and the fact that he himself is almost never quoted by American or European behavioral scientists, in contrast with, for instance, Vinogradova, is a fact that makes one reflect about the crucial importance of communication of results and of exchange of ideas in research, and makes one welcome the timely translation of the current book. Behavioral (and neurophysiological) work under Krushinsky's inspiration would surely not be dissonant in the current field of comparative cognition; it would fit, for instance, in the context of Piagetian studies of animal behavior (Dore & Dumas, 1987; Dumas & Dore, 1991).

Krushinsky's book, with all its scholarship, is about a single basic insight: the existence of elementary cognitive processes and the relevance of their study for an integral science of behavior. He wrote that a "great deal of experimental data exist, and important theoretical generalizations are being formulated concerning mechanisms of learning and instinct. But these two important components of behavior are not sufficient for formulation of a general theory of behavior. Such a theory requires a third component to be added—elementary reasoning." (xxii) His book represents a creative exploration of that third domain, made in the spirit and enthusiasm of pioneers. It is a thought-provoking book, written at the threshold of a new era in the comparative study of cognition.

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