

THE COGNITIVE ANIMAL
Empirical and Theoretical Perspectives on Animal Cognition

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Animals often behave adaptively in response to a novel stimulus because the stimulus resembles others for which the appropriate response is already known. Such an adaptation expresses an ability to categorize. In effect, in the absence of categorization, each object or event would be perceived as unique, and generalizations would be impossible. Therefore it is not surprising to find categorizing abilities in various animal species, although most of the empirical evidence concerns birds (mainly pigeons) and primates. Since categorization is a fundamental aspect of information processing, its study is crucial for increasing our understanding of animals' cognitive abilities.

This essay describes some of the studies that have been carried out in the past 5 years with two species of baboons, both in laboratory-controlled conditions (Guinea baboons, *Papio papio*) and in outdoor settings (olive baboons, *Papio anubis*). These studies aimed to explore different levels of categorizing behaviors (and their underlying processes) in monkeys confronted with various tasks. Furthermore, we were interested in comparing monkeys and humans tested with similar stimuli and procedures.

A useful general framework for the investigation of these behaviors was provided by Herrnstein (1990), who described categorization abilities in animals in five levels of increasing abstractness, including (1) discrimination, (2) categorization by rote, (3) open-ended categorization (namely, category formation resting on a perceptual similarity between individuals that belong to a given class), (4) concepts, and (5) abstract relations. Herrnstein (1990) uses two criteria to define conceptual categorization (level 4). The first criterion is met when a rapid generalization about members of a class of items is observed. The second criterion, which is related to conceptual processing, implies categorization abilities that go beyond perceiving a similarity

between exemplars of a class. Thus, level 4 is more complex than open-ended classification, the latter being related to the use of perceptual dimensions of stimuli. [See Schrier et al. (1984) for an example in macaques, D'Amato and Van Sant (1988) for an example in cebus monkeys, and Vauclair and Fagot (1996) for an example in Guinea baboons.] Level 5 of Herrnstein's categorization is attained when a subject is able to use abstract relations not only between objects but also between concepts, such as in conceptual matching or in conceptual identity (for example, the mastery of a "sameness" relation). The evidence for capacities to perform the first three levels of categorization is abundant for several animal species (see Zayan and Vauclair 1998 and Thompson and Oden 2000 for reviews). It is, however, much less clear concerning levels 4 and 5.

Laboratory Studies with Guinea Baboons

Several experiments were conducted with baboons in order to assess the abilities of these monkeys to discriminate objects on the basis of their membership in a category and to study the nature of the representations of categories the baboons formed. In all the experiments reported in this section, we used a video task requiring the baboons to manipulate a joystick that controlled the movements of a cursor on a screen (Vauclair and Fagot 1994). Briefly, with this technique, the subject was required to manipulate the joystick so as to "touch" with the cursor a response stimulus that matched the sample stimulus on an arbitrary (experimenter-defined) basis.

In one of our studies, we examined our monkeys' abilities to categorize artificial stimuli (Vauclair and Fagot 1996). More specifically, we explored how baboons categorize alphanumeric characters displayed in various typefaces. For

this purpose, the baboons were first trained in a symbolic matching-to-sample task with 21 different fonts of the characters "B" and "3" as sample forms, and color squares as comparison forms. After training, novel fonts were displayed. The monkeys showed positive transfer of categorizing performance to the novel stimuli of the characters used in the original training. Such results demonstrate that the original learning was not achieved by rote, because in that case the animals would have demonstrated no transfer to the novel typefaces. Thus the baboons' performance indicates that these monkeys were able to exhibit level 3 behavior (open-ended categories in Herrnstein's sense).

A proper assessment of categorization requires not only that subjects conceive that different objects have common class attributes but also that the subjects can discriminate among individual members within a category (Thompson 1995). Thus, in order to dismiss simple stimulus generalization, it must be demonstrated that stimuli to be classified in the same category are discriminably different from one another. This control was used in our study (Vauclair and Fagot 1996), but it must be pointed that it is rarely used in investigations of categorizing abilities of animals. We also demonstrated in further studies similar abilities of our monkeys to categorically process spatial relations such as "above" and "below" categories (Dépy et al. 1999) as well as "long" and "short" distances (Dépy et al. 1998).

A hallmark of categorical processing in humans is the ability to extract a prototype of a given category. A possible way to investigate the issue of categorical representations is therefore to search for a prototype effect. This effect, which was initially reported in the human literature (e.g., Rosch and Mervis 1975), is expressed by a better categorizing performance with prototypical stimuli representing the central tendency of the category than with other, less typical exemplars. For example, humans think that the sparrow is a better exemplar for the "bird" category than the ostrich.

Demonstration of prototype effects in animals is controversial. Some authors (von Fersen and Lea 1990) have described it in pigeons, while others (e.g., Huber and Lenz 1993) did not find it. Only one study (Jitsumori 1994) has assessed prototype effects in nonhuman primates. In this research, artificial stimuli defined by three two-valued positive or negative dimensions (color, shape, and background color) were presented to rhesus monkeys. The stimuli used in training included only two of the three positive or negative dimension values. In transfer, both the prototypes and novel exemplars of the two categories were shown to the animals. Three of the five monkeys demonstrated a high level of transfer with the prototypes containing all three positive or negative features. However, for those monkeys, there was no statistical difference between the performance achieved with prototypes and that obtained with the nonprototypical stimuli.

Given the contrasting evidence for the use of prototypical representations in animals, we further investigated prototype effects by testing two different species of primates. Identical polymorphous artificial stimuli were presented to both humans and baboons in a symbolic matching-to-sample task. In line with Jitsumori (1994), the rationale of our study with baboons (Dépy et al. 1997) was first, to train subjects to classify two out of three feature stimuli (color, shape, position) and second, to assess transfer of performance with the prototypes of each category. Analyses of data searched for possible prototype effects in both species and focused on species differences and similarities in the procedures creating the categories.

Whereas our human participants solved the task in a propositional way, the results showed that baboons were faster in categorizing prototypical forms than nonprototypical forms. However, an analysis of the training data indicated that the baboons did not extract the prototypes, but responded according to a peak shift phenomenon. This phenomenon (e.g., Mackintosh 1995) could explain the choice of prototypical stimuli as being made, not because these stimuli

represented the central tendency of the class, but because they corresponded to the exemplars sharing the least common features with the alternative category. In fact our monkeys used a mixed procedure that consisted in memorizing salient cues between stimuli (e.g., the background color) or specific associations between exemplars and response associations.

Studies with Olive Baboons in a Natural Setting

Tasks requiring the categorization of items on the basis of their functional similarity, such as the distinction between food and nonfood items, are good candidates for studying level 4 behavior. This kind of classification indicates the presence of conceptual categorization given that the items to be classified do not necessarily resemble each other. The animal literature provides only few cases of conceptually based, functional categorizations. In one study by Watanabe (1993), pigeons were trained with real objects (4 edible and 4 inedible stimuli) and then tested with printed color photographs (6 novel stimuli, each belonging either to the food or nonfood category). Generalization to the novel stimuli regardless of the type of stimulus presented (picture or real object) was taken as evidence that pigeons displayed object-picture equivalence based on functional classification. The evidence for similar abilities in nonhuman primates comes from the work of Savage-Rumbaugh et al. (1980). Although the aim of these authors was to demonstrate the mastery of reference in linguistically trained chimpanzees, their study offers clear-cut evidence of categorizing abilities in apes. In this experiment, the chimpanzees were first trained to classify real items in two categories (food and tools). Then the subjects easily transferred their categorization to novel objects and later to pictures and arbitrary symbols (lexigrams) of the respective categories.

In one of our studies (Bovet and Vauclair 1998), olive baboons living in small social groups in an outdoor enclosure were individually trained

and tested on the natural category of food versus nonfood with real objects using an adapted version of a Wisconsin General Test Apparatus. The monkeys were first trained to categorize two objects, one food and one nonfood; then 80 other objects (40 food and 40 nonfood) were presented and the categorizing response to each object was recorded. The baboons showed a high and rapid transfer of their categorizing abilities to the novel items. A similar performance for vervet monkeys was described by Zuberbühler et al. (1999). These abilities also persisted in subsequent experiments in which we used cutout photos and various modes of picture presentations. This set of data further demonstrates the abilities of the baboons to relate real objects to their pictorial representations (Bovet and Vauclair 2000).

The same procedure of successive simple discriminations in a two-alternative forced-choice procedure was used in follow-up studies (Bovet and Vauclair 2001). In a first experiment, the monkeys had to judge two physical objects as "same" or "different" (perceptual identity). For example, they were required to judge two apples as being the same, or an apple and a padlock as being different. In a crucial test (second experiment) of conceptual identity (corresponding to Herrnstein's level 5), the baboons had to combine their previously acquired skills in order to classify as "same" two (different) objects that belonged to the same functional category (food or nonfood) and apply that learning to new exemplars. For example, they had to classify as "same" an apple and a banana, or a padlock and a cup, and as "different" an apple and a padlock. This ability corresponds to level 5 of Herrnstein's classification scheme. The monkeys attained a high level of performance at the end of the experiment with totally novel objects (i.e., objects novel in the task but left in the monkeys' enclosure before the experiment). Such results demonstrate the mastery of the "same-different" relation and the ability to conceptually judge as same or different objects in the previously learned [categories](#).

Discussion and Prospects for Future Work

A number of issues can be raised about categorization processes from the studies reported in this essay. They concern in turn (1) the presence of categorization procedures in animals outside of visual perception, (2) the adaptive value of categorization treatments, (3) the interest and importance of studying categorization in the social domain, and (4) the limits of categorization procedures in animals, and possible differences with human categorization.

First, it is important to stress that the examples provided here dealt with the processing of visual objects. However, acoustical stimuli are also categorically organized, not only in non-human primates (e.g., May et al. 1989; Ramus et al. 2000), but also in rodents (e.g., Ehret 1992) and in birds (Weary 1989). Note also that the involvement of categorization procedures for organizing information in the environment goes well beyond perception and concerns the coding of objects and space. [An example of the categorization of geometric versus nongeometric information in a reorientation task by rhesus macaques can be found in Gouteux et al. (2001).]

Second, our experiments with two baboon species show that they are able to categorize stimuli by using varied kinds of procedures, the extent of which may depend on the species and individual experiences with the objects and procedures. In all cases, categorizing strategies appear to be adaptive given that they allow the animals to respond efficiently to sets of different

This latter feature can be exemplified in the experiment with dimensional stimuli (Dépy et al. 1997). Baboons adopted a strategy for processing these stimuli based on the use of background color as a dominant cue for discrimination. It could be stated that the multiplicity of these strategies, as well as their opportunistic use, ensures the production of responses that are adapted to changing and varied environmental conditions.

Third, category formation and some of its underlying cognitive processes have been discussed so far mainly with respect to physical objects or features. There is, however, another context in which animals elaborate natural categories, that of their relations with conspecifics, a domain considered to allow the most complex expression of cognitive processes (e.g., Humphrey 1976). Animals may represent the classes of their conspecifics as well as the classes of relationships established between conspecifics or between the latter and themselves. As claimed elsewhere (Vauclair 1996; Zayan and Vauclair 1998), two types of social categories could be fruitfully studied: intraspecies recognition, including recognition of individual conspecifics, and representation of dominance hierarchies and their transitivity in linear orders. Moreover, it is particularly important to study categorizing processes in monkeys and apes because of their phylogenetic proximity to humans and because of their complex cognitive abilities.

Rare experimental studies are available on social categorization in nonhuman primates; they concern the mother-infant bond and dominance-subordination relation in vervets (Cheney and Seyfarth 1980) and macaques (Dasser 1988). However, because of the controversies surrounding the results and interpretations of these experiments (e.g., Thompson 1995) and the limited number of subjects tested, these experiments need to be both replicated and extended. In particular, it would be useful to test and compare monkeys and apes confronted with similar problems for which they would have to infer a kin or a hierarchy relation in their conspecifics as well as their **ability to use transitive inference** within these relations. For example, movies of conspecifics could be shown to these animals in which animal *A* is dominant over *B* and *B* is dominant over *C*. Several indexes could be used to assess dominance relationships, such as avoidance, access to food, and facial expressions or submissive gestures (de Waal 1982). The subjects could be trained with a conditional pro-

cedure to choose the dominant individual in a pair. Then they could be tested for their abilities to infer (transitive inference), for example, that A is dominant to C.

Fourth, the experiments that we carried out on monkeys tested in two different setups (laboratory and more natural conditions) permit one to evaluate in some way the respective role of these different environments in the expressions of categorization competence. Thus the studies on functional categorization with untrained animals (Bovet and Vauclair 1998, see earlier discussion) suggest that when they were tested with biologically relevant stimuli (grouping objects in food and nonfood categories has obvious ecological significance for these animals), monkeys were able not only to judge the sameness between physical objects but also the sameness of functional concepts. Such a high degree of abstraction and conceptualization by monkeys has, to my knowledge, not yet been reported in the literature. Note, however, that chimpanzees were successful in a conceptual matching task (Thompson et al. 1997), whereas sea lions approached this level of abstraction when tested in an equivalence class membership task (Schusterman and Kastak 1998).

Moreover, and contrary to Premack's (1983) contention, we demonstrated that cognitive competence comparable to relational matching does not necessarily require previous training with explicit tokens and symbols. In effect, our monkeys' previous training only involved categorizing objects that belonged to one of two categories, and using the same-different relation between objects (within and between the two categories).

A final issue that needs to be briefly considered is related to the existence of likely differences between monkeys' and humans' strategies in solving categorization problems. Our experiments most of the time involved both monkeys and human participants who were tested with similar procedures. This practice, which is seldom followed in research, allows direct comparisons of the procedures used by each species. A comparison of the results calls for qualitative differences be-

tween strategies expressed by humans, who used propositional reasoning for categorization of polymorphic stimuli (see also Fagot et al. 1998) and those expressed by baboons, who relied on perceptual discriminations. Such discrepancies, which were also observed when we compared baboons and 3-year-old children (Bovet et al. 2001), indicate the limits of a comparative approach to categorization processes.

Categorizing procedures used by animals are simultaneously dependent on environmental constraints on their cognitive competence (for example, the nature and the salience of available stimuli) and their past experience. Attempts at homogenizing stimuli and methods seem to be insufficient to elicit the use of homologous procedures in the species under comparison. Such effort is, however, needed, along with a consideration of the cerebral structures involved in solving the task (Roberts 1996) in order to determine if the processing is homologous or if it is an effect that directly derives from interspecific cognitive differences.

In any case, it can be expected, through such investigations, to obtain novel data and interpretations about categorization and to increase our knowledge concerning general cognitive abilities and the levels of representation of the social relationships of monkeys and apes. More generally, this enterprise of comparative cognition should lead to a better comprehension of human cognition, given that the latter is the product of both our ontogenetic history and our phylogenetic past.

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