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BRIEF REPORTS

Judgment of conceptual identity in monkeys

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Baboons (*Papio anubis*) were tested on categorization tasks at two different conceptual levels. The monkeys showed their ability (1) to judge as identical or different the objects belonging to two categories, on a perceptual basis, and (2) to perform a judgment of conceptual identity—that is, to use the *same/different* relation between two previously learned categories. This latter experiment represents the first demonstration of judgment of conceptual identity in a monkey species.

The purpose of our experiments was to investigate abstract concept formation in baboons. One kind of concept formation is the judgment of conceptual identity, whereby the subject has to judge the relationship between concepts' sameness/difference at a conceptual level (Thompson & Oden, 2000). For example, the pair of letters AA is conceptually similar to the pair of letters BB rather than CD. In this case, the subjects are matching on the basis of the relations between the relations. In the few available experimental investigations of conceptual matching, human infants (Tyrrell, Stauffer, & Snowman, 1991; Tyrrell, Zingaro, & Minard, 1993) and chimpanzees (Premack, 1983; Thompson, Oden, & Boysen, 1997) have succeeded on this task, but monkeys have consistently failed on this kind of conceptual matching task (Grant-Webster, Gunderson, & Burbacher, 1990; Thompson & Oden, 1996, 2000; Tomasello & Call, 1997).

According to Herrnstein (1990), categorization abilities in animals can be described at five levels, with increasing abstractness, including (1) discrimination, (2) categorization by rote, (3) open-ended categorization, (4) concepts, and (5) abstract relations. 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, as in conceptual matching or in conceptual identity.

In previous studies, using either a response generalization paradigm (e.g., D'Amato & Van Sant, 1988) or a habituation/dishabituation paradigm (e.g., Zuberbühler, Cheney, & Seyfarth, 1999), monkeys have been shown to perceive items as equivalent or belonging to the same category. These experiments showed monkeys' ability to form open-ended categories (D'Amato & Van Sant, 1988) or to use concepts (Zuberbühler et al., 1999), which correspond to Levels 3 and 4, respectively, of Herrnstein's classification scheme; however, monkeys have not demonstrated the ability to explicitly judge relational identity. To our knowledge, the only nonhuman animal for which evidence for conceptual identity has been found has been the chimpanzee.

The main goal of our study was to test whether monkeys are able to master conceptual identity of a somewhat different type—namely, a *same/different* relationship between two functional categories. In a previous experiment, 4 Olive baboons were trained to categorize objects into two different functional classes, foods and nonfoods. Subsequent generalization tasks demonstrated positive transfer to novel exemplars of the classes (Bovet & Vauclair, 1998), a Level 4 ability according to Herrnstein (1990). The same procedure, successive simple discriminations in a two-alternative forced choice procedure, is used in the present study. In Experiment 1, the monkeys had to judge two physical objects as *same* or *different* (perceptual identity). For example, they judged two apples as being the same or an apple and a padlock as being different. In a crucial test of conceptual identity (Experiment 2), the baboons had to combine their previously acquired skills in order to classify as *same* two (different) objects that belong 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 *differ-*

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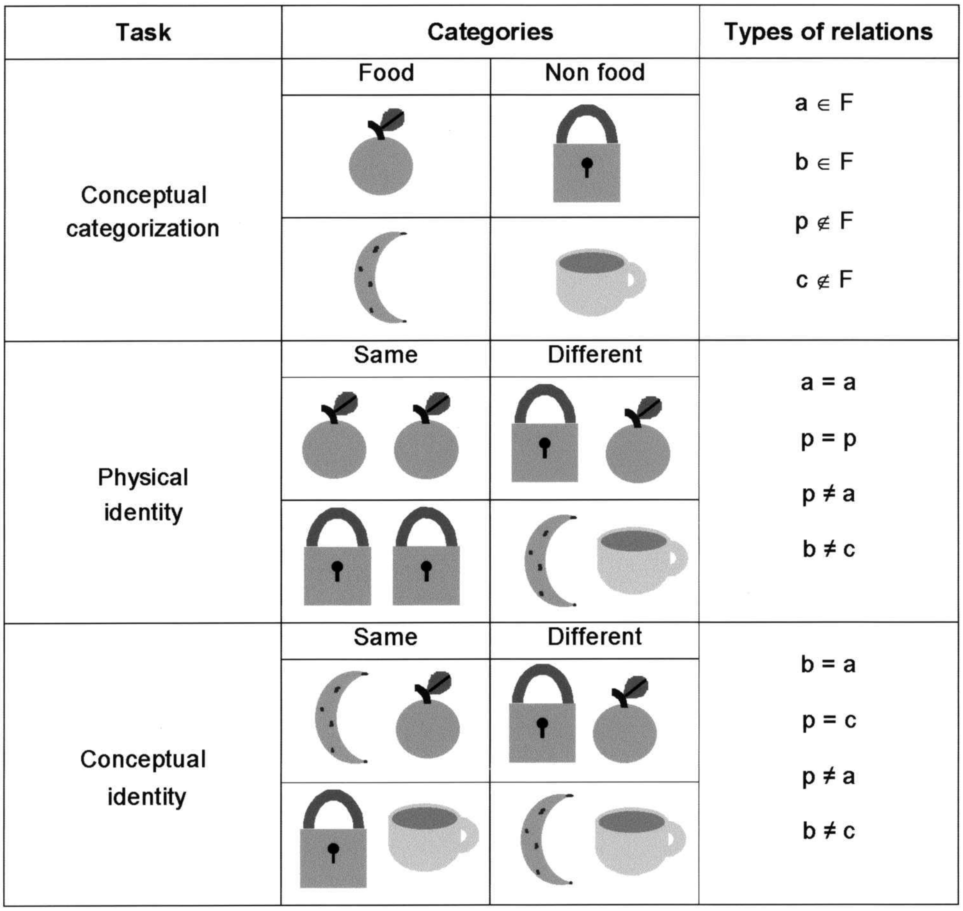

Figure 1. Tasks successively mastered by the baboons. ∈, belongs to; =, perceptual or conceptual identity; F, food; a, apple; b, banana; p, padlock; c, cup.

ent an apple and a padlock (see Figure 1). This ability corresponds to Level 5 of Herrnstein's classification scheme.

GENERAL METHOD

Subjects

The subjects were 4 laboratory-born adult baboons (*Papio anubis*)—2 males, Sylvestre (17 years old) and Balthazar (14 years old), and 2 females, Esperance (9 years old) and Ida (5 years old). The baboons were housed in social groups (1 male and 5–8 females) reared in indoor and outdoor quarters (35 square meters each) at the Station de Primatologie of the Centre National de la Recherche Scientifique, Rousset, France. The subjects were not food deprived, but they received their daily food ration (fruit, monkey chow, and vegetables) at the end of the daily training and testing. The subjects had been previously trained to categorize objects into food or nonfood categories (Bovet & Vauclair, 1998).

Apparatus

The monkeys were individually tested in their home enclosure with an adapted version of a Wisconsin General Test Apparatus (see Figure 2). The apparatus was attached to the bars of the enclosure for the experimental sessions. It was made of a vertical board (65 × 80 cm) consisting of a one-way screen that concealed the tester from the baboons' view during the experiments but allowed the experimenter to see the subjects; a horizontal board on which to present the stimuli behind a Plexiglas window; and two openings for the manipulanda (two ropes).

Stimuli

Food and nonfood objects were used as stimuli. Food objects consisted of various types of vegetables, plants, cereals, fruits, and sweets. Nonfood objects consisted of natural and man-made objects of various forms and materials (e.g., glass, plastic, wood, metal, paper, textile, stone). The objects of both categories were matched as closely as possible for size and color, so that two objects from the same categories did not resemble each other more than two objects from different categories. Prior to each experiment, all the stimulus objects had been left in the baboons' enclosure for 1 full day. Thus, the monkeys had had ample opportunity to manipulate and/or eat the objects prior to testing. Manipulation time varied across individuals and objects: The food items were generally quickly eaten, but some baboons manipulated the other objects for a long time, whereas others showed indifference toward the nonfood objects.

Procedure

At the start of each trial, the experimenter placed the two objects on the board, while the subject's view of the board was blocked by an opaque screen. The screen was then raised, and the subject had 5 sec to respond by pulling one of the two ropes, according to the relation (*same* or *different*) between the presented objects (Experiment 1) or between the presented categories (Experiment 2). If the

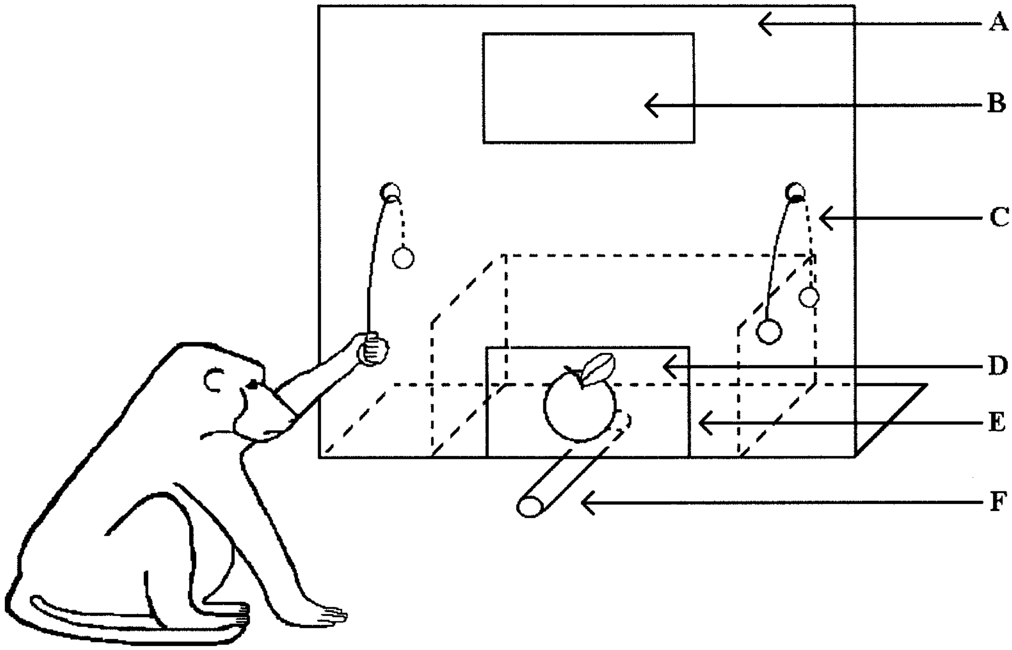

Figure 2. Test apparatus. The background is indicated by dashed lines. A, wooden board; B, one-way mirror; C, rope sliding through a hole and terminated by a wooden ball; D, transparent Plexiglas; E, board for placing the stimulus object; F, food dispenser.

subject did not respond during this interval or if he or she did not pull the rope to the end, an opaque screen was lowered for 5 sec, masking the subject's view of the board. The screen was then raised again, and the same objects were presented. The subjects rarely failed to respond within the first 5 sec. If the subject's response was correct, a food reward (small pieces of apple or grains of corn) was provided, and another pair of objects was immediately presented (within 5 sec). In the event of an error, a 10-second time-out was introduced, followed by the presentation of a new object. The orientation of the objects varied over trials. Each baboon was trained/tested about 1 h a day, 5 days a week, which represents an average of 185 trials per day.

EXPERIMENT 1
Perceptual Identity

Method

The monkeys' task was to pull one rope when the two presented objects were the same and the other rope when the two objects were different. The rope on the right side was associated with *same* for 2 of the monkeys and with *different* for the other 2 monkeys. In this phase, when two different objects were presented, they were always two objects belonging to different categories. The subjects were first trained with two pairs of objects (four possible combinations), and then, to assess transfer, when they reached a performance criterion of 80% correct responses for 100 consecutive trials, pairs involving new objects were presented.

A total of 36 different objects (18 food and 18 nonfood) were used in 684 possible combinations. That is, there were 648 (36 X 18) trials with *different* pairs (two different combinations were made with each pair of *different* objects according to the relative position of the 2 objects) and 36 trials with *same* pairs presented to each subject. Each new pair of objects was first presented in the 4 possible combinations between the 2 objects of the pairs; then, each object was presented in combination with all the preceding objects. Each new combination of objects was tested until a subject completed 8 out of 10 consecutive trials correctly. To avoid response bias, trials with novel pairs of objects were interspersed among trials involving familiar pairs, and trials with *different* objects were interspersed among trials involving pairs of *same* objects (mostly pairs of familiar objects, since most of the new combinations were pairs of *different* objects). Thus, from 1 to 3 familiar pairs of objects were interspersed with trials involving each novel object. To demonstrate a *same–different* judgment, we are primarily concerned with first-trial data for each novel pair of objects. Therefore, the analysis focused on these data.

Results

We separated the 36 stimuli into nine blocks of four objects. Each point on the functions presented in Figure 3 represents the percentage of correct responses for the first presentation of each of those four objects with all the preceding objects.

On average, it took the baboons 12 objects, which means 84 tests (6×12 *different* trials + 12 *same* trials) to reach a performance criterion of 80% correct responses on the first trials with new pairs of objects. This criterion was achieved in an average of 9,689 trials per individual.

The baboons performances continued to improve over trials involving the next 24 objects (Figure 3). At the end of the experiment, all 4 subjects were tested on the last 4 novel objects, presented in combination with all of the previous stimuli. This phase represented 140 novel object combinations (corresponding to the last point of the curve on Figure 3). The accuracy levels were 96% [$\chi^2(1) = 120$, $p < .001$], 91% [$\chi^2(1) = 92$, $p < .001$], 91%

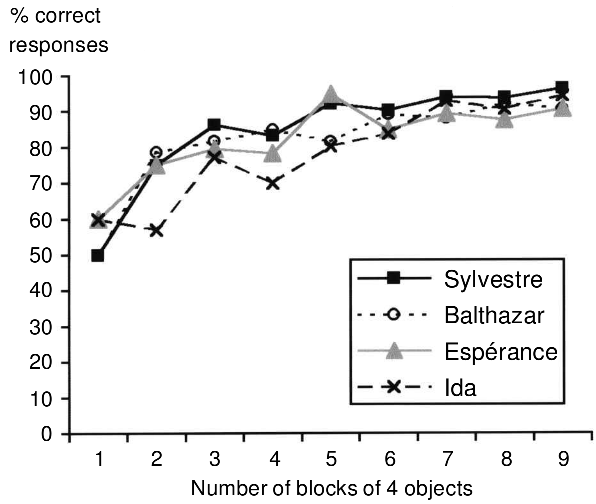

Figure 3. Percentages of correct responses for the first presentation of a novel pair of objects for perceptual identity.

[$\chi^2(1) = 92, p < .001$], and 94% [$\chi^2(1) = 109, p < .001$], respectively.

If we focus only on the trials involving new object pairs, the baboons' performances are still good. On the last 12 pairs of objects (48 combinations), the baboons achieved scores of 87.5% for Sylvestre [$\chi^2(1) = 27$, $p < .001$], 91.7% for Balthazar [$\chi^2(1) = 33$, $p < .001$], 89.6% for Esperance [$\chi^2(1) = 30$, $p < .001$], and 85.4% for Ida [$\chi^2(1) = 24$, $p < .001$].These results provide evidence that the baboons were able to class as same or different two physically identical or different objects.

EXPERIMENT 2
Conceptual Identity

Method

The subjects were the 2 males involved in the previous experiments. The 2 females gave birth during Experiment 1 and thus became less motivated during the test sessions. They finished Experiment 1 much later than the 2 males and thus were not included in Experiment 2.

The task in Experiment 2 was to pull one rope (the right side rope for Sylvestre, the left side rope for Balthazar) when the two presented objects belonged to the same category (two foods or two nonfoods) and to pull the other rope when the objects belonged to different categories (one food and one nonfood). The baboons were first trained with one block of four different objects (shown to them in the six possible combinations), and new blocks of four objects were introduced after a performance criterion of 80 % (out of 100 consecutive trials) was reached.

Each new block of four objects was first presented in the 6 possible combinations involving the four objects, and then each of those new objects was presented in combination with each of the preceding objects. A total of 36 different objects (18 food and 18 nonfood) was used, and all 630 pairwise combinations were presented to each subject. As in Experiment 1, eight correct responses out of 10 consecutive trials were required for a given pair of objects before a novel pair was presented, and trials with novel pairs of objects were interspersed among trials involving familiar pairs. Here too, we focused on the first-trial performance during successive transfer tests for each novel pair of objects.

Results

Both baboons started this experiment responding as they did in the first experiment, that is, by pulling the rope for *different* when two different objects were presented, even when those two objects belonged to the same category. Thus, their performance was far below chance at the beginning of the experiment. On average, it took 14 objects (91 transfer tests) to reach the criterion of 80% correct on trials involving one or two new objects (see Figure 4). This criterion was reached after an average of 14,576 trials (17,851 for Sylvestre, 11,300 for Balthazar).

At the end of the experiment, the last four objects were presented in combination with each of the previous objects. This allowed for 134 novel combinations. Both baboons obtained a high score (see Figure 4): 91% for Sylvestre [$\chi^2(1) = 229, p < .001$] and 81% for Balthazar [$\chi^2(1) = 174, p < .001$]. The baboons' performances are even better if we consider the trials involving novel objects only over the last six blocks (see Table 1). Such percentages provide convincing evidence that the monkeys mastered this conceptual identity task.

GENERAL DISCUSSION

Categorization is a fundamental component of many cognitive processes and has, therefore, been the subject of many animal experiments (see Herrnstein, 1990, Thompson, 1995, Vauclair, 1996, and Zayan & Vauclair, 1998, for reviews). However, very few studies have examined functional categorization in animals. Functional categorization involving food has been investigated by Watanabe (1997) in pigeons and by Savage-Rumbaugh, Rumbaugh, Smith, and Lawson (1980) in chimpanzees. Other investigators have studied the formation of functional categories in pigeons, using a discrimination procedure involving repeated reversals (Vaughan, 1988). Similarly, functional or equivalence class membership

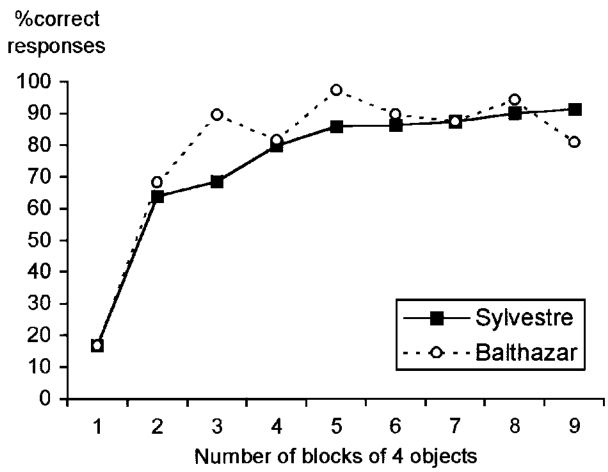

Figure 4. Percentages of correct responses for the first presentation of a novel pair of objects for conceptual identity.

Table 1
Percentages of Correct Responses Given for the First Presentation of the Combinations Realized With a New Block of Four Objects for the Last Six Blocks in Experiment 2

Subject	Same Category (n = 12)	χ^2	Different Categories (n = 24)	χ^2	Total (n = 36)	χ^2
Sylvestre	100.0	12*	91.7	16*	94.4	28*
Balthazar	91.7	8†	79.2	8†	83.3	16*

*$p < .001$. †$p < .01$.

has been studied in a California sea lion, using a matching-to-sample procedure (Schusterman & Kastak, 1998).

We decided to use this kind of categorization (in which the members of the class share a functional property but do not look alike), because, as has been explained by Herrnstein (1990), conceptual categorization is more abstract than perceptual categorization (for which the stimuli share visual properties and are, thus, physically similar). Our task involved functional rather than perceptual categorization, because the only possible property the baboons could have used to classify the objects was their edibility. It is of interest to note that the subjects' classificatory errors could often be explained by their food preferences, which varied across the individuals. Thus, uneaten food items (e.g., marshmallows for Sylvestre) were classified in the nonfood category (see Savage-Rumbaugh et al., 1980, for similar findings).

In Experiment 2, the hypothesis that the baboons could master the task by means of a simple discrimination based on the total hedonic value of the display (if moderate hedonic value, then respond *different*; if high or no hedonic value, then respond *same*) can be dismissed. In fact, no errors occurred when one highly valued food object was presented with a nonhedonic object or when two low valued food objects or two small food objects were presented.

The use of three-dimensional (3-D) stimuli (instead of the two-dimensional stimuli more typically used in this kind of research) was chosen to facilitate functional categorization in our previous study (Bovet & Vauclair, 1998). It is likely that the use of 3-D stimuli made the function of the objects more salient (Bovet & Vauclair, 2000) and, therefore, augmented the rapid generalization from a few training objects to novel food and nonfood objects and facilitated the demonstration of conceptual identity.

Numerous training trials were required for the baboons to reach the 80% correct criterion in the two experiments reported here. It is likely that the monkeys relied on rote learning of all the combinations in these early trials. Indeed, they required fewer trials to acquire the perceptual identity task than to acquire the conceptual identity task. This is not surprising, given the greater conceptual complexity of the latter task.

For Experiment 1, the identity rule is not the only possible explanation for the baboons' successful performance. The subjects could also have learned to discriminate the stimulus arrays on the basis of symmetry (a stimuli configuration consisting of two identical objects is bilaterally symmetrical, whereas a configuration consisting of two different objects is not). However, in Experiment 2, the configuration could not be used to solve the task, because the two objects presented were always different and, consequently, the configuration was never perceptually symmetrical.

In Experiment 2, for each block of four objects, there were four *different-categories* trials and two *same-category* trials. The ratio of *same* to *different* is thus not equal. However, the results show that the subjects were not responding with a bias toward the *different-categories* response, because both baboons made slightly more errors for the *different-categories* trials than for the *same-category* trials (Table 1).

The high level of performance attained by the 2 baboons at the end of Experiment 2 with totally novel objects (i.e., objects novel in the task but left in the monkeys' enclosure before the experiment) demonstrates mastery of the *same–different* relation and the ability to conceptually judge as *same* or *different* the previously learned categories.

Moreover, contrary to Premack's (1983) contention, cognitive competence comparable to relational matching does not require previous training with explicit *tokens* and *symbols*. Our subjects' 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).

Our experiments suggest that, when tested with biologically relevant stimuli (grouping objects in food and nonfood categories has obvious ecological significance for these animals), monkeys are able to judge not only the sameness between physical objects, but also the sameness of functional concepts. Such a high degree of abstraction and conceptualization by monkeys has not previously been reported in the literature.

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