Picture Perception in Monkeys and Pigeons: Transfer of Rightside-up Versus Upside-down Discrimination of Photographic Objects Across Conceptual Categories*

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ABSTRACT. Monkeys and pigeons were trained to discriminate between normally oriented full frontal pictures of humans and upside-down reversals of the same pictures as stimuli. Monkeys displayed a high level of transfer to the new pictures of full frontal and rear views of humans and silhouettes, but failed to transfer to the close-up and far human faces. Pigeons showed poorer transfer to the silhouettes and higher transfer to the far human faces than did monkeys. Further transfer tests were performed with non-human pictures, including monkeys, birds, mammals, and man-made objects. Pigeons failed to transfer to the non-human pictures. This indicates that the pigeons had learned to classify the pictures based on some concrete features specific to the humans and that the transfer to the new versions of human pictures could be explained by simple stimulus generalization based on perceptual similarity. Two out of four monkeys did transfer fairly well to the non-human pictures, except for the man-made objects. High levels of transfer to the non-human natural pictures suggested that the monkeys classified the pictures on the basis of the orientation of objects represented by the pictorial displays.

Key Words: Concept discrimination; Picture perception; Categorization; Orientation discrimination; Monkey; Pigeon.

INTRODUCTION

The ability of animals to form concepts based on natural categories has been investigated by using pictorial stimuli in a go/no-go discrimination paradigm, often under the assumption that the animals were responding to the pictures in the same way as they would respond to the objects represented. HERRNSTEIN and LOVELAND (1964) first demonstrated that pigeons learned to discriminate between two classes of slide pictures which were distinguished only by the presence or absence of people. Since then, pictures of a variety of different categories have been employed to investigate concept formation in pigeons, including pigeon vs. non-pigeon, fish vs. non-fish, tree vs. non-tree, oak leaf vs. non-oak leaf, water vs. non-water, etc. (CERELLA, 1979; HERRNSTEIN & DE VILLIERS, 1980; HERRNSTEIN et al., 1976; POOLE & LANDER, 1971; SIEGEL & HONIG, 1970; WASSERMAN et al., 1988). Based on the finding of high levels of transfer to a variety of new instances, HERRNSTEIN and others have argued that pigeons may form natural concepts comparable to those of humans. Recently, research similar in general aim to that of the pigeon studies has been

undertaken in the monkey (D'AMATO & SANT, 1988; SCHRIER & BRADY, 1987; SCHRIER et al., 1984; YOSHIKUBO, 1985). Evidence for natural category concepts has generally been obtained in this animal similarly to pigeons.

In the typical concept formation experiments in animals, one class of pictures contained objects of a single category and the other class of pictures contained the complement of this category. The stimuli within a given category are generally perceived to resemble one another more than they resemble stimuli of other categories. This may be almost as true for animals as it is for humans, as demonstrated by SANDS et al. (1982) in monkeys and by WASSERMAN et al. (1988) in pigeons. Given the excellent long-term memory for large sets of pictorial stimuli in monkeys (JITSUMORI et al., 1988; RINGO & DOTY, 1985) and pigeons (VAUGHAN & GREENE, 1984), the categorization implemented by these animals could be based on memory of every individual stimulus, and a high level of transfer to new instances could be due to simple stimulus generalization from previous exemplars.

Another problem of the concept formation experiments is that the representational character of the pictorial stimuli could not be identified empirically. D'AMATO and SANT (1988) correctly pointed out that experimental instantiations of natural category concepts are usually impoverished versions of the real thing. Indeed, the fact that animals can readily classify new instances of people and non-people pictures does not necessarily mean that the animals have learned the concept of lifelike humans in the real world. Previous studies on monkeys, in which orienting and/or approaching responses to a variety of monkey pictures were employed as measures of social preferences, have demonstrated that monkeys perceive representational character of the pictorial stimuli (BUTLER & WOOLPY, 1963; REDICAN et al., 1971; SACKETT, 1965; SWARTZ, 1983). In pigeons, studies directly addressed to this issue have not yet been undertaken by using pictures of natural objects.

Based on the above arguments, we trained pigeons and monkeys in an orientation discrimination task instead of the traditional concept formation task. First, the subjects were trained to discriminate between normally oriented full frontal pictures of humans and upside-down reversals of the same pictures as stimuli. They, then received transfer tests with a variety of pictures of humans seen from behind, in silhouette, and as a close-up or distant facial view. After retraining on the initial discrimination, further transfer tests were performed with non-human pictures including monkeys, birds, mammals, and man-made objects. If the subjects learn the task on the basis of memorizing every individual training stimulus, then they will tend to show less transfer as the transfer pictures become less and less similar to the training pictures. If the subjects learn to classify the stimuli by relying on the orientation of the objects represented, then transfer should not be confined to novel pictures of the particular training category but should extend to pictures of other categories. Namely, across-category generalization that transcends perceptual similarity and is mediated by an abstract concept should occur. Thus, the series of transfer tests undertaken in the present study should be able to test whether the subjects learn to classify the stimuli based on memorizing every individual training picture or based on an abstract concept.

The results of the transfer tests should provide some idea as to whether or not the animals see two-dimensional color pictures as representing semantic objects. For the subjects to classify a variety of novel stimuli correctly, the stimuli should inherently contain perceptual information on spatial orientation. Identification of the orientation of an object would appear to require a higher order of cognitive process than recognition of an object itself. Occurrence of the across-category generalization suggests that animals perceive the representational character of pictorial stimuli or they see somewhat semantic objects in two-dimensional pictures. On the other hand, tests with man-made objects should yield

little transfer. The pictures of man-made objects may not inherently contain perceptual information of spatial orientation for animals, and our subjects had never seen these objects before.

METHOD

SUBJECTS

Four macaques, consisting of two male rhesus monkeys (*Macaca mulatta*) and two male Formosan monkeys (*Macaca cyclopis*), born and reared at the Primate Research Institute, Kyoto University, served as subjects. Their ages ranged from 4 to 9 years old. The rhesus monkeys (Monkeys 2 and 4) had prior experience of concept discrimination between pictures with rhesus monkeys vs. without rhesus monkeys, and between pictures with rhesus monkeys vs. with Japanese monkeys (YOSHIKUBO, 1985). One of the Formosan monkeys (Monkey 3) was experimentally naive, and the other (Monkey 1) had been trained in a brightness discrimination task in a previous experiment. These two Formosan monkeys had never seen picture stimuli before. The monkeys were maintained at about 90% of their free-feeding body weights during the experiment. They were housed in individual cages and had free access to water in accordance with the "*Guide for the Care and Use of Laboratory Primates*" of the Primate Research Institute, Kyoto University, published in 1986 on the basis of the 1985 version of the guideline of the National Institute for Health.

All four pigeons had prior experience of rightside-up vs. upside-down discrimination of slide pictures showing an out-door or in-door scene with full frontal views of one or two humans. No living creatures other than humans were included in the pictures. The pigeons were maintained at about 80% of their free-feeding body weights with constant access to water and grit in their home cages. They were not included in any experiment for almost eight months prior to the present study.

APPARATUS

The monkeys were each tested in an experimental cage (75 × 75 × 75 cm) located in a dark experimental room with masking white noise. A houselight mounted on the outside of the cage dimly illuminated the cage during the experimental sessions. The front of the cage contained a transparent window (35 × 15 cm). Mounted behind the window was a color video monitor on which the picture stimuli (24 × 15 cm) were displayed using a razor disc system (TEAC, LV200) controlled by a computer (NEC, PC98). Below the window, about 15 cm above the floor of the cage, there was a response lever which could be illuminated by a small white light attached directly above the lever. The food reward (a small piece of apple, sweet potato, or a raisin) was delivered into a container located to the right of the lever. Operation of the feeder device was accompanied by a single beep of a beeper mounted on the outside of the right-hand panel.

The pigeon experimental cage (36.0 × 28.0 × 40.0 cm) contained a transparent rectangular key approximately 5 cm in front of a screen (9.4 × 9.4 cm). A carousel autofocus projector (Kodak, 5600) projected 35-mm color slides onto the screen. The height and width of the slides as they appeared on the screen were 6.5 and 9.5 cm, respectively. Reinforcement consisted of 3-sec access to mixed grain at an aperture positioned 12 cm below the key. A microcomputer system (NEC, PC98) controlled the experimental events, collected the responses, and was used to analyze the data.

Stimuli

The training stimuli consisted of 140 color pictures containing one or two humans differing in age, sex, race, and nationality. Color prints of humans, prepared from a wide assortment of books and magazines, were cut along their outlines. The cutout prints were photographed against a white unpatterned background. Humans were always in full view with their faces visible from in front.

The 175 novel stimuli used in Test 1 consisted of five versions of human pictures, with 35 pictures in each: (1) full frontal views of humans; (2) full rear views of humans with their faces invisible; (3) full views of humans in black-on-white silhouette; (4) close-up human faces; and (5) far human faces.

The 175 novel stimuli used in Test 2 were from five different categories, with 35 pictures in each: (1) full frontal views of humans; (2) monkeys (New World and Old World monkeys including apes); (3) birds (pigeon, eagle, sparrow, crow, macaw, etc.); (4) four-legged mammals (dog, cat, horse, rat, leopard, etc.); and (5) man-made objects (automobile, bike, lamp stand, clock, chair, etc.). In some pictures, the monkeys, birds, mammals, and man-made objects were in frontal view. In the others, they were in side view. The man-made objects were asymmetrical around a horizontal axis so that the orientation of the stimuli was readily discriminable by human observers.

Procedure

The subjects were trained in a go/no-go discrimination task similar to that utilized by Herrnstein and his co-workers (Herrnstein, 1979; Herrnstein et al., 1976; Herrnstein & de Villiers, 1980). One session consisted of 70 trials; namely 35 positive trials and 35 negative trials separated by 5-sec intertrial intervals. Each trial was initiated by the presentation of a picture. The response lever for the monkeys was dimly illuminated during the presentation of the picture stimuli. The duration of each presentation was varied irregularly with an average duration of 30 sec (range, 10 to 90 sec).

In positive trials, the pictures were normally oriented (rightside-up), and responding by the subject (a lever press in the monkeys and key peck in the pigeons) was reinforced on a variable interval of 30-sec schedule (range, 3 to 90 sec). Since the schedule of reinforcement was independent of the trial duration, zero to three reinforcements could be earned during a single positive trial. In negative trials, the pictures were rotated by 180 degrees (upside-down), and responding by the subject was not reinforced. A negative trial terminated after its initial scheduled interval had expired and 5 sec had passed without responding. This 5-sec penalty for a response during a negative trial was superimposed on the basic schedule of the trial duration.

During the baseline training, 140 pictures of full frontal views of humans were randomly allocated into two sets of 70 pictures. Each set appeared during each alternate daily session. The order of the pictures in a set was randomized and changed every session. The role of a given picture, either as a positive stimulus or a negative stimulus, was quasi-randomly determined for each session, under the restriction that no more than three of the same trial type could occur in succession.

In positive trials, the number of responses made prior to the first reinforcement of the trial was used to calculate the response rate. The response rate in negative trials was calculated by using the number of responses made prior to when reinforcement would have occurred if the stimulus had been positive instead of negative. The training continued until 90% or more of the total responses occurred in positive trials for three consecutive daily sessions.

Having attained the above criterion, the subjects were given Test 1 in which transfer to new human pictures of the five different versions (full frontal and rear views of humans, humans in silhouette, close-up human faces, and far human faces) was tested. Each picture appeared twice during the test of five sessions, once as a positive stimulus (normally oriented) and once as a negative stimulus (top-bottom inverted). The pictures of each version appeared at equal frequency within a session in a predetermined quasi-random order, under the restriction that no more than three pictures of a given version could occur in succession. The reinforcement contingencies were in the effects in the presence of normally oriented displays. There was no penalty for responses to pictures of upside-down reversals. Other procedural details were the same as those in the baseline training.

After completion of Test 1, the subjects received retraining for at least three sessions and until there was no consistent change in performance. The subjects were then given Test 2 in which transfer to non-human pictures was tested. Monkeys were tested with pictures of five different categories (humans, monkeys, birds, mammals, and man-made objects) and pigeons with pictures of four different categories. The pigeons were not tested with pictures of mammals. The procedural details were the same as in Test 1 except that pigeons received four test sessions rather than five.

RESULTS

The average number of sessions required to reach the acquisition criteria was 15.3 (range, 10 to 27) for pigeons and 27.5 (range, 24 to 34) for monkeys. The pigeons learned the discrimination very rapidly probably due to previous experience of orientation discrimination.

Figure 1 summarizes the results of Test 1 (upper panel) and Test 2 (lower panel). Mann-Whitney's rho was employed as an index of discrimination. It expresses the proportion by which the rank for responding to a normally oriented (positive) stimulus is above that to an upside-down (negative) stimulus. When discrimination is perfect, rho should be 1.0; when discrimination is absent, it should be 0.5; and when discrimination is completely inverted, it should be 0. The shaded regions between the middle horizontal lines in Figure 1 show where the values of rho are statistically insignificant at the 0.05 level, and the regions between the top and bottom horizontals show where they are at the 0.01 level (two-tailed Mann-Whitney U test). Response rates (number of responses per minute) to the positive and negative stimuli in each stimulus class are given in Table 1, together with data for the baseline performance obtained from the last three training sessions conducted immediately before each test.

The monkeys displayed a high level of transfer ($p < .01$) to the new pictures of full frontal and rear views of humans and silhouettes, but failed to generalize to the close-up and far human faces. Only two monkeys (Monkeys 2 and 3) showed a modest transfer to the far human faces to an extent slightly above the 0.05 level of significance. The failure of transfer to the close-up human faces was generally due to reduced responding to the positive stimuli as shown in Table 1. However, the failure of transfer to the far human faces was due to overresponding to the negative stimuli.

In comparison with the results for monkeys, the pigeons displayed a relatively poor transfer to the silhouettes but a relatively high transfer to the far human faces. Three of the four pigeons transferred to the silhouettes ($p < .01$ in Pigeons 2 and 4, and $p < .05$ in Pigeon 3), but the transfer was far from complete. The data in Table 1 indicate that the reduced transfer to the silhouettes was due to overresponding to the negative stimuli. The four pigeons revealed a significant level of transfer to the far human faces ($p < .01$), whereas the transfer
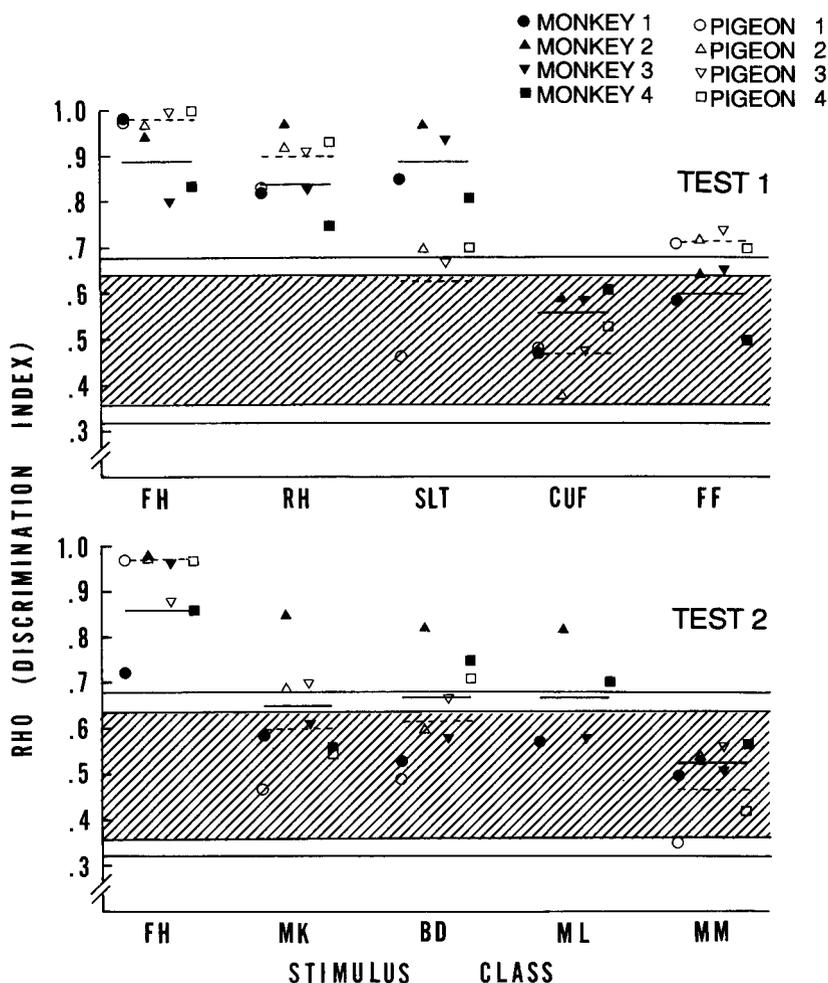
Fig. 1. Discrimination index, rho, for each stimulus category in each subject in Test 1 (upper panel) and Test 2 (lower panel). The short solid horizontal lines indicate the mean value of rho for each stimulus class in the monkeys. The short dashed horizontal lines indicate the mean value of rho for each stimulus class in the pigeons. FH: Full frontal views of humans; RH: full rear views of humans; SLT: silhouettes; CUF: close-up human faces; FF: far human faces; MK: monkeys; BD: birds; ML: mammals; MM: man-made objects.

to the close-up human faces did not significantly exceed chance ($p > .05$). As shown in Table 1, the inverted far human faces suppressed responding more reliably than did the close-up human faces.

In Test 2, both the monkeys and pigeons retained a high level of transfer to the new set of full frontal pictures of humans ($p < .01$), whereas they all showed no transfer to the man-made objects ($p > .05$). With the non-human natural pictures, Monkey 2 displayed virtually complete transfer ($p < .01$ for monkeys, birds, and mammals), Monkey 4 displayed good transfer to the birds and mammals ($p < .01$) but not to the monkeys, and Monkeys 1 and 3 failed to transfer across categories. In the case of pigeons, three out of the four subjects showed transfer to the pictures of monkeys ($p < .01$ in Pigeons 2 and 3) and/or birds ($p < .01$ in Pigeon 4, and $p < .05$ in Pigeon 3), but the transfer was always far from complete. The

Table 1. Response rate in responses/minute.

Subject	BSL		FH		RH		SLT		CUF		FF	
	S+	S−	S+	S−	S+	S−	S+	S−	S+	S−	S+	S−
Monkey 1	40.5	9.8	54.9	8.0	48.4	13.7	45.7	10.4	20.2	27.6	51.5	48.9
2	59.4	.9	53.2	2.3	51.9	2.6	56.0	2.5	.3	.1	62.8	31.8
3	26.9	4.2	16.9	6.2	22.0	4.9	25.4	1.5	4.0	3.3	16.3	12.4
4	36.0	1.8	37.4	6.9	37.6	16.1	22.2	3.9	18.3	11.9	33.4	36.5
Pigeon 1	98.4	7.2	103.5	8.3	106.7	46.4	108.0	80.6	61.8	72.8	70.2	38.7
2	138.0	10.2	147.8	9.3	138.3	17.0	142.1	64.7	114.8	120.8	117.9	58.2
3	168.6	6.6	148.7	3.0	159.3	39.3	150.9	67.8	73.8	58.7	99.0	57.6
4	93.6	6.6	93.2	4.1	89.9	13.4	91.4	45.6	64.4	57.5	66.9	28.8

Subject	BSL		FH		MK		BD		ML		MM	
	S+	S−	S+	S−	S+	S−	S+	S−	S+	S−	S+	S−
Monkey 1	53.3	8.8	59.2	35.5	55.2	48.1	59.0	49.4	50.9	41.3	58.9	59.2
2	72.0	4.0	59.8	4.5	54.7	19.4	43.7	8.2	57.0	18.0	6.6	1.8
3	22.0	1.7	23.7	4.6	10.6	6.2	7.1	2.9	10.9	8.4	10.5	9.4
4	43.3	4.9	44.2	14.4	28.6	28.2	30.9	12.6	46.0	35.4	25.4	21.8
Pigeon 1	96.0	9.8	95.7	16.7	72.5	69.5	91.2	75.8	—	—	86.1	93.0
2	139.6	14.0	142.7	17.6	102.3	54.9	141.5	84.0	—	—	117.5	99.5
3	163.8	10.2	150.6	14.1	116.4	62.1	141.8	64.5	—	—	111.8	86.9
4	96.0	8.8	106.5	12.2	59.9	51.3	97.8	59.9	—	—	90.3	81.6

S+ : Positive (rightside-up) stimuli; S− : negative (upside-down) stimuli; BSL: baseline training; FH: full frontal views of humans; RH: full rear views of humans; SLT: silhouettes; CUF: close-up human faces; FF: far human faces; MK: monkeys; BD: birds; ML: mammals; MM: man-made objects.

data in Table 1 indicate that the failure of transfer across categories in the pigeons and monkeys was generally due to an increase in responding to the negative stimuli. One exception was found in the performance of Monkey 2 with the man-made objects, where responding to both the positive and negative stimuli was largely reduced.

DISCUSSION

The monkeys and pigeons displayed virtually complete transfer to the new pictures of full frontal and rear views of humans. However, transfer to the close-up and far human faces (Test 1) and to the man-made objects (Test 2) was generally reduced. The most important single result was perhaps that two of the monkeys showed good transfer to the non-human natural pictures in Test 2.

Comparisons of performance between the monkeys and pigeons may suggest an interesting taxonomic difference in the ability to make use of information in pictorial displays. In Test 1, the difference between the monkeys and pigeons was most marked in the transfer to the silhouettes. The high level of transfer to the silhouettes exhibited by the monkeys suggests that color may not be critical in this species. In the case of pigeons, the absence of color information prevented reliable suppression of responding to the inverted pictures. However, the pigeons responded rather highly to the normally oriented silhouettes, as much as they did to the normally oriented frontal or rear views of humans. Thus, the human-like shape is of some significance for eliciting responses in pigeons.

The far human faces represented the only stimulus class to which the pigeons displayed a higher level of transfer than the monkeys. Although the shape of the full human body was lost in these pictures, the pictures did contain an outlined form overlapping with, although not identical to, the face region of humans which appeared in the training stimuli. Such a local feature suppressed responding by the subjects to the negative stimuli more

reliably in the pigeons than in the monkeys. Monkeys may have a tendency to attend to global features, whereas pigeons may attend to a number of distinctive local features and learn the task at a more concrete level than monkeys. This notion is consistent with the work of ROBERTS and MAZMANIAN (1988) who reported that pigeons learned at a faster rate than did monkeys in concrete but not more abstract problems of categorization.

Both monkeys and pigeons generally responded at a low rate to the normally oriented close-up human faces. Each face occupied most of the area of the picture so that the outline of a face itself was lost. Without outlined forms, it may be difficult for animals to perceive objects in pictorial displays. HERRNSTEIN and DE VILLIERS (1980) reported that pigeons classifying fish and non-fish slides had trouble with close-up views of the head region of a fish. In Cebus monkeys trained to discriminate between person and non-person slides, D'AMATO and SANT (1988) also reported that more than 80% of errors to new persons were made to the same slides which presented a human in close-up view. However, observations of the subjects performing the present task revealed an interesting finding. Monkey 2, the subject which showed high levels of transfer to the non-human natural pictures, had been threatened by the close-up human faces. Actually, this monkey avoided the close-up faces as shown by its severely reduced responding to these pictures. Such a reaction could have led to an underestimation of the transfer.

In Test 2, the pigeons failed to transfer to the non-human pictures. This indicates that the pigeons learned to classify the pictures based on some concrete features specific to humans. Pigeons are reported to be able to remember more than 320 slide pictures (VAUGHAN & GREENE, 1984). It seems quite possible therefore that in the present experiments, the pigeons learned to respond individually to the 140 normally oriented pictures and 140 top-bottom reversals. Although it remains to be seen whether or not pigeons can recognize an upright picture and its top-bottom reversal as the same picture presented in different orientations, the transfer to the new versions of human pictures exhibited in Test 1 may be explained by simple stimulus generalization from the original training stimuli.

Two of the four monkeys, like the pigeons, failed to transfer to the non-human pictures. Nevertheless, the two other monkeys (Monkeys 2 and 4) did transfer fairly well to the non-human natural pictures. One exception was the relatively poor transfer by Monkey 4 to the monkey pictures. This monkey had prior experience of concept discrimination with monkey pictures, which might have adversely affected its performance in the present task. However, it is not clear why this was not also the case for Monkey 2 which had similar prior experience of concept discrimination. The considerable amount of transfer displayed by these two monkeys cannot be explained by stimulus generalization based on perceptual similarity, because the non-human natural pictures must be discriminably very much different from the human pictures, as evidenced by the reduced transfer shown by the pigeons and the other monkeys. It may be reasonably assumed that these two monkeys classified the pictures based on the orientation of the objects represented by the pictorial stimuli. These two monkeys, therefore, did appear to be capable of recognizing the representational character of two-dimensional pictorial stimuli. However, what they were actually seeing is beyond the scope of the present study.

The present experiments provided evidence that monkeys do have an ability to perceive representational character in two-dimensional displays. The monkeys which exhibited the across-category generalization had prior experience of concept discrimination with pictorial stimuli, but none of them had had an opportunity to learn associations between objects and pictures directly. The findings suggest that in monkeys, learning of object-picture associations is not a prerequisite for perception of the representational character of pictures. On the other hand, the two other monkeys which had no prior experience of concept

discrimination revealed no across-category generalization. It seems therefore that prior experience of concept discrimination with pictorial stimuli may play an important role in picture perception and/or formation of an abstract concept in animals. Accordingly, the data obtained with pigeons do not necessarily indicate that nonprimate species such as pigeons do not have an ability to perceive representational character in pictorial displays. The critical variables, including prior experience with pictorial stimuli, responsible for picture perception and concept formation in animals should be assessed systematically.

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