JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1995, 63, 165–174 NUMBER 2 (MARCH)

PIGEONS' DISCRIMINATION OF PAINTINGS BY MONET AND PICASSO

SHIGERU WATANABE, JUNKO SAKAMOTO, AND MASUMI WAKITA

KEIO UNIVERSITY

Pigeons successfully learned to discriminate color slides of paintings by Monet and Picasso. Following this training, they discriminated novel paintings by Monet and Picasso that had never been presented during the discrimination training. Furthermore, they showed generalization from Monet's to Cezanne's and Renoir's paintings or from Picasso's to Braque's and Matisse's paintings. These results suggest that pigeons' behavior can be controlled by complex visual stimuli in ways that suggest categorization. Upside-down images of Monet's paintings disrupted the discrimination, whereas inverted images of Picasso's did not. This result may indicate that the pigeons' behavior was controlled by objects depicted in impressionists' paintings but was not controlled by objects in cubists' paintings.

Key words: stimulus control, concept, pattern discrimination, vision, key peck, pigeon

When we see paintings by Picasso and Monet, we can with some accuracy recognize which is Picasso's and which is Monet's, even if we have never seen the particular paintings before. There are many possible cues for this discrimination, such as color, style of brushing, favorite subjects, and so on, but no single feature differentiates each artist. It is also clear that we have acquired such visual concepts of paintings of Picasso and Monet by experience. Can pigeons discriminate paintings of one artist from those of another artist? If they can, do they also show generalization to paintings of other artists belonging to the same group, such as an impressionist or a cubist? Porter and Neuringer (1984) reported successful learning of musical discrimination of Bach and Stravinsky by pigeons. Can pigeons discriminate visual arts also?

Birds have excellent visual ability comparable to that of humans, and there have been many experimental studies showing acquisition of visual concepts in birds. Since Herrnstein and Loveland (1964) successfully trained pigeons to respond to color slides on which a human being appeared and not to respond to those without a human, there have been many studies demonstrating learning to discriminate natural concepts (e.g., Cerella, 1979; Herrnstein & de Villiers, 1980; Herrnstein, Loveland, & Cable, 1976; Roberts & Mazmanian, 1988; Watanabe, Yamasita, & Wakita, 1993), artificial concepts (Bhatt, Wasserman, Reynolds, & Knauss, 1988; Watanabe, 1991), and symmetry of objects (Delius & Habers, 1978).

Most of these natural-concept experiments used a slide projector as the stimulus-presentation device, and pigeons showed transfer of discrimination of photographs to real objects and of real objects to photographs (Watanabe, 1993). Representational paintings have features similar to photographs, but paintings patterned after impressionism are not precise reflections of the real world. They often are considered to be a reflection of the artist's subjective world. We can, however, identify "objects" in the paintings by Monet, Renoir, and Cezanne. In other words, we find a relation between these paintings and real objects. However, such a relation is often weak in the paintings by Picasso, Matisse, and Braque. Realism is relevant only for a perceiver who can see a painting as a representation of a three-dimensional world. If realism makes a difference to a pigeon, we can presume that it can see a painting as a representation of a three-dimensional world.

EXPERIMENT 1

In this experiment pigeons were trained on a discrimination between photographs or videos of paintings by Monet and those of Picasso. The paintings differed in their color, sharpness of contour, and objects. Potential cues for discrimination were examined by as-

The authors wish to express their gratitude to R. J. Herrnstein for encouragement and comments on this research. This research was supported by Grant-in-Aid for Promotion of Sciences 05206113. Address correspondence and reprint requests to Shigeru Watanabe, Psychology Department, Keio University, Mita 2-15-45, Minato-ku, Tokyo, Japan.

sessing effects of distortion, such as left-right reversal and upside-down reversal. Keller and Schoenfeld (1950) defined a *concept* as a generalization within a class of stimuli and a discrimination between the classes. The generalization of the discrimination of paintings by Monet and Picasso to novel paintings of these artists and those of other artists was tested.

Method

Subjects

Eight experimentally naive pigeons (*Columba livia*) were used for the present experiment. They were individually housed in stainless steel cages and were maintained at about 80% of their free-feeding body weights.

Apparatus

The experimental chambers were two identical operant conditioning chambers (30 cm by 30 cm by 30 cm) with a rectangular glass pecking key (5 cm by 7 cm). The key could be activated by a force of 0.2 N. A frosted glass screen (5 cm by 7 cm) was attached 1 cm behind the key. The key was mounted 20 cm above the floor and 13 cm above the aperture of a food hopper. Stimuli were projected on the screen by a slide projector (Super Cabin 2) in one chamber and by a video projector (Phillips LCP5000) in another chamber. A microcomputer (Sanyo MSX) controlled the experiment. The projected stimuli provided the only illumination in the chamber. The chamber was not sound isolated, but white noise (70 dB) was continuously broadcast.

Stimuli

Two different sets of stimuli, taken from picture books, were used as training stimuli (Table 1). Each set consisted of 10 different paintings by Monet and 10 by Picasso. Set A was used for training with the slide projector, and Set B was used for training with the video projector. "Typical" paintings were selected as stimuli. "Atypical" paintings (such as those of Picasso's blue period) were not used as stimuli. Table 2 lists stimuli used for the generalization test. Three novel paintings by Monet and Picasso and three each by Cezanne, Braque, and Delacroix were used as testing stimuli after training with Set A. Four novel Monet paintings, four new Picasso paintings, and four each by Renoir, Matisse, and Delacroix were presented in the generalization test after training with Set B.

Procedure

The pigeons were first trained to peck the key illuminated by a projector lamp without any painting stimulus. Then they were divided into two groups of 4 birds each. In the Monet S+ group, responses to paintings of Monet were reinforced by 4-s access to a feeder containing hemp seeds and responses to paintings of Picasso were extinguished, whereas in the Picasso S+ group paintings of Picasso were associated with reinforcement and those of Monet were not. Two different sets of stimuli were used. Two birds in each group received training with Set A, and the other 2 were trained with Set B.

A training session consisted of 20 randomly ordered presentations of each painting once, each lasting 30 s, separated by a 5-s blackout period. During presentation of S+, reinforcement was available on a variable-interval (VI) 30-s schedule, whereas no reinforcement was available during S− periods (mult VI 30-s ext). The subjects received one training session every day.

This discrimination training continued until the subjects showed a discrimination ratio above 90%, calculated by dividing the number of responses to S+ by the total number of responses, summed over two successive sessions. Then the following tests were carried out under extinction (i.e., pecking did not activate the food hopper during the tests). The subjects received at least two sessions of discriminative training between tests. If the subjects did not show at least 90% correct on the two sessions, additional training was given until the subjects reached the criterion again.

Test 1. Color of paintings by Monet might differ from those by Picasso. Differences in color thus might serve as cues for discrimination. In this test, monochromatic pictures of all training paintings were used to examine the possibility that color cues controlled the discrimination. The order and period of stimulus presentation were similar to those in daily training sessions. Monochromatic slides were used for Set A, and monochromatic images were produced by tuning the video projector for Set B.

Test 2. Most of the paintings by Picasso have sharp contours, but most of those by Monet

Table 1

Paintings used for training. S indicates catalogue number in *Shincho Bijutsu Bunko* (Shinchosya, Tokyo, 1974–1976), and R is that in *Classici dell'Arte* (Rizzoli, Milano, 1966–1979).

	Set A	Year	Catalog number	Set B	Year	Catalog number
Monet	Terrace of Saint-Adresse	1866	S3	Terrace of Saint-Adresse	1866	S3
	Dinner of Sisley	1869	S9	River	1868	S5
	Mrs. Monet	1870	S10	Mrs. Monet	1870	S10
	Red poppy	1873	S15	An impression:sun rise	1872	S12
	Capucines boulevard	1873	S18	Station of Saint-Lazare	1877	S17
	Pears and grapes	1880	S20	Pears and grapes	1880	S20
	Poplars of Giverny	1888	S25	Lady with parasole	1886	S23
	Pond of water lily	1899	S27	Pond of water lily	1899	S27
	Palazzo da mula in Venezia	1908	S29	Water lily	1914	S31
Picasso	Girls in Avignon	1907	S10	Les demoiselles D'avignon	1907	R4
	Man with a violin	1911	S13	Donna con ventaglio in poltrona	1908	R141
	Girl with a ring	1919	S16	Fabbrica	1909	R267
	Guitar, cup and fruits	1924	S20	Donna dalle mani intrecciate	1909	R318
	Model and artist	1928	S22	Il poeta	1912	R455
	Woman playing with a ball on the beach	1932	S24	"Ma jolie"	1914	R775
	Nude woman with a comb	1940	S26	Uomo con pipa	1915	R854
	Still life with a pan	1945	S28	Natura morta su un caminette	1921	R953
	Women of Algeria	1955	S30	Three musicians	1921	S17
	Nude woman under the pine tree	1959	S32	Dance	1925	S21

Table 2

Paintings used for tests. S and R indicate catalogue numbers as Table 1. M indicates catalogue number in *Matisse* by J. Guillaud and M. Guillaud (Guillaud Edition, 1987, Paris).

Test stimuli after training with Set A			Test stimuli after training with Set B		
New Monet			New Monet		
La Grenouillere	1869	S8	Le Grenouillere	1869	S8
Lady with a parasole	1886	S23	The Thames ant the capital	1871	S11
Water lily	1914	S31	Church	1883	S22
New Picasso			Palazzo da mula in Venezia	1908	S29
Dance	1925	S21	New Picasso		
Woman looking at the glass	1937	S25	Donna con ventaglio	1909	R224
Still life with an ox head	1942	S27	Natura morta spagnola	1912	R471
Cezanne			Foglio di musica e chitarra	1912	R577
Sitting man	1898	S17	Arlecchino	1913	R615
Still life with onions	1895	S23	Matisse		
Big water bathing	1898	S27	Notre-dame	1902	S3
Braque			La Tovaglia	1908	R107
Female musician	1917	S13	Blouse roumaine	1940	M413
Still life with "le Jour"	1929	S24	Apricot	1948	S30
An easel and a woman	1936	S27	Renoir		
Delacroix			La senna ad argenteuil	1883	R96
Still life with a lobster	1827	S5	Canottieri ad argenteuil	1883	R97
July 28th	1830	S8	Donna alla grenouilere	1879	R373
Atelier	1830	S9	Frutta del meridione	1881	R486
			Delacroix		
			Still life with lobster	1827	S5
			Atelier	1830	S9
			July 28th	1830	S8
			Shopin	1838	S15

do not. In this test all training paintings were presented out of focus to examine the role of contour. Other procedures of the stimulus presentation were identical to those in daily training sessions. In these pictures, two lines (0.43 mm wide) separated by 0.43 mm fused completely on the screen.

Test 3. Training stimuli were used here but three S+ and three S− pictures were left-right reversed and another three S+ and three S− pictures were upside down. Six normal stimuli were also presented. The same testing procedure was used here (i.e., each test stimulus was presented once for 30 s).

Test 4. As shown in Table 2, two different sets of stimuli appeared in generalization tests. One set, which was used after training with Set A, consisted of three novel paintings by Monet, three novel paintings by Picasso, and three each by Cezanne, Braque, and Delacroix. These 15 new stimuli and six old stimuli used for discriminative training (three each by Picasso and Monet) were randomly presented three times each. The other set, which consisted of four novel paintings each by Monet and Picasso and four each by Renoir, Matisse, and Delacroix, was used after training with Set B. These 20 new stimuli and eight old stimuli (four each by Picasso and Monet) randomly appeared three times each during the tests.

Results and Discussion

All subjects' behavior came under stimulus control. The number of sessions to reach the criterion ranged from 6 to 22 for the Monet S+ group and 8 to 24 for the Picasso S+ group. There was no statistically significant difference in speed of acquisition between the Monet S+ and Picasso S+ groups (two-tailed t test, = 0.86, $df = 6$) or between Set A and Set B ($t = 1.64$, $df = 6$).

During the training period, the subjects responded more often to some paintings than to other paintings. There might be, thus, paintings that are easy to discriminate and those

that are hard to discriminate. To examine the role of each painting in acquisition of discrimination, total number of responses emitted to each S+ painting until each subject reached the criterion were analyzed. Because the number of sessions to the criterion differed among subjects, the rank order of the responses to each S+ painting was used for the analysis. The Spearman's rank-order correlation coefficient (rho) between 2 subjects in the Monet S+ group trained with Set A was −.02, and that with Set B was .06. The rho between the 2 subjects in the Picasso S+ group trained with Set A was .19, and that with Set B was .37. None of the correlations was statistically significant. There was thus no systematic bias of responding caused by particular stimuli, even though individual subjects subjects showed differences in responding to each stimulus.

Figure 1 presents results of Tests 1 and 2. Because there were individual differences in absolute number of pecks, percentage of correct responses is shown in the figure. All birds maintained their discrimination in the monochromatic-stimulus test, although some birds showed less than 90% correct. Thus, color was not a crucial cue for the painting discrimination. There was no statistically significant difference between the Monet S+ group and the Picasso S+ group (unpaired two-tailed t = 0.176, df = 6).

Most of the paintings of impressionists lack sharp outlines, whereas most of the paintings of cubists have sharp contours. Sharp contours that might be a cue for discrimination were investigated in Test 2. Although D24 and B34 in the Picasso S+ group showed less than 90% correct responding in the test of focus, other birds showed more than 90% correct responding. D24 saw Set A, and B34 saw Set B. Birds can show individual differences in selective stimulus control in discriminations of compound stimuli consisting of shape and color cues (Reynolds, 1961) and in discrimination of more complicated stimuli (Watanabe et al., 1993). There was no statistically significant difference in percentage correct between the Monet S+ and Picasso S+ groups in the test of focus (unpaired two-tailed t = 0.635, df = 6). Results of Tests 1 and 2, together with the analysis of the categories of subjects of paintings, suggest that neither category, color, nor edge sharpness uniquely controlled the discrimination.

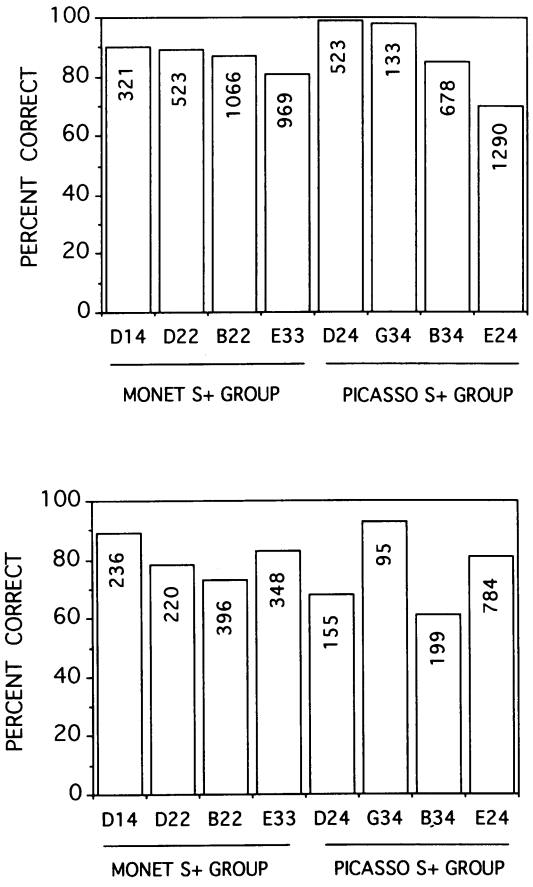

Fig. 1. Results of Tests 1 (top) and 2 (bottom). The vertical axis indicates percentage correct for each individual. The number in each bar indicates total number of responses emitted to S+ and S− during testing. The birds saw the monochromatic pictures in Test 1 (upper panel) and out-of-focus pictures in Test 2 (lower panel).

Figure 2 shows results of Test 3. The response to each stimulus is shown as percentage of correct responses. The subjects emitted responses to the mirror image and the upside down images of both S+s. Discrimination between S+ and S− was clear, even when the stimuli were reversed or inverted. The reversed images, however, reduced responding in the Monet S+ group relative to responding on normal pictures, but did not consistently suppress responding in the Picasso S+ group. The difference between responding to the original S+ and their upside-down images was statistically significant in the Monet S+ group (t = 8.69, $p < .05$).

Figure 3 presents results of Test 4. The

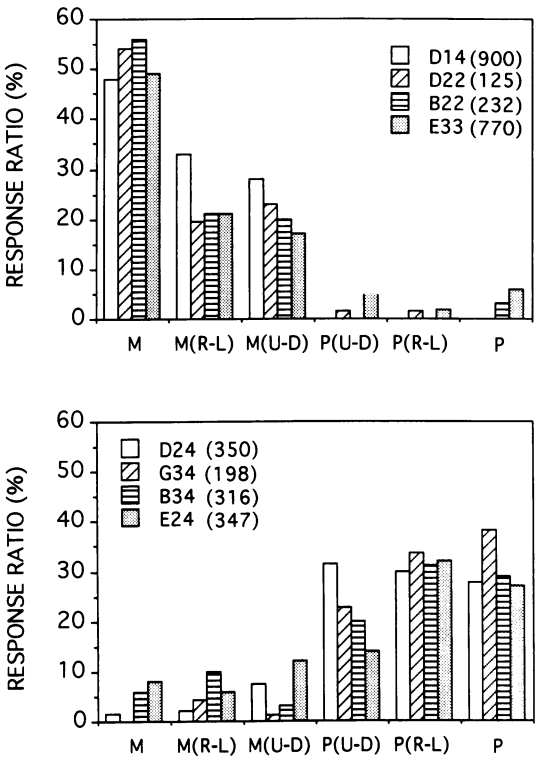

Fig. 2. Results of Test 3. The vertical axis indicates relative response to each category of stimuli as a proportion of the total number of responses emitted by each subject during the test. The numbers in parentheses show the total numbers of responses. The upper panel shows results from the birds that were trained to respond to paintings by Monet, and the lower panel shows those from birds trained to respond to paintings by Picasso. M indicates paintings of Monet, and P indicates those of Picasso. (R-L) and (U-D) indicate left-right reversal and upside down, respectively.

correct response to each painting was expressed as percentage of total responses in the test. The birds trained to respond to paintings by Monet showed relatively high responding to the novel paintings of Monet and paintings of other impressionists (Cezanne and Renoir). Thus, they showed generalization to novel paintings by Monet and generalization to other impressionists. The subjects showed some individual differences in response to Delacroix. Although a difference between discrimination of new Monet and Delacroix was statistically significant in the group data ($t = 4.86$, $p < .05$, $df = 3$), D22 responded more often to the Delacroix paintings than to those of Cezanne.

The subjects in the Picasso S+ group seemed to generalize their responses to the novel Picasso paintings and to those of Braque and Matisse. A statistical analysis, however, identified a statistically significant difference between responding to the original Picasso and novel Picasso paintings (two-tailed paired t test, $t = 3.47$, $p < .05$, $df = 3$) and between responding to the original Picassos and other abstract paintings ($t = 3.51$, $p < .05$, $df = 3$). These results suggest that stimulus control might have been based partly on each original S+ stimulus. Nevertheless, the subjects maintained the discrimination between the abstract paintings and those of the impressionists. These results are consistent with generalization based on each original S+ painting. All birds emitted responses less often to paintings by Delacroix than to original Picassos ($t = 4.67$, $p < .05$, $df = 3$).

Flatter generalization of the Monet S+ group suggests that the subjects in this group formed a categorical discrimination, whereas the relatively steeper generalization in the Picasso S+ group suggests that the birds in this group learned both categorical and individual-painting discriminations.

EXPERIMENT 2

Experiment 1 demonstrated pigeons' ability to discriminate paintings of Monet and Picasso. If pigeons could not learn discrimination among paintings of Monet or among those of Picasso, the results of the generalization in Experiment 1 might reflect confusion among paintings by each artist. In Experiment 2, pigeons were trained a pseudoconcept discrimination similar to those examined by Wasserman, Kiedinger, and Bhatt (1988) and Watanabe (1991). The subjects had to discriminate two arbitrary groups of paintings, each consisting of paintings by Monet and Picasso.

METHOD

Subjects and Apparatus

Two experimentally naive pigeons (*Columba livia*) were used. They were maintained under conditions like those in Experiment 1. The experimental chamber with a screen for the slide projector was used. Details of the apparatus were identical to those of Experiment 1.

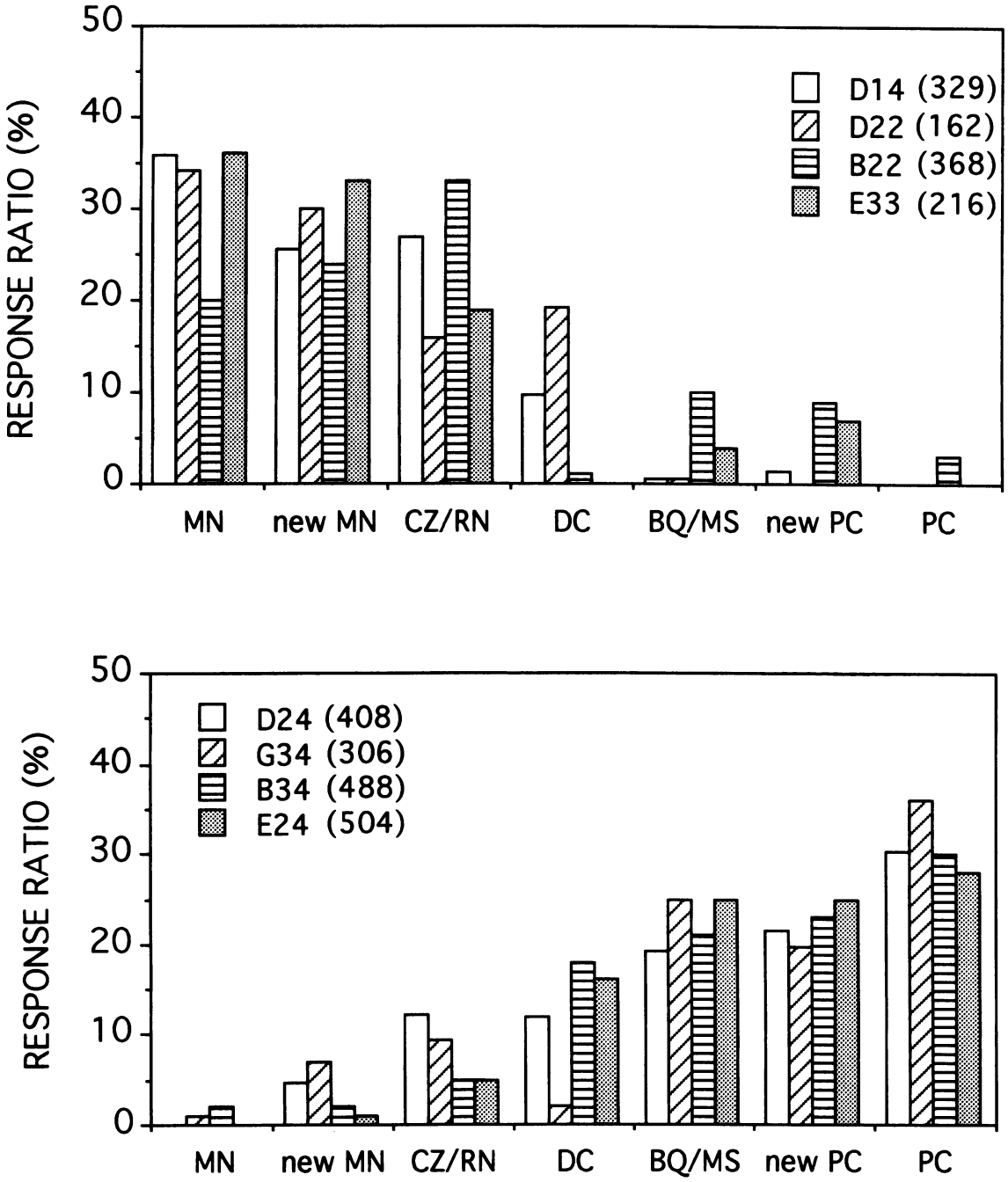

Fig. 3. Results of Test 4. The vertical axis indicates relative response to each category of stimuli as a proportion of the total number of responses emitted by each subject during the test. The numbers in parentheses show the total numbers of responses. The upper panel shows results of birds in the Monet S+ group, and the lower panel shows those of birds in the Picasso S+ group. D14, D22, D24, and G34 were trained with Set A, and B22, E33, B34, and E24 were trained with Set B. Each bar indicates proportion of test responses to each category of stimuli during testing. MN: paintings by Monet used for the discriminative training; new MN: paintings by Monet that were never presented during training; CZ: paintings by Cezanne; RN: paintings by Renoir; DC: paintings by Delacroix; BQ: paintings by Braque; MS: paintings by Matisse; new PC: paintings by Picasso that were never presented during training; PC: paintings by Picasso used for training.

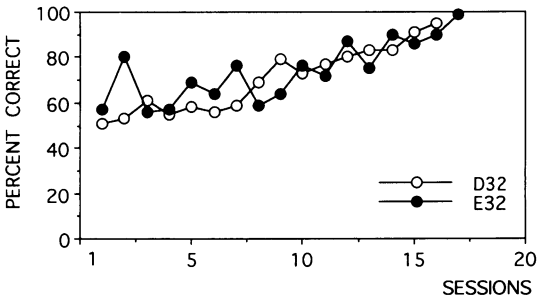

Fig. 4. Learning curves of 2 subjects in Experiment 2, showing percentage of correct pecks over sessions.

Stimuli

Set A was used, but S+ consisted of four paintings by Monet (S10, S15, S22, and S29 in Table 1) and five by Picasso (S13, S20, S22, S24, and S32 in Table 1), and S− consisted of the remaining paintings in Set A.

Procedure

The subjects received discrimination training similar to that in Experiment 1. After they reached the criterion of discrimination, a monochromatic-stimuli test (Test 1), an out-of-focus stimuli test (Test 2), and rotated-stimuli tests (Test 3) were carried out under extinction. Details of these testing procedures were as in Experiment 1.

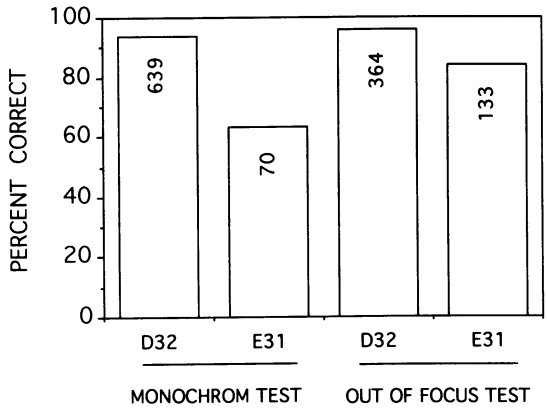

Fig. 5. Results of Tests 1 and 2, showing percentage of correct responses. Pigeons saw monochromatic pictures in Test 1 and out-of-focus pictures in Test 2. The number in each bar indicates total number of responses emitted by a subject during testing.

Results and Discussion

Pigeon D32 reached the criterion of 90% correct over two successive sessions after 16 sessions, and E32 reached criterion after 17 sessions. Figure 4 shows learning curves of the 2 subjects. The results clearly demonstrate the pigeons' ability to acquire the discrimination. The number of sessions required to reach the criterion were comparable to those observed in Experiment 1. Wasserman et al. (1988) reported that pigeons had difficulty in learning a pseudoconcept, but Watanabe (1991), using edible and nonedible objects as discriminative stimuli, did not find a statistically significant difference between development of a pseudoconcept and a more natural concept. Keeping in mind that the number of subjects was small in both Wasserman et al.'s experiments and ours, and that the pigeons showed substantial individual differences in speed of acquisition of the complicated discrimination tasks, difficulty of pseudoconcept discriminations seems to depend on the kinds of stimuli involved.

The Spearman's rho between the rank orders of total numbers of responses emitted to each stimulus until the subjects reached the criterion was .16. Thus, no stimuli were especially easy to discriminate.

Figure 5 shows results of Tests 1 and 2. Both subjects maintained their discrimination well in the test with out-of-focus stimuli. Although E31 showed some decrease of discrimination in the test of monochromatic stimuli, its performance was well above chance level. Thus, these single cues did not uniquely control the discrimination. D32 responded often to the mirror images and to the upside-down images of S+, whereas E31 showed a decrease in responding to these stimuli (Figure 6).

GENERAL DISCUSSION

The present results showed that pigeons' discriminative performance could be controlled by paintings of different styles. A previous study by Porter and Neuringer (1984), who reported discrimination by pigeons between music of Bach and Stravinsky, and the present study suggest that pigeons have abilities that enable them to identify both musical and visual artists.

Removal of color or sharp contour cues disrupted performance in some birds, but we could not identify any single cue for the discrimi-

nation. Because paintings of Monet and Picasso differ in many aspects, we are suggesting a polymorphous concept (Lea & Harrison, 1978; Lea, Lohman, & Ryan, 1993) in this case.

We observed a decrease in responding to left-right reversed or upside-down stimuli in the Monet S+ group but not in the Picasso S+ group. Using geometric figures, Delius and Hollard (1987) demonstrated that pigeons can easily identify rotated patterns when the original pattern is given. Wasserman et al. (1988) also reported accurate responding to rotated stimuli after category discrimination, but their birds showed some decrement of responding to upside-down stimuli. Using bird faces as stimuli, Phelps and Roberts (1994) did not find effects of picture orientation. Pigeons in our experiments discriminated well the reversed S+ from the S− and the reversed S−. The reversed stimuli, however, decreased responding more in the Monet S+ group than in the Picasso S+ group. It is not clear why the birds showed this difference in stimulus control.

Pigeons trained to respond to figures of the cartoon character "Charlie Brown" maintained their responding when a scrambled chimera of his body parts was presented (Cerella, 1980). Although Wasserman, Kirkpatrick-Steger, Van Humme, and Biederman (1993) confirmed discrimination of component parts of complex visual stimuli in pigeons, they demonstrated the importance of spatial organization in picture perception. These studies employed drawings that should not have any ecological importance for pigeons. In a related study, we trained pigeons with a pigeon's face (that should have biological importance) and found that the birds did not maintain the discrimination in response to scramblings of parts of the pigeon's face (Watanabe & Ito, 1991).

These results and the present tests with rotated paintings suggest that this distortion disrupts control when the original stimulus represents a real object (as in Monet's paintings), but less disruption is produced when the stimulus has a weaker relation with the real world (as in Picasso's paintings). The fact that the pigeons could learn the category discrimination (Experiment 1) and the pseudocategory discrimination (Experiment 2) suggests that they can group stimuli into one group and that they can also discriminate each stimulus. Humans can not only discriminate between paintings by Monet and Picasso but can also discriminate each picture. Such flexible classification is one of the bases of human cognitive abilities.

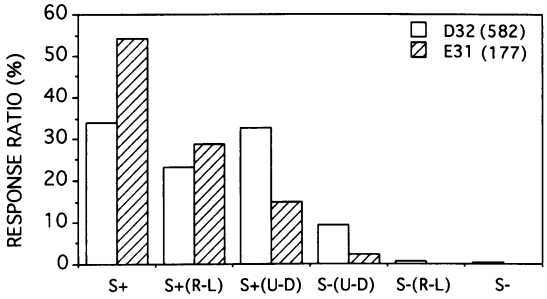

Fig. 6. Results of Test 3. The vertical axis indicates proportion of responses to each category of stimuli relative to the total number of responses emitted by each subject during testing. The numbers in parentheses show the total number of responses. (R-L) and (U-D) indicate left-right reversal and upside down, respectively. S+ and S− indicate the stimulus associated with reinforcement and extinction, respectively.

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Received June 15, 1994
Final acceptance October 19, 1994