

*STIMULUS PROPERTIES OF CONSPECIFIC BEHAVIOR*

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Two experiments identified the conditions in which the behavior of one bird acquired discriminative control of the behavior of a second bird. The schedule-controlled behaviors of the "stimulus" bird were differentially correlated with the components of a multiple schedule according to which the pecking of an "experimental" bird produced food. In Experiment 1, three pairs of pigeons acquired a successive discrimination and two reversals with the conspecific stimuli. Experiment 2 included a control condition in which no systematic relationship existed between the conspecific stimuli and the component schedules. While differential responding during the components of the multiple schedule was again found when the conspecific stimuli were available, differential responding did not occur in the control condition. Test conditions included in the experiments indicated that (a) the differential responding was not dependent on the discriminative properties of reinforcement, (b) the pecking of the stimulus and experimental birds was temporally interrelated, (c) the visual conspecific stimuli were critical to the maintenance of the discrimination, and (d) the observed stimulus control immediately generalized to an unfamiliar conspecific.

*Key words:* stimulus control, conspecific stimuli, discrimination, generalization, multiple schedule, differential-reinforcement-of-other-responses, differential-reinforcement-of-high-rate, pecking, pigeons

The objective of the present experiments was to study the conditions under which the behavior of one animal may acquire discriminative control of the behavior of a conspecific. These conditions identify the origins of a social interaction that is a necessary antecedent of more complex social behaviors and of potential importance in the context of evolution.

Extensive research, primarily with pigeons and precisely controlled stimuli, has led to an understanding of the determinants of discrimination among stimuli and the generalization of responding to similar stimuli (Rilling, 1977; Terrace, 1966). Recently, investigators have described the acquisition of differen-

tial responding to classes of complex stimuli that preclude complete description (Herrnstein & Loveland, 1964; Herrnstein, Loveland, & Cable, 1976; Lubow, 1974; Malott & Siddall, 1972; Siegel & Honig, 1970). Herrnstein and his colleagues, for example, reported that pigeons exposed to successive discrimination procedures responded differentially to pictorial stimuli that included variable instances of objects ordinarily described as a "chair," "tree," and a "person." The birds responded accurately, and the performance generalized to new exemplars of the stimulus classes.

The present research sought to establish that the behavior of one animal may be controlled by stimuli arising from variable and animate conspecific behaviors. Such a finding would encourage the interpretation of social behavior in terms of the principles of learning. The potential merit of this analysis is exemplified by the research of Hoffman and his colleagues wherein aspects of imprinting, a phenomenon long associated with an ethological approach to the study of behavior, may be understood in the context of the principles of elicitation, reinforcement, and the stimulus control of behavior (for a review, see Hoffman & Ratner, 1973).

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## EXPERIMENT 1

Arrangements in which the behavior of one animal leads to the reinforcement of a second conspecific have been studied (e.g., Baron & Littman, 1961; Boren, 1966; Skinner, 1962). Only one experiment, however, has directly examined the circumstances under which the behavior of one organism acquired discriminative control of the behavior of a conspecific. Danson and Creed (1970) described procedures in which the rate of a chain-pull response of one monkey was correlated with the components of a multiple (*mult*) schedule for a second monkey. They concluded that animate conspecific stimuli yielded discrimination and generalization data comparable to that obtained with static and simple stimuli.

In the present experiment, pairs of pigeons were exposed to multiple schedules that provided reinforcement for two different classes of behavior. For the "stimulus" birds, the schedule components were correlated with visual stimuli presented behind the response disc. For the "experimental" birds, the only environmental stimuli that were correlated with the component schedules were provided by the behaviors of the stimulus bird.

## METHOD

*Subjects*

Six White Carneaux pigeons were maintained at 85% of their free-feeding weights by postsession feedings. All birds were experimentally naive and between 1 and 2 years of age at the beginning of the experiment.

*Apparatus*

A standard cubicle (BRS/LVE 131-02) was modified as shown in Figure 1 to permit the independent and selective presentation of food pellets and visual stimuli to two pigeons in the same environment (cf. Millard & Austin, 1976). The interior was divided into two compartments 36 cm high by 30 cm wide by 17 cm deep. A clear Plexiglas partition was hinged on the vertical midline of the wall opposite the intelligence panel. The moving edge of the partition was held by a wing nut assembly on the midline of the panel below the grain feeder opening. The partition was less than maximal height and width to reduce obstruction of the forced-air circulation and the mask-

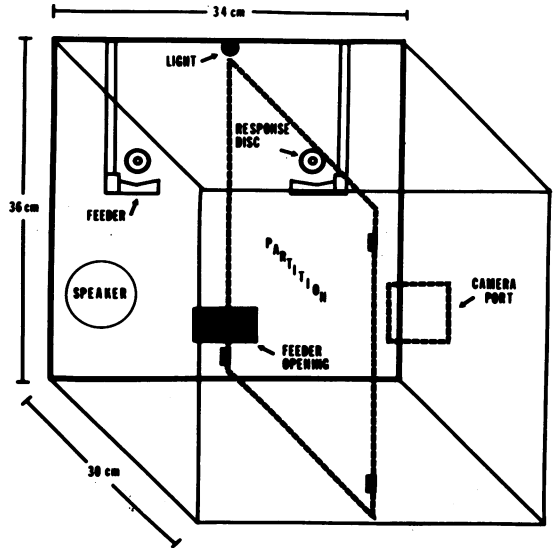


Fig. 1. Schematic drawing of the experimental environment.

ing noise (100 dB re .0002 dynes/cm<sup>2</sup>). On the intelligence panel, two standard response discs were located 24 cm above the floor and 7 cm from the partition. A force of at least .18 N was required for an effective response.

Food pellets (45 mg) were delivered to each bird by dispensers connected to feeder troughs located 5 cm below the response discs (Millard, 1979; Richardson & Loughhead, 1974). The grain magazine was not used in this experiment.

A final modification permitted the presentation of visual stimuli behind the clear 2.5-cm response discs, restricting the visibility of these stimuli to the ipsilateral bird. The normal opaque projection area of the inline projectors (IEE 10-6871) was reduced from 4.90 to .20 cm<sup>2</sup>. The projectors were moved 3.0 cm behind the discs by use of longer bolts and spacers, and a 1.75-cm aperture was placed directly behind the discs. Wratten neutral density filters reduced the intensity of the hue stimuli (576 and 601 nm) to less than 1.0 cd/m<sup>2</sup> as measured by a Tektronix J16 digital photometer. General illumination was provided by a shielded light on the intelligence panel above the partition. A Sony camera, monitor, and videorecorder were used for remote observation of the birds.

The experimental events were controlled by standard programming equipment located in an adjacent room.

### Procedure

Following weight reduction, individual birds were trained to peck the response disc with each peck followed by a pellet and were then given 5 80-min sessions in which pecks were reinforced according to a variable interval (VI) 30-sec schedule. The stimulus and experimental birds were placed on the left and right sides of the partition, respectively. All VI schedules were composed of 2 repetitions of 10 intervals (Fleshler & Hoffman, 1962).

In the final procedure, each bird was exposed to an independent multiple schedule having two tandem (*tand*) components. In one component (VI-DRH), disc pecks separated by 2 sec or less (differential-reinforcement-of-high-rate or DRH) were intermittently reinforced [i.e., VI 45-sec (IRT < 2 sec)]. In the second component (VI-DRO), 12-sec periods in which no pecks occurred (differential-reinforcement-of-other responses or DRO) were intermittently followed by a reinforcer [i.e., VI 35-sec ( $\bar{R}$  > 12 sec)]. The 80-min sessions were composed of 20 2-min stimulus periods of each kind in a random sequence with the restriction that not more than 3 components of the same kind occurred consecutively.

In Condition 1, the experimental and stimulus birds were exposed to unlike components during the session. Thus, when the stimulus bird was exposed to the VI-DRH component, the experimental bird was exposed to the VI-DRO component and vice versa. In Condition 2, both birds were simultaneously exposed to like components. The pairs of birds were given 50 sessions under both Conditions 1 and 2, and returned to Condition 1 for 50 additional sessions.

To identify the controlling stimuli in this experiment, the relationship between the behavior of the stimulus bird and that of the experimental bird was studied. An interbird interresponse time (interbird IRT) was defined as the time from the last response of the stimulus bird to the next response of the experimental bird. If the stimuli correlated with the pecking of the stimulus birds controlled the responding of the experimental birds, the frequency distributions of the interbird IRTs would differ as a function of the condition (Condition 1 versus Condition 2). In that pecking of the stimulus birds was required for delimiting this measure, the analysis is appro-

priate for periods in which the *stimulus birds* were in the VI-DRH component.

The generalizability of conspecific stimulus control was assessed in the first session after the end of the second determination of Condition 1. The experimental birds were paired with a different stimulus bird and given a 12-min session composed of 3 2-min periods of each kind with extinction in effect. As a test of the relative importance of aural and visual stimuli for the maintenance of the differential responding, the birds were returned to Condition 1 for 10 additional training sessions. The clear partition was covered with opaque paper, and a 12-min session was programmed with extinction in effect for the experimental birds.

In a discrimination procedure, it is important to establish that differential responding is controlled by the putative discriminative stimuli rather than the discriminative properties of reinforcement (Jenkins, 1969). In the fourth decade of sessions in each condition, two stimulus periods of each kind were arranged with extinction in effect for the experimental birds. These periods were inserted in the normal sequence to insure that each test period preceded a component of each type. Response rates in these periods were compared to the rates obtained during the regular stimulus periods.

## RESULTS

### *Stimulus Birds*

The acquisition of the hue discrimination by the stimulus birds was completed by the 18th session as indicated by the asymptotically high rates of pecking in the VI-DRH component and essentially zero rates of pecking in the VI-DRO component. Cumulative records for a complete session for each bird are shown in Figure 2. The percent of pecks that occurred in the VI-DRH component, an index of discrimination, was equal to or greater than .98 for the remaining 144 sessions. Slight decreases in the VI-DRH response rates over the three conditions were evident, but neither the VI-DRH nor the VI-DRO rates varied systematically as a function of the condition. Thus, regardless of the behavior of the experimental birds on the other side of the partition, the hue stimuli controlled similar pecking rates in each condition. The rates of responding for

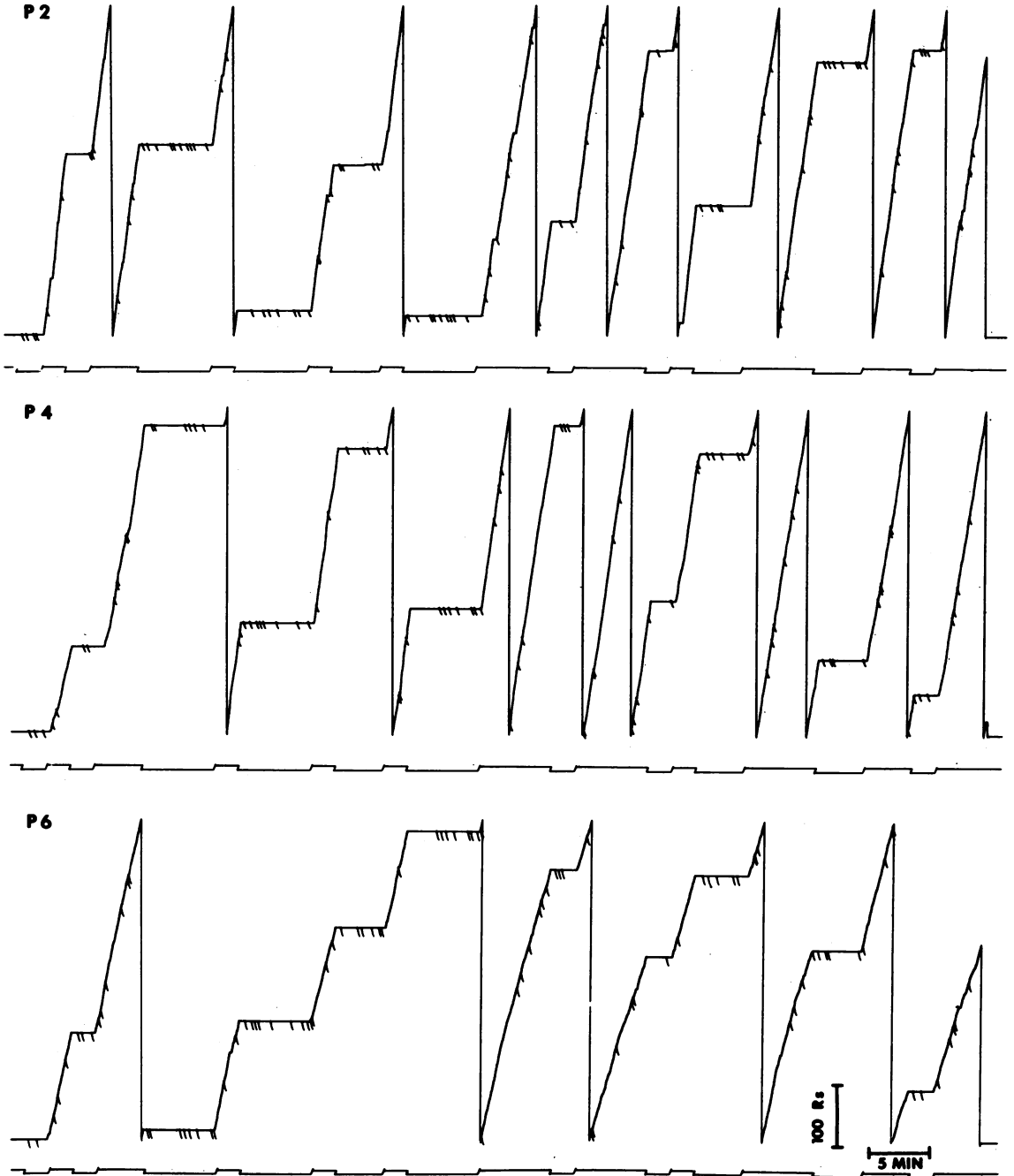


Fig. 2. Full-session cumulative records for the stimulus birds (P2, P4, and P6) from the 25th session in Condition 1. Downward deflection of the response pen indicates the delivery of a pellet. Downward deflection of the event pen indicates the VI-DRO component was in effect.

the last 10 sessions in each condition are included in Table 1.

The VI schedules on which the criterion responses produced food in the two components resulted in essentially equal reinforcement

rates with the difference between components during the last 10 sessions never exceeding .12 pellets per min.

In order to describe the responses other than disc-pecking, systematic video observa-

Table 1

Mean response rates and discrimination indices for the stimulus (S) and experimental (E) birds in each condition. The numbers within parentheses are standard deviations about the means. Values are based on the last 10 sessions in each condition.

Bird	Condition	Responses/min		Discrimination Index
		VI-DRH	VI-DRO	
P1(E)	1	76 (8.4)	6 (2.1)	.92
	2	78 (3.8)	4 (2.2)	.95
	1	72 (6.1)	5 (1.8)	.93
P2(S)	1	137 (9.7)	0 (0)	1.00
	2	119 (7.7)	0 (0)	1.00
	1	114 (8.6)	0 (0)	1.00
P3(E)	1	91 (4.3)	8 (1.9)	.93
	2	99 (6.0)	4 (1.4)	.94
	1	94 (5.2)	4 (1.7)	.96
P4(S)	1	105 (4.2)	0 (0.3)	1.00
	2	101 (3.3)	1 (0.7)	1.00
	1	99 (4.3)	1 (0.2)	.99
P5(E)	1	50 (5.5)	3 (1.6)	.95
	2	48 (3.4)	4 (1.1)	.93
	1	47 (2.9)	3 (1.5)	.94
P6(S)	1	75 (2.6)	0 (0)	1.00
	2	65 (3.8)	0 (0)	1.00
	1	62 (3.9)	0 (0)	1.00

tions were conducted in each condition. A classification was developed similar to that described by Staddon and Simmelhag (1971). A primary distinction was made between pecking and orienting, the latter defined as the momentary pointing of the beak toward one of the features of the environment (see Table 2). A behavior was scored when the stim-

ulus bird *changed* from one response to another. The next entry was not made until the bird initiated a different behavior. Thus the obtained score was a measure of the frequency of response initiations. A time sampling procedure was used in which five stimulus periods of each kind were recorded during the last two sessions in each condition. The tapes were independently scored by two research assistants with the playback at approximately half the recording speed. Interobserver reliability was assessed by the effective percentage agreement method (Hartmann, 1977, p. 108). Unlike simple percentage agreement, this score is a more sensitive measure of agreement because it eliminates the number of agreements on the *nonoccurrence* of behaviors. This measure was computed for one session in each condition and was found to vary within the range of .85 to .98. These data are summarized in Table 2.

The results indicated that the stimulus birds engaged in fewer different behaviors during the VI-DRH component than during the VI-DRO component. High rates of pecking occurred in most of the VI-DRH component. The low within-bird variability indicated that the VI-DRO schedule maintained stable response patterns over sessions. P6, for example, alternated between orienting to the disc and the left wall with an occasional 360° turn. Similarly, P4 turned in a 180° motion from the left wall to the partition. The control of behavioral patterns by DRO schedules has not been studied extensively, but these data were

Table 2

Response initiations per min for the stimulus birds in the two components of the multiple schedule. The means are based on an accumulated 10 min of observation over the 3 conditions. Numbers in parentheses are standard deviations of the means.

Bird	Component	Peck				Orient						
		Disc	Trough	Glass	Floor	Magazine	Disc	Left Wall	Rear Wall	Glass	Other	Total
P2	VI-DRH	1.25 (0.66)	0.26 (0.14)	0.20 (0.32)	0.13 (0.08)	0 (0)	0 (0)	0.54 (0.46)	0.33 (0.38)	0.26 (0.38)	0 (0)	3.33 (0.69)
	VI-DRO	0 (0)	5.55 (2.30)	5.22 (1.84)	0.41 (0.30)	0.05 (0.04)	0.27 (0.20)	0.41 (0.14)	0.36 (0.24)	0.36 (0.20)	0.05 (0.09)	12.72 (4.27)
P4	VI-DRH	0.62 (0.24)	0.41 (0.30)	0.20 (0.36)	0 (0)	0.12 (0.08)	0 (0)	0.04 (0.07)	0 (0)	0 (0)	0 (0)	1.41 (0.83)
	VI-DRO	0.02 (0.04)	5.38 (1.30)	4.19 (0.80)	0 (0)	1.13 (1.43)	0.46 (0.67)	1.24 (0.16)	0.08 (0.07)	0.10 (0.18)	0.13 (0.24)	12.80 (3.12)
P6	VI-DRH	5.29 (0.47)	0.33 (0.38)	2.25 (0.54)	0.20 (0.19)	0.70 (0.31)	0.08 (0.07)	1.08 (1.44)	0.04 (0.09)	1.29 (0.79)	0 (0)	11.70 (1.38)
	VI-DRO	0 (0)	0.66 (0.30)	1.88 (0.24)	0.22 (0.23)	0.33 (0.14)	4.08 (1.44)	3.86 (0.49)	1.16 (0.25)	1.33 (0.50)	0 (0)	13.58 (2.24)

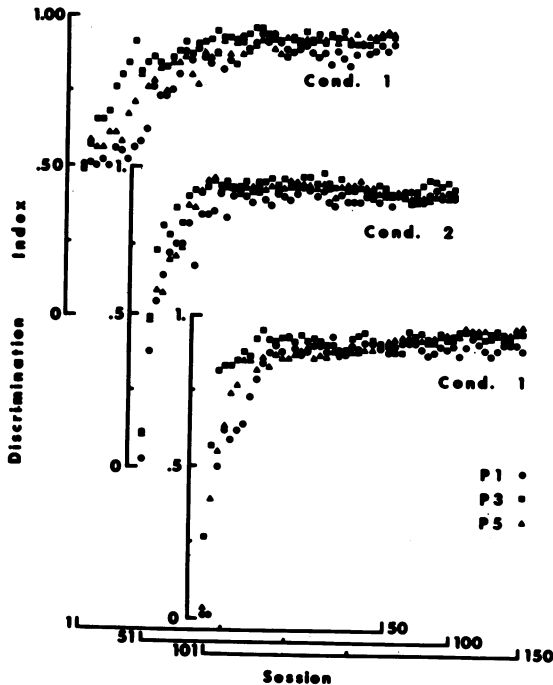


Fig. 3. Discrimination indices for the experimental birds (P1, P3, and P5) for the three conditions.

consistent with research that included observational data (e.g., Staddon, 1972; Zeiler, 1971).

A final point is that all stimulus birds tended to remain in the vicinity of the response disc during the VI-DRO component. Thus, it was unlikely that the differential responding of the experimental birds was based simply on the position of the stimulus birds within the left side of the cubicle.

#### Experimental Birds

Discrimination indices for the 3 experimental birds over the 150 sessions are presented in Figure 3. Initial acquisition of the discrimination was evident by the 10th session with each reacquisition requiring approximately 15 sessions. An example of the development of the differential responding is shown in the sequence of cumulative records in Figure 4. Variability among the birds was small though a consistent order of acquisition was observed with P3 preceding P5 and P1. The mean pecking rates and discrimination indices from the last 10 sessions in each condition are included in Table 1. The obtained reinforcement frequencies in these 10 sessions ranged from 1.06 to 1.31 pellets per min, with the difference between the means of the two components

consistently less than .15. Therefore, like the stimulus birds, the reinforcement frequencies in the two components of the multiple schedule were essentially equal. The average pecking rates of the experimental birds were consistently lower in the VI-DRH component and higher in the VI-DRO component than the corresponding rates of the stimulus birds.

Inspection of the data in the early sessions of Condition 1 revealed that the discrimination indices for the stimulus birds consistently "lead" those of the experimental birds as would be expected if the differential responding of the experimental birds was dependent on the differential responding of the stimulus birds to the hue stimuli. Video observations of the stimulus birds showed that pecking occasionally did not occur immediately after transitions from the VI-DRO periods to the VI-DRH periods. This delay appeared to be the result of behavioral topographies, such as turning and trough pecking, incompatible with viewing the hue behind the disc. If the behavior of the stimulus birds actually controlled the responding of the experimental birds, such imperfect control of the behavior of the stimulus birds should be reflected by "errors" of the experimental birds during these transitions. For example, if a stimulus bird did not immediately begin to peck the disc following a transition in Condition 1, the experimental bird would continue to peck despite the prevailing VI-DRO schedule. To assess this possibility, the stimulus birds' response latencies after these transitions and the number of responses made by the experimental birds were measured during the last five sessions in each condition. The mean latencies for the three stimulus birds were 3.38, 6.54, and 4.83 sec, respectively. The mean response rates of the experimental birds during these latencies were within  $\pm 14\%$  of the expected rates (listed in Table 1), given the behavior of the stimulus birds. Thus these data confirmed that the responding of the experimental birds was controlled by pecking of the stimulus birds and provided internal validation that the contralateral hue stimuli did not function as discriminative stimuli for the experimental birds.

#### Interbird IRT Analysis

As a more precise measure of the effect of the behavior of the stimulus birds on the ex-

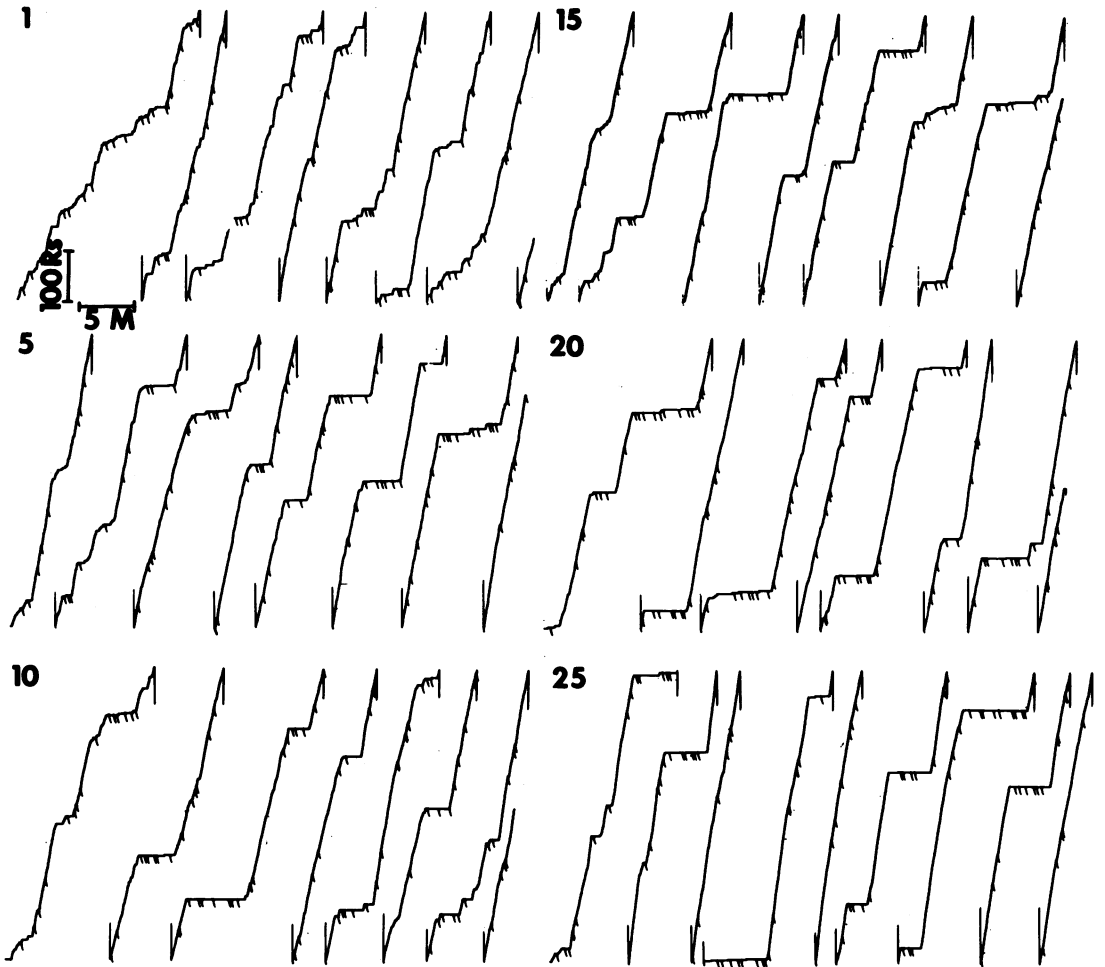


Fig. 4. Full-session cumulative records for an experimental bird, P3. Numbers indicate the session in Condition 1.

perimental birds, relative frequency distributions of the interbird IRTs, derived from the last 10 sessions in each condition, were determined (see Figure 5). A systematic relationship between the pecking of the stimulus and experimental birds was evident. In Condition 1, the stimulus birds were exposed to the VI-DRH schedule while the experimental birds were exposed to the VI-DRO schedule. These distributions showed that, as time increased without a peck by the stimulus bird, the experimental birds pecked more frequently. In fact, more than 75% of all pecks by the experimental birds occurred after 8 sec had elapsed since the last peck of the stimulus bird. The slight increments in the distributions from Condition 1 between 1 and 3 sec were a result of the fact that once an experi-

mental bird initiated pecking it often continued to peck for 1 or 2 sec.

A different relationship obtained in Condition 2 in which both birds were concurrently exposed to the VI-DRH schedule. The distributions showed that more than 80% of the pecks occurred within 3 sec or less of a peck of the stimulus birds. Based on this analysis, it was concluded that the pecking of the experimental birds was controlled primarily by stimuli correlated with the pecking of the stimulus birds.

#### Generalization Test

In the 151st session, the birds were paired with different stimulus birds to assess the degree of response generalization. A 12-min extinction session was programmed with Condi-

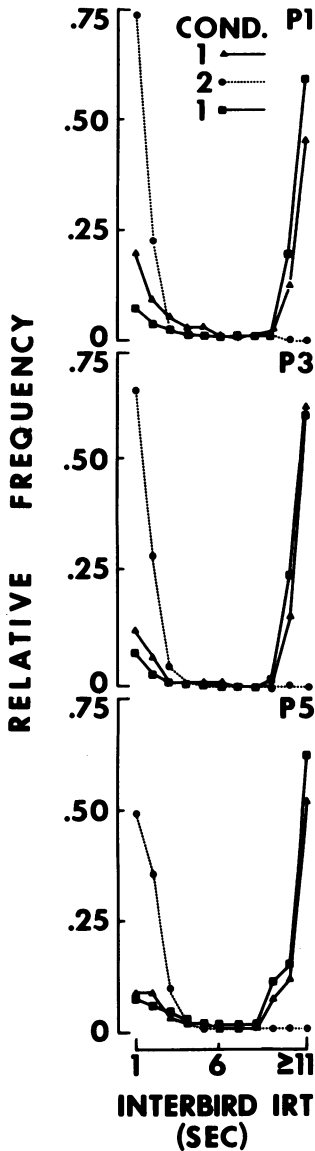


Fig. 5. Relative frequency distributions of the interbird IRT measure for the three experimental birds in each condition. Each point is based on an average over the last decade of sessions in each condition.

tion 1 in effect. The rates in this session were comparable to the rates during the preceding 10 sessions (see Table 2) despite the prevailing extinction condition. Additionally, video observations during the test showed little disruption of either the stimulus or experimental birds performance. Thus, the stimulus control immediately generalized to the behavior of another conspecific.

#### Aural-visual Test

Following the generalization test, a second test was conducted to assess the relative importance of aural and visual conspecific stimuli for the maintenance of the differential responding. The original pairings of the birds were reinstated, and 10 additional training sessions were given with Condition 1 in effect. In the next session, the clear partition was covered, and the 12-min test was programmed. The results presented in Table 3 suggested that the aural stimuli were not sufficient for the maintenance of the differential responding. The response rates of the experimental birds approximated the rates observed during the initial sessions in Condition 1.

#### Extinction Test

The extinction test periods were included in the fourth decade of sessions in each condition to determine the possible discriminative properties of reinforcement. Responding during these periods is summarized in Figure 6. The mean response rates were highly similar to those obtained in the regular stimulus periods. Therefore, the differential responding of the experimental birds was dependent on the conspecific stimuli rather than the discriminative properties of reinforcement.

## EXPERIMENT 2

The objective of this experiment was to establish the generality of the findings in Experiment 1 by systematically replicating the conditions. A baseline procedure was included in which the behaviors of the stimulus birds were not differentially associated with tandem (*tand*) schedules of the experimental birds. A mixed (*mix*) reinforcement schedule was used for this purpose. Additionally, the stimulus birds were brought to asymptotic levels of differential responding before pairing with the experimental birds. This permitted a comparison of the relative rates of acquisition of the stimulus and experimental birds.

#### Subjects and Apparatus

Four naive White Carneaux pigeons were used in the apparatus described in Experiment 1.



Table 3

Response rates and discrimination indices for the experimental (E) and stimulus (S) birds during the 12-min generalization test and the 12-min aural-visual test. Note that for the generalization test, the birds were re-paired: P1-P4, P3-P6, P5-P2.

Bird	Generalization test			Aural-visual test		
	Responses/min		Discrimination Index	Responses/min		Discrimination Index
	VI-DRH	VI-DRO		VI-DRH	VI-DRO	
P1(E)	54	7	.89	43	48	.47
P2(S)	118	0	1.00	111	0	1.00
P3(E)	62	7	.90	41	56	.42
P4(S)	93	1	.99	97	2	.98
P5(E)	42	8	.84	36	27	.57
P6(S)	54	0	1.00	58	0	1.00

Procedure

Feeder training, peck training, and exposure to a VI 30-sec schedule proceeded as in Experiment 1. Two pigeons, designated as stimulus birds, were subsequently exposed for 20 sessions to a multiple schedule in which the counterbalanced discriminative stimuli (576 and 601 nm) were projected behind the left disc. The tandem schedules were as in Experiment 1 with the change that the values of the VI schedules were increased, vis., *mult tand VI 55-sec (IRT < 2 sec) tand VI 45-sec (R̄ > 12 sec)*. In this experiment, a session was composed of 60 1-min stimulus periods sequenced randomly with the restriction that not more than 3 components of the same kind occur consecutively. During these 20 sessions, the experimental birds were not present. An experimentally naive pigeon, however, was placed on the right side of the partition in order to accustom the stimulus birds to the presence of a conspecific. No contingencies were programmed for this bird.

Pairs of stimulus and experimental birds were then formed. The experimental birds were presented a mixed schedule composed of two tandem schedules identical to the components of the multiple schedule, i.e., *mix tand VI 55-sec (IRT < 2 sec) tand VI 45-sec (R̄ > 12 sec)*. Thus, in this baseline condition, there was no systematic relationship between the component schedules and the behavior of the stimulus birds. The multiple schedule of the stimulus birds and the mixed schedule of the experimental birds were synchronized so that transitions from one component to another occurred simultaneously. The sequence was programmed so that the probability that both birds were exposed to

identical components was .50 for each session. In Condition 2, the mixed schedule of the experimental birds was changed to a multiple schedule of identical tandem schedules. In this condition, the stimulus and the experimental birds were simultaneously presented either the VI-DRH or the VI-DRO schedules. For Condition 3, this relationship was reversed with the birds exposed to unlike components. Thus Conditions 2 and 3 in this experiment were comparable to Conditions 2 and 1, respectively, of Experiment 1.

The sequence of conditions and the number of sessions in each condition were identical for the two pairs of birds: Condition 1, 20 sessions; Condition 2, 30 sessions; Condition 3, 30 sessions. Periodic video observations and the interbird IRT data were collected during the last five sessions in each condition. Following Condition 3, a 12-min generalization test was conducted with new pairings of the birds. The original pairings were then reinstated and the birds were returned to Condition 3 for 10 sessions with the aural-visual test completed during a final test session.

RESULTS

Stimulus Birds

The differential responding of the stimulus birds stabilized before the 18th session of training and was maintained during the subsequent 110 experimental sessions. Response rates and discrimination indices for these birds, P7 and P9, are included in Table 4. P7 showed a slight decrement in the VI-DRH response rates over the sessions; however, neither bird showed systematic variation of response rates as a function of the experimental conditions. Informal

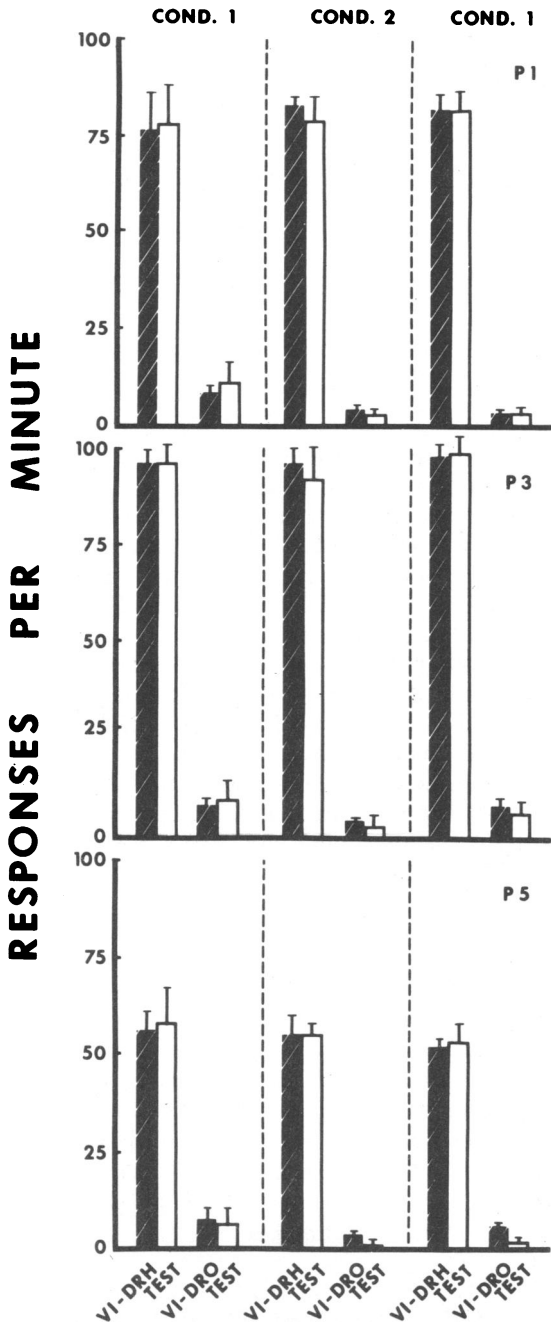


Fig. 6. Response rates of the experimental birds during the extinction test periods and the regular VI-DRH and VI-DRO stimulus periods. The means are derived from the fourth decade of sessions in each condition. Vertical lines above the bars indicate one standard deviation.

video observations suggested that the stimulus birds engaged in consistent patterns of behavior. As in Experiment 1, the behaviors main-

Table 4

Mean response rates and discrimination indices for the stimulus (S) and experimental (E) birds in each condition. The numbers within parentheses are standard deviations of the means. The values are derived from the last five sessions in each condition.

Bird	Condition	Responses/min		Discrimination Index
		VI-DRH	VI-DRO	
P7(S)	1	123(8.1)	0(0)	1.00
	2	121(6.1)	1(.3)	1.00
	3	116(7.7)	1(.6)	1.00
P8(E)	1	42(9.1)	38(7.9)	.53
	2	73(7.7)	6(3.0)	.92
	3	37(8.9)	35(7.3)	.51
P9(S)	1	76(6.4)	5(2.7)	.94
	2	73(5.5)	0(0)	1.00
	3	76(3.1)	0(0)	1.00
P10(E)	1	71(4.7)	0(0)	1.00
	2	69(2.9)	0(0)	1.00
	3	52(11.3)	46(10.1)	.54
P10(E)	1	89(8.7)	9(2.9)	.90
	2	43(12.2)	38(10.0)	.53
	3	82(7.6)	10(3.1)	.89

tained by the VI-DRO schedule were primarily directed toward features of the intelligence panel. The mean reinforcement frequencies in the last five sessions of each condition varied from .98 to 1.11 pellets per min.

Experimental Birds

The discrimination indices for the two experimental birds, P8 and P10, are shown in Figure 7 for the last 5 sessions in the 2 determinations of Condition 1 and the 30 sessions in Conditions 2 and 3. No evidence of consistent differential responding was found in Condition 1 in which there was no systematic relationship between the conspecific stimuli and the component schedules.

In Conditions 2 and 3, however, both birds showed differential responding within 10 sessions and stabilized within 20 sessions. The mean response rates and discrimination indices are included in Table 4. As in Experiment 1, the response rates of the experimental birds were consistently lower in the VI-DRH component and higher in the VI-DRO component than the corresponding rates of the stimulus birds. The mean reinforcement frequencies during these sessions varied from .68 to .78 pellets per min in Condition 1 and from .89 to 1.06 pellets per min in Conditions 2 and 3. For both birds, the difference between the

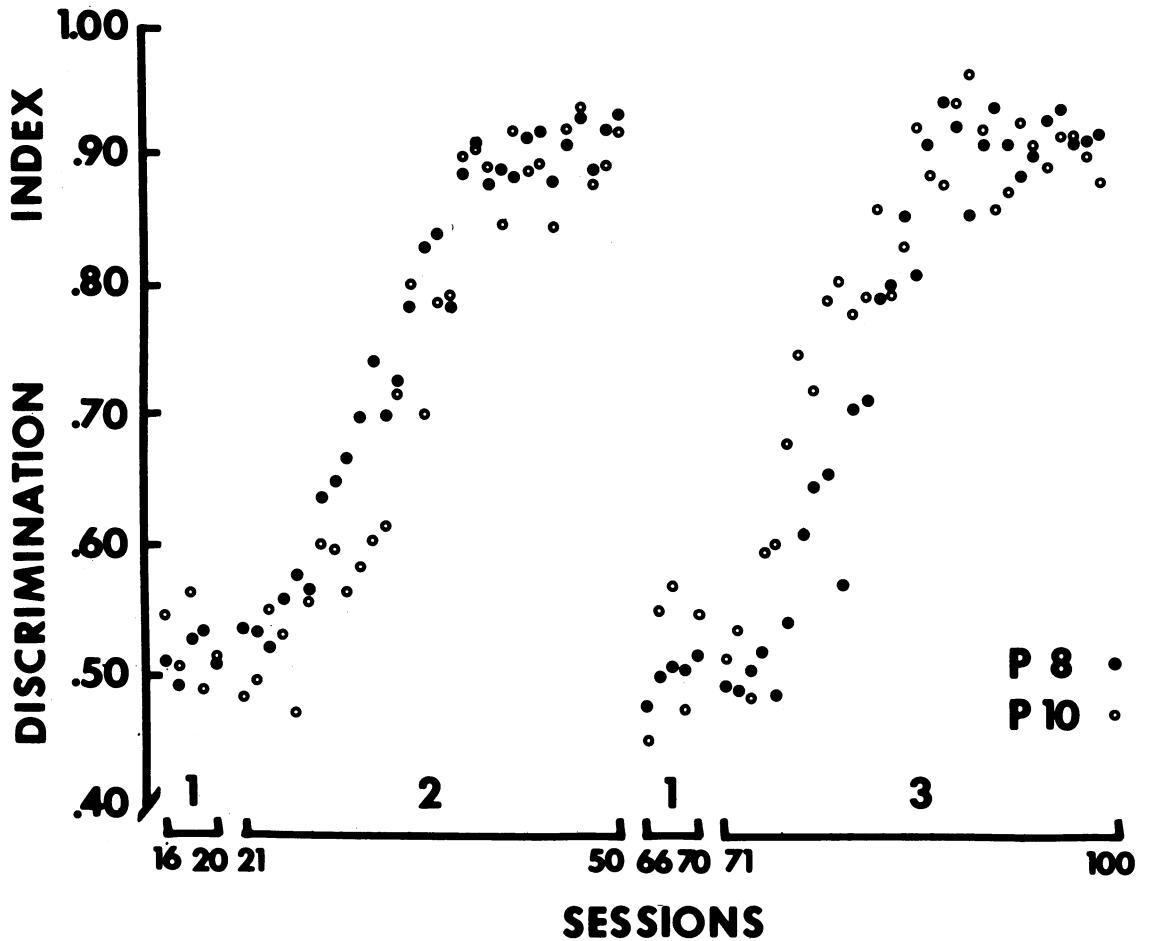


Fig. 7. Discrimination indices for the experimental birds (P8 and P10) for the last five sessions in the two determinations of Condition 1 and the 30 sessions in Conditions 2 and 3.

component reinforcement frequencies never exceeded .19 per min in a condition.

Observation of the stimulus birds during transitions from the VI-DRO components to the VI-DRH components indicated that the mean latencies to the first response were too low to permit an "error" analysis of the sort conducted in Experiment 1. As in Experiment 1, however, the responding of the experimental birds appeared to be dependent on whether the stimulus bird was pecking during these transitions rather than on the schedule component in effect.

*Interbird IRT Analysis*

In Condition 2, the stimulus and experimental birds were simultaneously exposed to the VI-DRH component. The relative fre-

quency distributions in Figure 8 showed that more than 80% of the pecks were within 3 sec of a peck by the stimulus bird. In contrast to this, the distributions from Condition 3 showed that more than 80% of the pecks occurred after 6 sec since the last peck of the experimental birds.

In Condition 1, the mixed schedule was in effect for the experimental birds and intermediate distributions were obtained. Approximately 60% of the pecks occurred within 3 sec of a stimulus bird peck, with the remaining pecks distributed rather uniformly over the remaining times. It was concluded that the pecks of the experimental birds were systematically related to the pecks of the stimulus birds and that this relationship changed with the conditions.

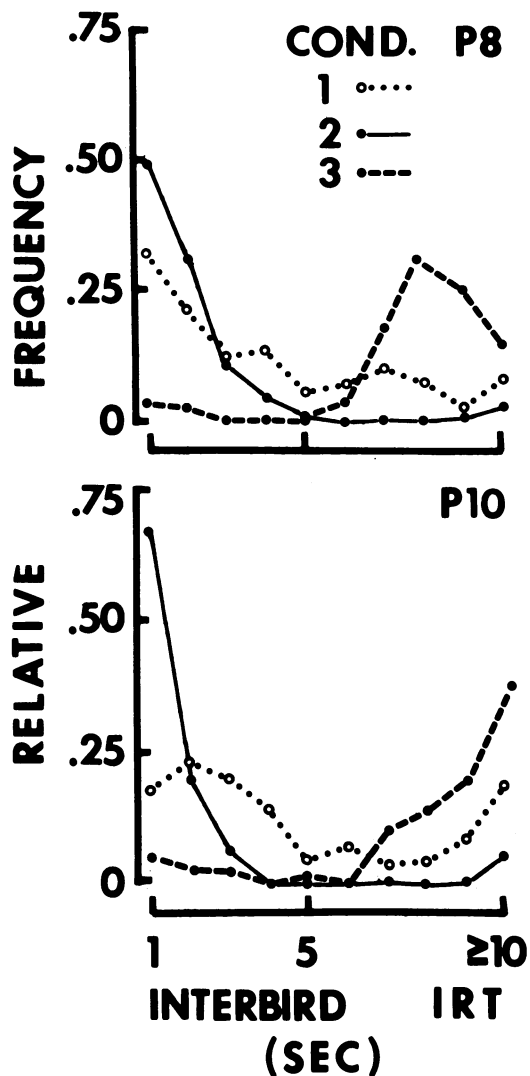


Fig. 8. Relative frequency distributions of the interbird IRT measure for the two experimental birds. Each point is based on an average over the last five sessions in each condition. The data for Condition 1 are from the second determination of that condition.

*Generalization Test*

The birds were re-paired and the 12-min extinction test was conducted in the 101st session. The data included in Table 4 confirmed that the differential responding of the experimental birds immediately generalized to the unfamiliar conspecific stimuli. Because the hue stimuli were counterbalanced for the stimulus birds, these data additionally showed that the red and green hues were not discriminative stimuli for the experimental birds.

*Aural-visual Test*

Following the generalization test, the original pairings of the birds were restored and additional training with Condition 3 was given for 10 sessions. In the next session, a 12-min extinction test was programmed in which the clear partition was covered. The results of this test (Table 5) showed that neither experimental bird maintained the differential responding in the absence of the visual conspecific stimuli.

GENERAL DISCUSSION

These experiments sought to determine the conditions in which the behavior of one bird controlled the differential responding of a conspecific. In the two experiments, the six experimental birds acquired the discrimination, and the differential responding endured throughout the experimental conditions.

Relative to the performance of the stimulus birds, the response rate of the experimental birds was consistently lower in the VI-DRH component and higher in the VI-DRO component. The source of this difference was uncertain though it was possibly a result of the

Table 5

Response rates and discrimination indices for the experimental (E) and stimulus (S) birds during the 12-min generalization test and the 12-min aural-visual test. Note that for the generalization test, the birds were re-paired.

Bird	Generalization test			Aural-visual test		
	Responses/min		Discrimination Index	Responses/min		Discrimination Index
	VI-DRH	VI-DRO		VI-DRH	VI-DRO	
P7(S)	114	0	1.00	92	0	1.00
P8(E)	54	10	.84	14	18	.44
P9(S)	62	0	1.00	70	0	1.00
P10(E)	71	11	.87	33	37	.47

variability of the conspecific stimuli and the displacement of the discriminative stimuli from the response disc (cf. Catania, 1964; Keller, 1974, Experiment 1; Schwartz, 1975). The present data additionally permitted a comparison of the acquisition rates of the conspecific behavior and hue discriminations. In Experiment 2, the stimulus birds acquired the hue discrimination before pairing with the experimental birds. A comparison of the number of hours required to asymptotic differential responding indicated that there was no consistent difference between the experimental and stimulus birds.

The interbird IRT analyses indicated that the pecking of the experimental birds was directly related to the behavior of the stimulus birds. As time increased since the last peck of the stimulus birds, the frequency of pecks of the experimental birds *decreased* if the VI-DRH schedule was in effect (Condition 2, Experiments 1 and 2) and *increased* if the VI-DRO schedule was in effect (Condition 1, Experiment 1; Condition 3, Experiment 2). An intermediate distribution was obtained in the condition in which the conspecific stimuli and the component schedules were uncorrelated (Condition 1, Experiment 2). Danson and Creed (1970, Experiment 2) reported that the response rates of the observing monkey covaried with the rates of the stimulus monkey. Based on these data they concluded that "response rate" was the discriminative stimulus. In the present experiments, the analyses of the interbird IRTs suggested that response rate, a derived measure, or the individual responses were the discriminative stimuli.

The interbird IRT analyses identified the discriminative stimuli when the stimulus birds were exposed to the VI-DRH component; however, the controlling stimuli associated with the VI-DRO component were not clearly specifiable. The observational data suggested that the VI-DRO schedule maintained response patterns in the stimulus birds and therefore it was possible that these behaviors contributed to the maintenance of the differential responding of the experimental birds. To the extent that the different behaviors of the stimulus birds were classes of conspecific stimuli, the experimental birds may be said to have acquired a concept in the sense described by Herrnstein (e.g., Herrnstein et al., 1976).

The results of the generalization tests indi-

cated that the conspecific stimulus control extended to an unfamiliar bird, and therefore the experimental birds accurately responded to new exemplars of the stimulus classes. The slight decrements in the discrimination indices of the experimental birds during these tests were primarily due to changes in the pecking rates while the stimulus birds were in the VI-DRO component. This would be expected because of the between-stimulus bird variability in the behaviors maintained by the VI-DRO schedule.

The results of the aural-visual tests suggested that the visual conspecific stimuli were critical to the maintenance of the differential responding. This was anticipated because of the loud masking noise used in the experiments and prior results that suggested the relative primacy of visual stimuli for the pigeon (e.g., Jenkins & Harrison, 1960; Rudolph & Van Houten, 1977). The interpretation of these results, however, is tentative because of the confounding of the elimination of the visual conspecific stimuli with a change in the experimental environment (i.e., the white paper on the partition). Finally, the maintenance of the differential responding was not dependent on the discriminative properties of the reinforcement. In Experiment 1, the response rates in the extinction tests were comparable to the rates in the regular stimulus periods. In Experiment 2, the mixed schedule-multiple schedule comparison showed that the discrimination indices approximated chance levels in the absence of a systematic relationship between conspecific stimuli and the component schedule (cf. Pierrel & Blue, 1967).

In the present experiments, a condition resulted in the birds engaging in similar behaviors (Condition 2, Experiments 1 and 2). To the naive observer, this might be interpreted as an example or outcome of "imitation." It was not, of course, but it is an example of one possible arrangement of social stimuli, non-social stimuli, and contingencies of reinforcement that yield similar behaviors among pigeons. Research on imitation and observational learning has a long history but is often marked by inconclusive results (for a review, see Davis, 1973; Galef, 1976). At the conceptual level, the uniqueness of these phenomena has been questioned by Gewirtz (1971; also see Skinner, 1953) who has proposed that imitation may be best understood in terms of

familiar principles of reinforcement and stimulus control. Rats and pigeons learn in imitation procedures (e.g., Church, 1957; Zentall & Hogan, 1976) but the importance of the present findings is the illustration that similar behaviors among organisms may originate in diverse interactions between social and non-social elements of the environment.

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