

## THE ACQUISITION OF OBSERVING

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Pigeons were exposed to stimuli correlated with the presence or absence of a variable-interval 60-second schedule of reinforcement only while they depressed a crossbar or "perch." In the first experiment, the stimuli were different tilts of a line displayed on the key. When the difference in brightness between the line and the background (salience) was maximal, seven of eight birds acquired the discrimination, but when the difference was reduced by 50%, only one succeeded. In the second experiment, wavelength of chamber illumination served as the relevant dimension. Neither experiment showed a large effect attributable to the magnitude of the difference (disparity) between the positive and the negative stimulus. Individual differences in time spent observing were positively correlated with level of discrimination in the presence of the stimuli. All birds produced the positive stimulus for a greater proportion of the available time than they did the negative stimulus. This may be the mechanism that provides selective reinforcement of observing. Finally, the formation of a discrimination was analyzed in terms of changes in the proportion of time spent in contact with the discriminative stimuli.

*Key words:* selective observing, discrimination learning, salience, disparity, observing response, key peck, perch press, pigeon

The first study of the acquisition of an artificial observing response during the formation of a discrimination was conducted by L. B. Wyckoff, Jr. Although his work was submitted as a doctoral dissertation in 1951, the empirical portion was not published until some years later (Wyckoff, 1969). The behavior required by Wyckoff for observation of the discriminative stimuli was standing on a pedal on the floor of the chamber, in front of the key. During an initial baseline session, various groups of birds depressed the pedal for means of 38 to 49% of the experimental session. In later sessions, when standing on the pedal changed the color of the key from white to red or green, pedal time was maintained at approximately the same level in groups for which the colors served as discriminative stimuli for pecking. But in the control group, for which the colors were not correlated with the probability of reinforcement, time on the pedal declined to a very low level. Meanwhile, pecking the key

increased in rate during portions of the session when a fixed-interval schedule of grain delivery was in effect and the positive discriminative stimulus ( $S^D$  or  $S+$ ) could be produced, and declined during portions when extinction was scheduled and the negative discriminative stimulus ( $S^A$  or  $S-$ ) was produced. The key-pecking data were analogous to those obtained during conventional studies of discrimination training in which no artificial observing response is required.

Wyckoff's goal was to provide a formal extension of Spence's theory of discrimination learning to deal with situations in which the subject did not originally make effective contact with the discriminative stimuli. The central issue for such a theory, it turned out, was the question of what maintained the necessary observing behavior. After all, when the positive and the negative stimuli were averaged, the frequency of reinforcement appeared to be no higher in their presence than in their absence. What was gained by performing the response?

Over the years, a number of theories have been proposed, but the most promising of these, we believe, is derived from a relatively limited set of data collected by Dinsmoor, Browne, Lawrence, and Wasserman (1971).

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These authors replicated the essential features of Wyckoff's study, using a similar operandum but keeping separate records of the time spent on the pedal during periods when a variable-interval (VI) schedule of reinforcement was in effect and S+ could be produced and during periods when extinction was scheduled and S- could be produced. They found that their birds produced S- more often than S+. But when a bird produced S+ it stayed on the pedal, prolonging its exposure to the stimulus, and when it produced S- it promptly stepped off the pedal, ending its exposure to the stimulus. Even though the two stimuli were available for approximately equal periods, each of the birds spent much more time in the presence of S+ than in the presence of S-.

This finding has important implications for a theoretical analysis of the role of observing responses in discrimination learning, but, as Browne and Dinsmoor (1974) pointed out, factors other than those intended could have contributed to the data. When the bird stepped on the pedal and produced S+, it would be likely to stay in much the same place and peck the key; the response could be prolonged for reasons that were not related to the observing contingency. But when the bird stepped on the pedal and produced S- it would have no reason to stay near the key, since pecking was never reinforced in S-. Using a tilting floor as their operandum, Browne and Dinsmoor were able to confirm some aspects of the earlier study, but the high initial level of time recorded as observing precluded analysis of other details that were of interest. Furthermore, since Browne and Dinsmoor delivered their grain on a response-independent basis, they could not study the concurrent development of discriminative responding on some other operandum.

One of the purposes of the present experiment, then, was to study the acquisition of observing and the attendant formation of a discrimination under conditions that are less vulnerable to alternative interpretation. For Wyckoff's pedal, which was located where the pigeon would almost inevitably stand on it much of the time while pecking the key, we substituted an operandum resembling a perch—a low-lying cross-bar running parallel to the front wall of the experimental chamber. The perch was located where the bird conveniently could, but need not, depress it while pecking

the key. For most birds, the baseline was much lower than for Wyckoff's pedal but still high enough to permit adequate contact with the observing contingency. Furthermore, a control perch was included to permit the evaluation for each bird of the effect of factors other than the observing contingency.

Another line of investigation that also leads into the present study comes from earlier work conducted by Dinsmoor, Sears, and Dout (1976). These authors noted that an interpretation in terms of observing or attention of several classic phenomena in the area of stimulus control rested on the assumption that observing was better maintained with a large physical difference between S- and S+ than with a small one. They therefore set out to examine this assumption, using a concurrent observing procedure in which pecking one side key produced members of one pair of discriminative stimuli and pecking the other key produced members of the other pair. Their data indicated that the magnitude of the difference between the stimuli did influence the level of observing. However, further analysis indicated that the situation was more complex than previously supposed. It was necessary to distinguish two basic dimensions of discriminative stimuli, their disparity and their salience. Salience was defined as the magnitude of the difference between the discriminative stimuli and the background stimulation, and disparity as the magnitude of the difference between the discriminative stimuli themselves. Furthermore, the Dinsmoor *et al.* data were collected at asymptotic levels of performance, whereas the phenomena to which they had theoretical application were observed during acquisition. The purpose of the present experiments, then, was to assess the separate influence of salience and disparity on the acquisition of observing.

## EXPERIMENT 1

### METHOD

#### *Subjects*

Sixteen White Carneaux hen culls, six to seven years old, were obtained from the Palmetto Pigeon Plant. All were experimentally naive. They were maintained at approximately 75% of their ad libitum weight by supplementary feedings, as needed, following experimental sessions.

### *Apparatus*

The birds were trained in a Lehigh Valley Electronics Model 1519 pigeon chamber, with an instrument panel of local manufacture. The panel was 35.2 cm wide and 34.8 cm high; from this panel the bird's working space extended back 30.8 cm to the rear wall.

The response key was mounted behind a circular opening, 2.5 cm in diameter, centered 24.3 cm above the mesh floor. A force of .25 N was required to record a key peck. Behind the key was mounted an Industrial Electronics Engineers Series 10 projection unit, which provided a variety of patterns. A 3-mm-wide black line bisecting a white ground could be projected in a horizontal axis or tilted 15° or 30° clockwise (S+) or counterclockwise (S-). The 30° difference between S+ and S- produced by tilts of 15° in either direction served as the small stimulus difference, and the 60° difference produced by tilts of 30° in either direction served as the large difference. The bulbs in the projection unit were Type 44, operating at 6.3 V, .25A. To reduce the contrast between the black line and its white background, two cells of the IEE projector could be lighted at the same time by bulbs reduced 50% in intensity by .3 Kodak Wratten No. 96 neutral-density filters. One cell projected the pattern, the other a blank field. The net result was a background of the usual level of illumination bisected by a gray line of the desired tilt.

The panel also included a shielded house-light (Type 757 bulb), centered at 4.5 cm from the top edge, and a rectangular opening, 4.7 cm high and 5.7 cm wide, centered laterally with its lower edge 10.3 cm above the floor, which gave access to the food hopper when it was raised. When raised, the hopper made an audible thump and was lighted by a concealed Type 757 (.8A) bulb operated at 28 V dc.

Below and to either side of the hopper opening, two lengths of stainless steel tubing running parallel to the wall provided the perch operanda for observing behavior. The central axis of each perch was 5.5 cm from the panel and 3.2 cm from the floor. Each perch extended 14 cm horizontally, and the gap between the two was 1.7 cm. A force of approximately .5 N was required to operate the pressure switch attached to the left perch and a force of .4 N for the right perch.

Experimental events were scheduled by Mas-

sey Dickinson solid-state switching modules, and data were collected on electromagnetic counters, running-time meters, and Gerbrands Type SHS cumulative recorders. The control and recording equipment was housed in an outer room. A blower attached to the experimental chamber provided masking noise and ventilation.

### *Procedure*

The purpose of the first few sessions of training was to establish key pecking. The line displayed on the key was always horizontal, the orientation later to be associated with a mixed schedule of reinforcement. The reinforcer was 3-sec access to mixed grain from the lighted hopper. First, each bird was trained by successive approximation to peck the key; 30 successive pecks were then reinforced. The next five sessions each lasted until 60 reinforcers had been delivered. The schedule for the first session was VI 15-sec, for the second, VI 30-sec, and for the remaining three, VI 60-sec.

Each bird was then assigned to its experimental condition. For half the birds a large difference (60°) between S- and S+ was used and for the other half a small difference (30°). For half the birds the line was presented at full contrast (high salience) and for the other half at 50% of the illumination of the surrounding field (low salience). The time the bird had spent on the left and right perches was compared. The perch on which it had spent more time during the four previous sessions was designated as the control perch; time spent depressing this perch continued to be recorded but had no programmed consequence. The perch on which the bird had spent less time was designated the effective perch; depressing this perch altered the stimulus on the key.

All subsequent sessions lasted 90 min. During the next four baseline sessions, the schedule of reinforcement for key pecking alternated at varying intervals (mean 45 sec) between VI 60-sec and extinction. When the effective perch remained in the up position, the line displayed on the key was horizontal (mixed-schedule stimulus); when the perch was held down, the tilt was that appropriate either to S- or S+, but the alternation between these two orientations did not coincide with the alternation between the two schedules of reinforcement; the line shifted independently be-

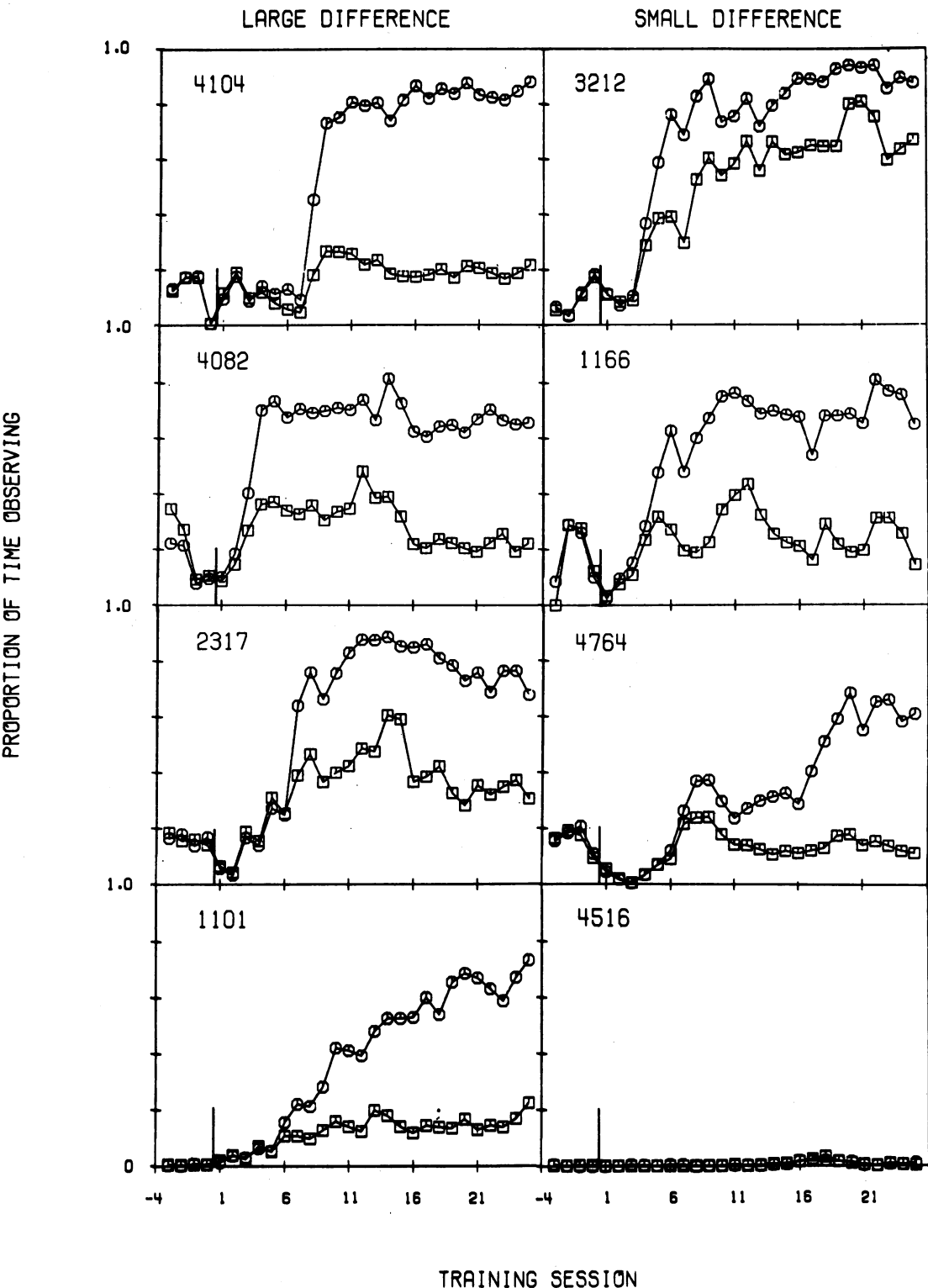


Fig. 1. Proportion of VI time and proportion of extinction time spent by each bird on the effective perch. Prior to Session 1, the stimuli were not correlated with the schedule of reinforcement (baseline). Circular points represent observing of S+ and square points observing of S-.

tween the positive and negative slopes at varying intervals averaging 45 sec.

The only change in procedure after completion of the baseline sessions was to synchronize the line tilt with the schedule of reinforcement. When reinforcement was being programmed on the VI schedule, the rotation was clockwise; when extinction was programmed, it was counterclockwise. This procedure was maintained for another 25 sessions.

#### RESULTS AND DISCUSSION

The salience (contrast) of the lines had a dramatic effect on the amount of observing. Even at the lower contrast, the lines were perfectly obvious to human observers. Nevertheless, only one of the eight birds trained with these stimuli gave any evidence either that its rate of pecking was influenced by the tilt of the line or that alteration of the tilt was reinforcing. For the other seven birds, time spent on the effective perch did not increase. Therefore, the data collected from this group will not be further analyzed.

On the other hand, all but one of the birds trained with the higher contrast lines yielded the expected pattern of results. The acquisition of observing is plotted for each of the eight birds in Figure 1. Time spent on the effective perch is plotted separately for periods in which the VI schedule was in effect and the positive tilt was therefore produced and for periods in which extinction was scheduled and the negative tilt was produced. The first four sessions are the baseline sessions, and the remaining 25 show the effects of the observing contingency. In five of the birds, the rise for the positive stimulus is quite sudden, reminding one of the data obtained by Zeaman and House (1963) for acquisition of a simultaneous discrimination by retarded human subjects, data that they used to support an analysis in terms of observing responses. One bird did not learn to observe, and the data for the other two birds show a more gradual rise. In most instances, the acquisition curve for observing the negative discriminative stimulus falls considerably below that for the positive, confirming the data obtained by Dinsmoor, Browne, Lawrence, and Wasserman (1971) with a floor pedal.

The pattern of behavior by means of which the birds selected larger amounts of S+ than S- time is illustrated by the section from an

Table 1

Mean length of time perch held down when producing S+ or S- (seconds).

	<i>Large Difference</i>		<i>Small Difference</i>	
	S+	S-	S+	S-
Effective perch	4.72	1.18	7.26	1.25
Control perch	1.96	1.46	2.27	1.61

operations record presented as Figure 2. Time flows from left to right. In each horizontal segment, the top line indicates the occurrence and duration of each observing response: The pen was displaced upward whenever the pigeon stepped on the effective perch. The second line indicates whether S+ (upward displacement) or S- was being produced. And the third line shows the occasional responses that this bird made on the control perch. Note that when the bird stepped on the effective perch and produced S+, it tended to stay there for a relatively long time. When it encountered S-, however, it quickly let the perch up again. The generality of this phenomenon is attested by the data presented in Table 1. The mean duration of the display is substantially higher for S+ than for S-.

Although Figure 1 suggests that the large difference between S+ and S- was more effective than the small, the effect was not statistically significant. In view of the all-or-none effect of salience (viz., most birds trained with low-contrast lines did not learn to observe), the small and unreliable effect of disparity (difference between S+ and S- in tilt) seemed somewhat surprising. The difference between the two stimuli is the factor that has traditionally been recognized as the important one. Before concluding, however, that this factor has a relatively small effect, it seemed incumbent upon us to repeat the test, using some other dimension, in case the outcome was simply the result of a poor choice of stimuli.

#### EXPERIMENT 2

Although the contrast between figure and ground (salience) of the discriminative stimuli proved to be a very effective determinant of the amount of observing in Experiment 1, the magnitude of the difference between the positive and negative tilts (disparity) did not. Negative results, however, are difficult to interpret.

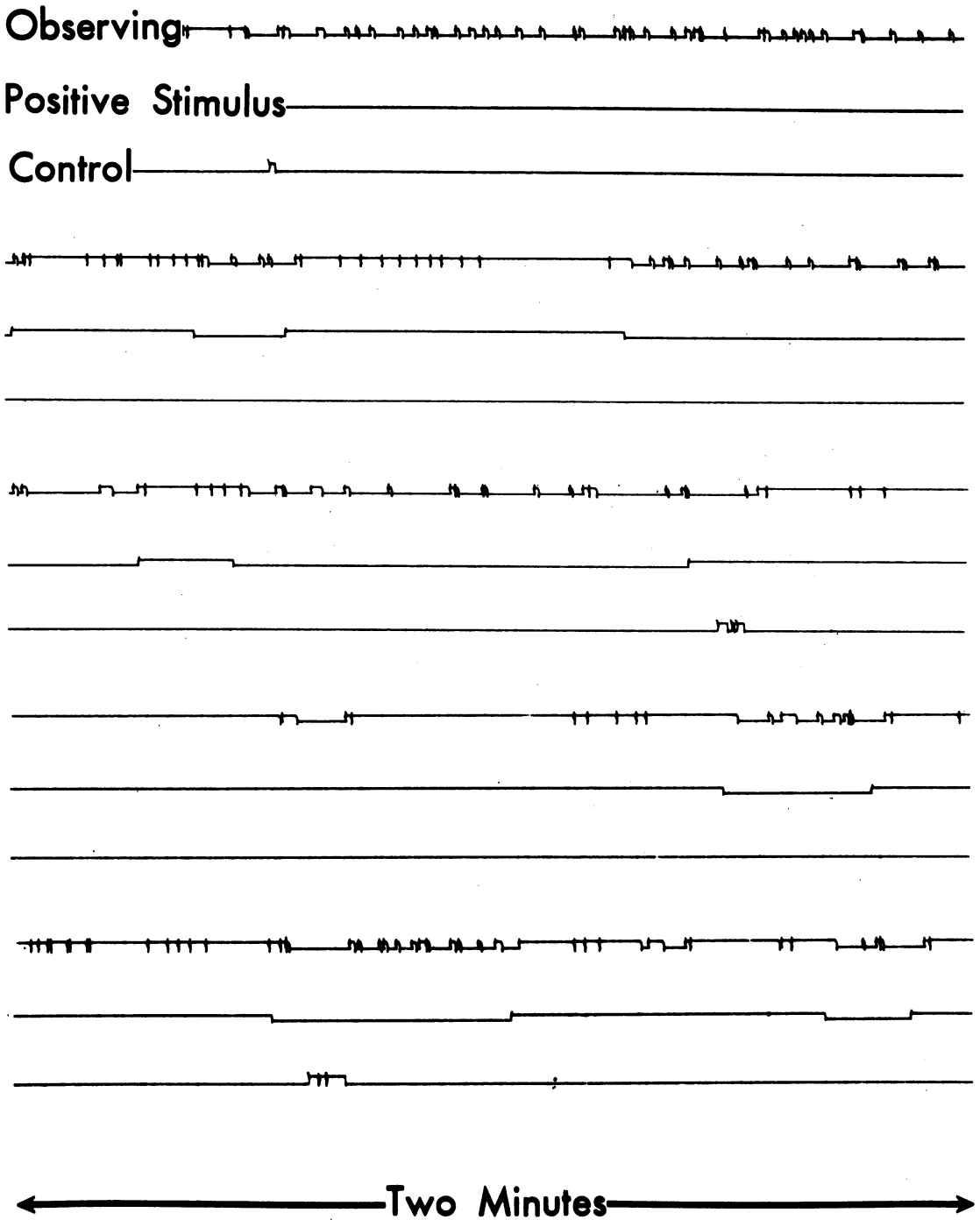


Fig. 2. A portion of the operations record obtained from Bird 4104 on an extra session after the completion of training. Time flows from left to right. For each horizontal segment, upward displacement of the top line indicates depression of the effective perch (observing), upward displacement of the second line indicates that the VI schedule was in effect on the key (i.e., S+ was available), and upward displacement of the bottom line indicates depression of the control perch.

They may be specific to the particular physical arrangements, such as the line tilts used as the discriminative stimuli. Although equivalent stimuli have been used in many studies of stimulus generalization, they appear to exert less control in general than do variations in wavelength. Furthermore, data reported by Touchette (1969; see also Skinner, 1965, pp. 199-200) suggest that individual subjects may look at and be controlled by different portions or aspects of such stimuli. In the present case, for example, it might have been the brightness ("white" or "black") at a particular locus on the key, rather than the slope of the line, that controlled a bird's pecking. If the bird were not responding to the slope, as such, a change of  $30^\circ$  might be no "larger" in any meaningful sense than a change of  $15^\circ$ . Indeed there appears to have been no systematic difference in the level of stimulus control exerted by these two pairs of stimuli.

In the hope of providing a continuum that might be more effective and on which very large or very small differences could be presented, we utilized wavelength as the stimulus dimension for Experiment 2. Furthermore, in order to analyze certain details of the birds' performances without concerning ourselves with the possibly distorting effects of approaches to S+ and withdrawals from S- (e.g., Hearst & Franklin, 1977; Peden, Browne, & Hearst, 1977; Wasserman, Franklin, & Hearst, 1974), we avoided the usual practice of displaying these stimuli on the key and instead illuminated the entire chamber with light of different wavelengths.

#### METHOD

##### *Subjects*

Thirty White Carneaux hen culls, six to seven years of age, were secured from the Palmetto Pigeon Plant. All were experimentally naive at the beginning of the study. They were maintained at approximately 75% of their ad libitum weight by supplementary feedings, as needed, following the experimental sessions.

##### *Apparatus*

To provide room for an overhead projection system, we mounted our pigeon panel in a Lehigh Valley 132-04 Medium Universal Test Cage Enclosure 50.8 cm long and 48.3 cm high. The panel was 35.9 cm high and 35.0 cm wide, and the pigeon's working space extended back

30.5 cm from the panel. Arrayed vertically along the midline of the panel were: a) a shielded houselight (Type 757 lamp, .8 A), 33.3 cm from the floor; b) a 2.5 cm diameter key, requiring a force of .25 N, 26.3 cm from the floor; and c) a rectangular opening 6 cm wide, extending from 11.1 to 15.9 cm above the floor, which gave access to the grain hopper when it was raised to the appropriate position. A concealed Type 757 lamp illuminated the raised hopper. On either side of the midline, 4.7 cm in front of the panel and 4 cm above the floor, were two 13.7-cm lengths of 1.5-cm O.D. stainless steel tubing, which served as perches; each was mounted on a pair of supporting shafts and required a force of .25 (left) or .27 (right) N to close a pressure switch. The ends of the tubing were separated by a gap of about 2 mm.

The surfaces of the pigeon's working space were painted flat white to reflect and diffuse incident light. Five multiple-projection units (Industrial Electronics Engineers) were mounted just below the ceiling at an angle such that they flooded the side wall to the left of the panel and illuminated the entire chamber. Each unit included four Type 1820X (28 V, .1 A) bulbs projecting through Kodak Wratten No. 92 (646 nm—"red") filters, and two each projecting through the following filters: No. 23A (605 nm—"orange"), No. 22 (599 nm—"yellow-orange"), No. 21 (594 nm—"yellow"), and No. 56 (555 nm—"green"). To the human eye, the brightness of the chamber appeared to be negatively correlated with the wavelength of the filter through which the light was projected. The pigeon's key was illuminated from the rear by a single Type 1820X bulb projected through another No. 22 (599 nm) filter to avoid reducing the saturation of the overall illumination.

The programming and recording system duplicated that used in Experiment 1.

##### *Procedure*

The procedure was the same as that for Experiment 1 except that illumination of the chamber with 599 nm was now the mixed-schedule stimulus, 594 nm and 605 nm were the small-disparity discriminative stimuli, and 555 nm and 646 nm were the large-disparity discriminative stimuli. Half the birds received the longer of the two wavelengths as the positive stimulus and half the shorter wavelength. Also, to avoid unduly low initial levels of per-

formance on the effective perch, if a bird depressed either perch for less than five min on the average during the prebaseline sessions, the bird's preferred perch was designated as the effective perch. For other birds, the non-preferred perch was used.

RESULTS AND DISCUSSION

One of the most influential factors governing the acquisition of observing in this experiment was the amount of time the bird spent on the designated perch prior to discrimination training. For comparison with the final level of performance this, too, will be expressed in terms of the proportion of VI time that the bird held the perch down. With one exception, none of the birds registering less than 5.1% during the baseline determination rose to more than 6.5% during the last four sessions of training. Bird 9760 did show a rise

from 4.5% to 54.4%, but its time on the control perch rose from 2.7% to 38.1%, rendering time on the effective perch somewhat suspect. Apparently a certain threshold level of exposure to the contingencies is required for learning to occur. Accordingly, the seven birds that showed the lowest levels of perching during baseline were excluded from further analysis. Subsequent results and conclusions therefore refer only to the 23 birds spending 6.6% or more of the VI periods during baseline sessions on one of the two perches.

We have presented the critical data for individual birds in Table 2. The first two columns show the percentage of VI time that the bird spent on the effective perch during the four baseline sessions and during the last four sessions of training; corresponding values are also presented for the control perch in the third and fourth columns. The data for percentage

Table 2  
Proportion of VI time and of extinction time spent on effective perch and on control perch.  
Individual means for four baseline sessions and for last four training sessions.

Bird	Positive Stimulus <sup>a</sup>	Effective Perch <sup>b</sup>	Proportion of VI time on perch				Proportion of extinction time on perch			
			Effective		Control		Effective		Control	
			Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
Large Difference										
2788	LW	L	.146	.463	.019	.108	.133	.151	.019	.025
4307	LW	L	.094	.671	.382	.226	.094	.272	.419	.365
2924	LW	L	.035	.273	.153	.398	.047	.127	.158	.375
5486	LW	R	.154	.389	.073	.170	.168	.145	.077	.152
2656	LW	R	.066	.565	.172	.314	.074	.197	.206	.485
1073	SW	L	.209	.809	.356	.207	.211	.448	.368	.449
2348	SW	L	.173	.826	.283	.295	.175	.332	.279	.132
4127	SW	L	.085	.757	.480	.013	.084	.287	.478	.029
9520	SW	L	.086	.694	.019	.001	.096	.150	.022	.002
9766	SW	R	.175	.410	.319	.094	.191	.375	.367	.158
1962	SW	R	.178	.633	.170	.347	.193	.345	.191	.251
2373	SW	R	.090	.527	.144	.340	.108	.271	.166	.373
Mean			.124	.585	.214	.209	.131	.258	.229	.233
Small Difference										
1044	LW	L	.201	.484	.332	.525	.213	.230	.376	.472
1086	LW	L	.111	.554	.258	.217	.129	.213	.282	.194
2568	LW	L	.070	.863	.215	.063	.082	.395	.248	.341
4245	LW	L	.183	.323	.496	.198	.195	.126	.525	.363
2606	LW	R	.108	.540	.195	.569	.138	.321	.204	.687
3129	LW	R	.194	.346	.236	.353	.227	.218	.253	.325
2448	SW	L	.267	.638	.032	.175	.276	.265	.039	.187
1761	SW	L	.037	.540	.372	.144	.048	.331	.375	.399
2566	SW	R	.266	.715	.235	.058	.308	.581	.273	.210
1113	SW	R	.121	.758	.047	.044	.134	.340	.046	.049
3978	SW	R	.066	.212	.038	.392	.074	.122	.047	.395
Mean			.148	.543	.223	.249	.166	.286	.243	.329

<sup>a</sup>LW indicates that the longer wavelength was used as the positive stimulus, SW the shorter wavelength.  
<sup>b</sup>L indicates that the left perch was effective, R that it was the right perch.



of extinction time are presented in Columns 5 through 8. For Birds 2606 and 3978, time spent on the control perch increased more during training than did time spent on the effective perch. Therefore, it is not clear for these subjects whether the increase in effective-perch time can be attributed to the observing contingency. However, as illustrated in Figure 3, all the birds showed substantial increments in effective-perch time, and in other cases these were not matched by corresponding increments on the control perch. For the four baseline sessions, the mean time during VI on the control perch ranged from 19.4 to 22.4%, and for the last four sessions of training, from 21.8 to 22.4%.

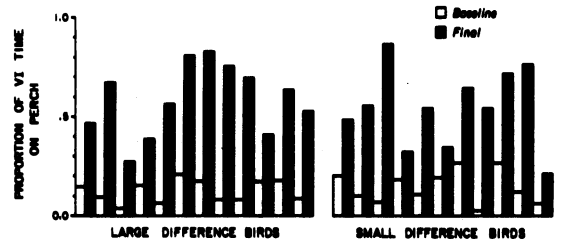


Fig. 3. Proportion of VI time spent on the effective perch by individual birds during the four baseline sessions and during the last four sessions of training.

The mean proportion of available time spent observing S+ is plotted for successive sessions in Figure 4. The first four sessions provide a baseline, and the remaining 25 sessions

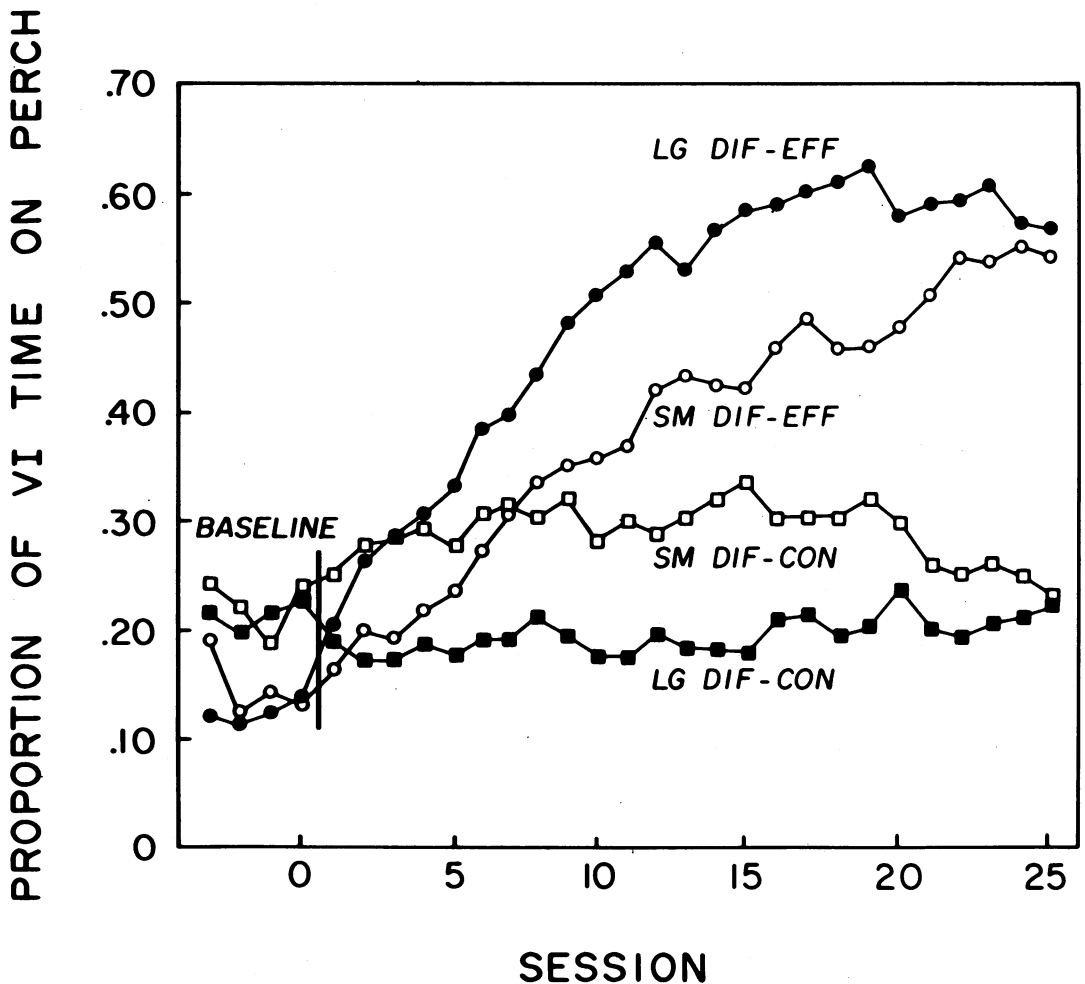


Fig. 4. Proportion of VI time spent on effective perch (observing S+) and proportion spent on control perch. The filled circles represent the mean of the large-difference group and the unfilled circles the mean of the small-difference group on the effective perch; the filled squares represent the mean of the large-difference group and the unfilled squares the mean of the small-difference group on the control perch.

show the effect of the observing contingency. The corresponding activity on the control perch is also plotted for comparison purposes. The data are presented separately for the birds allowed to produce a large difference in wavelength (91 nm) between the positive and negative stimulus and for those allowed to produce only a small difference (11 nm). There was a statistically significant difference between the two groups in the level of control exerted by S+ and S- over the rate of pecking the food key ( $p < .02$  by Mann-Whitney U Test on S+ rate divided by sum of rates for last four sessions). However, even when we made some rather questionable assumptions and applied an analysis of variance, we were unable to demonstrate that the corresponding difference for time spent observing was greater than would be expected by chance. Again, as in Experiment 1, the data suggest a difference but do not conclusively demonstrate it. The disparity between the two stimuli does not appear to be as influential as their salience.

#### *Discriminative Control*

In his original study of observing, Wyckoff (1952, 1969) suggested that the effectiveness of a pair of discriminative stimuli in maintaining observing was a function of the control they exerted over responding in their presence: "Exposure to discriminative stimuli will have a reinforcing effect on the observing response to the extent that S has learned to respond differently to the two discriminative stimuli" (Wyckoff, 1952, p. 435). Later, the idea was taken up by Hendry (1969) and incorporated, under the heading of the Cue Hypothesis, as a subcategory of his Information Hypothesis (Hendry, 1969, pp. 18-22). Similarly, Sutherland and Mackintosh (1971), working within a deductive framework, suggested that the degree to which an "analyzer" (attention to a specific dimension) was strengthened depended on the degree to which the difference in response strength to the S+ and the S- was increased on a given trial (pp. 64-65). If analyzer strength and response strength are each cumulated for a number of trials, this translates into the same relationship: A high level of discrimination maintains a high level of attention.

There are several ways to examine this relationship. In the present experiment, as indi-

Table 3

Pearson product-moment correlations between proportion of VI time spent observing and discrimination index (S+ rate divided by sum of rates) for pecking while observing, together with the probability that the observed correlation would arise by chance.

Sessions	Correlation	Probability
baseline	-.22	.161
1-4	.70	.001
5-8	.71	.001
9-12	.59	.002
13-16	.49	.009
17-20	.40	.028
21-24	.31	.077

cated earlier, we did not obtain a statistically significant difference in observing between birds receiving a large difference between S- and S+ and birds receiving only a small difference (Figure 4), even though there was a reliable difference in the discriminative control of pecking by the two pairs of stimuli. Individual differences, however, proved more revealing. In Table 3 we present product-moment correlations between observing (proportion of VI time on effective perch) and stimulus control (rate of pecking in S+ divided by sum of rates in S- and S+). The correlations have been tabulated for blocks of four sessions and are significant at the .01 level for the first four blocks (16 sessions) of training. Beyond that point, the correlations remain positive but decline in magnitude because the performances of the individual birds converge as they approach asymptote.

The difficulty with this analysis is that both amount of observing and level of discriminative control are dependent variables; since neither has the status of an independent variable, it is difficult to tell whether one is "cause" and the other "effect." One might try to resolve the issue by examining the sequential order in which the two effects appear, i.e., which changes first. Unfortunately, it is difficult to measure the control exerted by S+ and S- early in training. Until the subject observes with some regularity, the stimuli are not present for a sufficiently large sample of time to permit accurate assessment of their effects. Later in training it is difficult to compare the level of discrimination with the level of observing because each is measured on a dif-

ferent scale. Until the two can be expressed in terms of a common unit, there is no way to tell which is "ahead."

### *Selective Observing*

The frequency with which the birds initiated observing by stepping on the perch was about the same during VI (when S+ was produced) as during extinction (S-). For birds in the large-difference group, the mean rate of perch depression in VI rose from 7.0 responses per minute during the baseline sessions to 17.3 for the last four sessions of training and the rate in extinction from 7.7 to 15.1. For birds in the small-difference group, the rise was from 7.7 to 14.6 responses per minute in VI and from 8.6 to 13.3 in extinction.

In terms of the mean length of time the bird held the perch down, however, once it was depressed, the performances were quite different. During baseline, the birds in the large-difference group kept on the future S+ or S- (non-correlated) for a mean of 1.0 sec each time it appeared. During the final four sessions, they kept S+ on for 2.9 sec and S- on for 1.1 sec. Similarly, during baseline the birds in the small-difference group kept the to-be-discriminative stimuli on for 1.6 sec. During the last four sessions of training, they kept S+ on for 4.7 sec and S- on for 1.9 sec.

This finding confirms the results obtained by Dinsmoor, Browne, Lawrence, and Wasserman (1971), using a pedal on the floor of the chamber as their operandum. By the end of training each of their birds kept the S+ on much longer than the S-.

Evidently the behavior of letting the perch up was under discriminative control. Before stepping on the perch, the bird was in the presence of the mixed-schedule stimulus (599 nm). Initial depressions of the perch were sometimes reinforced by the production of S+ and sometimes punished by the production of S-. When S+ appeared the bird continued to hold the perch down, although not for as long as the birds used by Dinsmoor, Browne, Lawrence, and Wasserman (1971) stayed on the floor pedal. In the presence of S+, holding maintains S+ and releasing the perch produces a return to a stimulus associated with a lower density of primary reinforcement. When S- appeared, the bird released the perch relatively promptly. This stimulus is thought to be aversive: Rand (1977), Rilling, Askew, Ahlskog,

and Kramer (1969), Rilling, Kramer, and Richards (1973), and Terrace (1971) have all presented data indicating that termination of an S- is reinforcing for pigeons. (But see also Coughlin, 1973.) By extending the period of observation when S+ appears but terminating it when S- is encountered, the subject provides itself with substantially more exposure to the positive stimulus, even though each stimulus is available for an equal portion of the session. Individual data have been presented in Table 2. During the final stages of training, all birds except 9766 produced S+ a much greater proportion of the time than they did S-. In many instances, a similar pattern appeared on the control perch, presumably because of some form of induction between the two perches. More commonly, however, the bird spent less time on the control perch during VI periods than it did during extinction, for session after session. Each of these effects was systematic for a number of individual birds, but we have no way of predicting which pattern will appear with any given bird. The reduction in time on the control perch during VI, as compared to during extinction, may be the result of interference from time spent on the effective perch.

Since the mean duration of the stimulus appears to be a parameter of its effectiveness as a reinforcer (Dinsmoor, Mulvaney, & Jwaideh, 1981), the selective exposure documented above may provide a solution to the dilemma originally posed by Prokasy (1956) and by Wyckoff (1959). Both of these authors thought that the reinforcing effect of the S+ and the punishing effect of the S- should balance out. This might be so if each were equally represented, since then the average frequency of primary reinforcement in their presence would be no higher than in their absence. But since the subject selects more of the time when the reinforcement schedule is in effect (S+) than it does of the extinction time (S-), the average frequency of primary reinforcement in the presence of the stimuli produced by the observing response is higher than the frequency of reinforcement in their absence. (See also Branch, 1970.) Not only is the schedule of reinforcement while observing enriched by the presence of more VI time than extinction time, but the schedule of reinforcement while the subject is not observing (mixed schedule) is depleted by the loss of more VI time than ex-

tion time. Thus, the mixed-schedule stimulus is reduced in attractiveness. The selectivity of observing may have implications not only for the reinforcing value of the stimuli produced by this response but also for the behavior itself: The density of reinforcement is higher when the subject is performing the observing response than it is when the subject is not performing the observing response. The specific topography required to observe the discriminative stimuli is selectively reinforced.

With an apparatus like that used by Prokasy (1956), of course, the subject is forced to spend equal amounts of time in the presence of S— and S+. On either type of trial, it is confined for the same duration in the delay chamber. Similarly, in most operant studies of observing, the duration of the stimulus display is determined by the experimenter rather than by the subject and is typically set at the same value for S+ as it is for S—. But the response required by the experimenter for the subject to make contact with the stimuli is only the first step in the observing sequence. Natural observing responses may also be required. Since these responses presumably follow the same rules as those demonstrated in the present experiment, the subject may still selectively observe S+ even when the experimenter has presented the two stimuli for equal periods of time. Therefore, the present theoretical account may be quite general in its application.

#### *The Role of Observing in Discrimination Learning*

Natural observing responses (or their equivalent at a more central level) may play a critical role in the acquisition of stimulus control. As Skinner noted many years ago (1938), there is often a large induction at the beginning of training between the subject's behavior in S<sup>D</sup> and that in S<sup>A</sup>. Reinforcement of the response in the presence of the positive stimulus may add almost equally to its rate in the presence of the negative stimulus (e.g., Ferster, 1951). Presumably a similar process operates in the opposite direction, with extinction in the presence of the negative stimulus lowering the rate of responding in the presence of the positive stimulus. This is what one would expect, of course, if the subject has not made adequate contact with the relevant stimuli. In effect, the animal is still on a mixed schedule, even though the differential stimuli are physically present.

But as the animal begins to observe the stimuli that are correlated with the receipt of the reinforcer (S+ and S—), the schedule is gradually transformed into an effective multiple schedule. If the subject is observing the positive stimulus when the instrumental response is reinforced, the strengthening effect of that reinforcer is now specific to those occasions when the positive stimulus is present and is observed by the subject. And if the subject is observing the negative stimulus during long periods without reinforcement, the weakening effect is specific to those occasions when the negative stimulus is present and is observed by the subject. Eventually, when the subject becomes proficient at observing and attending to the relevant stimuli, very little induction occurs.

It is the increasing independence of the two performances that indicates the formation of a discrimination. When control is complete, the rate and pattern of performance in the presence of the positive stimulus conform to the schedule of reinforcement that prevails in the presence of that stimulus rather than to the schedule that holds for the session as a whole. Since there is typically no reinforcement delivered in S—, the frequency of reinforcement in the presence of S+ is much higher than that for all session time, and it is not surprising that the rate of responding in S+ increases during discrimination training. Yet this increase has been seen by some writers as an anomaly and has been attributed to behavioral contrast, even in studies in which no change has been programmed in the frequency of reinforcement (e.g., Freeman, 1971, p. 347; Nevin, 1973, p. 124; Reynolds, 1961, p. 57).

In similar fashion, as the subject observes S— an increasing portion of the time, more of its behavior in the presence of that stimulus should be appropriate in its rate. Although observing of the negative stimulus may never reach the same level as observing of the positive stimulus, such responses as turning away from an S— displayed on the pigeon's key, for example, may themselves interfere with the instrumental response and may contribute to the reduction in its rate (Rand, 1977).

In conventional studies of the formation of a discrimination, the investigator has no record of when the subject is observing and when it is not observing the stimulus. Therefore, he or she tabulates as responses in S+ all those

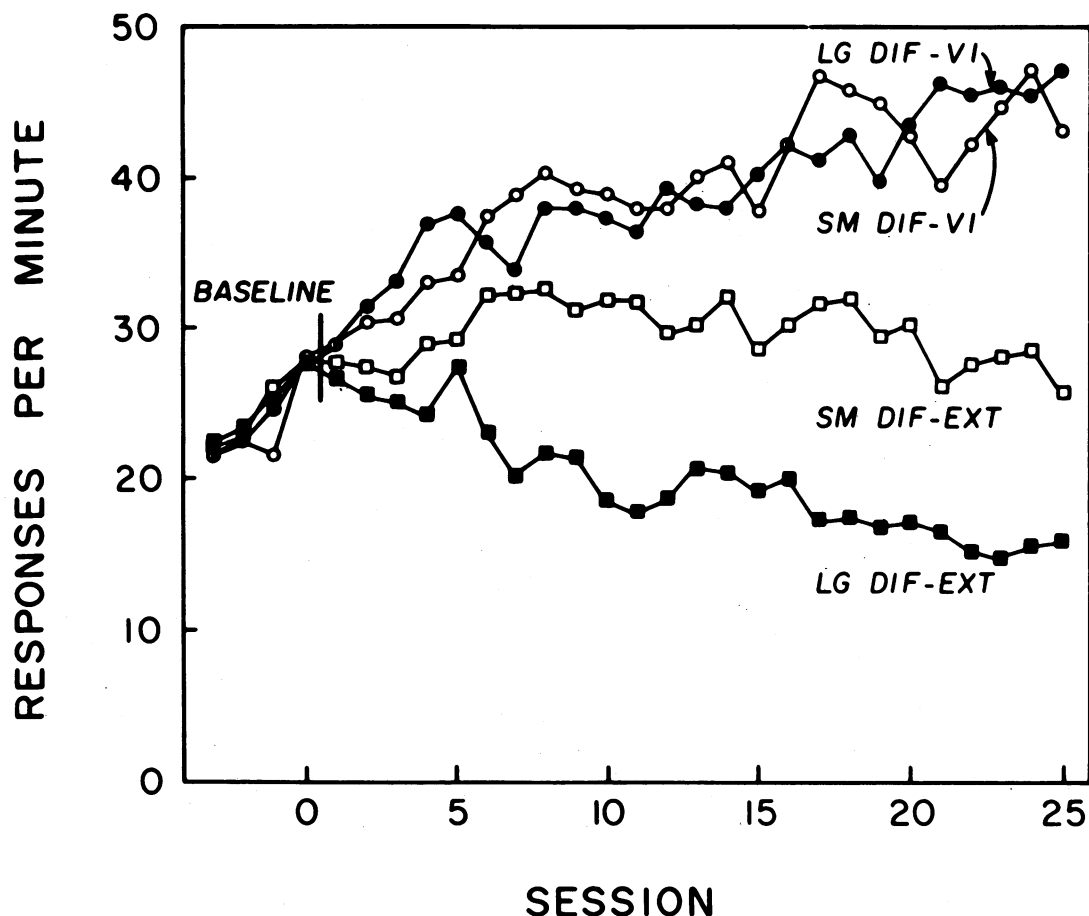


Fig. 5. Rates of pecking the food key during periods of reinforcement at a variable interval (circular points) and during extinction (squares). The filled symbols represent the means for the group receiving a large difference in wavelength between S+ and S-; the unfilled symbols represent the means for the group receiving a small one.

that occur while S+ is available, regardless of whether it is actually observed by the subject. Similarly, all responses when S- is available for observation are counted as responses to or responses in the presence of S-. As training continues, the frequency of responding increases in the first of these categories and decreases in the second. An index based on the relationship between the two rates is used to measure the progress of the discrimination (Dinsmoor, 1951, 1952).

In the present study, the stimuli were actually present only when the bird held down the effective perch. Nevertheless, when the results are analyzed in the same way, much the same pattern emerges. The mean rates of key pecking during VI and during extinction are plotted for successive sessions in Figure 5. They show an increasing divergence as training continues and the birds acquire increasing

exposure to the discriminative stimuli. Data for individual subjects are presented in Figure 6 and Table 4. Birds 2606 and 3978, which had shown questionable reactions to the observing contingencies (Table 2), also failed to discrim-

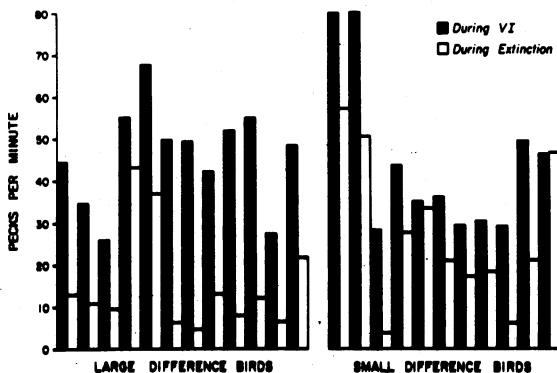


Fig. 6. Rates of pecking by individual birds in VI and in extinction during last four training sessions.

Table 4

Mean pecks per minute by individual birds during VI and extinction periods averaged over four baseline sessions and over last four training sessions. Mean discrimination index (VI rate/sum of rates) for last four sessions.

	<i>Baseline</i>		<i>Final</i>		<i>Discrimination Index</i>
	<i>VI</i>	<i>Extinction</i>	<i>VI</i>	<i>Extinction</i>	
<i>Large Difference</i>					
2788	22.2	23.0	44.5	12.9	.778
4307	14.9	15.8	34.7	10.7	.782
2924	30.9	30.2	25.8	9.6	.729
5486	20.5	20.9	55.2	43.2	.560
2656	34.1	36.1	67.7	36.9	.648
1073	29.1	30.7	49.8	6.3	.889
2348	20.4	20.3	49.2	4.5	.917
4127	18.4	17.6	42.1	13.0	.763
9520	20.6	20.3	52.7	7.7	.877
9766	31.1	30.9	54.8	12.0	.824
1962	20.5	22.1	27.1	6.5	.811
2373	26.2	27.7	48.2	21.6	.691
<i>Small Difference</i>					
1044	29.9	32.2	79.7	56.9	.584
1086	40.6	39.8	80.0	50.2	.617
2568	20.4	21.1	28.1	3.9	.879
4245	27.5	26.9	43.6	27.7	.608
2606	20.0	21.1	34.9	33.4	.510
3129	22.7	23.5	35.9	20.9	.633
2448	17.7	18.0	29.3	17.1	.636
1761	13.3	16.4	30.2	18.4	.625
2566	22.3	22.5	29.0	6.1	.828
1113	26.2	25.1	49.2	21.1	.699
3978	23.8	24.4	46.1	46.5	.498

inate between S+ and S- in their key pecking, but all the rest attained discrimination indices well above the .5 level. With the exception of 2924, all birds showed an increase in the rate of pecking in S+, but the results for S- were less consistent. Many birds showed substantial decreases in rate, especially in the large-difference group, but nearly half the birds in the small-difference group showed an increase. This is the major discrepancy between our data and those typically obtained in other studies. Several factors may have contributed to this discrepancy. First, note that the stimuli employed for the small-difference group were deliberately chosen with the aim of producing relatively weak stimulus control. Second, note also that our stimuli were diffuse, rather than being localized on the key as in most studies using pigeons; when stimuli are displayed on the key, turning away or withdrawing from that locus may interfere with pecking (Rand,

1977). Finally, in our study the S- disappeared as soon as the pigeon stepped off the perch. Therefore, the bird had less reason to continue any reactions that might interfere with pecking, as compared to a situation in which the stimuli remain present throughout the experimental session. Given these factors, our data seem consistent with those obtained when contact with the discriminative stimuli depends only on natural observing responses.

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