SEPARATING THE EFFECTS OF SALIENCE AND DISPARITY ON THE RATE OF OBSERVING

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Pigeons producing deliveries of grain on a mixed variable-interval, extinction schedule by pecking a center key could also produce discriminative stimuli on concurrent variable-interval schedules by pecking the left or right observing key. The stimuli produced by each observing key were varied independently. In the first experiment, the negative discriminative stimulus was at the far end of the spectrum from the key illumination accompanying the mixed schedule and from the positive discriminative stimulus. When the magnitude of the difference between the latter two stimuli (salience) was varied, more pecks occurred on the observing key producing the larger of the two differences than on the key producing the smaller difference. In the second experiment, the stimulus accompanying the mixed schedule was at the far end of the spectrum, and the magnitude of the difference between the two discriminative stimuli (disparity) was varied. The proportion of pecks occurring on each observing key shifted systematically in the direction of the key producing the larger difference. The salience of the discriminative stimuli and their disparity each has an independent influence on the frequency of observing when the other is controlled, but the effect of the salience appears to be the more substantial.

Key words: salience, disparity, observing, discriminative stimuli, magnitude of stimulus difference, concurrent schedules, pigeons

In several historically important phenomena such as the easy-to-hard effect, transfer of stimulus control (fading), and overshadowing, it has been found that the degree of control gained by one pair of discriminative stimuli has an influence on the degree of control exerted by another (see, e.g., Fantino & Logan, 1979; Mackintosh, 1974; Sutherland & Mackintosh, 1971). Effects of this sort lend themselves quite readily to interpretation in terms of observing or of attention to the respective pairs of stimuli. Note that in each case it is the stimuli that differ by a larger magnitude that exert the greater degree of control. If an explanation in terms of observing or attention is valid, these facts suggest that stimuli that differ by a large amount should be more frequently observed or attended to than those that differ by only a small amount.

In an experiment conducted in this laboratory, Dinsmoor, Sears, and Dout (1976) at-

tempted to test the validity of such a relationship. Higher or lower intensities of the illumination behind the pigeon's key served as the positive and negative discriminative stimuli—counterbalanced as to role—for food-reinforced pecking. The birds could occasionally produce 30-sec displays of these altered levels of key illumination by pecking either member of a pair of auxiliary keys, known as observing keys, to the left and to the right of the food key. Whether the stimulus displayed was positive or negative at a given moment depended on whether the programming circuit was currently making food deliveries available on a variable-interval schedule or was withholding all reinforcement (extinction). The magnitude of the difference between the positive and negative stimuli depended on which side key had been pecked. As predicted, the authors found that their pigeons pecked at higher rates on the key that produced discriminative stimuli differing by a relatively large amount than they did on the key producing stimuli that differed by a smaller amount.

In a second experiment, however, reported in the same paper, it was found that the relationship was more complex than had hitherto been supposed. During those periods when no

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discriminative stimulus was displayed, the keys were illuminated at an intermediate level, as in the first experiment. Inasmuch as the schedule of food delivery in the presence of the intermediate intensity might at a given moment be either variable-interval or extinction, this stimulus was a mixed-schedule stimulus. The intensities of the two discriminative stimuli were manipulated independently. When the difference between the positive stimulus and the mixed-schedule stimulus was varied, a positive relationship emerged, as before. But when it was the difference between the negative stimulus and the stimulus for a mixed schedule that was varied, the relationship was reversed: The pigeons pecked at lower rates when producing the larger differences and at higher rates when producing the smaller differences.

This finding was not entirely unexpected. Previous work in our laboratory had indicated that only the positive discriminative stimulus was reinforcing (Browne & Dinsmoor, 1974; Dinsmoor, Browne, & Lawrence, 1972); data from other observing experiments had indicated that the negative discriminative stimulus was punishing (Blanchard, 1975; Mulvaney, Dinsmoor, Jwaideh, & Hughes, 1974). But the discovery that the two halves of the continuum between the positive and the negative stimulus had opposite effects suggested that the problem had not been properly analyzed in the experimental literature up to that time. For example, in many of the early studies of discrimination learning, the experimenter used two cards of different shades of gray to indicate whether the left alley or the right alley was correct. To increase the difference between these cards, one could be made a lighter and the other a darker gray. At the extreme, one card might be white and the other black. But since the rest of the apparatus was usually painted an intermediate shade of gray, making the stimulus cards black or white increased their contrast with the surrounding visual field. The magnitude of the difference between each of the discriminative stimuli and their background stimulation, which Dinsmoor *et al.* (1976) labeled the "salience" of the stimulus, might be as important or more important than the magnitude of difference between the two stimuli ("disparity.") Although to the best of our knowledge this problem has not been discussed in the relevant literature,

there are some indications that, when independently varied, the salience of the discriminative stimuli does have an effect. Pierrel, Sherman, Blue, and Hegge (1970) found that at the high end of the range, equal differences between S+ and S-, measured in decibels, maintained higher levels of discrimination than did equal differences at lower intensities. Similarly, in a concept formation experiment using human subjects, Trabasso (1963) found that when the relevant dimension, the angle of the leaves to the stem in a flower design, was made more salient by coloring it red or green, his subjects acquired the discrimination more rapidly. Trabasso attributed this effect to greater attention by the subject to the appropriate stimulus.

Unfortunately, the stimulus arrangements used by Dinsmoor *et al.* (1976) did not permit separate assessment of salience and disparity. Because an intermediate brightness appeared on the keys when there was no discriminative stimulus (i.e., no display produced by the observing response), the difference between either stimulus alone and this constant or background stimulation (salience) lay along the same physical dimension as the difference between the two discriminative stimuli themselves (disparity). The purpose of the present experiments, then, was to examine the role of each of these factors in isolation from the other. In Experiment 1, the salience of the positive stimulus was varied, with the disparity between the discriminative stimuli and the salience of the negative stimulus controlled. In Experiment 2, the disparity between the discriminative stimuli was varied, with their salience controlled. Also, to extend the generality of our previous results, we used the spectral distribution or wavelength (a qualitative or "metathetic" continuum—Stevens, 1975) rather than the intensity of the key illumination ("prothetic" continuum) as the dimension separating the relevant stimuli.

EXPERIMENT 1

Subjects

Data were collected from four 7-year-old barren White Carneaux hen culls (434, 7229, 8445, and 8824), secured from the Palmetto Pigeon Plant. Throughout the experimental routine the birds were maintained at 75% of

their ad lib weights by supplemental feeding, as needed, following the experimental session.

Apparatus

The same apparatus was used in both experiments. When data were to be collected, the subject was enclosed in a Lehigh Valley Model 1519 pigeon chamber. The panel bearing the keys and the feeder was 35.2 cm wide and 34.9 cm high, measured from the mesh floor. The bird's working space extended 30.8 cm from this panel to the rear wall. The panel contained three circular openings, 2.5 cm in diameter, arranged in a horizontal row 25.4 cm above the floor. The left and right openings were centered about 11.4 cm from their respective side walls and 6.2 cm from the midpoint of the central opening. Behind each of these openings was a Lehigh Valley response key with a paddle made of a light-diffusing plastic .3 cm thick.

Behind each of the keys was located an Industrial Electronics Engineers Series 10 projection unit. The unit contained 12 Type 44 6.3-V lamp bulbs that could be lighted individually, each with a wavelength filter and a lens system for projecting light at a fairly uniform intensity on the rear of the key. In the present experiments, four of these bulbs were normally lighted at any one time, but different sets of bulbs produced different distributions of wavelength. Sometimes the same filters were used with each lighted bulb and sometimes they were mixed. Four each of the following filters were normally available: (a) Roscolene No. 854 "steel blue," rated at 40% luminous transmission, peaking in the region of 450 to 500 nm and descending to a trough between 600 and 700 nm; (b) Kodak Wratten No. 21, rated at 57% luminous transmission and with a dominant wavelength of 593.7 nm under Standard A Illuminant (incandescent tungsten, 2856K); (c) Kodak Wratten No. 22, rated at 48% luminous transmission and with a dominant wavelength of 598.8 nm. For brevity in exposition, the three filters will be described as blue, 594 nm, and 599 nm filters. The latter two were orange to human observers. During early training in Experiment 1, before testing began, a Kodak Wratten Filter No. 12, 584 nm, was used in place of the 594 filter.

The orange filters, 594 and 599, were chosen in part because they were among the most similar in their spectral distributions of any pair

in the Kodak series. The blue filter was substituted for one that might be logically orthogonal to the wavelength dimension (i.e., "white") because of the problems involved in measuring or controlling the brightness and the saturation (see comment in Blough, 1975, p. 147; control group in Figures 2 and 3, Selekman, 1973). It was assumed that the blue, lying at the opposite end of the spectrum from the two orange filters, was sufficiently different from either one that it could be considered functionally orthogonal to the difference between them. Another consideration was that we expected less generalization with a roughly complementary color than with one that was merely low in saturation.

Type 44 lamps were used, connected via switching contacts to a regulated 6.3-V supply. Since this type of lamp draws as much as 2.5 A when cold (P. Meretsky, personal communication, 1964), each lamp was also connected directly to the power supply, via an 11-ohm ballasting resistor, to keep it warm throughout the session. The rectification network required to prevent backpaths in the switching system reduced the voltage across the lamps when "off" to .8 V (no visible lighting of the key) and when "on" to 2.4 V. Operating the lamps at less than rated voltage undoubtedly produced a shift in the wavelength distribution toward the red end of the spectrum and the wavelengths reported specify the properties of the filters employed rather than those of the light passing through them.

Owing to the time required for the filaments of the newly energized set of lamps to reach operating temperature, the keys darkened perceptibly each time the color was changed. Because this might provide an unwanted cue to the subject, a relay was arranged to cut off key illumination for about one-half sec following every peck on either observing key. The darkening of the keys also provided a visual feedback for accurate, on-target responses. A force of approximately .12 N was required on the surface of the paddle to operate the switch behind each key and register a response.

Procedure

The purpose of the preliminary sessions was to train the birds to perform, on cue, the component responses required for our testing routine. Initially, the side keys were covered with opaque plastic tape and the center key was

illuminated with a dominant wavelength of 599 nm (mixed-schedule stimulus). The hopper was raised for 3 sec each time grain was delivered. During the first five sessions after shaping, the birds received 60 reinforcers per session on a variable-interval (VI) schedule (establishment of pecking). On the first session, the schedule was VI 15-sec, on the second VI 30-sec, and on the remaining three sessions VI 60-sec. During Sessions 6 to 15 (discrimination training) pecking the center key was reinforced on a multiple schedule in which the color of the key shifted after a variable length of time with a mean of 45 sec. When the key was illuminated through the 584 nm filters, pecking was reinforced on a VI 60-sec schedule; when it was illuminated with blue light, pecking was never reinforced (EXT).

At this point, the birds had had experience with all three colors and appropriate schedules of reinforcement on the center key. On Session 16, the center key was covered with tape, the left observing key was uncovered for the first time, and pecking was reinforced on a mixed VI 60-sec EXT schedule (599 nm). On Session 17, the same procedure was applied to the right observing key. Finally, on Session 18, concurrent observing was instituted. The same stimulus was displayed on all three keys. When the keys were illuminated at 599 nm, pecking the left or the right observing key each produced on a VI 30-sec schedule a display, which lasted for 30 sec, of whichever discriminative stimulus was appropriate at the time. In the absence of discriminative stimulation, the schedule of reinforcement on the food key was a mixed VI 60-sec EXT with 2.5-sec presentations of grain. Following a successful observing response on either the left or the right key (i.e., during a display period), the schedule was a multiple VI 60-sec EXT. The stimulus associated with reinforcement was 584 nm, and the stimulus present during periods of extinction was blue illumination of the keys. During Sessions 20 and 21, to facilitate rapid and reliable establishment of observing, grain deliveries were withheld in the presence of the mixed-schedule stimulus (599). This increased the value of the positive discriminative stimulus (584) as a conditioned reinforcer. Except for this temporary procedure, however, no changes were made after Session 18 except in the hues displayed on the keys as positive discriminative stimuli.

Between Sessions 48 and 49, the 584-nm filters associated with the VI schedule were replaced by filters with a dominant wavelength of 594. Manipulation of the independent variable, magnitude of wavelength difference between the positive discriminative stimulus and the background or mixed-schedule stimulus (599), began on Session 73. The spectral distribution of the stimulus produced by pecking the left observing key and the spectral distribution of the stimulus produced by pecking the right observing key were varied independently. When all four bulbs lighted for the positive discriminative stimulus were behind 594-nm filters, the difference was designated as "large"; when two of the bulbs were behind 594 filters and the other two were behind 599 filters, the difference was designated as "medium"; and when only one of the bulb was behind a 594 filter, with the other three behind 599 filters, the difference was designated as "small." Although there was a concomitant change in the physical difference between S+ and S-, note not only that the variation was extremely small, relative to the total range between the two stimuli, but also that the change was in a direction opposite to that which would account for our results. Beginning with Session 73, when the positive discriminative stimulus produced by pecking the left observing key was reduced to medium, changes were made after every fifteenth session, as shown in Table 1. Early in testing, relatively large differences were employed, to be certain that the observing response would be maintained. Later, when the birds' sensitivity was expected to be greater and large differences might encounter a ceiling effect, smaller differences were presented. Comparisons favoring the left key were alternated with comparisons favoring the right, in order to reduce the likelihood of the birds forming a position preference that might be resistant to subsequent change.

RESULTS

The rate of pecking by each of the birds on the left and the right observing keys for each of the last five sessions under a given set of stimulus values is presented in Table 1. Pecks occurring in the presence of a discriminative stimulus were not counted. To summarize these data, the median proportion of observing responses that occurred on the left key is

Table 1

Pecks per minute on each of the observing keys during the last five sessions within each block. The parameter that varied with successive blocks was the magnitude of the difference between the positive discriminative stimulus produced by pecking a given key and the background or mixed-schedule stimulus (salience). "Small" indicates that only one 594-nm filter was used, "medium" indicates two, and "large" indicates four; the remaining filters were 599 nm.

Session	Size of Difference		434		7229		8445		8824	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
68	Large	Large	4.80	7.58	12.93	10.18	4.59	1.23	4.79	4.47
69			10.00	5.73	13.38	11.66	4.14	1.42	7.00	6.55
70			7.25	3.94	15.21	11.94	4.95	1.56	4.98	2.72
71			6.09	4.96	10.27	11.33	4.13	1.09	2.59	2.98
72			6.00	6.97	14.18	9.49	2.13	1.17	2.05	1.31
83	Medium	Large	3.52	5.22	4.77	7.46	0.04	5.34	0.23	3.31
84			4.38	6.22	3.12	7.44	0.02	4.81	0.25	2.78
85			2.47	3.97	1.20	7.36	0.00	6.16	1.19	3.41
86			2.52	5.95	3.81	5.98	0.00	5.66	1.70	3.23
87			6.20	6.20	4.24	6.91	0.00	5.07	0.85	4.22
98	Large	Medium	7.33	1.58	9.99	0.47	2.81	1.16	3.94	1.91
99			9.16	1.59	12.58	0.23	2.86	3.77	6.13	2.07
100			7.69	1.18	12.94	1.03	2.86	2.81	4.67	1.03
101			8.24	0.95	9.79	0.44	4.95	1.61	3.44	0.43
102			9.85	1.07	13.73	0.91	3.49	2.13	5.44	1.16
113	Small	Medium	4.08	5.27	1.46	3.55	0.94	2.77	0.73	1.61
114			3.56	6.53	0.46	3.47	0.37	3.66	1.05	1.40
115			2.06	5.57	1.22	3.50	0.91	2.29	0.79	1.29
116			3.49	3.86	2.35	4.85	0.84	1.56	2.86	2.33
117			4.08	4.55	2.31	3.68	0.33	2.54	1.75	2.29
128	Medium	Small	4.67	3.28	9.44	1.49	2.71	1.46	1.96	0.59
129			4.95	3.12	7.26	0.87	2.39	1.76	1.18	0.37
130			4.79	3.96	5.24	1.88	4.05	1.20	1.02	1.47
131			7.96	4.15	5.32	1.93	2.84	1.41	0.59	2.17
132			8.22	3.63	10.99	2.46	2.41	1.30	0.23	0.73
143	Small	Large	4.13	4.94	7.96	4.22	2.78	2.66	0.05	0.15
144			3.91	7.51	9.40	5.86	2.67	2.56	0.37	0.43
145			4.03	4.93	9.51	6.81	2.48	3.39	0.00	0.00
146			6.14	7.29	12.60	5.75	2.32	2.94	0.17	0.19
147			3.98	6.31	9.16	5.18	2.07	2.72	0.05	0.11

plotted in Figure 1. In most cases, if the difference between the mixed-schedule stimulus and the positive discriminative stimulus that was produced by pecking the left key is greater than the corresponding difference produced by pecking the right key, the rate of pecking the left key is also higher. In other words, the proportion of total responses is greater than .5. In 24 determinations, there are only two exceptions to this rule. And in only one case (the next to last determination for Pigeon 8824) is the shift from one block of sessions to the next in the wrong direction.

The data for the four birds have been averaged to produce the session-by-session plot presented in Figure 2. Although there are some unexplained fluctuations, the trends within

each block show that the relative rate of observing on the two keys (proportion on left key) is quite sensitive to the relative salience of the positive discriminative stimulus that each of them produces.

The relationship between salience and observing does not appear to be mediated by any effect of the salience on the bird's discrimination between the positive and the negative stimulus. As might be expected, given the large difference in wavelength between the two stimuli, the birds discriminated very well under all experimental conditions. There were very few sessions for any bird in which an index calculated by dividing the rate of pecking for food in S+ by the sum of the rates during both discriminative stimuli fell below .99. We

Fig. 1. Rate of pecking the left key divided by the sum of rates for both observing keys. Data are shown individually for four birds and represent medians for the last five sessions under each condition. The upper letter beneath each bar indicates whether pecking the left key produced a large (L), medium (M), or small (S) change in the color of the keys as the positive discriminative stimulus, and the lower letter presents the corresponding information for the right key. The arrows indicate the direction in which the data should have changed under that combination of magnitudes if there is a positive relationship between size of stimulus change (salience) and rate of pecking. (Experiment 1)

could find no indication of a systematic trend. If the bird observed the stimulus, it reacted to it in an appropriate fashion, pecking if it was the positive stimulus and refraining from pecking if it was the negative member of the pair.

EXPERIMENT 2

The findings obtained in Experiment 1 confirmed the suggestion made by Dinsmoor *et al.* (1976) that the salience of the stimuli may be an important determinant of the amount of observing that occurs. The background with which the discriminative stimuli were to be compared was represented by the mixed-schedule stimulus, which was present whenever the discriminative stimuli were not on the keys. The relative rate of observing changed markedly in response to shifts in the magnitude of the difference between the positive discriminative stimulus and this mixed-schedule or background stimulus.

This finding, however, raises a second question. Much or all of the systematic variation in rate of observing obtained by Dinsmoor *et al.* (1976) can be accounted for by the effects of stimulus salience. In their experiment, the mixed-schedule stimulus lay midway between the two discriminative stimuli, along the same dimension. Thus, it is impossible to tell whether any of the effects obtained by those authors can be attributed to the magnitude

Fig. 2. Rate of pecking the left key divided by the sum of rates for both observing keys. Mean of the four birds' data for each experimental session. The upper letter in each pair indicates whether pecking the left key produced a large (L), medium (M), or small (S) change in color when the positive discriminative stimulus was produced, and the lower letter indicates the corresponding information for the right key. The arrows indicate the direction in which the data should have changed under that combination of magnitudes if there is a positive relationship between size of stimulus change (salience) and rate of pecking. (Experiment 1)

of the difference between the positive and the negative stimulus, per se, independent of their salience. The purpose of our second experiment, therefore, was to determine whether the magnitude of the difference between the two stimuli has an effect on rate of observing when their salience is controlled. The basic strategy was the same as that employed in the first experiment. Blue illumination of the key was used as the mixed-schedule or background stimulus, on the assumption that this wavelength was so different from those used for the positive and negative discriminative stimuli that no interaction would occur when the latter were varied within a very restricted range (5 nm). The salience of both discriminative stimuli remained very large under all experimental conditions.

Subjects

The data for the second experiment were collected from three additional White Carneaux hen culls (4472, 5330, and 9754), also secured from the Palmetto Pigeon Plant. Their ages ranged from 5 to 7 years. A fourth bird was discarded when its rate of pecking dropped to a very low level for a number of

sessions following what appeared to be an injury to the leg.

Apparatus

The apparatus was the same as that used in Experiment 1.

Procedure

Except for the assignment of hues to stimulus functions, the procedure for Experiment 2 was also the same as that for Experiment 1. During initial training and when a mixed schedule of reinforcement was in effect on the food key, the keys were illuminated with blue light. The negative discriminative stimulus was produced by the lighting of four lamps behind filters with a dominant wavelength of 599 nm. The positive discriminative stimulus was produced by the lighting of four lamps, two lamps, or one lamp behind filters with a dominant wavelength of 594 nm and the corresponding lighting of zero, two, or three lamps behind 599-nm filters. The combinations produced differences between the two discriminative stimuli designated, respectively, as large, medium, and small. It should be noted that this variation was quite small in relation to the total range between the positive stimulus and the mixed-schedule stimulus (blue), which we viewed as an orthogonal dimension in this design. It should also be noted that the changes in magnitude were opposite in direction. When the disparity was increased, the salience decreased by an equal absolute amount; when the disparity was decreased, the salience increased. The changes in salience were therefore opposite in direction to those required to account for our results.

Between Sessions 75 and 76 all filters were replaced, because, following prolonged usage, visual inspection showed a fading that produced a slightly brighter and more yellow display than originally specified for the 594 and 599 stimuli. Collection of test data began on Session 99, following a seasonal interruption of laboratory work, with both left-produced and right-produced stimulus differences set large in magnitude. The sequence of test conditions was copied from Experiment 1 and is shown in Table 2.

RESULTS

In Experiment 2 the S+ and S- were never more than a few nm apart and, as might be an-

ticipated, they did not exert as precise control over the food-key responding as did the orange and blue used in Experiment 1. Discrimination indices were calculated by dividing the rate of pecking displays of the positive stimulus by the sum of rates during both stimuli. Median values for the last five sessions under each set of experimental conditions are presented for individual birds in Table 3. The large, medium, and small differences cover only a small range of values, and the discrimination indices are not consistently related to the size of the difference. Although voltages were calibrated and the same lamps and filters were employed, the birds tended to discriminate displays produced by pecking the right key better than the equivalent displays produced by pecking the left key.

The rate at which each of the birds pecked each of the observing keys is presented for the last five sessions under a given set of stimulus values in Table 2. A summary of these data is plotted in Figure 3, which shows the median proportion of observing occurring on the left key. The shifts in proportion are sometimes quite small from one block of sessions to the next, but they are predictable in direction. In 16 of 18 cases the shift is toward the observing key producing the larger of the two differences between the positive stimulus and the negative stimulus. The probability of this result arising by chance is less than .01 (sign test).

A session-by-session plot of the mean proportion on the left key for all three birds is presented in Figure 4. Again, the systematic variation is small in magnitude, much smaller than in the previous experiment, but the trend is still visible. Even with the salience of the discriminative stimuli controlled, the magnitude of the difference between them appears to have some influence on the frequency of the response that produces them. Stimulus disparity is also a determinant of the amount of observing.

GENERAL DISCUSSION

Our data indicate that the salience of the discriminative stimuli and their disparity each has independent effects on the rate of observing. In Experiment 1, we held the difference between the positive and the negative stimulus (disparity) at a very large and nearly constant value while we varied the magnitude of

Table 2

Pecks per minute on each of the observing keys during the last five sessions within each block. The parameter that varied with successive blocks was the magnitude of the difference between the positive discriminative stimulus produced by pecking a given key and the negative stimulus (disparity). "Small" indicates that only one 594-nm filter was used, "medium" indicates two, and "large" indicates four; the remaining filters were 599 nm.

Session	Size of Difference		4472		5330		9754	
	Left	Right	Left	Right	Left	Right	Left	Right
109	Large	Large	25.70	24.12	8.26	4.39	19.53	15.35
110			26.38	24.85	9.12	4.54	16.87	16.04
111			27.36	25.89	7.51	3.80	17.53	20.90
112			25.72	23.99	7.37	4.63	22.76	17.45
113			27.14	25.62	7.36	4.36	20.21	14.95
124	Medium	Large	29.65	29.76	5.35	4.18	14.69	15.57
125			28.78	29.28	5.87	3.44	18.96	19.86
126			28.54	28.81	5.47	3.02	19.52	19.83
127			31.61	29.46	6.10	4.44	14.22	18.31
128			31.44	27.75	5.86	4.60	13.12	22.03
139	Large	Medium	28.10	23.84	8.75	4.62	8.62	11.97
140			27.40	24.10	10.07	4.44	7.93	14.81
141			27.35	24.31	10.82	4.32	12.08	15.09
142			26.27	24.22	10.56	4.26	12.02	19.71
143			26.38	22.74	8.37	4.54	10.49	17.36
154	Small	Medium	29.68	25.54	8.96	6.16	10.31	21.34
155			29.33	26.32	8.10	5.16	7.80	17.79
156			27.64	24.75	8.68	5.93	11.43	22.27
157			28.55	27.21	9.97	6.06	9.18	16.26
158			26.81	23.99	10.24	5.71	9.64	19.03
169	Medium	Small	30.49	26.66	13.06	6.43	14.21	12.64
170			27.73	24.55	13.30	5.65	14.65	14.40
171			27.37	21.81	13.56	6.23	11.60	12.37
172			26.62	21.26	11.37	5.07	11.92	15.85
173			26.70	21.67	15.03	5.99	10.90	13.81
184	Small	Large	26.34	22.27	11.28	6.69	12.51	13.31
185			26.43	24.10	11.57	7.67	9.26	14.01
186			24.34	22.62	11.83	8.40	11.01	11.62
187			27.47	24.65	11.08	6.56	10.90	11.40
188			28.35	25.98	13.43	10.78	10.80	11.73
199	Large	Small	27.83	24.06	10.81	8.59	15.86	15.20
200			25.83	21.19	10.83	8.01	19.58	14.54
201			27.84	24.90	10.31	8.10	14.14	8.21
202			26.82	23.58	11.26	7.19	15.31	14.27
203			30.18	27.54	11.04	8.04	17.24	15.64

the difference between the positive stimulus and the stimulus associated with the mixed schedule (no discriminative stimulus). In all four birds, the relative rate of pecking the two observing keys was quite sensitive to the relative magnitude of the difference produced by either response (i.e., salience of the positive stimulus). The more salient the positive stimulus, the greater was its effectiveness as a reinforcer.

In Experiment 2, it was the difference between the discriminative stimuli and the background or mixed-schedule stimulus (salience) that we held at a large and nearly constant

value. Meanwhile, we varied the size of the difference between the two discriminative stimuli (disparity). For each of the three birds in this experiment, the relative rate of pecking the two observing keys shifted in the expected direction with changes in the relative magnitude of the difference produced by either response. The greater the difference, physically, between the positive and the negative stimulus, the greater was the net reinforcing effect.

The variation in rate of pecking produced in Experiment 2 by manipulating the size of the difference between the two discriminative stimuli (disparity) was smaller and less consis-

able to maintain the birds' performances on the observing key. Apparently even a near-perfect discrimination between two stimuli does not guarantee a strong tendency to observe the same two stimuli. The problem, presumably, in Experiment 1 was that the change in stimulation when S+ was produced by pecking the observing key was very small and was therefore not very effective as a reinforcer. Conversely, the change when S- was produced was very large, which should maximize its punishing effect (Dinsmoor *et al.*, 1976). When the experimental arrangements are analyzed in this way, it does not seem surprising that responding was typically very low on the observing key. In Experiment 2, on the other hand, the change in stimulation when either S+ or S- was produced by pecking the observing key was quite large and, in accord with the present formulation, both consequences should be highly effective. Since experimental subjects are more affected by the positive than by the negative consequence in observing studies—else they would not ordinarily observe—the net effect when both are strong should be highly positive. At the same time, since the positive and the negative stimuli were very similar the discriminative performance was much poorer than we have come to expect for colors displayed on a key. Evidently a high level of discrimination between the two stimuli is not necessary for a high level of observing to develop.

The conclusion that the difference between the background or mixed-schedule stimulation and S+ (salience) is more influential in maintaining observing than is the difference between S- and S+ (disparity) is consistent with the results obtained by Dinsmoor, Mueller, Martin, and Bowe (1982). These authors examined the effect of salience and disparity during the acquisition of observing, rather than at an asymptotic level, and employed a sustained action (holding down a "perch"), rather than a momentary response (pecking), as their observing behavior. In their first experiment, they found that a different form of salience than used herein—the degree of visual contrast between black lines of different tilt as the discriminative stimuli and the white ground of the key on which they were projected—exerted a profound influence: 7 of 8 birds in the high contrast group, but only 1 of 8 birds in the low contrast group, acquired the observing re-

sponse. However, in two attempts to substantiate the influence of the size of the difference between S- and S+ (disparity), the same authors obtained results that were positive in direction but of such small magnitude that they were unable to demonstrate statistical significance. In the Dinsmoor *et al.* (1982) experiments, there was some question as to whether the factors of salience and disparity could be compared in quantitative terms, inasmuch as each was represented by a different physical dimension. In the present experiments, however, the physical dimensions were the same, but essentially the same conclusion was reached: The disparity between the stimuli has less influence on the amount of observing behavior than does their salience.

The tenuous nature of the association we have found between the frequency of observing and the magnitude of the physical disparity between S- and S+ bears on a theoretical issue of ancient and honorable lineage (see Fantino & Logan, 1979; Kelleher & Golub, 1962; Nevin, 1973), the discriminative stimulus hypothesis of conditioned reinforcement. At one time, it was strongly suspected in operant circles that the effectiveness of a stimulus as a conditioned reinforcer was causally related to its effectiveness as a discriminative stimulus. In their survey of conditioning research, for example, Keller and Schoenfeld (1950) suggested that the discriminative function might be a necessary condition for the reinforcing one. They proposed the following rule: "In order to act as an S^r [conditioned reinforcer] for any response, a stimulus must have status as an S^D [discriminative stimulus] for some response" (p. 236). Similarly, in his original study of observing, Wyckoff (1952) hypothesized a quantitative relation between the two functions: "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" (e.g., p. 435). And, using a hypothetico-deductive approach, Sutherland and Mackintosh (1971) proposed an equivalent rule for the strength of a stimulus analyzer, the intervening variable representing attention within their system: "When the effect of reward outcome is to increase the existing difference in the strength of a given response to two different outputs, the analyzer would increase in strength, when the effect is to de-

crease the existing difference the analyzer would be decreased in strength" (p. 64).

However, the relationship between the discriminative and the reinforcing functions of stimuli does not appear to be as strong or as consistent as required by these formulations. It cannot be denied that frequency of observing and level of stimulus control sometimes vary together. For example, both increase during discrimination training, and individual subjects that perform well in one respect also do so in the other (Dinsmoor et al., 1982). But it is not clear that the discriminative performance is necessary for the observing to be reinforced, only that the positive and negative stimuli be correlated with variations in the schedule of reinforcement (Badia, Ryan, & Harsh, 1981; Browne & Dinsmoor, 1974; Fantino & Case, 1983; Fantino, Case, & Altus, in press; Kendall, 1973a, 1973b; Ryan & Badia, 1982; Steiner, 1967). Indeed, with a different type of design, Dinsmoor and Clayton (1966) showed that when termination of electric shock is used as the primary reinforcer, so that not even a consummatory response is required in the presence of the predictive stimulus, that stimulus may still acquire reinforcing properties. (See also Carlton & Marks, 1958; Murray & Strandberg, 1965). The traditional hypothesis seems to have reversed cause and effect. It is not the discriminative performance that is necessary for observing but the observing that is necessary for the discriminative performance. Perhaps Keller and Schoenfeld's (1950) dictum should be revised to read: In order to act as a discriminative stimulus for any subject, a stimulus must be observed by that subject.

It seems inevitable that other correspondences will also be found. For example, when such fundamental parameters as the frequency or the magnitude of the primary reinforcer are varied, widespread effects should be observed, and different stimulus functions may commonly change in the same direction. Changes in food or water deprivation should also have pervasive effects. But concurrent changes in two dependent variables when a third, independent, variable is manipulated do not necessarily imply a direct linkage between the two dependent variables. Similarly, when the physical characteristics of a stimulus are altered, all functions of that stimulus may be expected to show concomitant variation. However, the cor-

relation is not always positive. Holding the positive stimulus and the mixed-schedule stimulus constant, Dinsmoor et al. (1976) varied the intensity of the light they were using as S—. As the intensity of the S— became more similar to that of each of the other two stimuli, decreasing its salience and its disparity, the rate of pecking on the observing key increased; as the intensity of the S— departed from those of the other two stimuli, increasing both salience and disparity, the rate on the observing key decreased. Changes that enhance discriminative performance do not necessarily promote greater observing. The relationship does not show the type of invariance that would lead us to speak of the discrimination as the cause, or the level of that discrimination as a determinant, of the conditioned reinforcing effect.

REFERENCES

- Badia, P., Ryan, K., & Harsh, J. Choosing schedules of signaled appetitive events over schedules of unsignaled ones. *Journal of the Experimental Analysis of Behavior*, 1981, 35, 187-195.
- Blanchard, R. The effect of S— on observing behavior. *Learning and Motivation*, 1975, 6, 1-10.
- Blough, P. M. The pigeon's perception of saturation. *Journal of the Experimental Analysis of Behavior*, 1975, 24, 135-148.
- Browne, M. P., & Dinsmoor, J. A. Wyckoff's observing response: Pigeons learn to observe stimuli for free food but not stimuli for extinction. *Learning and Motivation*, 1974, 5, 165-173.
- Carlton, P. L., & Marks, R. A. Cold exposure and heat reinforced operant behavior. *Science*, 1958, 128, 1344.
- Dinsmoor, J. A., Browne, M. P., & Lawrence, C. E. A test of the negative discriminative stimulus as a reinforcer of observing. *Journal of the Experimental Analysis of Behavior*, 1972, 18, 79-85.
- Dinsmoor, J. A., & Clayton, M. H. A conditioned reinforcer maintained by temporal association with the termination of shock. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 547-552.
- Dinsmoor, J. A., Mueller, K. L., Martin, L. T., & Bowe, C. A. The acquisition of observing. *Journal of the Experimental Analysis of Behavior*, 1982, 38, 249-263.
- Dinsmoor, J. A., Sears, G. W., & Dout, D. L. Observing as a function of stimulus difference. *Journal of Experimental Psychology: Animal Behavior Processes*, 1976, 2, 154-162.
- Fantino, E., & Case, D. A. Human observing: Maintained by stimuli correlated with reinforcement but not extinction. *Journal of the Experimental Analysis of Behavior*, 1983, 40, 193-210.
- Fantino, E., Case, D. A., & Altus, D. Observing reward-informative and uninformative stimuli by normal children of different ages. *Journal of Experimental Child Psychology*, in press.

- Fantino, E., & Logan, C. A. *The experimental analysis of behavior: A biological perspective*. San Francisco: Freeman, 1979.
- Kelleher, R. T., & Gollub, L. R. A review of positive conditioned reinforcement. *Journal of the Experimental Analysis of Behavior*, 1962, 5, 543-597.
- Keller, F. S., & Schoenfeld, W. N. *Principles of psychology: A systematic text in the science of behavior*. New York: Appleton-Century-Crofts, 1950.
- Kendall, S. B. Redundant information in an observing-response procedure. *Journal of the Experimental Analysis of Behavior*, 1973, 19, 81-92. (a)
- Kendall, S. B. Effects of two procedures for varying information transmission on observing responses. *Journal of the Experimental Analysis of Behavior*, 1973, 20, 73-83. (b)
- Mackintosh, N. J. *The psychology of animal learning*. New York: Academic Press, 1974.
- Mulvaney, D. E., Dinsmoor, J. A., Jwaideh, A. R., & Hughes, L. H. Punishment of observing by the negative discriminative stimulus. *Journal of the Experimental Analysis of Behavior*, 1974, 21, 37-44.
- Murray, A. K., & Strandberg, J. M. Development of a conditioned positive reinforcer through removal of an aversive stimulus. *Journal of Comparative and Physiological Psychology*, 1965, 60, 281-283.
- Nevin, J. A. Conditioned reinforcement. In J. A. Nevin (Ed.), *The study of behavior: Learning, motivation, emotion, and instinct*. Glenview, Ill.: Scott, Foresman, 1973.
- Pierrel, R., Sherman, J. G., Blue, S., & Hegge, F. W. Auditory discrimination: A three-variable analysis of intensity effects. *Journal of the Experimental Analysis of Behavior*, 1970, 13, 17-35.
- Ryan, K. A., & Badia, P. Signal duration and choosing between signaled and unsignaled reward. *Animal Learning and Behavior*, 1982, 10, 55-60.
- Selekman, W. Behavioral contrast and inhibitory stimulus control as related to extended training. *Journal of the Experimental Analysis of Behavior*, 1973, 20, 245-252.
- Steiner, J. Observing responses and uncertainty reduction. *Quarterly Journal of Experimental Psychology*, 1967, 19, 18-29.
- Stevens, S. S. *Psychophysics*. New York: Wiley, 1975.
- Sutherland, N. S., & Mackintosh, N. J. *Mechanisms of animal discrimination learning*. New York: Academic Press, 1971.
- Trabasso, T. R. Stimulus emphasis and all-or-none learning in concept identification. *Journal of Experimental Psychology*, 1963, 65, 398-406.
- Wyckoff, L. B., Jr. The role of observing responses in discrimination learning. Part I. *Psychological Review*, 1952, 59, 431-442.

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