AUTOSHAPED RESPONDING: A BASELINE FOR STUDYING STIMULUS PREFERENCE

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In an autoshaping procedure with pigeons, trials consisted of the illumination of two keys, each with a different color, and then a response-independent feeder operation. Over successive conditions, all key-color pairs were arranged from the set of amber, red, green, and blue lamps. During sessions with a given pair, the left-right configuration of the colors varied irregularly, and the two colors alternated in illuminating the feeder. With one red and one green key, for example, red appeared sometimes on the left and sometimes on the right, and the feeder was alternately lit red or green on successive trials. Both total pecks and proportion of trials with at least one peck on a key of a given color were generally greater for red and amber than for green and blue, and relations among preferences were generally transitive across different color pairs. Repeating the procedure with decreased red and amber intensities and increased green and blue intensities reduced red and amber pecking relative to green and blue pecking, implying that differences in responding were determined more strongly by intensive than by chromatic properties of the stimuli.

Key words: autoshaping, discrete trials, preference, key color, key intensity, two-key procedure, feeder, key peck, pigeons

In autoshaping, a pigeon's key pecks are generated when, in repeated trials, a lit key is followed by a response-independent feeder operation (Brown & Jenkins, 1968). Research on autoshaping has typically been concerned with the properties of autoshaped responding, the range of conditions over which such responding occurs, and its relation to other phenomena of behavior and learning (e.g., Jenkins & Moore, 1973; Keller, 1974; Locurto, Terrace, & Gibbon, 1981; Schwartz & Gamzu, 1977). Aside from its theoretical interest, however, autoshaping is a procedure that generates responding in the presence of stimuli without arranging differential consequences for that responding, and thus is potentially a useful tool for studying controlling properties of stimuli.

Avian color preferences may be involved in imprinting and in the development of feeding,

and their origins may be ontogenic or phylogenetic (e.g., Hess, 1956; Jones, 1954). The relevant literature extends from casual observations of the behavior of adult birds (e.g., Austin, 1974; Blieden, 1974; Brancato, 1974) to experiments that control visual stimulation from the time of hatching (e.g., Kovach, 1971; Mayer & Hailman, 1976), with color stimuli ranging from painted surfaces or stimulus cards to projected monochromatic sources (e.g., Delius, 1968; Sahgal & Iversen, 1975; Salzen, Lily, & McKeown, 1971; Tracy, 1970). The present experiments illustrate the application of an autoshaping procedure to the study of such preferences.

In operant research, color preferences in adult pigeons are a practical concern, because a common feature of complex schedules is the correlation of different key colors with different schedule components (e.g., Catania & Sagvolden, 1980). The present two-key autoshaping procedures were therefore arranged not with monochromatic sources but rather with a type of stimulus lamp often used in research with complex schedules. Trials consisted of the simultaneous illumination of two keys, each a different color, followed by a response-independent feeder operation. On alternate trials, the feeder was lit by one or the other

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key color, to minimize effects of differential relations between the key colors and the feeder color (Fisher & Catania, 1977; Sperling, Perkins, & Duncan, 1977). Successive conditions included each of the six possible pairings of the colors amber, red, green, and blue. Because the responding on a given key may have depended on either the chromatic or the intensive properties of the stimuli projected on the keys (e.g., Zolman & Lattin, 1972), three of the color pairings were then repeated with a decreased intensity of the key color that generated the most responding and an increased intensity of the one that generated the least.

METHOD

Subjects

Eight adult male Silver King pigeons were maintained at about 80% of their free-feeding weights. Their histories in the experimental chamber consisted of two daily 35-min sessions with the houselight lit followed by a feeder training session.

Apparatus

The chamber included two translucent Gerbrands pigeon keys, 2 cm in diameter and mounted 6.5 cm apart center-to-center about 23 cm above the floor (Catania, 1969). Each key was operated by a minimum force of about .13 N, and when lit its operation produced a click from a relay mounted behind the panel. A standard Gerbrands feeder was centered below the keys. At the upper-right corner of the panel, a white 6-W ac lamp behind a 2.5-cm-square window of translucent plastic served as a houselight. A ventilating fan and white noise from a speaker on the panel masked sounds from the electromechanical scheduling and recording equipment, located in a separate room.

Three candelabra sockets equally spaced behind each key and two sockets above the feeder accommodated Westinghouse D18 amber, red, green, or blue 7.5-W ac Christmas lamps (white lamps were used in the feeder only during feeder-training sessions). In sessions with a given pair of key colors, lamps of one color were arranged in one socket behind each key and in one feeder socket, and lamps of the second color were arranged in a second socket behind each key and the remaining feeder socket. Throughout most conditions, therefore, intensity levels at each key and in the feeder were

those provided by a single lamp of a given color. At these levels, amber and red keys looked substantially brighter than green and blue keys to human observers. In later sessions, an additional lamp was placed in the third socket behind each key, so that two green or two blue lamps could be lit simultaneously (bright green or blue), and a series resistance was arranged for the remaining sockets, so that the voltage drop across the single amber or red lamp behind each key was reduced from about 120 to about 70 volts (dim amber or red). This arrangement increased the intensity of green or blue key lights and decreased the intensity of amber or red key lights. To human observers, amber and red keys looked slightly dimmer than green and blue keys at these levels, and the decreased voltage did not substantially affect their spectral characteristics.

Procedure

In the feeder-training session for each pigeon, first the feeder was held operated with the feeder opening topped up with mixed grain until the pigeon had eaten for 30 sec. Then 5-sec feeder operations were arranged until the latency from feeder operation to eating was less than 2 sec on two consecutive presentations, but for a minimum of five presentations if this criterion was met sooner. In feeder-training sessions, the feeder was lit by white lamps during its operation.

The successive daily autoshaping sessions that followed consisted of 60 trials each. The houselight was on throughout each session. The sequence of events in a trial was an inter-trial interval of 24 sec, 3 sec of lit keys, and finally a 3-sec feeder operation. A given pair of different colors from the set amber, red, green, and blue was arranged both for the two keys and for the feeder throughout a given session. The left-right arrangement of the two colors on the keys varied irregularly from trial to trial. For a given color, both its probability of appearing on the left key on a given trial and its probability of appearing on the same key on trial $N + 1$ as on trial N equaled .50. The two colors alternated regularly from trial to trial in illuminating the feeder, and each feeder color appeared about equally often in combination with each left-right key-color arrangement.

Each color pairing was arranged for three consecutive sessions. The pigeons began ses-

sions in staggered order so that each of the four key colors was equally represented in initial autoshaping sessions. The color pairs were then changed simultaneously for all the pigeons involved in the procedure on a given date until for each pigeon each possible color pair had been arranged and the initial color pair had been repeated (cf. Table 1). Sessions with dim amber or red and bright green or blue keys then followed for the color pairs red-blue, amber-green, and red-green. The experiment was terminated during sessions with altered intensities of amber-blue after most and perhaps all of the eight pigeons were exposed to an intermittent apparatus failure.

RESULTS

Table 1 shows, for each pigeon, the sequence of key-color pairs and the proportion of trials with at least one peck on a key of a given color in each condition. (Note the reversal of colors, corresponding to the pair of sockets behind each key, in the replication of the original color pair for each pigeon: e.g., R,G and G,R for Pigeon 25.) Because no systematic changes in the data were evident across the three sessions of each key-color pair, data for each pair and pigeon are arithmetic means taken across all three sessions with that pair. Changeovers from one key to the other were unusual within a trial, and therefore the sum of the two proportions for a given pair is essentially equal to the overall proportion of trials on which at

least one peck occurred. For example, in the first condition for Pigeon 25, the pigeon pecked a red (R) key on 24% of the trials and a green (G) key on 52% of the trials, for a total of 76%; thus, on the remaining 24% of the trials, neither key color was pecked. In subsequent analyses, trials without pecks are ignored in the calculation of relative pecking on a key of a given color. In the R,G condition for Pigeon 25, for example, the relative proportion of trials pecked for red, $R/(R + G)$, is $.24/ (.24 + .52)$ or .32.

For most pigeons, the overall proportion of trials with at least one peck increased from the first to subsequent conditions. Perhaps for this reason the relative pecking on the original color pair was not well recovered for some pigeons in the replication with that pair (especially Pigeons 25 and 32). Nevertheless, the overall pattern of preferences was fairly consistent not only within the data for individual pigeons but also across pigeons. In general, amber and red were pecked more often and on a larger proportion of trials than green and blue. Within these two classes, amber typically generated more pecking than red, and green more than blue. These relations are summarized in Table 2, which compares proportions of trials with at least one peck on a given key-color with another statistic, mean pecks per trial on a given key-color (total pecks divided by total trials of that color). To the extent that the probabilities of initiating and of continuing pecks on a given key-color were directly

Table 1

Proportion of trials with at least one peck on a given key-color over the three sessions of each key-color pair (Stimulus X, Stimulus Y). In the last three conditions, stimulus intensities were increased (+) or decreased (-). A—amber; B—blue; G—green; R—red.

Pigeon Stimuli (X, Y)	25	26	27	28	29	30	31	32
B,A	.., ..	.., ..	.., ..	.01, .02	.13, .30	.., ..	.., ..	.., ..
R,G	.24, .52	.., ..	.., ..	.19, .01	.83, .12	.., ..	.16, .08	.., ..
B,G	.10, .88	.05, .14	.., ..	.22, .27	.46, .54	.04, .46	.39, .54	.., ..
A,R	.36, .64	.19, .23	.36, .35	.53, .43	.49, .49	.14, .23	.48, .49	.21, .22
B,R	.03, .97	.06, .39	.00, .94	.43, .57	.03, .95	.00, .43	.46, .54	.01, .84
A,G	.91, .07	.60, .04	.98, .00	.74, .26	.98, .01	.26, .00	.63, .36	.88, .00
A,B	.98, .02	.30, .06	.89, .00	.47, .53	.94, .06	.24, .00	.56, .32	.74, .00
G,R	.02, .98	.07, .17	.00, .91	.., ..	.., ..	.01, .41	.22, .28	.00, .69
G,B	.., ..	.22, .20	.51, .42	.., ..	.., ..	.59, .01	.., ..	.44, .19
R,A	.., ..	.., ..	.53, .46	.., ..	.., ..	.., ..	.., ..	.21, .05
B+,R-	.11, .50	.26, .07	.58, .09	.59, .17	.14, .59	.07, .42	.07, .09	.33, .13
G+,A-	.21, .74	.28, .31	.28, .77	.46, .54	.29, .68	.58, .36	.59, .37	.02, .24
G+,R-	.24, .73	.29, .08	.53, .46	.43, .56	.47, .48	.63, .32	.52, .18	.03, .13

Table 2

Proportion of trials with at least one peck on a given key-color, mean pecks per trial, and relative left-key pecks, across all pairings of each color but excluding the first condition for each pigeon. A—amber; B—blue; G—green; R—red.

Pigeon	Proportion of trials				Pecks per trial				Left pecks (Left/Total)
	A	R	G	B	A	R	G	B	
25	.75	.86	.32	.05	6.7	7.8	2.1	0.1	.54
26	.36	.26	.11	.11	0.6	0.4	0.2	0.2	.48
27	.78	.79	.17	.14	8.3	6.7	1.6	1.3	.46
28	.58	.40	.18	.40	4.5	2.6	0.7	2.5	.35
29	.80	.76	.22	.18	9.3	8.3	2.0	1.4	.56
30	.21	.36	.20	.00	0.2	0.6	0.5	0.0	.30
31	.56	.44	.37	.39	5.7	4.0	2.6	2.4	.84
32	.56	.58	.15	.07	1.8	1.4	0.3	0.2	.60
Mean	.58	.55	.22	.17	4.6	4.0	1.2	1.0	.52

related, the two statistics of Table 2 should have varied together. In general, they did so. The two statistics showed different orderings of amber (A) and red (R) for Pigeons 27 and 32, and of green (G) and blue (B) for Pigeon 31. The only difference across the A and R and the G and B pairs occurred for Pigeon 30 in the orderings of A and G. In most cases, preferences were consistent with the relative responding summarized in Table 2 and therefore were transitive (e.g., given R preferred to A and A preferred to B, R is preferred to B). Relatively small proportions of trials with pecks and relatively few pecks per trial occurred for Pigeons 26 and 30, both of which began sessions with the color pair B,G. This effect on total output of pecks of the sequence

of presentation of color pairs, however, did not have obvious effects on the preference orderings of colors. Another potential source of variability was the distribution of pecks to the left and right keys (right column of Table 2). Because each color of a pair appeared equally often on both keys, an attenuation of differences in pecking across colors might be expected to accompany a preponderance of pecks on one key. This was to some extent the case for Pigeon 31, which made 84% of its pecks on the left key.

Data with original and altered intensities for the key-color pairs B,R, G,A, and G,R are presented in Table 3. As measured by relative proportion of trials with at least one peck on a given key-color, pecking shifted toward the stimulus with increased intensity in all but one case (Pigeon 31, B,R); as measured by relative pecks per trial, pecking shifted without exception in that direction. In 10 of the 24 cases for relative proportion of trials and in 13 of the 24 cases for relative pecks per trial, the statistic changed from less than to more than .50; in each of these cases, in other words, the most pecked and least pecked key-colors of the pair were reversed by the altered intensities.

DISCUSSION

If a higher probability of pecking one stimulus than another can be called a stimulus preference, then the present pigeons generally preferred amber and red to green and blue. Whatever the basis for the preferences, their

Table 3

Relative proportion of trials with at least one peck on a given key-color and relative pecks per trial, each calculated for the Stimuli X, Y as $X/(X + Y)$, with original and with altered intensities for each pigeon. Abbreviations as in Table 1.

Stimuli (X, Y) Pigeon	Relative proportion of trials						Relative pecks per trial					
	B,R	B+,R-	G,A	G+,A-	G,R	G+,R-	B,R	B+,R-	G,A	G+,A-	G,R	G+,R-
25	.03	.18	.07	.22	.02	.25	.01	.07	.01	.07	.00	.06
26	.10	.79	.06	.48	.30	.79	.10	.82	.04	.66	.30	.82
27	.00	.86	.00	.26	.00	.53	.00	.87	.00	.25	.00	.53
28	.43	.78	.26	.46	.03	.44	.34	.74	.20	.42	.02	.42
29	.03	.20	.01	.30	.13	.49	.01	.24	.00	.22	.03	.54
30	.00	.15	.00	.62	.01	.67	.00	.19	.00	.65	.01	.76
31	.45	.43	.36	.61	.44	.74	.32	.57	.18	.60	.44	.76
32	.01	.72	.00	.09	.00	.20	.01	.73	.00	.08	.00	.11
Mean	.13	.51	.10	.38	.12	.51	.10	.53	.05	.37	.10	.50

magnitude in a procedure with minimal contingencies has practical implications. If identical relations of these stimuli with food reinforcers generate different quantities of pecking for each, then these effects must be taken into account in the design of experiments (cf. Catania & Sagvolden, 1980; in that study, all pigeons had first served in a pilot version of the present experiment, within which they produced data comparable to those of Table 2). The sorts of preferences demonstrated here are probably sufficiently weak within typical operant procedures to be quickly overridden by schedule contingencies, but they must not be neglected in the occasional procedure within which they might continue to operate (e.g., procedures on the topographical tagging of autoshaped responding, Keller, 1974).

The consistency of preferences in a range of conditions extending over many sessions was not consistent with a major role of the incidental contiguities of pecks on a given key-color and subsequent food deliveries. For example, consider pecking generated by both colors in Condition A,G for Pigeon 25 (Table 1). During the only preceding sessions with A, in Condition A,R, stimulus A had generated pecks on 36% of the trials. During those with G, first in Condition R,G and then in Condition B,G, stimulus G had generated pecks on 52% and then on 88% of the trials. By the time of Condition A,G, fewer A pecks than G pecks had been generated and followed by food deliveries, but when these two stimuli were presented together, A pecks occurred on 91% of the trials and G pecks on only 7%. This is opposite to what might have been predicted from the earlier contiguities.

The effects of dimming amber and red and brightening green and blue indicate that the preference was more strongly determined by the intensive than by the chromatic properties of the stimuli. Whether chromatic properties contributed at all to the preferences cannot be judged from the present data; the relevant research would call for stimuli with spectral composition and other properties more precisely defined. The present two-key procedures, however, may be more relevant in extensions to various other stimulus dimensions. For example, given that pigeons readily peck spots or edges on a key, perhaps because of histories with respect to pecking grain and other small objects, a study of stimulus preference as a

function of the size and shape of geometric figures may bear on the choice of stimulus classes for experiments incorporating such stimuli in their design (e.g., Jenkins & Sainsbury, 1970; Morgan, Fitch, Holman, & Lea, 1976; Sainsbury, 1971). In another possible extension, preferences given pairs of pictures illustrating trees, animals, or other natural classes may clarify the role of ontogenic and phylogenetic histories in the shaping of natural concepts or categories (e.g., Cerella, 1979; Herrnstein, 1979; Herrnstein, Loveland, & Cable, 1976).

The differential responding examined here was generated in the absence of an explicit discriminative history. It was modulated but not produced by the intensive properties of stimuli and did not depend on its consequences in their presence. It is therefore not easily accommodated either by the language of elicitation or by the language of stimulus control.

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