KEY PECKING IN PIGEONS PRODUCED BY PAIRING KEYLIGHT WITH INACCESSIBLE GRAIN¹

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In Experiment I, keylight was paired with inaccessible grain delivery (under two conditions of keylight intensity) to determine if autoshaping would occur in the absence of primary reinforcement. In Experiment II, the procedure was repeated with accessible grain, for comparison. In Experiment III, the procedures were repeated with explicitly unpaired presentations of keylight and either inaccessible or accessible grain. The results indicated that key pecking occurred as quickly in the presence of keylight pairings with inaccessible grain as with accessible grain, though (except for one bird) key pecking was not maintained with inaccessible grain. Furthermore, compared to the dim keylight, the bright keylight greatly suppressed key pecking when paired with inaccessible grain, and reduced the rate of key pecking when paired with accessible grain. Little key pecking occurred in groups exposed to explicitly unpaired presentations of keylight (whether bright or dim) and grain (whether accessible or inaccessible). When the birds in Experiment III were retested with explicitly paired presentations of keylight and grain, little key pecking was observed, suggesting suppressive effects of prior explicitly unpaired presentations. It is suggested that the effects of key-brightness manipulation were produced by the association of grain with cues other than the response key, or by distraction produced by partial illumination of the grain hopper.

Brown and Jenkins (1968) found that key pecking in pigeons could be produced by the repeated temporal pairing of a lighted response key and grain, a phenomenon they called autoshaping. They also found that key pecking would continue even if these responses had no effect on grain delivery.

Since then, attempts have been made to determine further the conditions under which autoshaping would occur and be maintained. Williams and Williams (1969), for example, found that key pecking would often continue even if it prevented grain from being delivered (omission procedure). The omission procedure pits operant procedures (reinforcement contingent upon not responding) against respondent procedures (stimulus-reinforcer pairings). While key pecking was substantially reduced, the fact that the omission procedure did not

eliminate responding indicates the strength of the stimulus-reinforcer association. Wessells (1974) eliminated approaches toward the key by omitting reinforcement when approaches toward the lighted key occurred, but eight to 13 sessions (40 trials each) were required to eliminate the response, and in spite of elimination of approach responses toward the key, orientation to the key persisted on all trials. Hursh, Navarick, and Fantino (1974) also reported elimination of key pecking with an omission procedure, though this finding was inconsistent and was apparently related to certain physical aspects of the operant box, (*i.e.*, black walls and no house illumination). Hursh *et al.* (1974) concluded that when responding under omission procedures does occur "... it is probably maintained by the reinforcing effectiveness of response-dependent offset of the keylight." According to this argument (also proposed by Herrnstein and Loveland, 1972), keylight offset becomes a conditioned reinforcer due to its pairing with food. Maintained responding under omission procedures presumably occurs because on trials without a response, keylight offset becomes associated with food, and the consequence of responding is keylight offset, a conditioned reinforcer. Hursh

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et al. (1974) suggested that the immediate occurrence of a conditioned reinforcer may be preferred over the delayed occurrence of primary reinforcement. Ingenious as the above explanation may be, it does not account for findings, similar to those of Williams and Williams (1969), that have used variations of the omission procedure. Schwartz (1972) found that neither keylight-offset/food pairings (which presumably establish keylight offset as a conditioned reinforcer) nor response-produced keylight offset (which presumably maintains responding) are necessary to produce maintained responding with the omission procedure.²

While it is doubtful that autoshaping can be explained by conditioned reinforcement, a conditioned reinforcer can be used to obtain key pecking in the absence of primary reinforcement. Patterson and Winokur (1973) reported that two pigeons given tone-grain pairings, pecked at a red response key that changed from green to red 5 sec before the tone was presented. Virtually no pecks occurred to the tone during tone-grain pairings, thus the new response occurred in the absence of primary reinforcement. Unfortunately, once responding began, noncontingent red-tone pairings were discontinued and replaced by response-contingent tone presentation in the presence of the red key, on an FI 5-sec schedule. The change in procedure might account for the observed sharp reduction in response rate over time. Responding to the red key recovered, however, when tone-grain pairings were interspersed among red- and green-key trials, with responses to the red key reinforced with tone presentation on an FI 1-min schedule.

The first experiment of the present study sought to determine if a more direct conditioned appetitive reinforcer, the sight of grain and sound of the grain magazine, could be used to obtain key pecking in magazine-trained pigeons when keylight is followed by inaccessible grain presentation, and whether responding would be maintained under these conditions. In addition, intensity of key illumination was also manipulated with the idea that

salience of the key might affect the probability of key pecking.

EXPERIMENT Ia

METHOD

Subjects

Ten experimentally naive female White Carneaux pigeons, approximately 1 yr old, were maintained at 75 to 80% of their free-feeding weights.

Apparatus

Two pigeon test chambers were used. The intelligence panels and depth of the boxes were 17.0 cm, the width of the boxes was 28.1 cm, and height was 32.8 cm. The grain hopper (midline 12.7 cm above the floor), response key (midline 25.4 cm above the floor), and houselight (midline 31.1 cm above the floor) were all located on the vertical centerline of the intelligence panels. The two boxes were the same except for the intensity of the keylight (incandescent source), which was 0.26 m-cd in the dim-key box and 4.18 m-cd in the bright-key box as measured at the surface of the key by a United Technology Opto-meter (model 40A) with diffuser and photometric filter. The brightness of the jewelled houselight was 0.036 m-cd as measured 25 cm away. The grain magazine contained mixed pigeon grain (Purina).

Procedure

Five birds were randomly assigned to each of the boxes: Subjects 1 to 5 to the bright-key box, Subjects 6 to 10 to the dim-key box. Magazine training occurred on Day 1 and involved placing the pigeon in the operant box with the magazine raised and the magazine light on. Once the bird started to eat, the magazine was lowered and then repeatedly raised (for 4 sec) and lowered at random intervals until 10 consecutive food approaches occurred.

On Day 2, each pigeon was exposed to presentations of 8 sec of keylight followed by 4 sec of inaccessible grain (a transparent piece of Plexiglas placed in the hopper over the grain preventing access to grain in the raised magazine). The first phase of training consisted of 300 such presentations (trials) separated by variable duration (mean 30 sec) intertrial intervals (ITIs). Key pecks were recorded but

²In a study presented at the 1973 meeting of the American Psychological Association, Wasserman reported that response-produced keylight offset is unnecessary for the establishment and maintenance of key pecking in pigeons exposed to an omission procedure.

had no effect on the sequence or duration of events. At the end of Phase I, the bird was removed from the box, the hopper barrier was removed, the bird was returned to the box, and Phase II began immediately. Phase II consisted of 200 trials, similar to those of Phase I, but with grain accessible when the magazine was raised. In addition, key pecks immediately terminated keylight and grain presentation. During both phases of training, the houselight was continuously on.

RESULTS AND DISCUSSION

Six of the 10 birds pecked at the lighted key during Phase I: all five birds in the dim-key box (Subjects 6 to 10), but only one of the birds in the bright-key box (Subject 5). The trial of the first peck, total number of responses, and number of trials with peck(s) for each bird are presented in Table 1.

The same six and one additional bird (Subject 3) responded during Phase II. Trial of the first response is presented in Table 1.

Table 1

Response measures for each subject in Experiments Ia and Ib. Subjects were exposed to 300 pairings of keylight and inaccessible grain, followed immediately by 200 pairings of keylight with accessible grain.

		<i>I Inaccessible Grain</i>		<i>II Accessible Grain</i>	
	<i>Bird</i>	<i>Trial First Peck</i>	<i>Total Pecks</i>	<i>Trials with Peck</i>	<i>Grain Trial First Peck</i>
<i>Experiment Ia</i>					
Bright key	1	—	0	0	—
	2	—	0	0	—
	3	—	0	0	37
	4	—	0	0	—
	5	252	7	5	61
Dim key	6	5	22	12	2
	7	50	5	3	3
	8	20	14	6	5
	9	44	41	28	5
	10	27	22	17	5
<i>Experiment Ib</i>					
Dim key	11	3	58	27	5
	12	6	11	5	46
	13	8	16	7	1
	14	29	3	3	26
	15	2	917	208	1
	$\overline{X}^*$	19.4	110.9	31.6	10.9
	Median*	14	20	9.5	5

*Dim-key data from Experiments Ia and Ib combined.

The results indicate a clear effect of manipulated brightness and further suggest that pigeons will peck at a keylight paired with inaccessible grain if tested under the right conditions. While the number of key pecks made during Phase I was generally small (median = 22), compared to the number of pecks one observes when grain is accessible (see, for example, Brown and Jenkins, 1968), trial-of-the-first-peck data are comparable to scores obtained with accessible grain (median = 27). Keylight pairings with inaccessible grain during Phase I also appeared to affect Phase II, for responding began again almost immediately when grain was made accessible (median trials to first peck in Phase II = 5). The data indicate that access to grain is not a necessary condition for initiating key pecking, though it may be necessary to maintain it.

The nominal difference between the two operant boxes was the intensity of the keylight. Experiment Ib attempted to ascertain whether, in fact, differential key brightness was responsible for differential key pecking.

EXPERIMENT Ib

To determine if the brighter key was responsible for the low probability of key pecking in that box, new birds were tested in the bright-key box with the key brightness reduced to that of the dim-key box.

METHOD

Subjects

Five experimentally naive female White Carneaux pigeons approximately 1-yr old (Subjects 11 to 15) were maintained at 75 to 80% of their free-feeding weights.

Apparatus and Procedure

The apparatus was the same as that used in Experiment Ia, with the brightness of the keylight in the bright-key box reduced to 0.26 m-cd. The procedure was the same as that used in Experiment Ia.

*In an independently performed study presented at the 1973 meeting of the American Psychological Association, Browne and Karpicke reported similar results. Forward pairings of keylight with inaccessible grain resulted in some key pecking by all five pigeons exposed to that condition, and when grain was subsequently made accessible, all birds began key pecking almost immediately.

RESULTS AND DISCUSSION

All five birds tested in bright-key box with the dim keylight pecked in both Phases I and II. The trial of the first peck, total number of responses, and number of trials with peck(s) for each bird are presented in Table 1, for both Phases I and II. Again, responding occurred early (median trial to first response = 6) but (except Subject 15) was not maintained (median responses = 16).

For birds in the dim-keylight condition in Experiments Ia and Ib, the distribution of responses over trial blocks plotted cumulatively is presented in Figure 1. The figure shows that all birds but Subject 15 had stopped responding by the end of Phase I. Thus, recovery of responding early in Phase II is attributable to the accessibility of grain, rather than to a carryover of Phase I responding. Persistent responding by Subject 15, but not by the other birds exposed to inaccessible grain, cannot be explained. Performance by Subject 15 is more typical of performance by birds exposed to accessible grain.

By what mechanism does the bright key prevent autoshaping? Intuitively, the brighter keylight should better elicit orienting responses, which in turn should facilitate the association between the keylight and grain. But perhaps the facilitated association was between some other cue and grain. Observations of the operant boxes while the birds were being tested indicated that the onset of the bright key significantly increased the overall brightness of the box, making additional cues visible. If so, any of the new cues could have become associated with the reinforcer, rather than the key. Supportive evidence for such speculation comes from the fact that a number of bright-key birds but none of the dim-key birds were observed to peck the floor or side of the box when the keylight came on. Unfortunately, no systematic data were taken. Wasserman (1973) proposed an explanation similar to the one above to account for the fact that an autoshaping procedure produced virtually no pecking in a box without house illumination. According to Wasserman (1973), the onset of keylight in a dark box produced many cues, any of which may have been associated with the reinforcer. In the well-illuminated box, onset of the keylight produced few extra cues, and thus the lighted key became associated

with the reinforcer. Similar effects of house illumination on autoshaping have been noted by Griffin and Rashotte (1973).

Alternatively, in the present experiment, it is possible that the bright keylight partially illuminated the grain hopper, which in turn acted as a distracting stimulus. Wasserman and McCracken (1974) recently found that simultaneous onset of keylight and feeder light, before grain delivery, resulted in virtually no key pecking.

If the bright keylight provided "extra" cues or added significantly to the ambient light in the grain hopper, thus competing with the keylight as a cue, then one should be able to observe a similar key-brightness effect in birds exposed to more traditional autoshaping procedures, *i.e.*, with accessible grain.

EXPERIMENT II

METHOD

Subjects

Ten experimentally naive female White Carneaux pigeons, approximately 1-yr old, were maintained at 75 to 80% of their free-feeding weights.

Apparatus and Procedure

The apparatus was the same as that used in Experiment I, with a dim keylight (0.26 m-cd) in one box and a bright keylight (4.18 m-cd) in the other. The procedure was the same as that used in Experiment I, Phase I, except that grain was accessible on all trials, and the experiment was terminated after 300 trials. Five birds were randomly assigned to each of the boxes: Subjects 16 to 20 to the bright key box, Subjects 21 to 25 to the dim-key box.

RESULTS AND DISCUSSION

The data from Experiment II are presented in Table 2. All birds pecked at the lighted key. A difference in the expected direction between the bright and dim conditions was found for trials to the first peck, Mann-Whitney $U(5,5) = 4$, $p = 0.048$, total number of pecks, $U(5,5) = 6$, $p = 0.111$, and number of trials with peck(s), $U(5,5) = 5$, $p = 0.075$. Apparently, when grain is accessible, the bright keylight partially suppresses but does not prevent pecking.

Fig. 1. Cumulative responses in blocks of 20 trials for birds exposed to a dim key paired with inaccessible grain (Experiments Ia and Ib).

Comparison of the data from dim-key birds in Experiments I and II indicates that while median total responses differ greatly (555 with accessible grain; 19 with inaccessible grain), the median trial of the first peck is virtually the same for both groups (13 with accessible grain, 14 with inaccessible grain).

Thus, pairings of a dim keylight with inaccessible grain produced pecking in pigeons as rapidly as pairings of the same keylight with accessible grain. The maintenance of key pecking, however, required keylight pairings with accessible grain. Thus, Patterson and Winokur's (1973) failure to observe maintained key pecking, when color change was paired with a conditioned reinforcer, may not have been due to the change in procedure (once responding had begun) from autoshaping to response-contingent tone presentation.

Table 2

Response measures for each subject in Experiment II. Subjects were exposed to 300 pairings of keylight with accessible grain.

	Bird	Accessible Grain		
		Trial First Peck	Total Pecks	Trials with Peck
Bright key	16	102	43	35
	17	80	149	81
	18	17	1000	171
	19	23	1904	224
	20	208	11	4
	$\bar{X}$	86.0	621.4	103.0
Dim key	Median	80	149	81
	21	46	246	131
	22	27	161	103
	23	5	2027	289
	24	13	555	214
	25	7	4127	294
	$\bar{X}$	19.6	1423.2	206.2
	Median	13	555	214

EXPERIMENT III

Though trial-of-the-first-peck data from Experiment I, dim-key condition, compare favorably with autoshaping data from other experiments, Hitzing and Safar (1970) found that prior exposure to keylight-only trials, followed by magazine training, was sufficient to produce key pecking in nine of 12 birds, within 16 subsequent presentations of keylight-only trials. Thus, it is possible that forward pairings of keylight with grain were not responsible for key pecking in Experiment I, especially since responding was not maintained. If responding in Experiment I was not due to keylight-grain pairings, then birds presented with keylight and grain with keylight signalling the absence of grain (explicitly unpaired) should perform as did the birds in Experiment I.

Experiment III involved a 2-by-2 design with bright-dim keylights and inaccessible-accessible grain as the two variables manipulated. All birds given inaccessible grain were then given accessible grain as in Experiments I and II. Finally, all birds were given forward pairings of keylight and grain to assess the effects of explicitly unpaired trials on subsequent explicitly paired trials.

METHOD

Subjects

Twenty experimentally naive female White Carneaux pigeons, approximately 1-yr old,

were maintained at 75 to 80% of their free-feeding weights.

Apparatus and Procedure

The apparatus was the same as that used in the first two experiments. All birds were magazine trained as described in Experiment Ia. On Day 2, all birds were exposed to explicitly unpaired presentations of keylight (8 sec) and grain (4 sec) such that grain presentation could not follow keylight by less than 15 sec. Grain presentations were arranged on a variable-duration (mean 15 sec) tape that started running 15 sec after keylight presentations and stopped with the next keylight presentation. The time between keylight presentations was of variable duration with a mean of 30 sec. For half the birds (Subjects 26 to 35), the grain was inaccessible as it was in Experiment I; for the remaining birds (Subjects 36 to 45), the grain was accessible as it was in Experiment II. Half the birds in each group (Subjects 26 to 30 and 36 to 40) were presented with a bright key (4.18 m-cd) while the remaining birds (Subjects 31 to 35 and 41 to 45) were presented with a dim key (0.26 m-cd). For birds receiving inaccessible grain presentations (control for Experiment I), Phase I consisted of 300 keylight presentations, after which Phase II began after the hopper barrier was removed. Phase II consisted of 200 keylight presentations explicitly unpaired with accessible grain presentations, but unlike the procedure of Experiment I, pecks on the lighted key were not reinforced and did not terminate the keylight. Birds receiving accessible grain presentations (control for Experiment II) received 300 keylight presentations and no second phase.

All birds were then given two weeks to return to, and stabilize at, their 75 to 80% weights, and were then retested under their original keylight and grain-accessibility conditions, except that all presentations of keylight were immediately followed by grain presentation, *i.e.*, keylight and grain were explicitly paired. The procedure was identical to that of Experiments I and II. The purpose of retesting the birds was to assess the extent to which the control conditions would retard or prevent key pecking when the birds were later exposed to the experimental conditions.

RESULTS AND DISCUSSION

The data from Experiment III are presented

in Table 3. In general, little responding was observed for birds exposed to explicitly unpaired presentations of keylight and grain, regardless of accessibility of grain or brightness of key.

Inaccessible Grain

Comparison of birds exposed to inaccessible grain presentations with similarly treated birds from Experiment I, suggests that pecking the dim key in Experiment I was largely due to the forward pairings of keylight and inaccessible grain (a conditioned reinforcer). Birds exposed to explicitly paired presentations of dim keylight with inaccessible grain, responded more, Mann-Whitney $U(5,10) = 3$, $p < 0.01$, responded earlier, $U(5,10) = 4$, $p < 0.01$, and on more trials, $U(5,10) = 0$, $p < 0.01$, than did birds exposed to explicitly unpaired presentations of dim keylight with inaccessible grain.

Comparison of the Phase II data is even more striking. In Experiment I, with explicitly paired presentations of the dim key and grain, all birds pecked the dim key when grain was made accessible. In Experiment III, with explicitly unpaired presentations of the dim key and grain, none of the birds pecked during Phase II when grain was made accessible.

When the birds in Experiment III were retested using the procedure of Experiment I, little key pecking occurred during either Phase I or Phase II. The data suggest that explicitly unpaired presentations may virtually eliminate key pecking to a keylight explicitly paired with grain. This conclusion must be tentative, however, because the effects of prior explicitly unpaired presentations are confounded with the effects of additional time in the operant box, additional presentations of keylight, and additional presentations of grain (both accessible and inaccessible).

Accessible Grain

Birds given explicitly unpaired presentations of keylight and grain (control for Experiment II) also showed little evidence of key pecking, either when the key was dim or bright.

Retesting the birds with explicitly paired presentations also resulted in little or no responding, in contrast to the large number of responses made by the birds given explicitly paired presentations in Experiment II. Since these results are not complicated by inaccessible grain presentations, they provide even better evidence for the suppressing effects of

Table 3

Response measures for each subject in Experiment III. Subjects were exposed to unpaired keylight and grain, and were later retested with paired keylight and grain.

		<i>I Inaccessible Grain</i>			<i>II Accessible Grain</i>		
	<i>Bird</i>	<i>Trial First Peck</i>	<i>Total Pecks</i>	<i>Trials with Peck</i>	<i>Trial First Peck</i>	<i>Total Pecks</i>	<i>Trials with Peck</i>
<hr/>							
<i>Unpaired</i>							
Bright key	26	—	0	0	—	0	0
	27	—	0	0	—	0	0
	28	—	0	0	—	0	0
	29	241	1	1	—	0	0
	30	—	0	0	—	0	0
Dim key	31	24	3	2	—	0	0
	32	167	8	2	—	0	0
	33	—	0	0	—	0	0
	34	191	3	1	—	0	0
	35	—	0	0	—	0	0
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<i>Paired</i>							
Bright key	26	—	0	0	101	2	2
	27	112	8	2	127	6	3
	28	—	0	0	—	0	0
	29	18	1	1	—	0	0
	30	—	0	0	—	0	0
Dim key	31	283	6	1	88	118	43
	32	49	14	2	—	0	0
	33	—	0	0	—	0	0
	34	13	3	1	—	0	0
	35	—	0	0	—	0	0
<hr/>							
<i>I Accessible Grain</i>							
<hr/>							
<i>Unpaired</i>							
Bright key	36	—	0	0			
	37	—	0	0			
	38	—	0	0			
	39	11	1	1			
	40	60	3	3			
Dim key	41	—	0	0			
	42	—	0	0			
	43	7	3	1			
	44	87	2	2			
	45	—	0	0			
<hr/>							
<i>Paired</i>							
Bright key	36	—	0	0			
	37	—	0	0			
	38	—	0	0			
	39	—	0	0			
	40	—	0	0			
Dim key	41	193	2	1			
	42	244	10	2			
	43	—	0	0			
	44	221	1	1			
	45	—	0	0			

the explicitly unpaired procedure on subsequent key pecking with the explicitly paired procedure. Such a conclusion assumes that similar suppression of key pecking would not occur for groups exposed to control procedures.

Gamzu and Williams (1973) also reported suppressed key pecking during keylight-grain pairings when preceded by explicitly unpaired presentations, and Wasserman and Molina (1975) have studied the phenomenon using a

number of different control procedures. In Wasserman and Molina's first experiment, using a within-subject design, they observed that when two stimuli were explicitly paired with grain, key pecking was initiated after many more trials to the one that had been explicitly unpaired with grain, than to the one that was novel. In their second experiment, Wasserman and Molina demonstrated that retardation of key pecking was not due merely to prior exposure to a later explicitly paired stimulus. In their third study, using a between-subject design, Wasserman and Molina found that key pecking was not retarded after prior exposure to explicitly unpaired presentations of a *different* stimulus with grain, while key pecking was retarded after prior exposure to explicitly unpaired presentations of the *same* stimulus.

GENERAL DISCUSSION

The results of Experiments I and III indicate that a conditioned reinforcer (inaccessible grain) that follows the onset of relatively dim keylight can initiate, but not maintain, key pecking in food-deprived pigeons, a finding in agreement with Patterson and Winokur (1973).

The results of Experiment I can also be viewed as an example of higher-order Pavlovian conditioning, since the noncontingent pairing of keylight and grain conforms to an operational definition of Pavlovian conditioning. Stimuli paired with the consumption of grain (1) during magazine training (*e.g.*, sound of the grain magazine) and (2) before experience in the operant box (*e.g.*, sight of grain), can later function as unconditioned stimuli to elicit key pecking when they follow presentation of a lighted key.

The results of manipulating keylight intensity in Experiments I and II indicate that a bright key will result in fewer "autopecks" than a dim key, perhaps because the bright key either illuminates the hopper (Wasserman and McCracken, 1974), or increases the visibility of "extra" cues in the box (Wasserman, 1973).

The results of Experiment III also suggest

that prior presentations of explicitly unpaired keylight and grain may greatly suppress key pecking during later explicitly paired trials.

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