THE DISRUPTION OF AUTOSHAPED KEY PECKING IN THE PIGEON BY FOOD-TRAY ILLUMINATION¹

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Two experiments investigated the effect of food-tray illumination on pecking a lighted key that signalled food presentation. Pigeons key pecked less when both feeder and key stimuli preceded grain delivery than when the keylight alone signalled food. This detractive influence of grain-tray illumination did not result after prior pairings of the keylight with food. The involvement of associative and physical variables in autoshaping the pigeon's key peck is considered in light of these findings.

If, after training hungry pigeons to consume mixed grain in a lighted food tray, the illumination of a small spot of light on a pecking key regularly precedes food delivery, then virtually all subjects will begin to peck the key after a modicum of keylight-food pairings (called autoshaping by Brown and Jenkins, 1968). Besides the localized character of the visual signal apparently necessary to evoke a directed peck with this procedure (Schwartz, 1973; Wasserman, 1972, Experiment 5), the likelihood of a peck to the key appears to be a function of the stimulus-reinforcer relations of other stimuli in the environment (see Allaway, 1971; Wasserman, 1973, 1974).

One interesting instance in which another stimulus may reduce control by the keylight was suggested by Moore (1971) and demonstrated by Gilbert (1973). If an improperly shielded keylight permits illumination to diffuse into the food-tray area, then the emergence of key pecking is slowed. The availability of the additional food-tray stimulus might also have contributed to the low level and brief duration of key pecking seen in Brown and Jenkins' original study of autoshaping (1968, Experiment 4).

The present experiments pursued these ini-

tial observations concerning the influence of food-tray illumination on autoshaping the pigeon's key peck. Here, food-tray illumination was explicitly rather than inadvertently provided and its effect on the emergence and maintenance of key pecking was investigated. In addition to the practical value these findings ought to have, they might also help to elucidate some important behavioral mechanisms of the autoshaping phenomenon.

EXPERIMENT I

The first experiment sought to determine the character and the magnitude of the effect of food-tray illumination on the emergence and persistence of autoshaped key pecking. Two groups of pigeons were initially given keylight-food pairings. For one group, the standard auto-shaping procedure was in effect. For the other group, food-tray illumination occurred along with response-key illumination. Subsequently, the treatment conditions of the two groups were reversed in order to assess the influence of the order of experimental treatments on key pecking.

METHOD

Subjects

Eight experimentally naive, adult homing pigeons were reduced to 75% of their free-feeding weights, were individually housed with water always available in the home cages, and were trained daily when they were within ± 20 g of their 75% weights.

Apparatus

Four three-key pigeon conditioning chambers were used. In each chamber, only the cen-

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ter key was used to signal food delivery and to record key pecks. This plastic key (1.9 cm in diameter) required at least 5 g (0.05 N) for activation and was positioned 9.4 cm above the solenoid-operated grain feeder and 4.9 cm below the houselight. The key was illuminated by a miniature display projector (IEE Series 10) that transilluminated the key with white light (28 V dc, No. 1820 bulb). Illumination of the food tray (LVE No. 114-10) was with an ESB 24 bulb. The houselight (28 V dc, No. 1820 bulb) was in a black housing that directed light toward the ceiling. The interior walls of the box and the response panel, which contained the response keys, houselight, and food tray, were constructed of aluminum. Distracting sounds were masked by white noise supplied to the pigeon training room. All scheduling and recording were performed on a PDP 8/I computer in an adjoining room.

Procedure

Initially, the pigeons were trained to approach and to eat quickly from the food tray. The birds were individually placed in a lighted test chamber with the food tray elevated, lighted, and filled to the brim with grain. After the subject had eaten for approximately 20 sec, the tray was lowered. Thereafter, the grain tray was exposed for 4-sec periods at irregular intervals. If the subject failed to eat from the tray after three consecutive presentations, the tray was held in the operated position until the bird had eaten for 4 sec. Tray training continued until each subject had efficiently eaten grain on a total of 20 tray exposures.

Experimental training began the next day. The subjects received 25 daily trials, each of which involved 8 sec of key illumination (conditioned stimulus or CS) followed immediately by 4 sec of grain availability (unconditioned stimulus or US). Successive trials were initiated at intervals averaging 60 sec (range: 40 to 80 sec). For all subjects, the US consisted of the illumination and elevation of the grain tray. The CS differed in the two conditions studied. The four subjects initially exposed to the conventional autoshaping procedure received as CS the illumination of the keylight (Group I). The other four initially received as CS the illumination of the keylight plus illumination of the feeder light

(Group II). This Phase 1 training lasted 10 days. During the 10 days of Phase 2, the training treatments were reversed. Finally, during the 10 days of Phase 3, the original experimental conditions of Phase 1 were reinstated. During all 30 training sessions, pecks to the lighted key were recorded but had no effect upon the presentation of stimuli and reinforcers. The houselight was continuously illuminated during all training sessions (see Wasserman, 1973).

RESULTS

In Phase 1, all four subjects in Group I pecked the lighted key and three of the four subjects in Group II did so, although very infrequently (Figure 1). Key pecking emerged sooner for Group I and reached much higher levels. The median number of trials to the first, second, and third trial with a key peck were: 27 *versus* 58, 33 *versus* 67, and 34 *versus* 82 (no overlap) for Group I *versus* Group II. In addition, from Day 2 until Day 10, there was no overlap in the individual number of daily trials with a key peck for subjects in the two groups. Observation of the pigeons in Group II revealed that their behavior was primarily controlled by the food-tray area when the key and feeder were illuminated. They would thrust their heads into the lighted alcove and frequently peck at the square opening in the bottom (see Gilbert, 1973). Pecks to the illuminated feeder bulb occurred very infrequently. The pigeons in Group II normally kept their heads in the alcove for the duration of the trial, only occasionally stepping back from the food well and orienting toward the lighted key.

When the conditions were reversed in Phase 2, key pecking initially decreased for Group I and increased for Group II (Day 10 to Day 11). The decrease in key pecking of three of the four subjects in Group I was quite small and transient: by the end of Phase 2, response levels were very similar to those at the end of Phase 1. The increase in key pecking of three of the four subjects in Group II was rather large and sustained over the course of Phase 2. Two birds (U and Y), which had never key pecked on more than 30% of a day's trials in Phase 1, responded on 100% of the trials on Day 11, and thereafter on more than 90% of the remaining trials during Phase 2.

Fig. 1. Per cent of daily trials with a key peck during successive training days in Experiment I. The filled circles denote scores from sessions involving only the keylight conditioned stimulus (KL) and the filled stars denote scores from sessions involving both keylight and feederlight stimuli (KL + FL). The four numbers above each set of data represent the number of the subject and the trials elapsing until the first, second, and third trial with a peck, respectively, in Phase 1 (Days 1 to 10; 250 trials). The number 250 indicates that the key-peck criterion had not been met by the end of Phase 1.

In Phase 3, the training conditions were again reversed. Three of the four birds in Group I maintained responding at or near 100% levels. Three of the four birds in Group II key pecked generally less often than they had in Phase 2.

EXPERIMENT II

The second experiment attempted to isolate factors responsible for the effects observed in Experiment I. First, in order to determine whether association of the feeder light with food during tray training may have interfered with the acquisition of control by the keylight during Phase 1 for Group II, tray training was conducted without a feeder light. Second, to assess whether the key pecking of Group II in Phase 2 was due to stimulus generalization of the feeder light to the keylight (see Logan, 1971), a differently colored (red) keylight was used. Finally, in order to determine whether the high frequency of key pecking of Group I during Phase 2 was due to discriminative control of keylight offset signalling grain delivery, the CS in this experiment overlapped with US presentation.

METHOD

Subjects

Eight experimentally naive, adult homing pigeons were maintained under the same deprivation and housing conditions used in Experiment I.

Apparatus

The experimental chambers differed from those described in Experiment I only in that the miniature display projectors were fitted with red cellophane filters.

Procedure

During initial tray training, the pigeons were trained to consume grain from an unlighted tray. The next day, Phase 1 began. Training for Group I ($n=4$) involved 12 sec of red illumination of the response key with grain available in a white-lighted tray during the last 4 sec. Training for Group II ($n=4$) involved 12 sec of red-key illumination and the simultaneous white-illumination of the feeder. During the last 4 sec of key and feeder illumination, the grain delivery mechanism was activated. Only key pecks occurring within the first 8 sec of CS presenta-

tion were recorded. Phase 1 training continued for 10 days. During Phase 2 (10 days), the treatment conditions were reversed. Finally, in Phase 3 (10 days), the Phase 1 training procedures were reinstated.

RESULTS

Tray training proved to be more difficult without a feeder light than is ordinarily the case with feeder illumination. Nonetheless, consistent approach and consumption from the food tray were established in the pretraining session.

In Phase 1, all subjects in Groups I and II occasionally pecked the lighted key (Figure 2), but key pecking for Group II emerged somewhat more slowly and reached generally lower levels. The median number of trials to the first, second, and third trial with a key peck were: 14 *versus* 18, 22 *versus* 36, and 26 *versus* 38 for Group I *versus* Group II. Furthermore, on Days 2 and 3, there was no overlap in the individual number of daily trials with a key peck for subjects in the two groups. Thereafter (Days 4 to 10), there was still no overlap in individual daily key-pecking frequencies between the two groups, with the exception of Bird 33 in Group II whose Phase 1 performance was comparable to Group I subjects.

When the experimental treatments were reversed in Phase 2, key pecking initially decreased for all four subjects in Group I and increased for all four subjects in Group II (Day 10 to Day 11). As in Experiment I, the decrease in key pecking for Group I subjects was quite small and transient, with response levels recovering to their pre-reversal levels within three training sessions. The key-pecking increases of three of the four Group II subjects were generally large and sustained. Bird 36, for example, responded on 92% of the trials on Day 11 after having key pecked on only 20% of the trials on Day 10.

Finally, in Phase 3, the original training conditions were reinstated. The birds in Group I responded approximately as they had at the end of Phase 1. Three of the four birds in Group II key pecked slightly less frequently than they had in Phase 2.

GENERAL DISCUSSION

To facilitate comparison of the findings of Experiments I and II, the proportion of

Fig. 2. Per cent of daily trials with a key peck during successive training days in Experiment II. The filled circles denote scores from sessions involving only the keylight conditioned stimulus (KL) and the filled stars denote scores from sessions involving both keylight and feederlight stimuli (KL + FL). The four members above each set of data represent the number of the subject and the trials elapsing until the first, second, and third trial with a key peck, respectively in Phase 1 (Days 1 to 10; 250 trials).

Table 1
Proportion of Trials with a Key Peck Over the Last Five Days of Training in a Given Phase

		Subject	Phase 1	Phase 2	Phase 3
Group I	Experiment I	B	0.70	0.46	0.40
		C	0.98	0.92	0.98
		D	0.95	1.00	1.00
		Q	0.78	0.98	1.00
		median	0.87	0.95	0.99
	Experiment II	37	0.99	0.99	0.99
		38	0.82	0.86	0.97
		39	0.87	0.98	0.83
		41	0.96	0.94	1.00
		median	0.92	0.96	0.98
Group II	Experiment I	T	0.02	0.00	0.00
		U	0.10	0.95	0.33
		X	0.00	0.28	0.22
		Y	0.13	1.00	0.79
		median	0.06	0.62	0.27
	Experiment II	23	0.13	0.42	0.31
		33	0.90	0.69	0.57
		40	0.49	0.99	0.82
		36	0.21	0.95	0.91
		median	0.35	0.82	0.69

trials with a key peck during the last five days of training in each experimental phase is shown in Table 1. Similar trends are seen in both experiments.

In Phase 1, Group I pigeons key pecked more frequently than Group II pigeons. The procedures employed in Experiment II enhanced the performance of Group II subjects but exerted little effect upon Group I subjects. Thus, when food-tray illumination accompanied response-key illumination, auto-shaped key pecking was markedly reduced. Furthermore, this impairment cannot be completely ascribed to prior association of the feeder light with grain during tray training. In Experiment II, Group II pigeons key pecked generally less often than those in Group I, even though tray training did not involve feeder illumination.

In Phase 2, the key pecking of most Group II subjects showed an immediate and sustained increase in both experiments. Although the increase in Experiment I could have been interpreted as being due to a tendency to peck into the white-illuminated food tray generalizing to the white-illuminated response key, the use of a red keylight in Experiment II argues against this interpretation. When the Phase 2 training procedures were begun, the key pecking of subjects in Group I at first decreased and then usually recovered to Phase I levels. While Experiment I employed a non-

overlapping CS-US arrangement in which CS offset was contiguous with US onset, Experiment II used an overlapping CS-US arrangement in which CS offset and US offset were coterminous (see also Schwartz, 1972). The maintenance of key pecking in Group I subjects, therefore, does not seem attributable to CS offset serving as a discriminative stimulus for grain presentation, since Experiment II eliminated this possibility. In Phase 3, most Group I subjects key pecked with about the same probability as they had at the end of Phase 2. Group II subjects displayed somewhat more variable behavior, but for the most part showed a decline in key pecking.

An understanding of many of these results may be gained by considering the concepts of overshadowing and blocking (for more extensive discussions see Kamin, 1969 and Mackintosh, 1971). Overshadowing refers to a reduction in control by one stimulus owing to the simultaneous presence of another, ostensibly more salient stimulus. For example, after prior pairings of a reinforcer with a compound stimulus consisting of low-salience and high-salience elements, control by the low-salience element might be much less than after training not involving the high-salience stimulus. As applied to performance in Phase 1, when both the keylight and the traylight preceded grain delivery, pecks to the lighted key were infrequent. When only the keylight

signalled reinforcer presentation, however, key pecks quickly increased to high levels and remained there. Apparently, tray illumination was more salient than key illumination and may have overshadowed control by the keylight.

Two questions emerge concerning the applicability of the overshadowing concept to the present findings. First, why is illumination of the food tray more salient than illumination of the response key? Although numerous possibilities present themselves (e.g., the lighted alcove is larger and/or brighter than the keylight), greater nearness of the illuminated alcove to the site of reinforcer reception may have been of primary importance. Indeed, Brown and Jenkins (1968) noted that autoshaping to a keylight was facilitated when the response key was within a few inches of the grain tray, instead of farther away. Future work should devote greater attention to the proximity of stimulus and reinforcer and how this variable influences the direction of autoshaped behaviors.

The second question is, does the feeder light actually impair the acquisition of control by the keylight? The rapid increase in key pecking of Group II subjects during the first day of Phase 2 (especially for Birds U, Y, and 36) speaks against an associative interpretation. Rather, this finding suggests that in Phase 1, Group II pigeons may have discriminated the lighting of both the response key and the tray area, but responding was controlled primarily by the latter (see Jenkins, 1973 for the distinction between noticing and responding).

Blocking refers to a reduction in control by one element of a compound stimulus owing to prior pairings of the other element with the reinforcer. Two of the present findings are amenable to analysis in terms of blocking. First, when exposed to the procedure involving both feeder and key illumination, Group I subjects, which had received prior pairings of only the keylight with food, key pecked much more than Group II subjects. To the extent that more key pecking indicates less control by the tray light, prior training with only the low-salience keylight may have blocked control by the feederlight. Second, under the Group II condition in Phase 1, subjects in Experiment I key pecked less often than subjects in Experiment II.

Fewer key pecks by the Experiment I subjects may have been due to the blocking of control by the keylight after prior pairings of the tray light with grain during tray training.

In conclusion, these findings indicate that the pigeon's peck may be directed toward the site of food reception or toward a spatially more distant stimulus. Which stimulus source will gain control of the autoshaped response would appear to depend upon (a) their physical properties and proximity, (b) the stimulus-reinforcer relations of those stimuli, and (c) the behavioral history of the individual pigeon with the stimuli.

REFERENCES

- Allaway, T. A. *Attention, information, and autoshaping*. Unpublished doctoral dissertation, University of Pennsylvania, 1971.
- Brown, P. L. and Jenkins, H. M. Auto-shaping of the pigeon's key peck. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 1-8.
- Gilbert, R. M. Keypecking by pigeons in an imperfect environment for autoshaping. *Bulletin of the Psychonomic Society*, 1973, 2, 10-12.
- Jenkins, H. M. Noticing and responding in a discrimination based on a distinguishing element. *Learning and Motivation*, 1973, 4, 115-137.
- Kamin, L. J. Selective association and conditioning. In N. J. Mackintosh and W. K. Honig (Eds.), *Fundamental issues in associative learning*. Halifax: Dalhousie University Press, 1969. Pp. 42-64.
- Logan, F. A. Incentive theory, reinforcement, and education. In R. Glaser (Ed.), *The nature of reinforcement*. New York: Academic Press, 1971. Pp. 45-61.
- Mackintosh, N. J. An analysis of overshadowing and blocking. *Quarterly Journal of Experimental Psychology*, 1971, 23, 118-125.
- Moore, B. R. *On directed respondents*. Unpublished doctoral dissertation, Stanford University, 1971.
- Schwartz, B. The role of positive conditioned reinforcement in the maintenance of key pecking which prevents delivery of primary reinforcement. *Psychonomic Science*, 1972, 28, 277-278.
- Schwartz, B. Maintenance of key pecking by response-independent food presentation: the role of the modality of the signal for food. *Journal of the Experimental Analysis of Behavior*, 1973, 20, 17-22.
- Wasserman, E. A. *Auto-shaping: the selection and direction of behavior by predictive stimuli*. Unpublished doctoral dissertation, Indiana University, 1972.
- Wasserman, E. A. The effect of redundant contextual stimuli on auto-shaping the pigeon's key peck. *Animal Learning and Behavior*, 1973, 1, 198-206.
- Wasserman, E. A. Stimulus-reinforcer predictiveness and selective discrimination learning in pigeons. *Journal of Experimental Psychology*, 1974, (in press).

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