AUTOSHAPED KEY PECKING MAINTAINED BY ACCESS TO A SOCIAL SPACE

DAVID B. PEELE AND C. B. FERSTER

THE AMERICAN UNIVERSITY

When four experimentally naive pigeons were exposed to occasional forward pairings of a keylight followed by a doorlight (that signaled access to a large social space), all subjects began to peck the lit key. In a second experiment, where the keylight either preceded the presentation of the doorlight or was presented independently of it, key pecking was maintained only in the former circumstance. The unconditioned stimulus in these experiments—arrival in the social space—did not elicit pecking. Hence, the conditioned response of key pecking and the unconditioned response of entering the social space differed. This demonstration of autoshaping with a social-space unconditioned stimulus argues against a stimulus-substitution account of the findings.

Key words: autoshaping, stimulus substitution, social reinforcer, key peck, pigeon

Brown and Jenkins (1968) demonstrated that the forward pairing of a keylight with delivery of grain to food-deprived birds was sufficient to produce pecking to the illuminated key. This phenomenon, which they called "autoshaping," resulted from a classical-conditioning procedure (delay conditioning) where the unconditioned response (UR) elicited by the sight of grain (US) seemed to be transferred as a CR to the keylight stimulus (CS).

A stimulus-substitution account of this finding has been proposed by Jenkins and Moore (1973) based on the similarity of the autoshaped response to that elicited by the US. They reported topographic identity between the conditioned and unconditioned response when grain or water served as the US. Further support for a substitution account comes from a study by Farris (1967). He found that when a CS preceded the introduction of a sexually receptive female quail, the subject (a

male quail) oriented toward the CS and exhibited courtship behavior normally elicited by the female. This is one of several examples of the cross-species generality of a substitution account of autoshaping (e.g., also see Boice & Denny, 1965; Rackham, 1971, as cited by Moore, Note 1; Stiers & Silberberg, 1974).

Despite these results, examples can also be found that are inconsistent with a substitution account of autoshaping. For instance, monkeys acquire the autoshaped response of panel pressing (with their hands) when food is the US even though this response bears no resemblance to that elicited by the delivery of food (Schwam & Gamzu, 1975; Sidman & Fletcher, 1968). Moreover, experiments using brain stimulation with rats (Peterson, Ackil, Frommer, & Hearst, 1972) and heat USs with chicks (Wasserman, Hunter, Gutowski, & Bader, 1975) also failed to demonstrate any correspondence between the autoshaped and US-elicited response (also see Wasserman, 1981, pp. 29-35). In fact, evidence has been presented by Woodruff and Williams (1976) that autoshaped key pecking may even occur without the occurrence of normal consummatory behavior toward the US. These findings suggest that stimulus substitution cannot be a complete account of autoshaping.

Why does stimulus substitution seem sometimes adequate, sometimes not? The answer may be related to whether components of the conditioned and unconditioned response are

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shared. For example, a pigeon's key contact with its beak as well as its consumption of food and water have common topographical elements. On the other hand, studies that have used CRs and URs that necessarily differ have shown that stimulus substitution need not occur. Interestingly, little of this work has been done with pigeons—the paradigmatic subject of autoshaping.

The present study addresses this issue by seeing whether autoshaped key pecking can be supported by a US unlikely to elicit pecking—in this case, access to a large social space. Creed and Ferster (1972) showed that this reinforcer maintained a key-peck operant, but it did so without eliciting pecking movements in the social space. For this reason, it provides a plausible test of adequacy of the stimulus-substitution account of autoshaped key pecking in pigeons.

EXPERIMENT 1

The present experiment demonstrates autoshaped key pecking in pigeons, with access to a large space and proximity to another bird as the US.

METHOD

Subjects

Four experimentally naive adult White Carneaux pigeons, two male (P2971 and P2940) and two female (P222 and P208), maintained at 90 to 100% of their free-feeding weights, were used.

Apparatus

The experimental apparatus consisted of two spaces of unequal size, connected by two one-way doors through which subjects could enter and exit the space. The basic design of the spaces resembled that used by Creed and Ferster (1972), as diagrammed in Figure 1.

The social space was covered with clear plastic, enclosing an area 1.7 by 1.4 by 2.6 m. Adjoining this area was a small confinement area (the food space) measuring .4 by .5 by .4 m. Centered 5 cm from the floor on the back wall of the food space was a food hopper for the delivery of grain. Water was continuously available in cups located next to the food hopper.

A .5-m square wire-mesh cage constructed from 2.5-cm mesh was located on the floor of

Fig. 1. Diagram of the experimental space. Arrows on the door indicate the direction of travel by the experimental subject.

the social space and allowed a clear view of a caged bird from the social space.

The doors connecting the spaces were Plexiglas, hinged on needle bearings, and closed automatically (by gravity) due to the offset of the hinges. An electromagnetic lock, mounted on the frames of the doors 25 cm from the side walls of the food space, attracted a small metal plate embedded in the face of the door to limit travel between the spaces. Centered above the door to the social space was a Gerbrands pigeon key with a clear Christmas-tree lamp mounted behind for its illumination. A magnet mounted on the bearing side of both doors operated a reed switch to provide an electrical indication of when the doors were open. Mounted 20 cm from the floor on the frames behind both doors were Christmas-tree lamps (doorlights), which were illuminated whenever the locks were disengaged. The doorlight behind the door to the social space was green and that behind the door to the food area was red.

In a second design used in Experiment 1, the door to the social space could be operated automatically by energizing a solenoid. This door was similar to the gravity-operated doors in every detail except for the use of the solenoid.

A series of platforms on the floor in front of and behind the doors recorded the location of the subjects in the two spaces. The platforms were hinged stainless-steel plates, each resting on a microswitch which provided an electrical signal whenever the subject stood on any part of the plate. The platforms were 20 cm square and were supported by a wooden frame.

Control of experimental conditions and recording of behavior were done by standard relay equipment located in the same room as the social and food spaces.

Procedure

Subjects served in pairs, one male and one female. On alternate days, subjects switched between serving as companion and experimental bird, with only the experimental bird having access to both spaces. While one pair of subjects (P2971 and P222) participated in eight-hour daily sessions, the other pair (P208 and P2940) was housed in the laboratory's pigeon loft with water and grit available. Similarly, while P208 and P2940 participated in 16-hour nightly sessions, P2971 and P222 were kept in the loft.

Door Training

Subjects were individually adapted to the apparatus for eight daily sessions. On Day 1, after 48 hr of food deprivation, each subject was locked in the confinement area for magazine training. A total of 40 four-sec presentations of grain resulted in all subjects eating reliably from the food hopper. Beginning on Day 2, and continuing throughout the experiment, the hopper was raised for 30 sec every 30 min regardless of the location of the bird in the spaces.

On Day 2, both the entrance and exit doors were propped open, allowing the bird unrestricted access to the two spaces. Over the next six sessions, the door to the food space was progressively closed by reducing the opening 2.5 cm each session unless the number of trips through the doors was less than the number when the doors were completely open. At this point in training, the procedures for P2971 and P222 differed from those for the other two birds. For P2971 and P222, the opening of the door that permitted transit from the food space into the social space was progressively reduced until the birds were reliably pushing through the door to the social space.

Door training was complete when Subjects P2971 and P222 were reliably pushing through the closed doors.

Stimulus Control of Exiting

Next, the transit through the doors was brought under the control of the doorlights that indicated whether the door was locked or open. These training sessions (beginning on Day 9) began by placing a subject in the social space with the red doorlight on, indicating that the door to the food space was unlocked. When the subject entered the food space, the red light went off, and the door locked. Unlocking the door to the social space was arranged by a variable time (VT) 1-min schedule. The green lamp mounted behind the door lit when the door to the social space was unlocked. For P2971 and P222, the green doorlight signaled that the door was unlocked; it remained so until the bird entered the social space. For P208 and P2940, the door opened automatically when the doorlight came on and remained open until the bird entered the social space. While a subject was in the social space, the door to the food space was always unlocked and the red doorlight illuminated. This phase lasted 10 sessions.

Autoshaping

An illustration of the autoshaping procedure is provided in Figure 2.

Daily autoshaping sessions began (see Square 1 of Figure 2) with the experimental subject in the social space, the red doorlight lit, and the

Fig. 2. Diagram of the autoshaping procedures, involving four steps in pairing the keylight presentation with the illumination of the doorlight (allowing access to the social space).

Table 1

The number of trips through the spaces, number of trials, and the occurrence of key pecks (Experiment 1).

Subject	Session	No. of Trips	Keylight:Doorlight Pairings (Trials)	Key Pecks	
				Lit Key	Dark Key
P208 Autoshaping	1	49	83	23	0
	2	73	368	16	0
	3	25	253	2	0
	4	53	216	0	0
	5	52	268	5	0
	CRF	6	2	(2)	0
	7	27	—	(27)	0
P2940 Autoshaping	1	37	56	0	0
	2	189	294	0	0
	3	16	18	0	0
	4	123	157	0	0
	5	38	40	0	0
	6	82	102	0	0
	7	158	184	0	0
	8	207	305	0	0
	9	210	215	4	—
	10	118	178	—	—
	11	110	165	1	—
	12	102	106	—	—
	13	26	26	—	—
	14	63	64	12	—
CRF	15	33	—	(33)	—
	16	30	—	(30)	—
P2971 Autoshaping	1	6	20	0	0
	2	1	2	1	—
	3	—	46	24	1
	4	5	9	10	—
	5	—	22	12	5
	6	1	40	1	—
CRF	7	6	—	(6)	—
	8	2	—	(2)	—
P222 Autoshaping	1	15	28	—	—
	2	20	56	—	—
	3	7	17	—	—
	4	12	62	3	—
	5	28	52	—	—
	6	22	31	—	—
	7	8	22	—	—
	8	18	34	—	—
	9	13	16	7	—
	10	14	20	45	—
	11	2	2	5	—
	12	27	27	35	—
CRF	13	4	—	(4)	—
	14	4	—	(10)	—

door to the food area unlocked. When the subject entered the food space (Square 2), both doors locked and the doorlights went out. After an average of three min, the key above the door to the social space lit for six sec (Square 3). Following offset of the keylight, the green doorlight lit and the lock released

for a prescribed period of time—two sec less than each subject's mean latency to exit the food space after doorlight illumination during the prior 10 sessions (see Square 4). When the subject entered the social space, the green doorlight went off and the red doorlight lit. If a subject failed to enter the social space

during its entrance interval, the door was again locked. A VT 3-min schedule defined the period until the next keylight/doorlight pairing (for P208 and P2940, the door to the social space opened automatically after the six-sec keylight interval and closed automatically at the end of the entrance interval).

All key pecks were recorded but had no scheduled consequences during autoshaping sessions. These conditions were in effect for 14 sessions or until the subject pecked the key during four of five sessions, whichever came first. The procedure was then changed to continuous reinforcement of pecking the key by onset of the doorlight and access to the social space. In this procedure, the keylight was on continuously while subjects were in the food space, but the door unlocked only after a peck. Once a peck occurred, the door to the social space remained unlocked until the subject exited.

RESULTS

No more than five autoshaping sessions were required for all subjects reliably to enter and exit the spaces under the control of the doorlight. The number of trips through the spaces (defined as an entrance into and exit from

the food space), the number of keylight/doorlight pairings, and the number of key pecks for each subject are shown in Table 1.

Automatic Door; P208 and P2940

Figure 3 summarizes the essential data for P208 and P2940, illustrating their allocation of time between the two spaces and the number of key pecks. P208 pecked the lit key 30 times in the first session of the autoshaping procedure (there was no pecking to the dark key). With the exception of Session 4, pecks continued to occur for five sessions. P2940 began to peck the lit key in the ninth session, with no pecks occurring to the dark key. Pecking occurred during two of the next five sessions, with as many as 12 pecks per 16-hr session. For both P208 and P2940, pecking continued to occur during the continuous-reinforcement sessions.

Push-Through Door; P2971 and P222

The procedures were also effective in producing autoshaped responding for the two subjects exposed to the push-through doors. Figure 4 shows that these autoshaped responses occurred beginning in Sessions 3 and 4 for P2971 and P222, respectively. In the five ses-

Fig. 3. Allocation of time in the social space and number of key pecks occurring during the experiment for subjects exposed to the automatic door design. Each data point represents a daily session. X refers to the mean amount of time spent in the social space during door training. (Experiment 1)

Fig. 4. Allocation of time in the social space and number of key pecks occurring during the experiment for subjects exposed to the push-through door design. Each data point represents a daily session. X refers to the mean amount of time spent in the social space during door training. (Experiment 1)

sions during which responding occurred, the range of pecks occurring per 8-hr session for P2971 was 1 to 24 and 3 to 45 for P222. As with the other subjects, pecking was maintained during the continuous-reinforcement sessions, sometimes in excess of the number of exits (see P222, second session).

As shown by the behavior of P222 and P2940, autoshaped key pecks were more likely when subjects no longer alternated between the roles of experimental and companion bird. Alternation ceased when one member of a pair completed the experiment as defined above (Sessions 7 to 12 and 6 to 14, for P222 and P2940, respectively). All instances of key pecking were followed by an exit into the large space (with the exception of P2971, Sessions 3 and 5, where the entire session was spent in the food space).

The birds were observed while in the apparatus to see whether responses resembling pecking occurred in either of the two spaces. The observation periods, conducted for 20 min during the beginning of each session, revealed that subjects typically walked around the caged companion, flapped their wings, and spent the majority of the time perched on top of the companion bird's cage. There were no observed instances of pecks directed toward the doorlight or to the caged companion; however, there was evidence of some interaction between the birds in the spaces. Typically, the caged companion faced and cooed at the experimental subject as it entered the large space. While exiting from the food space, subjects were observed to walk into the unlocked door at a slight angle, with the wing contacting and opening the door. In no instance of exiting were subjects observed using the beak to push open the unlocked door.

DISCUSSION

The forward pairings of the keylight and doorlight successfully autoshaped key pecks for all subjects. Key pecking was acquired whether the door opened automatically or by pushing. There was a difference in the proportion of time spent in the large space, however. P2971 and P222, with the push door, spent less session time in the large space than P208 and P2940, with the automatic door.

The number of autoshaped key pecks that occurred with space as a US was considerably less than that obtained when food or water

is used (e.g., see Brown & Jenkins, 1968; Jenkins & Moore, 1973). This could be due to the difference in deprivation procedures for space and social contact (i.e., being confined briefly in the food space) vs. food and water. In addition, food-related behavior occurring in the food space may have contributed to the low rate of autoshaped pecking; that is, eating may have competed with activities involved in exiting and social contact. As a result, the number of pecks per trial appears low, as those trials occurring while the bird oriented and ate from the hopper necessarily lacked any orientation to the key by the bird.

EXPERIMENT 2

Experiment 1 demonstrated the capacity of the US (access to a large social space) to produce autoshaped key pecking by pigeons. Before it can be concluded that the forward pairings of the keylight and the doorlight (signaling access to the social space) were responsible for producing key pecks, it must be shown that key pecking fails to occur when the stimuli are presented independently. In autoshaping experiments using other USs, key pecking failed to occur when the keylight did not predict presentation of the US (e.g., Gamzu & Williams, 1973; Wasserman, Franklin, & Hearst, 1974).

Experiment 2 assessed the role of forward pairings of keylight and doorlight in the production of key pecking. The role of the keylight was varied so that its illumination was either differential or random with respect to presentations of the space US. These two conditions were imposed over blocks of 24-hr sessions, with a single subject serving as the experimental bird.

METHOD

Subjects

Two experimentally naive White Carneaux adult pigeons, one male (P329) and one female (P208), maintained at 90 to 100% of their free-feeding weights, were used.

Apparatus

The apparatus with the push-through doors was used, with one modification. A food hopper, located 7 cm from the grid floor and centered on the back wall of the cage, was installed for presenting grain to the caged com-

panion. Water was made continuously available to the caged companion in cups located next to the food aperture.

Procedure

The procedure for door training and stimulus control of exiting was the same as in Experiment 1. However, the male subject (P329) served exclusively as experimental bird and the female subject (P208) as companion bird throughout the experiment. Data were collected each morning from continuous, 24-hr sessions. Thirty-second grain presentations for the caged companion were initiated only when the experimental subject received food while in the food space.

Following initial training, nine sessions were conducted where presentations of keylight and doorlight (signaling access to the social space) occurred independently of each other (nondifferential condition). When the subject was in the food space, the 6-sec keylight and 5-sec doorlight presentations were arranged by two separate VT 3-min schedules.

Beginning in Session 10, forward pairings of keylight and doorlight were presented while the subject was in the food space, as in Experiment 1. These pairings continued for four

sessions (differential condition). Sessions 14 to 17 were a reversal to the nondifferential condition, followed by a return to the differential condition in Sessions 18 to 21.

RESULTS

The allocation of time in the two spaces and the number of key pecks are presented in Figure 5.

Prior to introduction of the autoshaping procedure, the subject spent approximately 75% of each 24-hr session in the social space. This allocation of time in the spaces was roughly maintained throughout the remainder of the experiment. During Sessions 1 through 9, under the nondifferential condition, key pecking failed to occur (see Table 2). During Session 10, the first session of exposure to the forward pairing of keylight and doorlight, there were three pecks to the lit key. Pecks to the lit key continued to occur during the next three sessions but declined when the nondifferential conditions were reinstituted in Session 14. During Sessions 14 through 17 a low rate of pecking to both the illuminated key and darkened key occurred, in contrast to the complete absence of dark-key pecking during the preceding condition. Finally, when

Table 2

The number of trips through the spaces, number of trials, and the occurrence of key pecks (Experiment 2)

Condition	Session	No. of Trips	Keylight:Doorlight Presentations	Key Pecks	
				Lit Key	Dark Key
Nondifferential	1	6	78	0	0
	2	8	94	0	0
	3	6	75	0	0
	4	9	97	0	0
	5	5	84	0	0
	6	4	109	0	0
	7	7	106	0	0
	8	5	106	0	0
	9	6	136	0	0
Differential	10	7	102	3	—
	11	12	97	45	—
	12	7	125	39	—
	13	6	112	24	—
Nondifferential	14	5	96	1	2
	15	4	86	1	1
	16	3	109	0	0
	17	4	95	1	2
Differential	18	3	129	—	—
	19	3	98	30	—
	20	3	65	11	—
	21	3	75	17	—

Fig. 5. Allocation of time in the social space and number of key pecks during differential conditions for P329 in Experiment 2. Each data point represents a 24-hr session.

the differential conditions were again introduced during Sessions 18 through 21, pecks to the illuminated key increased in frequency, with no pecks occurring to the dark key.

DISCUSSION

It is clear from the data that the forward pairings of the keylight and doorlight were responsible for the maintenance of pecking in Experiment 2. When the keylight and doorlight were presented independently, the subject either failed to peck the key or pecked at a lower and nondifferential rate to both the lit and unlit key. As such, these data demonstrate that if the probability of the US given the keylight equals the probability of the US in its absence, then pecking fails to occur. Overall, the results indicate that autoshaped key pecking could be reliably maintained during differential conditions, but not during nondifferential conditions.

GENERAL DISCUSSION

The results of the present experiments may be summarized as follows: (1) The forward pairing of a keylight with access to a social space induced key pecking in four experimentally naive pigeons (Experiment 1); (2) as with other studies of autoshaping phenomena (e.g., Gamzu & Williams, 1973), this pecking was maintained only when the keylight was predictive of access to the social space (Experiment 2).

Taken together, these experiments establish that access to a social space can induce and maintain autoshaped responding in pigeons. Although these data expand the list of reinforcers that can support autoshaping, this ex-

pansion does not define our interest in this study. Instead, we were interested in breaking the conjunction of shared movements so often seen in autoshaping studies. Is it merely coincidental that autoshaped key pecking and eating of grain share movements in common, or is that correspondence critical to the induction of key pecking?

Research addressing this question has altered either the US itself (Jenkins & Moore, 1973) or the consummatory behavior it produces (Woodruff & Williams, 1976). Unfortunately, these studies do not answer the question conclusively. Although Jenkins and Moore found clear-cut differences in the key-peck topographies maintained by grain as the US vs. a water US, it is still the case that many movements were shared between the conditioned and unconditioned responses.

In the Woodruff and Williams study, the correspondence between the topographies of the CR and the UR was attenuated by altering the normal consumption of water. The water US was delivered directly into the bird's mandible via an implanted cannula; therefore, head movements were not necessary for the consumption of the water US, yet pecks were maintained by the presentation of a keylight signaling water delivery. Although this result can be used to question a substitution mechanism in autoshaping, their explanation based on a "learned-releaser" hypothesis subsumes stimulus substitution. According to this hypothesis, the fixed-action pattern of the UR elicited by water delivery was mimicked by the autoshaped response. Therefore, stimulus substitution remains a viable account: One need only argue that the CR and the UR correspond. Although drinking, beginning with approach toward the water and ending with swallowing movements, was altered by eliminating approach, it remains possible to assume that movements of the head were involved in the actual UR elicited by water delivery. One need only argue that the form of the CR was species-specific consummatory behavior, determined by the surrogation by the CS of the US. In addition, when pigeons' consummatory behavior has been restructured by removal of their upper beak, the form of their autoshaped responses resembled the modified form of consuming the grain reinforcer and not that observed before surgical intervention (Premack & Klipec, 1981).

Rather than appeal to stimulus substitution or learned releasers, we believe the results of the present study can best be interpreted as showing that elicited key pecks in the auto-shaped design reflect the bird's natural tendency to peck at discrete signals—that is, stimuli whose presentation reliably precedes the presentation of “relevant” events. This idea—that the pigeon pecks at localized stimuli when they signal relevant events—was first proposed by Brown and Jenkins in their original demonstration of autoshaping. This interpretation is consistent with a sign-tracking hypothesis (Hearst & Jenkins, 1974) because this hypothesis does not attempt to predict what behavior will be seen in tracking the stimulus.

The strategy of the present experiment was to choose a reinforcer that supported behavior that differed entirely from the to-be-conditioned response of key pecking. Our finding of moderate autoshaping in this context demonstrates that stimulus substitution need not occur either directly (e.g., Jenkins & Moore, 1973) or indirectly (via a learned-releaser mechanism; see Woodruff & Williams, 1976) to maintain autoshaping. These data join others (Peterson et al., 1972; Sidman & Fletcher, 1968; Wasserman, 1981) in demonstrating the inadequacy of a substitution mechanism in accounting for autoshaping. Moreover, they offer the first demonstration of this inadequacy in the paradigmatic subject for the study of autoshaping—the pigeon.

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