NONDISCRIMINATED AVOIDANCE OF SHOCK BY PIGEONS PECKING A KEY[1]

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Four pigeons were trained to avoid shock by pecking a key on a free-operant avoidance schedule in which no exteroceptive stimulus signalled impending shock. Response rate was an inverse function of response-shock interval when shock-shock interval was held constant at 2 sec and response-shock intervals varied from 5 to 40 sec. Amphetamine increased response rates in two subjects and reserpine markedly reduced responding in one.

Several recent studies of aversive control have dealt with the problem of shaping and maintaining key pecking in pigeons with a shock avoidance or escape contingency. Hoffman and Fleshler (1959) reported failure in an attempt to use a method of successive approximations to develop a situation in which the bird would peck a key to terminate a pulsating shock. Rachlin and Hineline (1967) confirmed the difficulty in shaping key pecking through a similar escape contingency but were able to establish and maintain the response if pigeons were trained to escape a train of shocks of gradually increasing intensity (Hineline and Rachlin, 1969). They were also able to produce discriminated avoidance responding in two of three pigeons. Some reports indicate the possibility of obtaining discriminated avoidance behavior in pigeons selecting responses, such as moving from one compartment to another in a shuttle box (Macphail, 1968) or flying form one perch to another (Bedford and Anger, 1968). Smith and Keller (1970) reported the conditioning of nondiscriminated avoidance in pigeons trained to avoid shocks by pressing a foot treadle. However, there are no data so far on nondiscriminated avoidance conditioning of key pecking. Smith and Keller (1970) suggested that the difficulty in obtaining avoidance with a key-pecking response may be explained by an

examination of the natural response repertoire of pigeons. Pecking can be observed in appetitive or aggressive activity, but not in escape or avoidance behavior. On the other hand, flying and running are part of the response repertoire present in escaping or avoiding aversive stimulation.

The present experiment sought to demonstrate the possibility of establishing and maintaining stable nondiscriminated avoidance behavior (Sidman, 1953) in pigeons, using key pecking as the response and a train of unsignalled shocks as the aversive stimulation. At the end of the experiment, pigeons were injected with amphetamine and reserpine, in order to compare the drug-induced behavioral changes with those currently observed in nondiscriminated avoidance responding in the rat.

METHOD

Subjects

Four experimentally naive, adult, male domestic pigeons were used. The subjects come from uncontrolled derivations of the species *Columba livia*. Their average weight was 300 g, with average height of 8 in. (20 cm). The birds were raised at the biotery of the *Faculdade de Medicina de Ribeirão Preto* and before the experiment they lived in a large, closed compartment in which the entire colony was kept. Subjects were kept in individual home cages and had free access to food and water throughout the experiment.

Apparatus

A standard experimental chamber for operant conditioning experiments with pigeons,

measuring 13.5 by 12 by 13 in. (33 by 30 by 32.5 cm), was used. Two translucent response keys 0.75 in. (2 cm) in diameter and separated by 1.75 in. (4 cm) were located in a wall, 8 in. (21 cm) from the floor and 5 in. (12.5 cm) from the side walls. The right response key was transilluminated by a red light; the left key was dark and inoperative throughout the experiment. A minimum force of 0.098 N was required to operate the response key. Each effective response produced auditory feedback by operating a relay.

The subjects had electrodes chronically implanted around the pubis bones, (Azrin, 1959a). Shock duration was controlled by a pulse-former and was delivered through a modified Foringer (USA) shock source, equipped with a 40-k ohm series resistor. Shock intensity was measured in milliamperes by using a 1-k ohm resistor in place of the birds. Shock-shock (SS) and response-shock (RS) intervals were controlled by electronic timers. Additional standard electromechanical equipment was employed for automatic scheduling and recording.

Procedure

The technique used to shape the key-pecking response through negative reinforcement was based on the methods described by Azrin (1959b) and Rachlin and Hineline (1967). The subjects were placed in the experimental chamber when the keylight was off. The outer door remained open, the subject being kept inside the chamber by a Plexiglas wall. The room was darkened, the only illumination coming from the red light behind the response key. On illumination of the response key, a train of 35-msec shocks at 0.5-sec intervals, with intensity gradually increasing from 0 to 10 mA was delivered. Initially, any movement of the subject's head toward the panel was followed by a safe 15-sec period of shock cessation. The response requirement was slowly changed by the method of successive approximations until the first effective key peck occurred. During the shaping process, shock intensity was manipulated by the experimenters according to the bird's behavior. For instance, when the animals attempted to escape through the Plexiglas front window, intensity was maximally increased. Any tendency to move away from the window was followed by a reduction in shock intensity. The same was true regard-

ing approximations toward the key panel, which were systematically followed by a reduction in shock intensity. If the response requirement was not reached when the intensity was increased to 10 mA, this maximum value of shock intensity was maintained until the required response occurred. After the first key peck, the RS interval was increased to 30 sec, and the session was continued until the one-hundredth response was emitted.

For the next session, SS interval was increased to 2 sec, the RS interval remaining at 30 sec. Shock intensity was set at 10 mA. For Subject P-51, the RS value was varied. A change in RS value was made only when cumulative response records indicated rate stability for at least five consecutive experimental sessions. Birds were run every day for 2 hr.

Drug Treatments

Subjects P-51 and P-52 were injected with different doses of *d* amphetamine hydrochloride (Sigma, U.S.A.). For P-52 1 mg/kg of reserpine (Serpasol[r] Ciba, Brasil) was also administered. Drugs were dissolved in distilled, deionized water for injections. Solutions were injected into the breast muscle in a volume of 1 ml/kg body weight. Amphetamine and reserpine were injected 15 min and 24 hr, respectively, before the experimental sessions began. During the determination of dose-response curves for amphetamine, P-52 was injected on Tuesdays and Fridays; Mondays and Thursdays were used as control sessions.

RESULTS

As a consequence of the shaping procedure described, all four pigeons developed stable key pecking. Table 1 gives the time for the emission of the first response; the subjects' data are presented in the order they were submitted to the procedure. Table 2 shows the number of sessions needed to reach the criterion of

Table 1

Length of time (minutes) in the shaping sessions before the first key peck occurred.

Subjects	Time (min)
P-51	335
P-52	50
RV	30
DL	130

Table 2

Data from the first experimental condition for all subjects. Response-shock intervals were 30 sec, shock-shock intervals were 2 sec. The second column shows the number of sessions required to reach the stability criterion. Mean response rates in the last five sessions are shown in the third column. In the fourth column are the percentages of shocks avoided.

Subject	Sessions	R/min	% Shocks Avoided
P-51	30	3.2	87.4
P-52	38	3.3	84.3
RV	27	8.7	95.7
DL	25	3.4	86.4

stability, the mean rate of responding on the last five sessions, and the percentage of shocks avoided on those sessions.

Cumulative records of Subject P-51 under three different RS values are shown in Figure 1. It can be seen in this figure that higher response rates were generated by shorter RS values. The quantitative functional relation-

ship between response rate and RS values in P-51 is represented in Figure 2. An approximately linear inverse relationship exists between the log of RS values and response rate, within the RS range from 5 to 30 sec. This regular function is interrupted at RS 40 sec. The proportion of scheduled shocks avoided tends to increase with increases in RS value, as a negatively accelerated function.

Figure 3 shows the performance of Pigeon DL on RS = 20 sec and SS = 2 sec in a session of 14 hr duration, after 199 sessions of exposure to several values of RS and SS intervals.

The first four segments on Figure 3 show more regularity in response rate than the remaining parts of the cumulative response curve. However, the last 10 hr of the extended session show an increase in rate of responding and a decrease in shocks delivered. Table 3 shows rates of responses and shocks on the extended session compared to the average rates and their range on four preceding and four following regular 2-hr sessions for Sub-
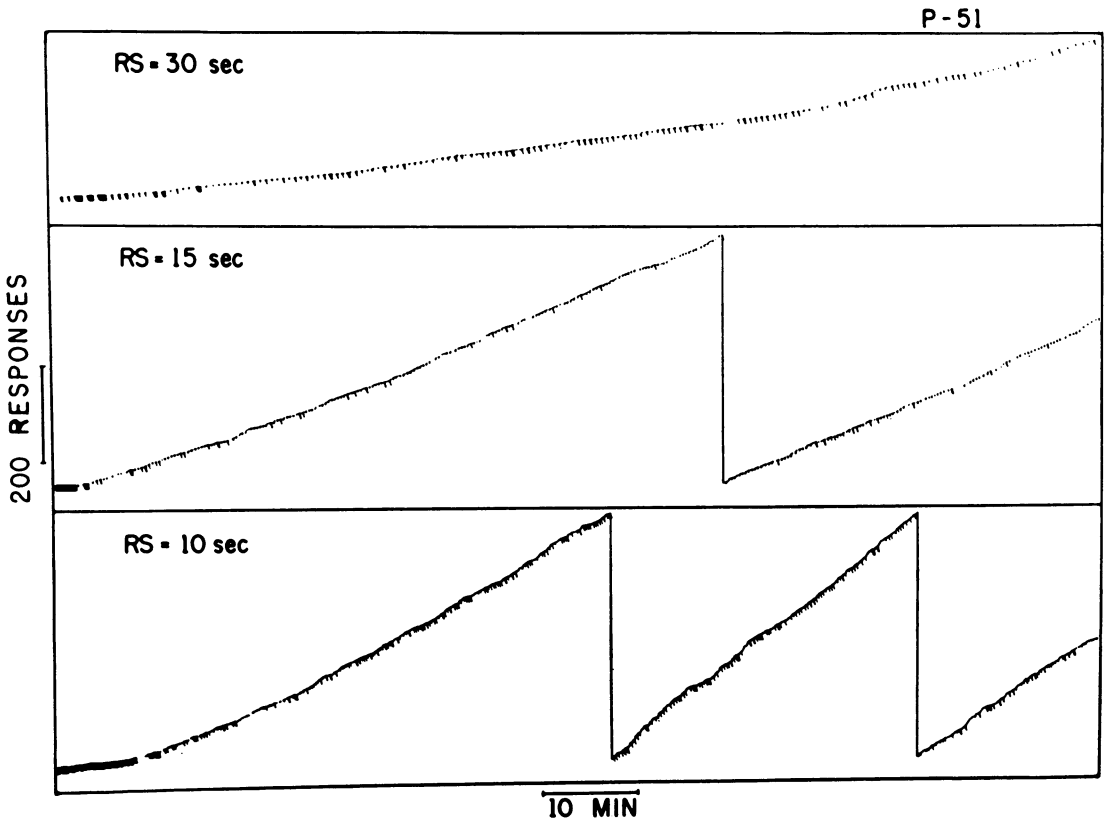

Fig. 1. Cumulative records of performance of one pigeon on the nondiscriminated electric shock (10 mA, 35 msec) avoidance schedule at RS values of 10, 15, and 30 sec respectively, and SS interval equal to 2 sec. Vertical deflection of recording pen indicates shock presentation.
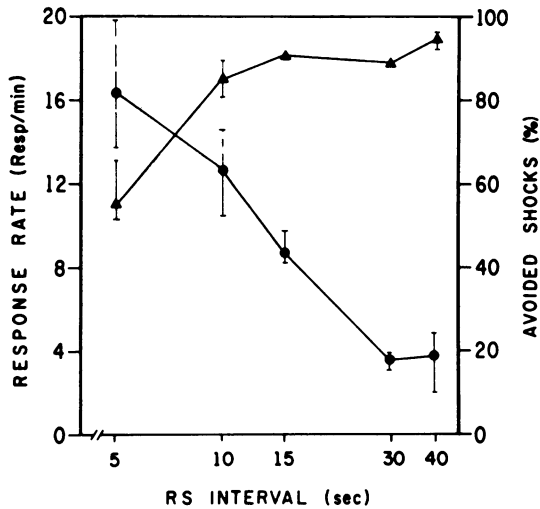
Fig. 2. Response rate (circles) and per cent of scheduled shocks avoided (triangles) as a function of RS length in Pigeon P-51 performing on a nondiscriminated avoidance schedule of electric shock (10 mA, 35 msec) postponement. The SS interval was 2 sec. Each point represents the mean of five determinations, vertical lines representing the range. The initial 15 min (warm-up period) were not considered in the computation of data shown in this figure.

Table 3

Performances of Subject DL on an extended session and on the preceding and following standard 2-hr sessions. RS and SS intervals were 20 sec and 2 sec, respectively.

		Four Preceding Sessions (2 hr duration)	Extended Session (14 hr duration)	Four Following Sessions (2 hr duration)
Resp/ min	Mean	18.3	20.2	18.9
	Range	16.8 − 20.3		15.8 − 22.2
Shocks/ min	Mean	1.0	0.6	1.1
	Range	0.9 − 1.2		0.7 − 1.3

sponse rate as well as in the proportion of scheduled shocks avoided. In contrast, 1 mg/kg reserpine, given 24 hr before, markedly reduced responding of P-52, irrespective of the great increase in shock rate (Table 4 and Figure 4). A complete dose-effect curve determination for amphetamine in P-52 was undertaken 10 months after the first series of drug injections, when the baseline behavior had stabilized at a higher response rate, as shown in Figure 5.

ject DL. The rate of responding on the extended session was within the range of response rates on the standard 2-hr sessions. The rate of shocks delivered was lower on the extended session when compared to the eight control sessions.

For Subjects P-51 and P-52, the injection of 0.3-3 mg/kg amphetamine 15 min before the experimental session caused increases in re-

DISCUSSION

Present results show that key pecking was successfully shaped in four pigeons by means of aversive control. Although systematic studies on the particular conditions involved in the shaping process are still in progress, some aspects of the present method seem to be im-

Table 4

Effects of amphetamine and reserpine on key-pecking nondiscriminated-avoidance performance.

Pigeon	Measurements	Control	Amphetamine (mg/kg)			Reserpine (mg/kg)
			0.3	1.0	3.0	1.0
P-51	Avoided shocks (%)	59.9 (55.6, 64.3)*	−	74.0	74.2	−
SS = 2 sec RS = 5 sec	Response rate (Resp/min)	18.2 (17.8, 18.6)	−	24.4	19.4	−
P-52	Avoided shocks (%)	96.2 (95.6, 97.2)	98.0	99.5	99.0	41.4
SS = 2 sec RS = 30 sec	Response rate (Resp/min)	3.2 (2.6, 3.7)	4.8	7.8	7.1	0.9

*Parenthesized values indicate the range of the response rates of two or three control sessions conducted during the period of drug treatment. The initial 15 min (warm-up period) of each session were not considered in the computation of the figures shown in this table.
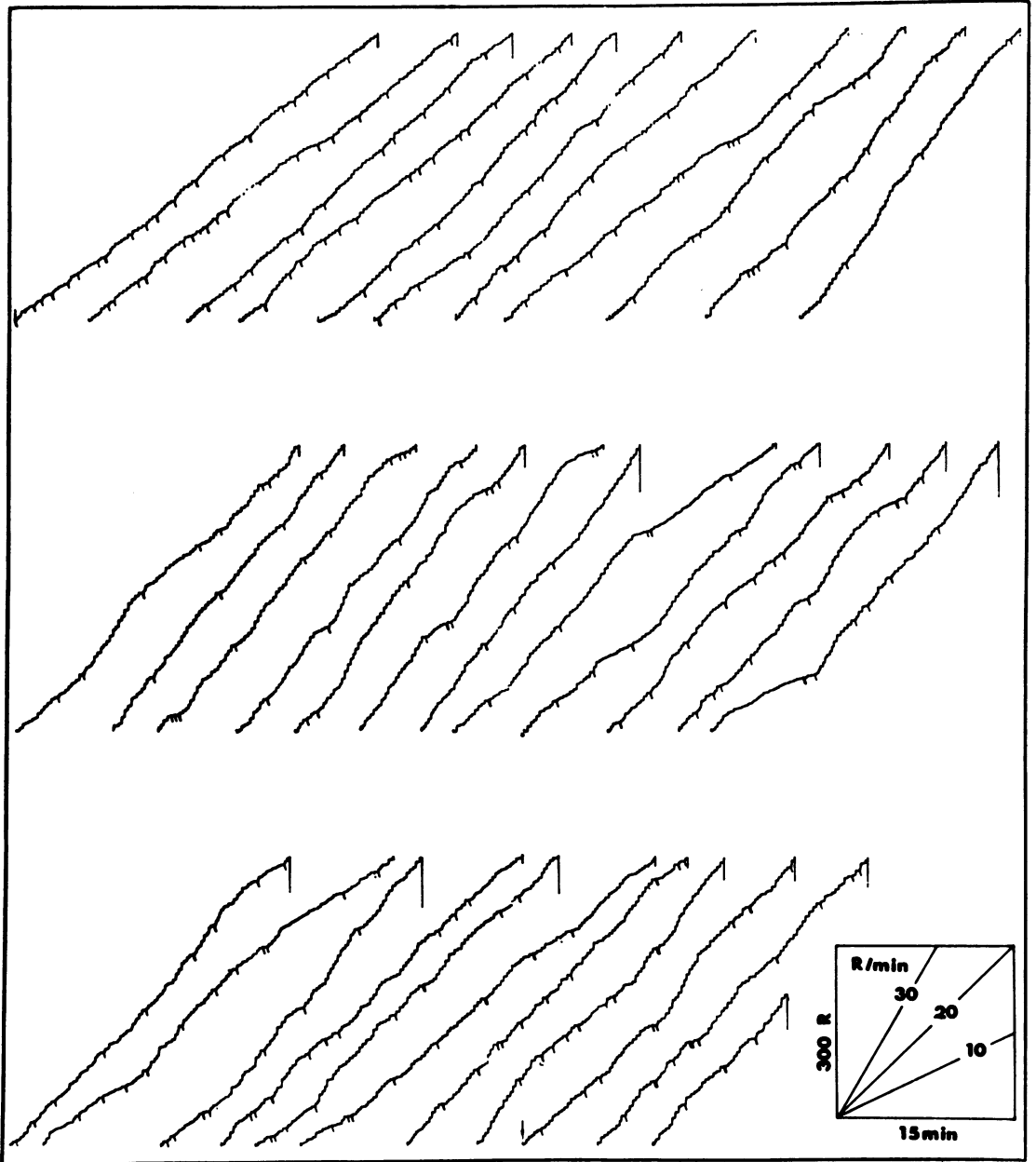
Fig. 3. Cumulative record of the performance of Subject DL in a 14-hr session. Response-shock and shock-shock intervals were 20 sec and 2 sec, respectively.

portant in the shaping of appropriate behavior and elimination of competing responses. Through manual control of shock intensity and continuous observation, shock intensity could be instantly and appropriately modified in response to subtle behavior changes. Any

movement toward the key resulted in a decrease in shock intensity; responses incompatible with key pecking were actually punished by increases in shock intensity.

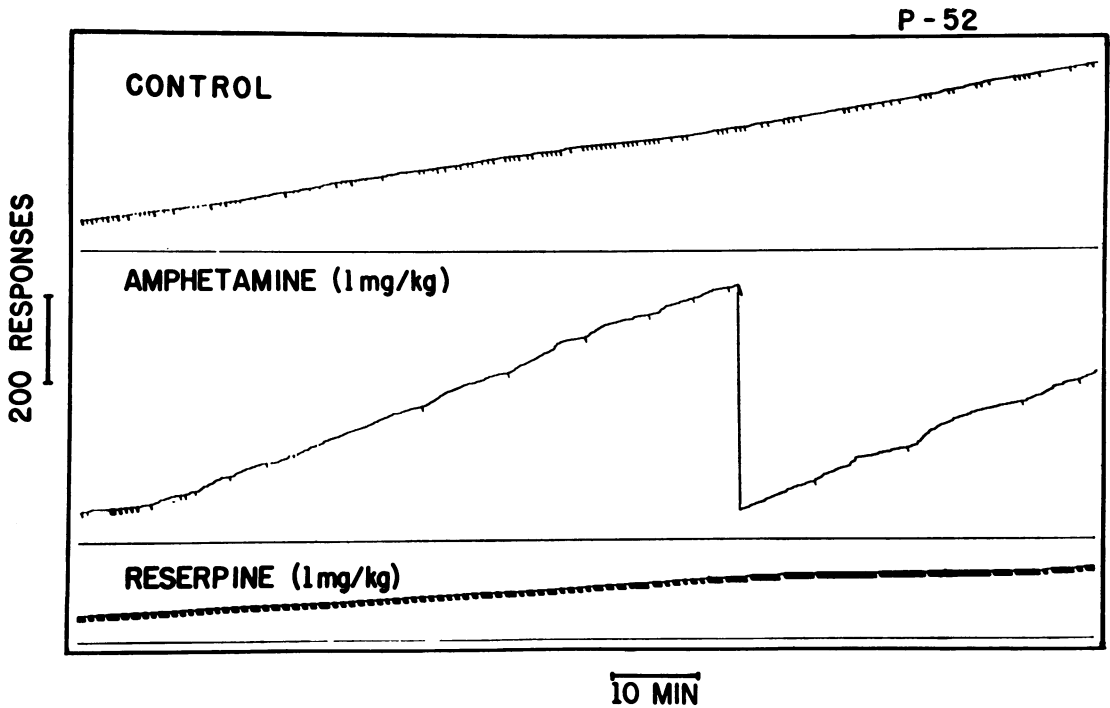Another factor believed to be important to the success of the shaping process and probably

Fig. 4. Cumulative records of performance of Pigeon P-52 on the nondiscriminated electric shock (10 mA, 35 msec) avoidance schedule during control session, 15 min after 1 mg/kg i.m. of amphetamine and 24 hr after 1 mg/kg i.m. of reserpine. RS and SS intervals were 30 sec and 2 sec, respectively.

also to the maintenance of stable avoidance behavior is the reduction of environmental stimuli to a minimum. Since there were no houselights, the keylight was the only source of illumination. Although a transparent Plexiglas window existed in the front of the experimental situation for observation purposes, the experimental room was darkened. Otherwise birds tended to face the front window and make repeated attempts to escape from the experimental chamber. As a consequence of these requirements, the shaping of key-pecking behavior under aversive control was a painstaking procedure, requiring several hours of continuous watching and manipulating. However, the present method probably illustrates a possibility rather than optimal conditions, more effective procedures being likely to develop in the future. Difficulties in shaping key pecking using electric shock have already been reported (Hoffman and Fleshler, 1959; Hineline and Rachlin, 1967; Smith and Keller, 1970). The present experiment showed that these difficulties can be partially overcome. Punishing incompatible responses by sudden increases in shock and making the response

key the only source of direct illumination seem to be the factors that made the present method succeed. The importance of ambient stimuli was discussed by Rachlin (1969) in a report of autoshaping of key pecking with negative reinforcement.

Reported difficulties in shaping and maintaining key pecking using shock as aversive stimulation were discussed by Bolles (1970) and Seligman (1970) as evidence against the notion of an arbitrary relationship between operants and their consequences. Bolles argued that successful avoidance can be achieved only when the response is chosen from among the species-specific defensive repertorie of the organism. Staddon and Simmelhag (1971) supported this point of view. Smith and Keller (1970) explained the difficulty in obtaining avoidance with a key-pecking response using a similar argument. Seligman suggested the notion of a continuum of preparedness for learning situations: "The organism may be more or less prepared by the evolution of its species to associate a given CS and US or a given response with an outcome." (Seligman, 1970, p. 408). Thus, pigeons learn easily to
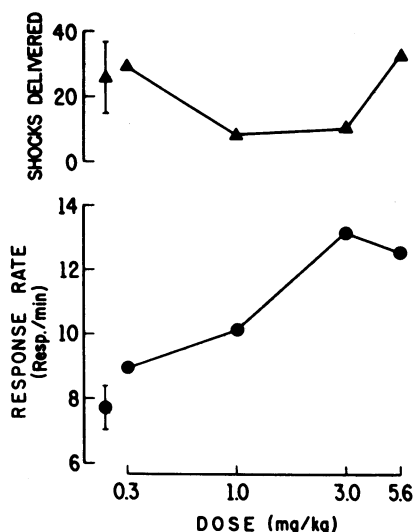
Fig. 5. Dose-effect curves for amphetamine on response rate (circles) and total number of shocks delivered (triangles) during a 2-hr session, for Subject P-52, responding under a RS = 30 sec, SS = 2 sec, nondiscriminated avoidance schedule of electric shock postponement. Each point in the curves represents the mean of duplicate determinations. Points outside the dose-response curves indicate the mean of eight control sessions; vertical bars, above and below the points, indicate two standard errors of the mean of two independent observations and have been considered as confidence limits.

fly away to avoid shock (Bedford and Anger, 1968) but it is difficult to train pigeons to escape or avoid shocks by pecking a key (Rachlin and Hineline, 1967; Rachlin, 1969).

The present results show that the response does not have to be a part of the natural escape or avoidance repertoire of the organism in order to obtain successful avoidance. It may be more difficult to shape such a response through aversive control, but once shaped it can be maintained under the avoidance paradigm. However, the present data cannot be used as an argument for or against Seligman's notion of a continuum of preparedness. Seligman defines the relative preparedness of an organism for learning about a situation by "*the amount of input (e.g.,* numbers of trials, pairings, bits of information, *etc.) which must occur before that output* (responses, acts, repertoire, *etc), which is construed as evidence of acquisition, occurs* (Seligman, 1970, p. 408). Thus, in order to compare the pigeon's preparedness to peck a key under aversive control to its preparedness to peck when presentation

of grain is the consequence, it is necessary to study the acquisition process under comparable conditions. With similar procedures for autoshaping of key pecking with positive and negative reinforcement, Rachlin (1969) reported that the acquisition under positive reinforcement took an average of 32 trials, while 92 trials, on the average, were needed under negative reinforcement. Rachlin suggested two factors that might account for the difference in acquisition: (a) operant level of pecking is higher under conditions of food deprivation, and (b) even naive pigeons are experienced with food and food deprivation, carrying to the experimental situation a repertoire of operants that had food as a consequence in the past. The difference in acquisition of the same response under positive and negative reinforcement might be lower if the pigeons had similar experience with shock.

The present data suggest another possibility for decreasing the number of trials in autoshaping under negative reinforcement. Rachlin pointed out the importance of ambient stimuli in determining the occurrence of key pecking: "Illuminating the key for a short period of time with a light contrasting significantly with its surroundings is required for key pecking to emerge with negative reinforcement" (Rachlin, 1969, p. 530). But in the autoshaping procedure used by Rachlin, the houselights were on when the keylight was illuminated. The contrast between the lighted key and its surroundings would be greater if the houselights were off. It seems reasonable to assume that acquisition would be more rapid when the response key is the only source of illumination and also the only source of stimulus changes.

Seligman's (1970) suggestion (that the difficulty in shaping key pecking under negative reinforcement exists because pigeons are unprepared—or counterprepared—to associate key pecking with the reduction or elimination of aversive stimuli) cannot be evaluated until more is known about the shaping of key pecking through aversive control. As food deprivation is a critical variable in shaping key pecking under positive reinforcement, frequency and intensity of shock may be critical for the establishment of key pecking under negative reinforcement. Preparedness of the subjects should be tested under optimal conditions for both procedures.

Evidence in favor of the similarity between the present study of avoidance behavior and such behavior observed in other species came from the results obtained with the two drug treatments used. Amphetamine increased response rates and reserpine decreased responding, shock rates being inversely affected. Comparable results have been reported for amphetamine and reserpine in the rat (Weissman, 1959, 1963; Heise and Boff, 1962). Nevertheless, little argument can be made for the specificity of these drug effects. Appropriate doses of amphetamine, with few exceptions, tend to increase responding occurring at relatively low baseline rates, such as those generated by the present experimental conditions. On the other hand, reserpine and other major tranquilizers have a general tendency to decrease responding in many experimental conditions (Kelleher and Morse, 1968).

The regularity of the dose-effect data for amphetamine in Subject P-52 otherwise suggests that the key-pecking nondiscriminated avoidance procedure in the pigeon provides a useful behavioral baseline for drug studies.

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