JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1977, 27, 393-398 NUMBER 2 (MARCH)

TWO TYPES OF PIGEON KEY PECKING: SUPPRESSION OF LONG- BUT NOT SHORT-DURATION KEY PECKS BY DURATION-DEPENDENT SHOCK[1]

BARRY SCHWARTZ

SWARTHMORE COLLEGE

The key pecking of eight pigeons was maintained on a variable-interval 1-minute schedule of food reinforcement. Sometimes, all responses between 35 and 50 milliseconds in duration produced a shock; sometimes, all responses between 10 and 25 milliseconds produced a shock; sometimes, shocks were produced by pecks without regard to duration (nondifferential punishment), and sometimes shocks were delivered independently of responding. Punishment of 35- to 50-millisecond responses selectively suppressed those responses, while punishment of 10- to 25-millisecond responses and nondifferential punishment suppressed responding overall but did not suppress responses of particular duration. Punishment of 35- to 50-millisecond responses suppressed key pecking slightly less than did nondifferential punishment. Punishment of 10- to 25-millisecond responses and response-independent shock produced roughly equal amounts of suppression, substantially less than the other punishment procedures. The data support the view that there are at least two kinds of key peck, identifiable on the basis of duration, one of which (short duration) is insensitive to its consequences.

Key words: punishment, key-peck duration, response-independent shock, pigeons

Schwartz and Williams (1972) reported a series of investigations that led them to conclude that the response class "key peck", defined in terms of switch closure, was composed of at least two subclasses, which could be identified on the basis of response duration. One class, of short duration (shorter than 30 msec) seemed particularly sensitive to Pavlovian, stimulus-reinforcer relations, but insensitive to operant, response-reinforcer relations. The other class, of long duration (longer than 30 msec) seemed sensitive to response-reinforcer relations. Schwartz and Williams showed that only short-duration responses occurred on omission procedures (Williams and Williams, 1969), which maintain responding by virtue of stimulus-reinforcer contingencies, and that only long-duration responses could be increased in frequency by differential reinforcement. Other studies of peck duration consistent with the conclusions of Schwartz and Williams (1972) have been reported by Schwartz and Gamzu (1977, Figures 6 and 7) and by Schwartz, Hamilton, and Silberberg (1975).

The present experiment was designed to extend the analysis of peck duration to a situation involving aversive control. If long-duration pecks, and only long-duration pecks, are controlled by their consequences, one would expect that electric shock following long-duration pecks would selectively suppress those pecks. Conversely, if short-duration pecks are not controlled by their consequences, one would expect that differential shock of short-duration pecks would not result in their selective suppression. In fact, one might expect that a procedure that shocked short-duration pecks would be equivalent to a procedure that delivered aversive stimuli independent of responding. Since there is substantial evidence that response-independent shock produces less suppression than response-dependent shock (Azrin and Holz, 1966; Church, 1969; Rachlin and Herrnstein, 1969), one would expect, on the basis of the present analysis, that shock of short-duration responses would result in substantially less overall key-peck suppression than shock of long-duration responses. The present research explored the possibilities that:

[1]This research was supported by NSF grant BMS 73-01403 to Swarthmore College, Barry Schwartz, principal investigator. Reprints may be obtained from the author, Department of Psychology, Swarthmore College, Swarthmore, Pennsylvania 19081.

1. Substantial and equivalent suppression of key pecking would result from shock of long-duration responses and from shock without regard to duration.

2. Much less suppression of key pecking would result from shock of short-duration responses and from response-independent shock.

3. Suppression produced by shock of long-duration responses would be selective; key pecks of durations within the region being shocked would be suppressed more than key pecks of durations outside that region.

4. Suppression produced by shock of short-duration responses would be nonselective; durations actually followed by shock would be suppressed no more than durations not followed by shock.

METHOD

Subjects

Eight experienced White Carneaux pigeons, maintained at 80% of free-feeding weights, had varied conditioning histories; none had been exposed to procedures involving reinforcement based on response duration, and none had received electric shock.

Apparatus

Four identical pigeon chambers (R. Gerbrands Co. Model G7313) each housed a three-key pigeon panel. The keys were normally closed (R. Gerbrands Co.); they required a force of 0.1 N and an excursion of approximately 0.5 mm to operate. Only the center key was activated. It was located 21 cm above the grid floor of the chamber. A grain hopper was located directly below the center key, 5.5 cm above the grid floor. A pair of houselights was located in the center of the ceiling of the chamber. A shock generator (Grason Stadler Co. Model E 1064) was connected through the chamber ceiling to wire bands secured around each of the pigeons' wings (Hoffman and Fleshler, 1959). Scheduling of experimental events, data collection and analysis were accomplished with a PDP8/E digital computer (Digital Equipment Corporation) using SKED software (State Systems Incorporated). Key-peck durations were recorded in the following manner: the interface between the computer and the chambers was constructed so that the break and remake of the response key were treated as logically different responses. On the break of the key, a part of the program began incrementing a counter number every 5 msec. When the key returned to its resting position (remake), a count was recorded in the counter that the program had reached. There were 20 such counters (the last of which recorded all key pecks of 100 msec or more) so that each session's duration data took the form of a histogram made up of 20, 5-msec class intervals. When this method of duration recording was tested against a millisecond timer, there was more than 99% agreement. All experimental events dependent on responses were produced by the remake, and not the break of the response key.

Procedure

Throughout the experiment, the pigeons' key pecks were maintained on a variable-interval 1-min (VI 1-min) schedule of reinforcement. Reinforcement was made available with a probability of 0.1 every 6 sec. Pecks produced 4-sec access to grain, at which time the houselights and keylights were extinguished and a light in the feeder was illuminated. The key and houselights were illuminated with white light at all other times in the daily 60-min session. At the start of each session, alligator clips, which were suspended from the ceiling and delivered shock, were attached to wire bands around each of the pigeons' wings. This procedure was followed whether or not shock deliveries were scheduled for a particular session. Throughout the experiment, the duration of each key peck was recorded in 5-msec class intervals.

The pigeons were exposed to the VI 1-min schedule for 21 sessions before being divided into two groups of four. For the members of one group, each peck between 35 and 50 msec in duration was followed by a 1.0-mA, 0.5-sec shock to the wings; pecks outside this duration range were not shocked. This will be called the differential shock procedure. Each pigeon in the other group (nondifferential shock) was paired with one of the pigeons in the differential shock group. Whenever a member of the differential shock group received a shock, a shock was scheduled for the next response emitted by its paired partner. Thus, the frequency and temporal pattern of shocks was similar for the two groups. This procedure was continued for 35 sessions, after which all pigeons were returned to VI without shock for 10 sessions. Then, the groups were reversed;

the previous nondifferential group received shock for each response between 35 and 50 msec and response-dependent shocks for the previous differential group were paired to those obtained by the first group. This procedure lasted for 35 sessions.

After 10 sessions of VI without shock, the set of procedures just described was recycled. Now, however, the differential shock contingency was on pecks between 10 and 25 msec in duration. For 35 sessions, one group received differential shock and the other received paired shocks that were response dependent but duration independent. After 10 more sessions of VI without shock, the groups were reversed, for 35 additional sessions. After 10 further sessions of VI without shock, the last phase of the experiment began. All pigeons received response-independent shocks at random intervals, superimposed on the VI schedule of food reinforcement. Frequency of shock delivery for each pigeon was matched to frequency of shocks that had occurred in the immediately preceding response-dependent shock procedure. After 21 sessions of this procedure, the experiment terminated.

RESULTS

Figure 1 presents responses per minute averaged across the last five sessions of each procedure, for each pigeon. All key pecks, independent of duration, were included in the computation of response rates. Paired partners are aligned horizontally. The procedures are identified on the X-axis. It can be seen that shock following 35- to 50-msec responses and nondifferential shock produced substantial suppression (for pigeons on the left of the figure, the second, fourth, and eighth bars; for pigeons on the right, the second, fourth, and sixth bars). In contrast, shock following 10- to 25-msec responses produced substantially less suppression of key pecking (for pigeons on the left, sixth bar, for pigeons on the right, eighth bar). Indeed, the magnitude of suppression produced by shock of 10- to 25-msec responses was virtually identical to that produced by response-independent shock (tenth and last bar in each panel). These data support the view that shock following short-duration responses is functionally similar to response-independent shock and that shock following long-duration responses is functionally similar

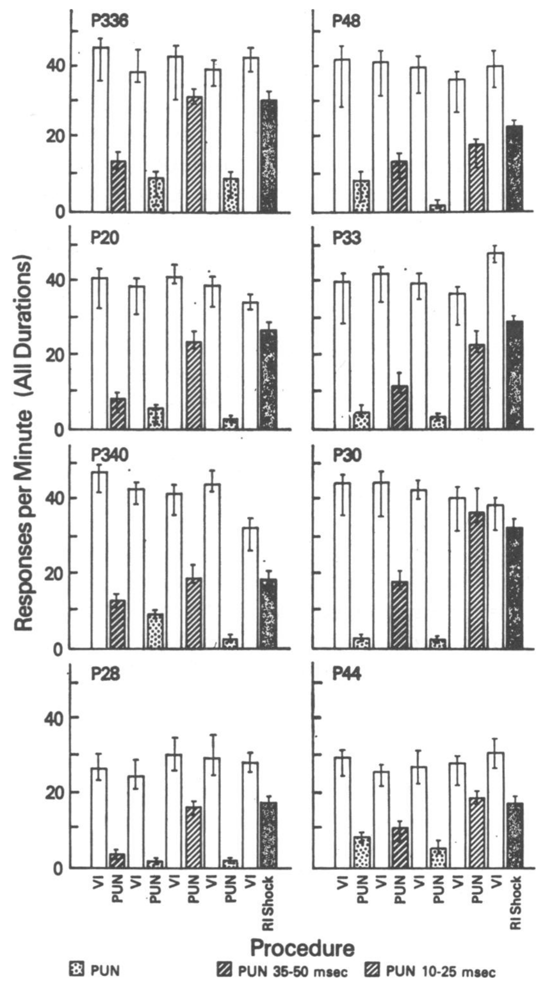

Fig. 1. Responses per minute (all durations) averaged across the last five sessions of each procedure. The procedures are identified on the x-axis. Pun 35-50 indicates shock following 35- to 50-msec responses; pun 10-25 indicates shock following 10- to 25-msec responses; pun indicates response-dependent but duration-independent shock; and R.I. shock indicates response-independent shock. The range of the daily mean response rates from the sessions represented by the individual bars is indicated by the crossed vertical line that runs through each bar. Data for individual subjects are arranged so that paired partners are aligned horizontally.

to response-dependent but duration-independent shock.

That this effect can not be attributed to shock frequency is clear from a comparison of the last bar in each panel with the one from the immediately preceding shock procedure. Shock frequency on these two procedures was matched for each pigeon. For the pigeons whose data are on the right, the immediately preceding shock procedure was of 10- to 25-

msec pecks, and suppression equalled that produced by response-independent shock. For pigeons whose data are on the left, the immediately preceding shock procedure was nondifferential, and suppression was much greater than that produced by response-independent shock.

Figure 2 presents evidence that long-duration but not short-duration responses were differentially suppressed by the differential shock procedure. The data are averaged across the last five sessions of each procedure, and paired pigeons are aligned horizontally. The first four bars in each panel present the relative frequency of 35- to 50-msec key pecks, which occurred on the procedures identified on the X-axis. The bars represent the proportion of all key pecks between 35 and 50 msec that occurred on these procedures. When only 35- to 50-msec responses were followed by shock (second bar), these responses were selectively suppressed. While 35- to 50-msec responses had comprised 10 to 25% of all key pecks during VI without shock (first bar), they comprised 3 to 9% of all key pecks when they were differentially shocked. Consideration of the range of frequences depicted by the two bars shows no overlap in relative frequency of 35- to 50-msec responses between the VI and differential shock procedures. In contrast, shock without regard to duration (fourth bar) had no selective effect on 35- to 50-msec pecks. Relative frequency of these pecks was about the same under nondifferential shock conditions as under VI without shock (third bar).

The last four bars in each panel present the relative frequency of 10- to 25-msec key pecks (proportion of all key pecks between 10 and 25 msec in duration) that occurred on procedures identified on the X-axis. Neither differential shock of 10- to 25-msec responses (sixth bar) nor nondifferential shock (eighth bar) influenced the relative frequency of these responses compared to their relative frequency during VI without shock (fifth, seventh bars).

Figure 3 presents relative frequency distributions of duration for two representative pigeons. The data are averaged across the last five sessions of each procedure, and the VI data are from the first exposure to this schedule. Hatched bars indicate 10- to 25-msec and 35- to 50-msec key pecks. It is clear from the figure that the only procedure that produced a change in the shape of the duration distribution was shock of 35- to 50-msec responses.

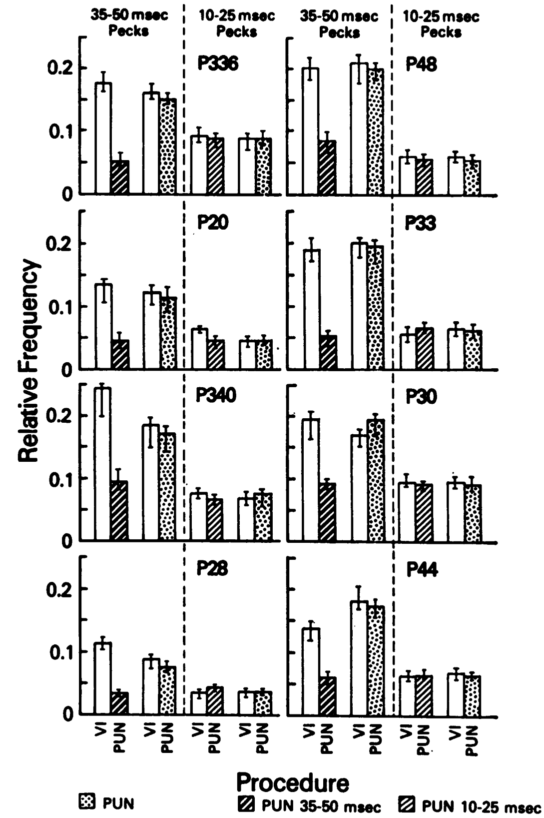

Fig. 2. Relative frequency of 35- to 50-msec and 10- to 25-msec responses that occurred in the procedures identified on the x-axis. The first four bars for each pigeon depict 35- to 50-msec responses; the last four depict 10- to 25-msec responses. The bars depict the proportion of total key pecks that fell within the specified region of the duration distribution and each bar is from a different procedure. The data are averaged across the last five sessions of each procedure, and the range of daily relative frequencies from the sessions represented by the individual bars is indicated by the crossed vertical line that runs through each bar. Paired partners are aligned horizontally.

Table 1 presents the mean number of shocks per hour and the mean number of reinforcements per hour obtained by each pigeon on each procedure that included shock. Each pair of pigeons (*e.g.*, 336-48) were yoked throughout the experiment. The table indicates that response suppression had little effect on reinforcement rate. In only one case did reinforcement rate decrease below 50 per hour, and in only six cases was it below 55 per hour. Shock rate, on the other hand, varied widely both among procedures and among pigeons. However, shock frequency comparisons between differential shock and paired

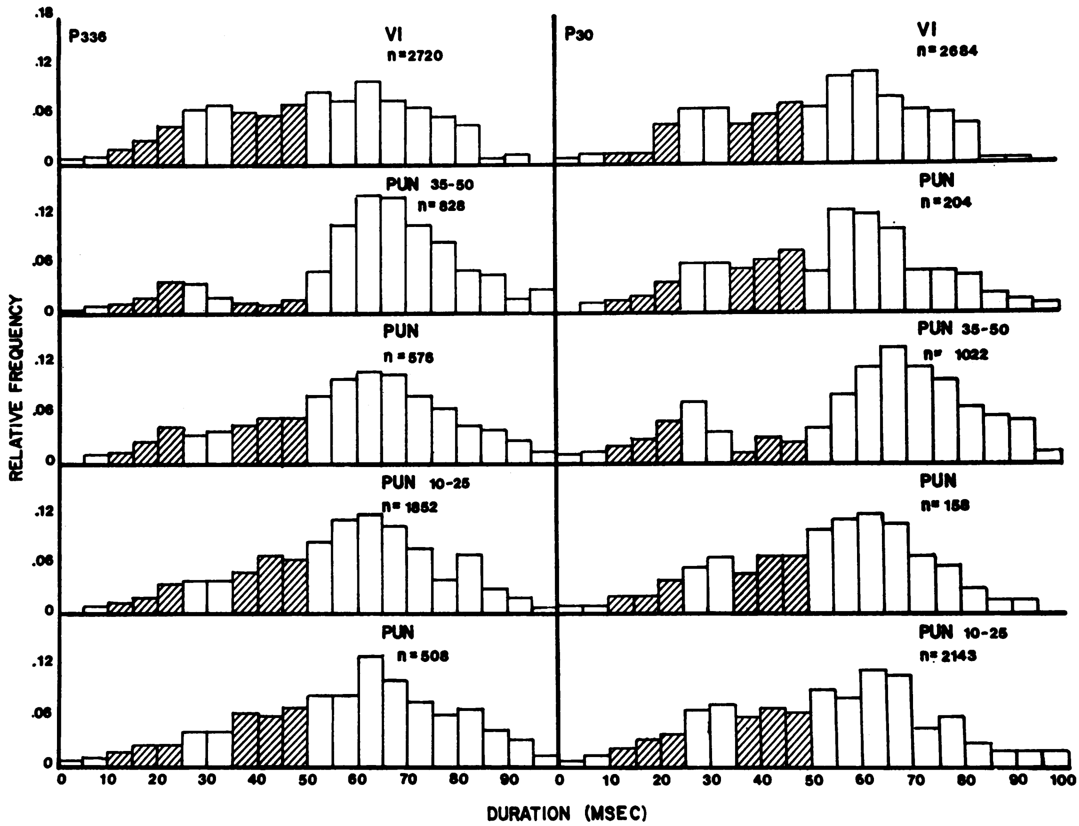

Fig. 3. Relative frequency distributions of duration for two pigeons, averaged across the last five sessions of each procedure. Durations are plotted in 5-msec class intervals, and 10- to 25-msec and 35- to 50-msec regions of the distribution are indicated by hatched bars.

nondifferential shock pigeons reveal only small differences. Consider for example, P336 and P48. While P336 received 50.4 shocks per hour when its 35- to 50-msec responses were being shocked, P48 received 48.8 shocks per hour under nondifferential shock. When conditions were reversed, P48 received 73.4 shocks per hour and P336 received 68.2 shocks per hour. These differences were typical of the other pigeons and the other procedures.

DISCUSSION

The present experiment provides clear support for the view that pigeons make more than one kind of key peck, and that only a subset

Table 1

Mean shocks per hour and mean reinforcements per hour across the last five sessions of each procedure that included shock, presented separately for each pigeon.

		Shocks/Hour					*Reinforcements/Hour*				
Procedure		*pun 35-50*	*pun*	*pun 10-25*	*pun*	*R.I. Shock*	*pun 35-50*	*pun*	*pun 10-25*	*pun*	*R.I. Shock*
A:	336	50.4	68.2	140.2	65.4	60.4	58.8	57.6	60.4	58.5	59.8
	48	73.4	48.8	72.2	136.3	68.0	61.2	55.8	59.6	52.4	61.2
B:	20	19.0	29.5	72.3	74.4	72.0	62.6	58.8	59.8	55.0	59.0
	33	31.8	16.1	92.5	69.1	89.2	61.6	57.0	59.6	53.2	62.2
C:	340	70.0	87.5	79.6	108.1	102.4	59.8	61.4	61.0	52.4	61.2
	30	91.2	63.2	148.8	68.8	142.2	60.6	50.8	59.6	51.6	60.0
D:	28	7.2	36.4	40.1	69.7	71.8	51.2	57.4	60.4	48.2	59.8
	44	43.0	7.0	80.0	38.7	79.4	61.4	61.0	59.6	56.4	59.4

of key pecks is actually controlled by contingencies of reinforcement and punishment (Schwartz and Williams, 1972). When short-duration responses are shocked, pigeons behave as if shock were response independent. When long-duration responses are shocked, these responses are differentially suppressed.

Schwartz and Williams (1972) found that short-duration responses occur with highest frequency on the omission procedure, (Williams and Williams, 1969), and one might imagine that this procedure creates tendencies to peck (owing to positive stimulus-reinforcer correlations) and tendencies not to peck (owing to negative response-reinforcer correlations) at the same time. Such a conflict might result in weak pecks or in pecks that barely brush the edge of the key. One would expect, however, that the shock employed in the present experiment would have similar effects. The data in Figure 3 reveal that this was not the case. Shock of 35- to 50-msec responses did not increase the frequency of short-duration responses; instead, the suppression of 35- to 50-msec responses was accompanied by an increase in the relative frequency of responses that were even longer. Similarly, shock of 10- to 25-msec responses and nondifferential shock did not increase frequency of short-duration responses. It would not be surprising if each of these procedures increased frequency of "weak strikes" and "glancing blows". The point is that such a presumed change in response topography is not correlated, in the present experiment, with changes in response duration.

There are other grounds for taking issue with the interpretation offered here. If there were two different classes of peck, identified by duration, one would expect that distributions of duration would be bimodal, or at least be sufficiently disjunctive that one could easily tell where the short-duration distribution stopped and the long-duration distribution began. The distributions in Figure 3 provide no evidence for the existence of two separate distributions. It seems likely that response duration is just an epiphenomenal correlate of some other property of responses which, if measured, might yield much clearer effects. Response force is one likely candidate. Other candidates include beak position (open or closed) and angle of strike. It is important to note, however, that if one accepts that duration is only an index of the "real" underlying distinguishing feature of these two classes of pecks, the effects obtained in this experiment become quite remarkable. Differential suppression during the punishment of 35- to 50-msec peck procedure was extremely accurate. Suppression tended to spread no more than 5 msec on either side of the punished region of the distribution. This precision seems to imply either that pigeons are in fact sensitive to the duration of their responses, or that the correlation between duration and the unidentified property of responses to which pigeons are sensitive is very high. Neither of these possibilities provides a problem for the interpretation of the present data. Duration seems to be, at the least, a convenient metric for distinguishing pecks that are sensitive to response-reinforcer relations from pecks that are insensitive to these relations.

REFERENCES

Azrin, N. H. and Holz, W. C. Punishment. In W. K. Honig (Ed), *Operant behavior: areas of research and application.* New York: Appleton-Century-Crofts, 1966. Pp. 380-447.

Church, R. M. Response suppression. In B. A. Campbell and R. M. Church (Eds), *Punishment and aversive behavior.* New York: Appleton-Century-Crofts, 1969. Pp. 111-156.

Hoffman, H. S. and Fleshler, M. Aversive control in the pigeon. *Journal of the Experimental Analysis of Behavior,* 1959, **2,** 213-218.

Rachlin, H. and Herrnstein, R. J. Hedonism revisited: on the negative law of effect. In B. A. Campbell and R. M. Church (Eds), *Punishment and aversive behavior.* New York: Appleton-Century-Crofts, 1969. Pp. 83-109.

Schwartz, B. and Gamzu, E. Pavlovian control of operant behavior: an analysis of autoshaping and its implications for operant conditioning. In W. K. Honig and J. E. R. Staddon (Eds), *Handbook of operant behavior.* Englewood Cliffs, New Jersey: Prentice-Hall, 1977.

Schwartz, B., Hamilton, B., and Silberberg, A. Behavioral contrast in the pigeon: a study of the duration of key pecking maintained on multiple schedules of reinforcement. *Journal of the Experimental Analysis of Behavior,* 1975, **24,** 199-206.

Schwartz, B. and Williams, D. R. Two different kinds of key peck in the pigeon: some properties of responses maintained by negative and positive response-reinforcer contingencies. *Journal of the Experimental Analysis of Behavior,* 1972, **18,** 201-216.

Williams, D. R. and Williams, H. Auto-maintenance in the pigeon: sustained pecking despite contingent non-reinforcement. *Journal of the Experimental Analysis of Behavior,* 1969, **12,** 511-520.

Received 15 April 1976.
(Final Acceptance 1 November 1976.)