KEY PECKING UNDER RESPONSE-INDEPENDENT FOOD PRESENTATION AFTER LONG SIMPLE AND COMPOUND STIMULI[1]

JOHN A. RICCI

KANSAS STATE UNIVERSITY

Sixteen pigeons were trained to peck a key using a response-independent (auto-shaping) procedure of food presentation. The 4-sec grain presentations were independent of responding but a keylight stimulus preceded each, with a 4-min interval between the grain presentation and the next stimulus. Subjects were divided into four groups, with two durations of the keylight (30 or 120 sec) and either one or four successive colors on the response key preceding food delivery. In Phase 2, the birds were continued with the same keylight duration but were presented the alternative number of key colors. All pigeons pecked the key during the stimulus. Birds in the two groups with the 30-sec stimulus duration began to respond significantly sooner than birds with the 120-sec duration. There were no significant differences in rate of pecking between groups by the last five days of Phase 1. In Phase 1, the pigeons exposed to the four stimulus components showed an increase in rate of pecking over the four components as grain presentation approached. The pigeons with one stimulus component did not exhibit this regularity. Analogous conditions in Phase 2 had similar results except for one group. The implications of the occurrence of key pecking due to response-independent food delivery for multiple and chained schedules were pointed out.

Two procedures are commonly used in "shaping" pigeons to key peck. The first, and most widely known, is the method of reinforcing successive approximations of the key-peck response (Ferster and Skinner, 1957). In this procedure, grain presentations are response dependent. The second method, often called auto-shaping, has only recently received much attention (Brown and Jenkins, 1968; Gamzu and Williams, 1971; Rachlin, 1969; Williams and Williams, 1969). This latter procedure differs from the first in that food presentations are scheduled independently of responding and follow keylight presentations. Using this response-independent method, pigeons will peck at a stimulus that is intermittently presented on the response key in a well-lighted box if the presentation of that stimulus regularly precedes access to food.

Brown and Jenkins (1968) showed that the presence of the stimulus preceding the grain presentation is necessary for the occurrence of the directed response-independent key pecking. Williams and Williams (1969) presented convincing evidence that response-independent key pecking is not primarily the result of adventitious reinforcement of the key-peck response. Several investigators (e.g., Gamzu and Williams, 1971) pointed out that pairings of stimuli and grain presentations that were sufficient to produce response-independent (non-adventitious) pecking, were also present in some more conventional response-dependent procedures. They suggested that perhaps purely response-independent effects can influence the results of response-dependent procedures where the presence of a keylight is correlated with access to grain.

Up to the present, however, durations of the keylight that have been reported to produce response-independent key pecking have ranged from 3 to 8 sec only, and show little evidence that this effect is not confined to a brief period just before grain presentation. The present experiment used durations of the keylight stimulus of 30 and 120 sec. Durations of this

order justifiably allow comparisons with standard response-dependent procedures where grain presentations are correlated with key color, such as in some multiple schedules.

Another variable examined here is the number of discrete stimulus components in sequence that make up the keylight stimulus. The use of sequential cues with a response-independent procedure will allow comparisons of the present procedure with responding maintained on response-dependent schedules where a sequence of cues is temporally related to the occurrence of grain presentations, such as in fixed-interval (FI) chain schedules.

METHOD

Subjects

Sixteen experimentally naive White King pigeons, obtained from a local supplier, were maintained at 75% of their free-feeding weight by daily sessions in the apparatus and, when necessary, by supplementary feeding in their home cages. One other subject died on the third day of the experiment and was replaced.

Apparatus

Two identical test chambers (Grason-Stadler, E6446CA) were each equipped with a transparent response key 5 in. (12.5 cm) above a solenoid-actuated food magazine. Each had a 10-W lamp mounted above the magazine which illuminated the opening on every grain presentation, and a 10-W lamp mounted on the far right of the panel, at approximately the same height as the response key, which provided general illumination at all times except during magazine presentation. Any of four colors (red, blue, green, or yellow) from a Multiple Stimulus projector (Grason-Stadler, #45801) could be presented on the key. A relay mounted inside the chamber provided auditory feedback whenever a response was made in the presence of the keylight but not during the intertrial intervals.

White noise, which ranged between 62 and 78 dB inside the test chambers (as measured on the A scale of a General Radio Co. sound level meter), masked extraneous noise. In an adjacent room, relay operated switching circuits, steppers, and clocks controlled both boxes; counters and print-out counters recorded responses. With this arrangement, two birds were run simultaneously, presumably without cues from the other box or control room.

Procedure

The pigeons, after being randomly divided into four groups, were all given magazine training. The experimenter held the deprived bird over the raised and filled magazine until the animal began to eat. He then carefully released the bird while the subject was still eating and closed the experimental chamber. After the pigeon had eaten for about 30 sec, the experimenter lowered the magazine and then quickly raised it again. Then, by presenting successively shorter periods of access to grain at successively longer intervals of time, the birds were trained to eat from the grain magazine within 4 sec of its presentation. This entire process took between five and 15 grain presentations. Special care was taken to avoid shaping the birds to peck the key. To assure that the birds would continue to eat, the first five presentations of food in the first conditioning session were of 10-sec duration, and the next five, of 8-sec duration; all subsequent magazine presentations were 4 sec. Immediately after magazine training, the birds were given the first 30 trials.

The experiment consisted of two phases. Table 1 summarizes the main features of the experiment. The first number in all group names refers to the total keylight duration in seconds; the second, to the number of components in Phase 1, and the third, to the number of components in Phase 2.

Phase 1 of the experiment was a simple 2 by 2 design. Two groups were trained under a 120-sec total stimulus duration. Group 120: 1-4 was presented a single color for 120 sec on every trial. Group 120: 4-1 was presented a series of four different colors in sequence each of 30-sec duration on every trial. Two other groups were trained under a 30-sec total stimulus duration. Group 30: 1-4 had only one color presented for the entire 30 sec; Group 30: 4-1 had four 7.5-sec colored stimuli presented in sequence on every trial. The orders of stimulus presentation used for the groups with four stimuli were ABCD, DCBA, BDAC, and CADB (A = yellow, B = green, C = red, D = blue), with one subject in each group having one of the orders. In each group with a single stimulus, each bird had a different color

Table 1

Summary of Procedure

	Procedure					
	Phase 1			*Phase 2*		
Group Name	*Stimulus Duration*		*Number of Components*	*Stimulus Duration*		*Number of Components*
	Total	*Component*		*Total*	*Component*	
Group 30: 4-1	30 sec	7.5 sec	4	30 sec	30 sec	1
Group 30: 1-4	30	30	1	30	7.5	4
Group 120: 4-1	120	30	4	120	120	1
Group 120: 1-4	120	120	1	120	30	4

stimulus. Figure 1 presents a schematic representation of these stimuli.

Sessions of 30 trials with intertrial intervals of 4 min were conducted for 20 consecutive days. The magazine was always presented at the offset of the keylight. Pecking in no way influenced either the stimuli or magazine presentation. The only effect of pecking was to produce the relay click during the stimulus periods. Responses were recorded during each quarter of the stimulus and during the intertrial intervals.

At the conclusion of Phase 1, 16 additional sessions were given for a second phase. During Phase 2, the subjects received a keylight of the same duration as in Phase 1 but were presented with the alternative number of stimulus components; *i.e.*, the groups with one color for the stimulus during Phase 1 had four colors for the stimulus in Phase 2, and *vice versa*. The color that had been the single stimulus in Phase 1 now became the initial stimulus for
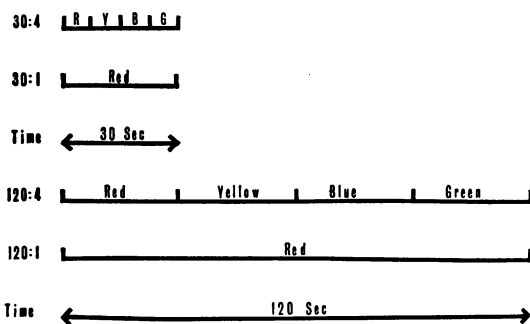

Fig. 1. Schematic diagram of the stimuli presented to the four groups. The specific color sequence is an example of the four sequences actually used for different subjects.

the four-component sequence in Phase 2. Analogously, the initial stimulus in four-component conditions of Phase 1 became the single stimulus used in Phase 2; *e.g.*, pigeons that received single stimulus D in Phase 1 received the sequence DCBA in Phase 2, and pigeons that received the sequence BDAC in Phase 1 received the single stimulus B in the second phase. Phase 2 was simply an interchange of number of stimulus components within duration conditions. In all other respects, the procedure was the same as Phase 1.

RESULTS

Figure 2 presents rates of responding during the stimulus on each day of the experiment for the four birds in each group. Each point represents mean responses per second for each subject on one day of training. The four panels in Figure 2 divide the subjects into their respective groups as indicated. This figure shows that all subjects pecked the key during the keylight presentation. In addition, considerable overlap can be seen in the response rates of individual subjects from one group to another. All but two subjects achieved a response rate of at least 0.1 response per second during Phase 1. These two birds, both in Group 120: 1-4, increased their rates of responding during Phase 2. All birds, except A-13, pecked during the stimulus at a rate of 0.3 response per second or better on at least one day of the experiment.

Although there were obvious differences in group rates for the first several days of Phase 1 (where all subjects in Group 120: 1-4 had essentially a zero rate) these differences were not
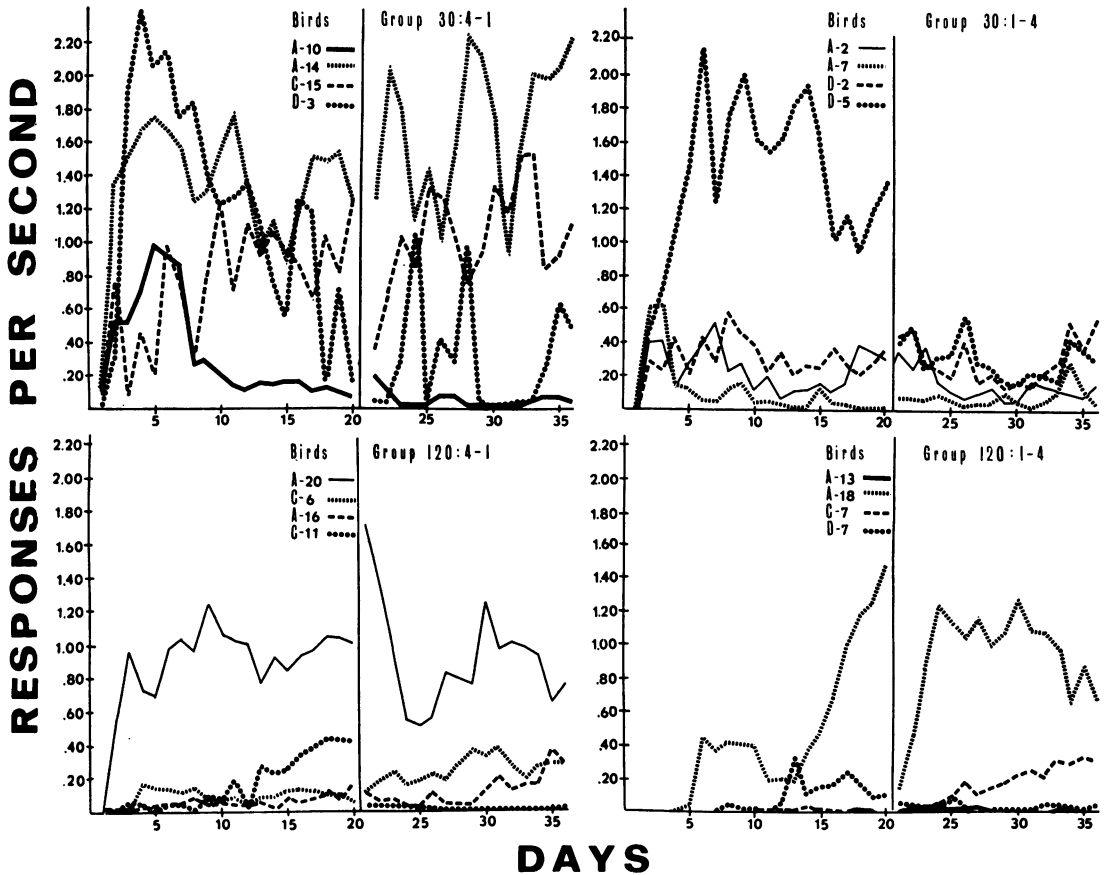
Fig. 2. Mean responses per second during the stimulus on each day of the experiment for the four birds in each group. Each panel shows response rates for the individual subjects in each separate group as labelled.

maintained throughout the experiment. Differences in the mean rates of pecking for the last five days of Phase 1 do not approach statistical significance (F (3,12) = 0.69).

Differences in rates of responding between groups during the initial portion of the experiment can be attributed to differences in when the birds began to respond. Two-tailed Mann-Whitney U-tests (1947) were used to determine if the groups with 30- and 120-sec keylight durations differed in the trial number of the first, fifth, and tenth pecks. Although differences in the trial number of the first peck were not significant (U (8,8) = 29, p < 0.40), differences in both the trial number of the fifth peck (U (8,8 = 11, p < 0.028) and the trial number of the tenth peck (U (8,8) = 5, p < 0.002) were statistically significant. The birds exposed to the 30-sec stimulus made their fifth and tenth pecks reliably sooner than the birds exposed to the 120-sec stimulus.

There were no clear effects of number of components on the initiation of responding (first peck U (8,8) = 21, p < 0.14; fifth peck U (8,8) = 14.5, p < 0.04; tenth peck U (8,8) = 20, p < 0.12). However, the birds receiving a four-component stimulus tended to peck sooner than the birds receiving a one-component stimulus for both the 30- and 120-sec stimulus conditions.

Figure 3 presents separately for each group the mean number of stimulus periods during which there was at least one peck on each day of the experiment. Number of trials up to a possible maximum of 30 per day is plotted as a function of days of training. During Phase 1, the two groups with 30-sec stimuli approximated asymptotic performance on this measure after the first day, while Group 120: 4-1 took four days to reach a comparable level. These three groups pecked on more than two-thirds of the trials for the remainder of the
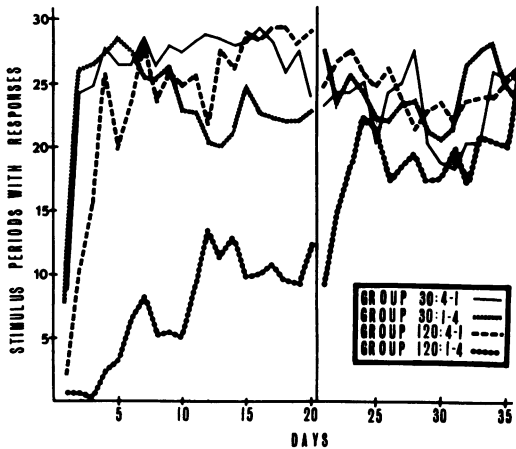
Fig. 3. Mean number of stimulus periods during which there was at least one peck on each day of the experiment, plotted separately for each group.

experiment (excepting two days in Phase 2 for Group 30: 4-1). The lower means in Phase 1 for Group 120: 1-4 are due almost entirely to the performance of two pigeons with low rates

in that group. During Phase 2, the performance of this latter group was more in line with the performance of the other three groups. The data presented in this figure clearly show the degree of consistency with which the subjects were pecking the key, even though there were variations in individual rates of responding.

The distributions of responses within the stimulus are presented in Figure 4. Days are plotted along the abscissa and the ordinate represents the mean per cent of total responding. Each subject's daily responses were counted separately during four equal time intervals, each corresponding to one quarter of the stimulus. Per cent responding in each quarter was calculated for each subject, and then mean per cent was calculated for the four subjects in each group. Each curve in this figure represents the mean per cent of the responding during successive quarters of the stimulus and is labelled from I to IV in order of distance from the grain presentation. That
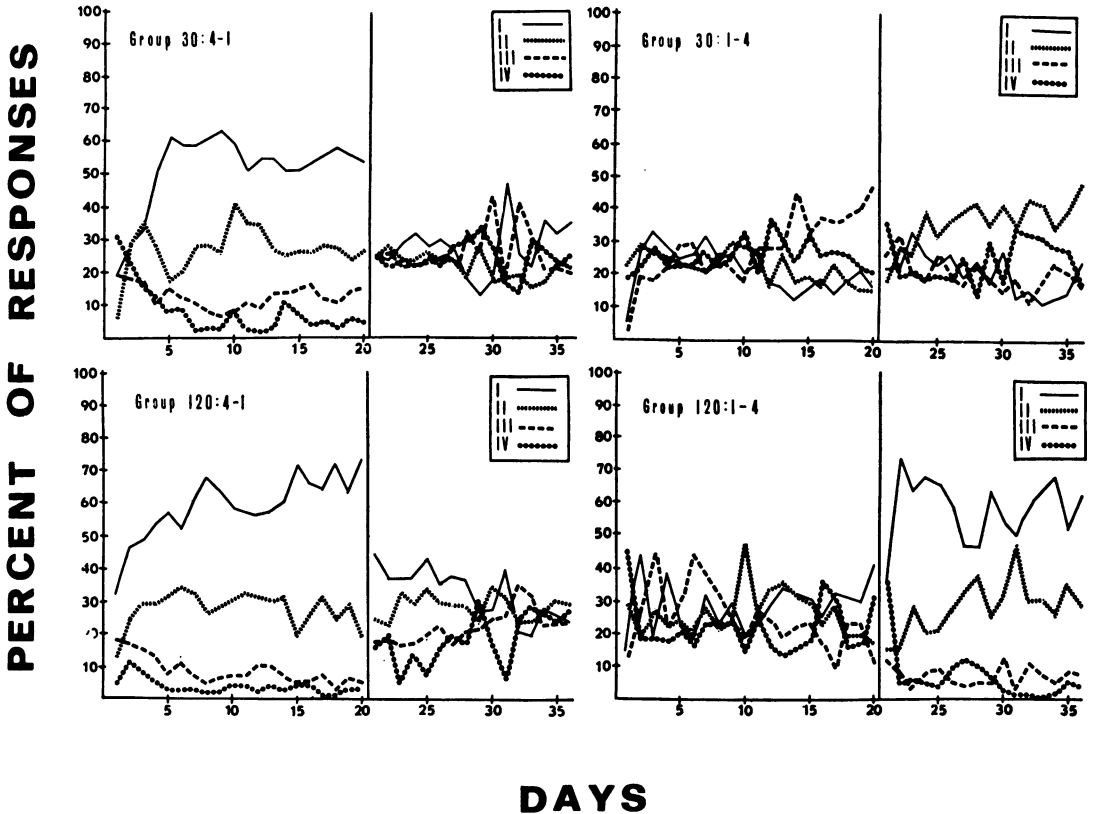

Fig. 4. Per cent distributions of responses during the stimulus quarters on each day of the experiment, plotted separately for each group. Each panel shows distributions for each separate group as labelled.

is, under four-component conditions these intervals correspond to the length of time each colored component stimulus was present, and under the one-component conditions these intervals simply divide the stimulus into four equal parts. For example, in the upper left-hand panel of Figure 4, curve I presents the mean per cent of responding in the 7.5 sec just before magazine presentation for Group 30: 4-1. Curve IV in the same panel presents the mean per cent of responding for the group in the first 7.5 sec after the keylight stimulus onset.

The remaining three panels present the comparable data for the other groups, as labelled. All points in each panel are based on the four birds in each group, except for Group 120: 1-4 where the Phase 1 results are on the performances of only two birds, D-7 and A-18. The other two birds in this group, C-7 and A-13, responded on only eight and two days, respectively, in the first phase. Both of these latter birds responded on all days in the second phase, and thus the Phase 2 results are plotted for all four birds.

The left-hand panels show response distributions for the groups with a four-component stimulus initially. In these panels, the Phase 1 results are distributed in an ordered fashion with the greatest number of pecks occurring in the interval just before magazine onset (I), and the smallest number of pecks occurring in the interval furthest away from magazine onset (IV). Every subject in Group 30: 4-1 showed this exact order on at least 15 of the 20 days in Phase 1; that is to say, this group effect was also obtained for each individual subject. In Group 120: 4-1, two birds, C-11 and A-20, showed this exact ordering on at least 17 of the 20 days, while the other two subjects in that group showed less-marked tendencies in the same direction.

The right-hand panels of Figure 4 present the response distribution data under conditions where a single component constituted the stimulus in Phase 1. Although individual subjects were fairly consistent in the manner in which their pecks were distributed from day to day, there were no clear group trends in response distributions during Phase 1.

Phase 2 results show once again responses distributed in an ordered fashion, with the greatest amount of pecking occurring during the interval just before magazine onset (I) for

Group 120: 1-4. Group 30: 1-4 was the only group where the four-component condition failed to produce an ordering of response distributions over the stimulus period at any time in the experiment. No group trends were apparent for this group.

Phase 2 one-component conditions, Group 30: 4-1 and Group 120: 4-1, yielded results similar to the initial one-component conditions, *i.e.,* no apparent group trends.

There was little or no pecking during the intertrial intervals for any bird. After the second day of training, every subject made at least 10 pecks during the stimulus periods for every one peck in the intertrial intervals. It is noteworthy that the intertrial intervals were two or eight times as long as the stimulus periods for the 120- and 30-sec groups respectively.

DISCUSSION

The main finding is that keylight durations of 30 and 120 sec produce and maintain key pecking in response-independent procedures. This is a considerable extension of the range of stimulus durations that have been studied with this type of procedure.

Williams and Williams (1969) demonstrated that pigeons tend to peck the key in response-independent procedures, even if the response serves to eliminate grain presentations. The pecking they observed cannot be dismissed as a "superstitious" behavior because their procedure precluded "accidental" reinforcement of key pecking and, in fact reinforced "not key pecking". Although the present study made no specific attempt to control for the effects of accidental reinforcement of pecking, in the light of the results of Williams and Williams it seems safe to maintain that the present results also cannot be attributed entirely to adventitious reinforcement.

The present data, along with previous related work, imply that whenever there are incidental pairings of keylight and food in procedures using pigeon subjects, there may also be an increased pecking tendency that is not the result of adventitious reinforcement. Gamzu and Williams (1971) showed this to be so even if the extent of the "pairing" is simply differential probability of grain presentation during two discriminable stimulus periods. The present experiment demonstrated that

stimuli that precede grain presentations by as much as 2 min may produce response-independent key pecking. Considering both of these findings, it seems plausible that the results of response-dependent procedures, such as discriminated operant schedules, which have incidental pairings between keylight and food, are confounded with an additional key-pecking tendency that is not the result of the response-reinforcer relationship. Discriminated operant procedures regularly employ discriminative stimuli of about the same duration as the stimuli used in the present experiment and food presentations occur on temporal schedules similar to the one used by Gamzu and Williams (1971). The positive behavioral contrast often observed in these procedures (*e.g.,* Reynolds, 1961) might be due, at least in part, to the effect of a response-independent key-pecking tendency during the positive discriminative stimulus.

Up to the present, response-independent procedures have generally employed only two stimulus conditions, one that preceded the grain presentation, and the other that was present at all other times. Variations of this procedure have included illumination of the key as the stimulus paired with grain presentation (Brown and Jenkins, 1968, Experiment IV); offset of key illumination as the paired stimulus (Brown and Jenkins, 1968, Experiment III); and constant key illumination where color change served as the paired stimulus (Gardner, 1969). In the present study, the single-stimulus conditions were similar to these former studies; and as in these studies, substantial pecking was observed only during the stimulus that preceded grain presentations and not during the intertrial intervals.

The present study differed from others in that in the four-component conditions a sequence of keylights preceded grain presentations. The use of four stimulus components in sequence resulted in an increasing rate of pecking over the components as the time of grain presentation approached. The use of stimuli in fixed sequence is similar to at least one response-dependent procedure, *i.e.,* chained FI schedules of reinforcement.

In such schedules, stimuli are incidentally paired with grain presentations. In this case, one stimulus always precedes food presentation, and the others never precede food presentation. An effect often obtained with these

procedures is that pigeons fail to maintain pecking in the initial components of longer chains (*e.g.,* Gollub, 1958). The procedure employed with four-component groups in the present study (with the addition of an intertrial interval) resembles an FI chain, and here, as in the response-dependent procedure, few responses are emitted during the initial components of the sequence. It is conceivable that the stimulus relationships present in the chain schedules may influence pecking independently of the reinforcing operation.

The influence of sequences of stimuli upon responses that are independent of their consequences is not without precedent. Hendry, *et al.,* (1969) presented response-independent shocks to rats at 6-min intervals while bar pressing was being maintained on a variable-interval schedule of reinforcement. For some rats, a single stimulus condition was maintained between shocks while for others a sequence of three stimuli each lasting 2 min was interspersed between shocks. When three stimuli were used, the rate of bar pressing decreased with each successive stimulus component, the lowest rate being in the component just preceding shock presentation. Although there was an immediate increase in bar pressing after shock with either one or three cues, with one stimulus there were no apparent differences in bar-pressing rates for the two 2-min intervals preceding shock. These results are quite comparable to the present results and seem to imply a commonality between the results of aversive and appetitive response-independent procedures.

REFERENCES

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.

Ferster, C. B. and Skinner, B. F. *Schedules of reinforcement.* New York: Appleton-Century-Crofts, 1957.

Gamzu, E. and Williams, D. R. Classical conditioning of a complex skeletal response. *Science,* 1971, 171, 923-925.

Gardner, W. M. Auto-shaping in bobwhite quail. *Journal of the Experimental Analysis of Behavior,* 1969, 12, 279-281.

Gollub, L. R. *The chaining of fixed-interval schedules.* Unpublished doctoral dissertation, Harvard University, 1958.

Hendry, D. P., Yarczower, M., and Switalski, R. C. Periodic shock with added clock. *Journal of the Experimental Analysis of Behavior,* 1969, 12, 159-166.

Mann, H. B. and Whitney, D. R.　On a test of whether one of two random variables is stochastically larger than the other. *The Annals of Mathematical Statistics,* 1947, **18,** 50-60.

Rachlin, H.　Auto-shaping of keypecking in pigeons with negative reinforcement. *Journal of the Experimental Analysis of Behavior,* 1969, **12,** 521-531.

Reynolds, G. S.　Behavioral contrast. *Journal of the Experimental Analysis of Behavior,* 1961, **4,** 57-71.

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.