

## EFFECTS OF VARYING THE DURATION OF GRAIN PRESENTATION ON AUTOMAINTEANCE<sup>1</sup>

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In a series of three experiments the effects of variation in grain duration on automaintenance were evaluated. In the first experiment, key illumination was followed by grain only when pigeons did not peck the key. Each subject was exposed to 2-, 4-, and 8-second feeder durations in blocks of 10 sessions. Subjects pecked on a high percentage of trials at all feeder durations. The mean peck latency was shorter in the 8-second condition than in the two other conditions in five of six subjects. The conditional probability of pecking given successive keylight-grain pairings did not increase as the number of pairings increased. The second experiment was identical to the first, except that key pecking had no scheduled consequence. Under these conditions, all three subjects showed substantial responding. The recorded measures showed no systematic relationship to feeder duration in this study. In the third experiment, two different stimuli were followed by feeder presentations of either identical (2- or 8-second) or different (2- and 8-second) durations within each session. Subjects tended to respond sooner and with a higher overall rate in the presence of the stimulus associated with the longer feeder duration only when different feeder durations were presented within the same session. This result was confirmed by direct observation of the pigeons. The results of these experiments suggest that the effects of varying grain duration may be small, compared to the effects of varying other variables. The results also suggest that the location as well as the frequency of pecking may be an important measure in the analysis of factors controlling the pigeon's key peck.

*Key words:* automaintenance, autoshaping, omission, reinforcer duration, key peck, pigeons

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In operant-conditioning procedures, pigeons' key pecking seems to be influenced by variation in feeder duration only when birds are exposed to different feeder durations correlated with different stimuli within an experimental session (Catania, 1963; Shettleworth and Nevin, 1965; Todorov 1973). It is, therefore, possible that these effects are a result of differential Pavlovian conditioning. This suggestion is plausible in light of recent autoshaping experiments that have shown pigeons' key pecks to be strongly influenced by stimulus-reinforcer relationships (Gamzu and Williams, 1973, Gamzu and Schwartz, 1973, Wasserman, Franklin, and Hearst, 1974). The

present series of experiments was designed to examine the conditions under which variations in feeder duration affect behavior maintained by stimulus-reinforcer contingencies.

### EXPERIMENTS I AND II

Williams and Williams (1969) found that when a change in key illumination was followed by grain, pigeons would peck the key even when responses cancelled grain for that trial. Inasmuch as the response-reinforcer and stimulus-reinforcer contingencies are in opposition in this procedure (omission procedure), the persistence of key pecking has been interpreted as a demonstration of a relatively stronger control over key pecks by the stimulus-reinforcer contingency (Schwartz and Williams, 1972). If increases in feeder duration strengthen key pecking in this procedure, the manipulation may be interpreted as having a relatively greater effect on the control exerted by stimulus-reinforcer relationships than on the control exerted by response-reinforcer relationships.

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Experiment I was conducted to evaluate the effects of variation in grain duration on behavior maintained by an omission procedure in an attempt to provide a strong demonstration of the effects of feeder duration on behavior maintained by stimulus-reinforcer contingencies. The effects of varying feeder duration were found to be slight in this experiment.

The failure to find substantive effects of grain duration in the first experiment may have resulted from an attenuation of responding by the omission contingency (Barrera, 1974). Experiment II was designed to assess the effects of exposure to different durations of grain presentation on the key pecking engendered by a classical conditioning delay procedure, in which grain presentations immediately followed the termination of aperiodic key illuminations of fixed duration, regardless of whether or not responding occurred.

## METHOD

### *Subjects*

Eight pigeons were maintained at approximately 80% of their free-feeding weights throughout the experiments. Four subjects (B-1, B-2, B-3, B-4) had a history of exposure to several automaintenance procedures; the remaining four were experimentally naive. Subjects A-9, A-10, A-11, A-12, B-1, and B-2 participated in Experiment I; Subjects A-9, B-3, and B-4 in Experiment II.

### *Apparatus*

The apparatus consisted of a Lehigh Valley Electronics two-key pigeon chamber measuring 30 by 46 by 45 cm. The keys were located 35 cm above the floor and 14 cm from the sides. The key on the right-hand side of the response panel remained covered by a metal plate at all times. The other key was illuminated during trials by two GE #1820 bulbs in series, with 63  $\Omega$  of fixed resistance and a 28-V power source. The feeder aperture was located directly between the two keys and 9.5 cm above the floor. General illumination of the chamber was provided by two unshielded GE #1820 bulbs located in the upper-right corner of the response panel. The houselight remained on at all times, except during feeder operation. Continuous white noise helped to mask extraneous sounds. Standard electro-

mechanical programming equipment adjacent to the experimental chamber was used to control the experiment and record data.

### *Procedure*

All subjects were trained to eat from the hopper in two sessions. The food magazine was raised until each bird had its head in the magazine aperture for 30 sec. The magazine was then operated on a variable-time 38-sec (VT 38-sec) schedule. Hopper presentations were either 2, 4, or 8 sec in duration. Each training session consisted of five hopper presentations of each duration. This yielded a total of 15 hopper presentations in each of the two pre-experimental sessions. The specific sequence of hopper durations was the same randomly generated order for all subjects.

On the third day, and on subsequent days for the remainder of the experiments, each pigeon was placed in the experimental chamber for sessions consisting of 40 trials. During a trial, the response key was illuminated for 8 sec. If no key pecks occurred while the key was illuminated, the key darkened at the end of a trial and grain was presented. During Experiment I, trials in which a key peck occurred did not differ from those previously described; however, these trials were not followed by grain presentations. In Experiment II, grain was presented following a trial regardless of the birds' behavior. Key pecks had no scheduled consequences at any other time. Trials were scheduled by a tape programmer on an equal-probability VT schedule (Catania and Reynolds, 1968) with a mean intertrial interval (ITI) of 30 sec.

The experimental manipulation consisted of varying the duration of grain presentations. Each condition consisted of 10 successive sessions during which each bird was exposed to one of the three different feeder durations. In Experiment I, the order of exposure to each of the conditions was counterbalanced as much as possible. Each subject was exposed to each of the conditions once and then re-exposed to the initial condition. The four naive subjects were equally divided between the 2-sec and 8-sec conditions during their initial exposure to the procedure.

In Experiment II, each subject was exposed twice to conditions in which the feeder duration was 2 or 8 sec, and to a 4-sec condition once. The first series of conditions exposed

all subjects to a 2- then an 8-sec condition. In the second series of exposures, the order of the condition was counterbalanced across subjects.

## RESULTS

### Experiment I

The naive birds initially exposed to a 2-sec hopper duration did not differ from those exposed to 8-sec presentations in their acquisition of the key-pecking response. All subjects began responding within 50 trials of the beginning of training.

Subjects pecked at least once on an average of about 60, 63, and 65% of the trials in the 2-sec, 4-sec, and 8-sec conditions respectively. This represents the average across all six subjects during the last five days of their initial exposure to a particular hopper duration. These group data are representative of the lack of any consistent effects of hopper duration on the number of trials with a peck within subjects. Rate of responding also did not show any systematic effects of the manipulation across or between subjects.

Table 1 shows the mean latency to the first peck on trials with a peck for all birds. Latency on trials with a peck, rather than the overall latency, is presented to facilitate comparison between birds. The mean latency is slightly longer during the 2- and 4-sec conditions than the 8-sec condition in five of the

Table 1

The mean latency to the first peck on trials with a peck is shown for individual subjects during the last five days of initial exposure to each hopper duration. The range of the latencies that compose each mean are presented below the appropriate numbers. The bottom row shows the group means and ranges.

S#	Feeder Duration		
	2-sec	4-sec	8-sec
A-9	4.02 3.54-4.56	4.14 3.42-5.04	3.30 3.00-4.08
A-10	4.74 3.72-5.28	4.86 4.50-5.34	3.60 2.58-4.74
A-11	3.84 3.12-4.62	3.66 2.40-4.38	3.48 2.94-3.84
A-12	5.40 5.04-5.76	5.34 4.62-6.36	4.08 3.84-4.50
B-1	4.74 4.26-5.22	5.04 4.32-6.36	4.44 3.42-4.92
B-2	4.92 2.82-6.06	3.66 2.82-4.02	5.46 5.04-5.94
Group	4.64 2.82-6.06	4.50 2.40-6.36	4.08 2.58-5.94

six subjects. There is no consistent difference exhibited in this measure when comparing the 2- and 4-sec determinations within a subject. The duration of the trial stimulus is approximately 8 sec long and the change in latency between the 2- and 8-sec conditions ranges (excluding B-2) from about a 0.33- to a 1.33-sec decrease, with the average difference equal (including B-2) to a little more than 0.5 sec.

Although the overall probability of a peck remained roughly constant across conditions, differences between the conditions might be reflected in an analysis of the sequential characteristics of the data. Figure 1 shows the conditional probability of a peck given a fixed number of consecutive stimulus-grain pairings (trials without a peck) for all three hopper durations. The group functions are representative of individual performance, therefore, data from all birds in all conditions were used to compute each point on the graph. The inclusion of the reversal data did not change the form of the distributions; their inclusion thus permits an increase in the number of observations on which the figure is based. The total number of pecks used to compute the measure depicted is shown in the upper-right corner of the figure. It is evident that the conditions do not differ on this measure, either in the magnitude or form of the function. The functions describing the probability of not pecking, given a fixed number of preceding trials without a pairing (trials with pecks), for the different conditions, are shown in Figure 2. Again, there are no obvious differences between conditions. In all cases, the function peaks at zero prior trials without a pairing and then declines to a lower asymptote at about three previous trials without a peck. These data may be characterized as indicating that when a pigeon is responding there is a tendency to continue to do so, and when the bird is not responding there is a tendency to remain that way. The tendency to change between these two states seems rapidly to reach an asymptotic level as a function of the number of successive pairings or nonpairings.

### Experiment II

Key pecking was reliably maintained throughout all phases of the experiment in all three subjects. During the last four days of each phase, subjects responded on an average of 48, 58, and 44% of the trials in the 2-,

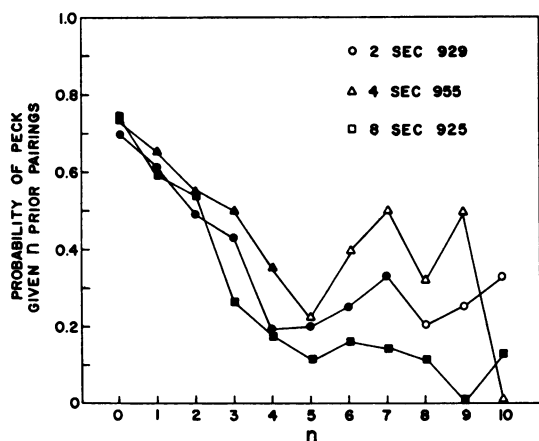


Fig. 1. The conditional probability of a peck given  $n$  prior successive pairings is shown in three hopper durations. The total number of pecks used to compute each graph is shown to the right of the appropriate symbol in the figure legend. Open points were computed from fewer than 15 opportunities to peck.

4-, and 8-sec feeder conditions respectively. The mean rates of responding on trials with a response were 15.78, 18.73, and 12.76 responses per minute, and the average latencies on trials with a response were 4.32, 4.20, and 4.17 sec for the 2-, 4-, and 8-sec feeder conditions, respectively. Individual subjects showed substantial day-to-day variability in all three measures.

In summary, although substantial responding was maintained by 2-sec, 4-sec, and 8-sec feeder durations, there were no systematic changes in any of the dependent variables looked at in this study as a function of the duration of grain presentation.

#### DISCUSSION

In Experiment I, there was no relationship between hopper duration and the trial with the first peck in the four naive subjects used. This study was designed with the hope of assessing the effects of different hopper durations on pecking controlled by stimulus-grain pairings. For this reason, each subject's history before experimental pairings was identical. However, there is reason to believe that other relations between grain and keylight, such as the hopper training followed by keylight in the present study, may be a sufficient condition for the development, though not maintenance, of key pecking (Hitzing and Safar, 1970; Downing and Neuringer, 1976). It is obvious that

at least the first peck of A-9, which occurred before any pairings, must have been due to factors of this sort. There is no reason to assume that these factors could not be at least partially responsible for the early behavior of other subjects; therefore, the hopper training procedures used in the present study may have obscured the effects that varying feeder duration might have on acquisition.

Another aspect of the results that deserves mention is the analyses of sequential dependencies. It is clear from previous work that the effectiveness of the keylight in controlling maintained pecking depends on its differential pairing with grain (Brown and Jenkins, 1968; Gamzu and Williams, 1971, 1973; Hitzing and Safar, 1970). If the strength of the behavior at any given point in time is related quantitatively to the number of prior successive pairings, then the probability functions depicted in Figures 1 and 2 should have taken a different form. The probability of a peck should increase as the number of successive pairings increases. Similarly, the probability of not pecking should increase as the number of successive trials without a pairing increases. Since this was not the case, the keylight may derive its effectiveness over some greater period of time or by some other process.<sup>2</sup>

The primary conclusion of this experiment is that neither the number of trials with a response nor the rate of responding was affected by duration of grain presentation. The latency of key pecks in the omission experiment was inversely related to the duration of grain presentations. These data, therefore, do not strongly implicate a differential effect of

<sup>2</sup>Additional data were collected for one subject (A-9) under the same circumstances, except that sessions lasted for 90 trials instead of 40. The form of the within-session probability function was identical to the ones reported here. Hence, the lack of within-session dependency does not appear to be unique to a 40-trial session. In all conditions, subjects tended to show waxing and waning on successive days. An account of the across-session dependencies might be based on the fact that on days in which subjects made fewer pecks, there were more hopper presentations. This may have resulted in a greater body weight in the subsequent session. However, in other studies (Balsam, unpublished data) much greater variations in body weight than were exhibited by the subjects in this study on successive days were shown to have no effect on the number of trials with a peck. Thus, it is unlikely that day-to-day fluctuations in body weight could account for the across-session dependencies in pecking.

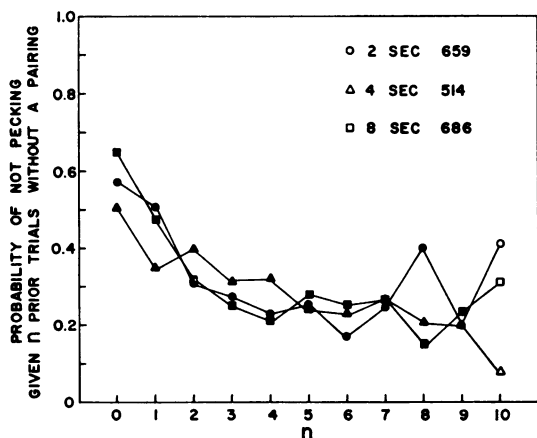


Fig. 2. The conditional probability for not pecking given  $n$  prior successive trials without a pairing is shown for the three hopper durations. The total number of trials used to compute each graph is shown to the right of the appropriate symbol in the figure legend. Open points were computed from fewer than 15 opportunities not to peck.

feeder duration on either stimulus—or response—reinforcer control of key pecking.

Previous studies have demonstrated a functional equivalence between key pecking and other classically conditioned responses, with respect to the manipulation of the conditional probability of US occurrence in the presence and absence of the CS (Gamzu and Williams, 1971, 1973; Wasserman, Franklin, and Hearst, 1974), the percentage of reinforced trials (Gonzalez, 1974), the effects of an omission contingency (Williams and Williams, 1969), and the qualitative nature of the US (Jenkins and Moore, 1973; Peterson *et al.* 1973; Wasserman, 1973a). Gantt (1938) found a direct relationship between the strength of the CR and the quantity of meat powder used as the US. The failure to find a consistent relationship between hopper duration and key pecking in Experiment II indicates a discontinuity in the functional equivalence of automaintained key pecks and other classically conditioned responses.

One possible reason for the invariance of key pecking when the hopper duration is changed is that other parameters of the procedure are exerting such relatively strong control over responding that the effects of varying feeder duration are minimized. Along these lines, Todorov (1973) found that when different frequencies and durations of grain pre-

sentation were arranged in the presence of two different stimuli on concurrent schedules, subjects were more influenced by the frequency than by the duration of grain presentation. In a classical conditioning procedure, as in the concurrent procedure, behavior is strongly influenced by differences in the frequency of grain presentation in the presence of different stimuli (Gamzu and Williams, 1971, 1973; Wasserman, Franklin, and Hearst, 1974). To the extent that the variables that control performance on multiple schedules of response-independent reinforcement combine in rules similar to those that determine concurrent performances, we would expect the behavior engendered by the delay procedure employed in Experiment II not to be greatly influenced by the duration of the grain presentation. More specifically, there is such a great difference in the rates of reinforcement in the presence of the CS (7.5 per minute) and the ITI stimulus (0.0 per minute), that variation in the feeder duration would not be expected to change performance greatly. On the basis of this analysis, variations in hopper duration might be expected to show their largest effect when stimuli are associated with different durations but equal frequencies of grain presentation within a session.

### EXPERIMENT IIIA

This experiment examined the within-session effects of associating different feeder durations with different stimuli on key pecking maintained by a delay procedure. This was carried out by associating two CSs of different colors with either equal or unequal feeder durations within each session.

#### METHOD

##### Subjects

One pigeon from the preceding experiments (A-9), and three additional subjects with histories of exposure to automaintenance procedures, were maintained at approximately 80% of their free-feeding weights.

##### Apparatus

The experimental enclosure was identical to the one employed in Experiment I, except for a slight modification in the houselights. General illumination was provided by an unshielded GE #1820 bulb directly above the

hopper aperture and by three additional #1820 bulbs mounted in the upper-left corner of the response panel.

#### *Procedure*

Each session was composed of 50 key illuminations, 6 sec in duration, presented on a VT 30-sec schedule. On half the trials, the key was illuminated red; on the remaining trials, the key was green. Different key colors presented in random order were associated with feeder presentations that were either of different (2-sec and 8-sec) or identical (2-sec or 8-sec) durations. Each subject was exposed to all four possible combinations of color and feeder duration until performance appeared stable for at least five consecutive days. The order of exposure to each condition was counterbalanced across subjects.

#### RESULTS

Substantial key pecking was maintained in all subjects throughout all phases of the experiment. In all conditions, subjects responded on approximately 77% of the trials. No systematic differences between conditions or between stimuli within a condition were evident in this measure during the last four days of exposure to each condition. When stimuli were associated with equal feeder durations, there was no systematic difference between stimuli (2-2 and 8-8 conditions) in the overall rate, running rate, or latency to the first peck on trials with at least one peck. The latency to the first peck in the presence of a particular stimulus did change as a function of whether or not identical or different feeder durations were occurring in the presence of the two stimuli. The only systematic difference in latencies occurred when the different CSs were associated with different hopper durations (2-8 and 8-2 conditions). In seven of the eight determinations, individual subjects showed shorter latencies in the presence of the stimulus correlated with the longer feeder duration. The mean latencies across subjects were 2.77 sec and 2.15 sec for the stimuli correlated with the 2- and 8-sec feeder durations, respectively.

The overall rate of responding is shown in the left panel of Figure 3 for each condition of Experiment IIIA. It can be seen that when the stimuli were correlated with different feeder durations in six of eight instances, the rate of responding is lower in the presence of

the stimulus correlated with the 2-sec feeder than in the presence of the stimulus correlated with the 8-sec feeder. Although three subjects show higher rates in the presence of the green stimulus in the 2-2 condition, three subjects show higher rates in the presence of the red stimulus in the 8-8 condition. Thus, it is unlikely that color preferences could be responsible for the differences obtained in the differential feeder conditions.

#### DISCUSSION

The only evidence in the present study of the duration of grain presentation being systematically related to key pecking was obtained when different stimuli, associated with equal frequencies but different feeder durations, occurred within the same session. The latencies to the first peck were shorter and the overall rates tended to be higher in the presence of a CS followed by an 8-sec feeder than in the presence of a different CS followed by a 2-sec feeder. Although much variability in the results is not accounted for by the manipulation of feeder duration, the data are suggestive that under some circumstances, key pecking may change as a function of feeder duration.

Experiments I and II demonstrated that when a stimulus correlated with extinction alternates with a second stimulus associated with a high frequency of hopper presentation, variations in the duration of grain presentation do not have pronounced effects on key pecking. The comparison of conditions 2-2 and 8-8 of Experiment IIIA extends this result to a situation in which two stimuli associated with equal frequency and duration of grain presentation randomly alternate with a third stimulus in whose presence grain is never presented. Again, variation in feeder duration across blocks of sessions does not affect any of the key pecking measures looked at in these studies.

When two different stimuli associated with equal frequencies and different durations of grain presentation alternate with a third stimulus in whose presence grain is never presented, differential key pecking may occur in the presence of the two stimuli associated with grain. The small size of the effect might be due to other parameters still exerting such strong control over key pecking that the manipulation of feeder duration has only

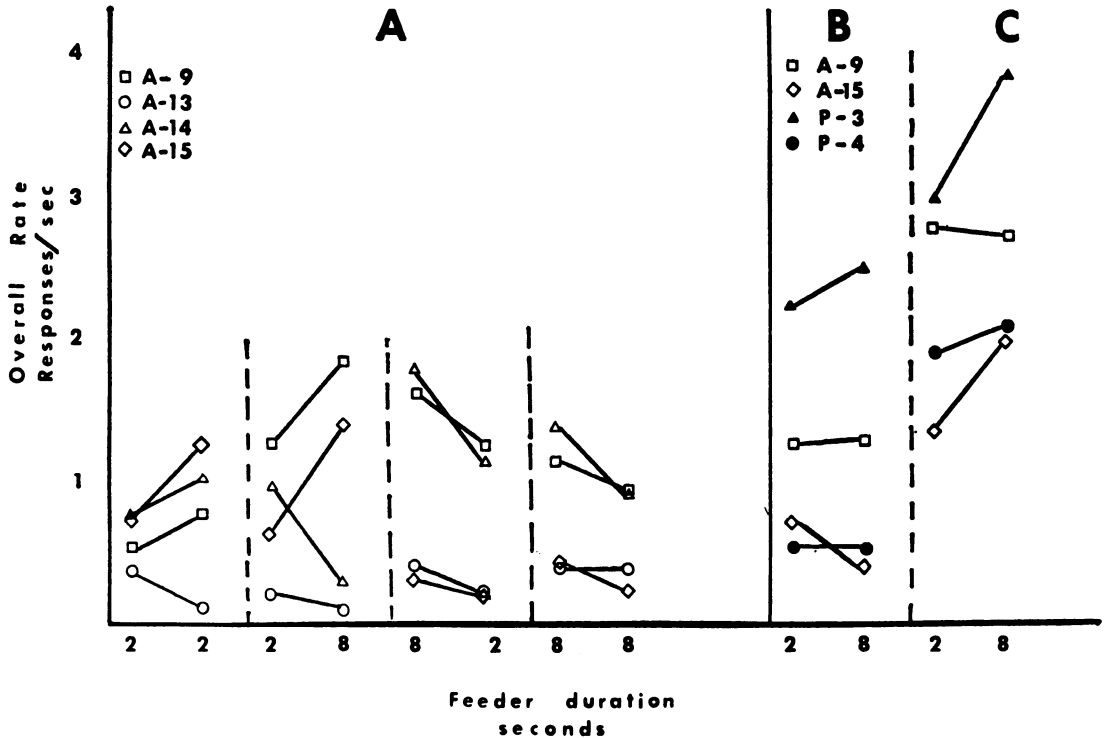


Fig. 3. In the left portion of the graph (A), the overall rate of responding from Experiment IIIA is shown for different combinations of feeder duration with CS color. Each pair of numbers on the abscissa designates the feeder duration associated with the green CS followed by the feeder duration associated with the red CS. The right-hand portion of the figure shows the data collected in Experiment IIIB. Panel B shows the overall rate of responding based on microswitch closures. Panel C shows the rate of responding based on manual observations.

slight effects on the response. Even though the relative rate of grain presentation in the presence of a CS has been changed from 1.0 to 0.5 from Experiment II to Experiment IIIA, several parameters that might influence key pecking remain unchanged, and might be exerting relatively strong control over key pecking in both experiments. The absolute rate of reinforcement and/or the temporal relationship between ITI, CS, and US are two possible sets of variables that interact with hopper duration in such a way as to make the effects of varying the duration of grain presentation minimal in the present studies.

In an experiment not reported here, subjects were exposed to a multiple variable-time 30-sec—variable-time 30-sec (*mult* VT 30-sec—VT 30-sec) schedule, with a 2-sec hopper in one component and an 8-sec hopper in the other. Components alternated every 30 sec. No key pecking was maintained by this procedure, nor did key pecking occur when the schedules

were changed to VT 15-sec in both components. Hence, merely having two stimuli associated with equal frequencies and different durations of grain presentation is not a sufficient condition for the maintenance of key pecking.

Another possible explanation for the failure to find large differences in key pecking in Experiments I and II is that microswitch closures may not be an accurate sample of the behavior conditioned by these procedures. In traditional classical conditioning experiments that demonstrate systematic changes in CRs, it is not the directed components of the CR that have been measured. For example, in the prototypical salivary conditioning experiment, parotid secretion is the dependent variable, not approach and contact to the CS. It is possible that the directed elements of a CR do not change in the same way as the nondirected elements. This would lead to outcomes such as those of Experiments I and II. The data of

Experiment IIIA, however, suggest an alternative. The large within- and between-subject variability might indicate that these procedures result in behavior that is not representatively sampled by measuring microswitch closures from behind the response key. In other words, the birds may be responding differentially in the presence of stimuli associated with different grain durations, but the recording procedure employed was insensitive to the differences in the CRs.

### EXPERIMENT IIIB

There are many reports that much of the pecking controlled by delay procedures does not result in electromechanically recorded key pecks (Brown and Jenkins, 1968; Moore, 1973; Wasserman, 1973b). Barrera (1974) found that subjects often made as many or more off-key pecks as on-key pecks. In this study, there was much variability between subjects as well as within subjects from day to day in the proportion of the total pecks comprised by those striking the key. There is reason to expect, therefore, that the procedures used in the first three experiments might have resulted in differential behavior in the presence of stimuli associated with different feeder durations, but this might not have been reflected in electromechanically recorded responses. The purpose of the present experiment was to collect a more detailed measure of the conditioned responses than the closures of the microswitch behind the response key, in a procedure similar to the one employed in Experiment IIIA.

### METHOD

#### *Subjects and Apparatus*

Two of the same pigeons (A-9, A-15) used in Experiment IIIA and two additional pigeons with a history of exposure to automaintenance procedures were maintained at approximately 80% of their free-feeding weights. The apparatus was the same as that employed in the preceding experiment.

#### *Procedure*

The basic procedure was identical to that employed in Experiment IIIA. Fifty 6-sec trials were presented on a VT 30-sec schedule. The key was illuminated green on half the trials and red on half. For two subjects, all

red trials were followed by 8-sec hopper presentations and green trials were followed by 2-sec hopper presentations. The feeder durations associated with each color were reversed for the two other subjects. All subjects were exposed to this procedure for 21 sessions.

An experienced observer watched each subject through a one-way mirror during the last four days of the experiment. The observer recorded all pecking movements that occurred during the final 30 or 31 trials of each session. The number of trials with at least one peck was also recorded. All recording was done with a hand-held microswitch in series with electromechanical counters. A second observer occasionally observed at the same time as the first observer. Interobserver reliability was computed each session by dividing the smaller total number of pecks recorded for each kind of trial by the larger number of pecks recorded for a particular kind of trial. The mean interobserver agreement was 92% and ranged from 99% to 89%.

### RESULTS

All four subjects responded on virtually every trial. Key closures occurred on an average of about 88% of the trials during the last four days of the experiment. There was no difference in the number of trials with at least one response in the presence of the stimulus associated with a 2-sec hopper and the stimulus associated with a 8-sec hopper. The electromechanically recorded data also showed no systematic relationship across subjects between hopper duration and either the overall rate of responding, the running rate, or the rate on trials with at least one response. The latency to the first response on trials with at least one response was shorter on 8-sec trials than on 2-sec trials for three of the four subjects. The mean latency in the presence of the 2-sec feeder signal was 2.67 sec and the mean latency in the presence of 8-sec feeder signal was 2.22 sec.

Panel B of Figure 3 shows the overall rate of responding computed from the behavior recorded by the microswitch behind the key. These data show no systematic relationship to feeder duration across subjects. Panel C shows the same measure computed from the data recorded by the observer. In all cases, it is evident that many pecking movements are not recorded by the microswitch behind the key. In the most extreme case, five times as



many pecking movements as key closures are occurring. Additionally, the observational data reveal that three of the subjects pecked more during the 8-sec trials than during the 2-sec trials. The mean rate of responding computed from the key-closure data is 1.19 responses per second for both the 2-sec and 8-sec signals. For the data recorded by manual observation, the mean rate of responding in the presence of the 2-sec signal is 2.29 responses per second and the mean rate in the presence of the 8-sec signal is 2.69 responses per second.

#### DISCUSSION

The latency data of this experiment replicate the findings of Experiment IIIA. When different CSs are associated with equal frequencies and different durations of grain presentation, subjects tend to respond with shorter latencies to the first peck on trials associated with longer feeder durations than they do on trials associated with a briefer hopper presentation. This relation held for 10 of 12 cases in Experiments IIIA and IIIB.

The results of this experiment suggest that the topographies conditioned by a delay procedure may not be accurately reflected in data collected by traditional recording techniques. When pecking was recorded by an observer, relationships between behavior and hopper duration were evident that were not always evident in the data collected from closures of a microswitch located behind the response key. The observer's data replicate the relationship found between overall rate and feeder duration found in Experiment IIIA; the microswitch closure data do not.

#### GENERAL DISCUSSION

The results of the three experiments suggest that when duration of grain presentation is varied in procedures such as those employed in the present studies, there are often only weak and variable effects on the pigeon's key peck. This may be due to the relatively stronger control exerted by other factors. The qualitative nature of the stimuli, frequency of grain presentation and/or temporal relationship between stimuli may exert strong control over both the rate of responding (Gamzu and Schwartz, 1973; Groves, 1973; Wasserman, *et al.*, 1974; Gibbon *et al.*, 1977) and the location at which pecks are directed

(Gamzu and Schwartz, 1973; Schwartz, 1973; Wasserman, 1973*b*; Wasserman and McCracken, 1974). The results of Experiment IIIB show that there were fewer pecking movements recorded as key closures than were recorded by an observer. These data suggest that much information about pecking movements may be lost when data based on key closures are the only ones recorded. The location as well as the frequency of pecking movements, therefore, should be employed as a dependent variable in a complete analysis of autoshaping.

Traditionally, we expect the tendency to respond to increase with successive pairings of the CS and US and for the tendency not to respond to increase as the number of successive nonreinforced CS presentations increases. The sequential dependencies shown in Figures 1 and 2 indicate that this is not the case in an omission procedure such as that employed in Experiment I. These data suggest that a subject's tendency to switch from a response state to a nonresponse state or *vice versa* declines as a function of the number of successive trials in a given state. When in a given state, a subject's tendency to remain in that state is high. This indicates that the tendency to respond in an omission procedure is a result of an averaging process of reinforced and nonreinforced trials that takes place over some period longer than the preceding seven or eight trials. Inasmuch as the tendency to respond did tend to wax and wane on successive days, perhaps the effects of reinforced and nonreinforced trials are integrated across the entire session.

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