Adventitious Reinforcement and Conditioned Reinforcement in Auto-Maintenance

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ADVENTITIOUS REINFORCEMENT AND CONDITIONED REINFORCEMENT IN AUTO-MAINTENANCE

by

Dennis H. Passe

A Thesis Submitted to the Faculty of The Graduate College in partial fulfillment of the Degree of Master of Arts

Western Michigan University
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INTRODUCTION

Auto-shaping and auto-maintenance as experimental procedures are concerned with stimulus-reinforcer relationships and the occurrence of certain behavior in the absence of programmed response-reinforcer relationships to shape or maintain that behavior. Current interest in this phenomenon is preceded by interest in "superstitious" responding as first reported by Skinner (1948). He reported that food deprived pigeons developed stereotyped and recurring behaviors when placed in situations of periodic and behaviorally non-contingent delivery of food. Other investigators have replicated his findings. A recent and rigorous exploration of superstitious responding was made by Staddon and Simmelhaq (1971) which entailed a systematic scrutiny of patterns of responses and their sequencing. Grain was presented to deprived pigeons on fixed and variable time schedules. It was found that stereotyped and recurring behaviors appeared with certain probabilities at specific times during the inter-food-intervals as training progressed. A high probability behavior just prior to the occurrence of grain presentation was almost invariably the pecking response.

The occurrence of pecking has been explored by Brown and Jenkins (1968) in conditions somewhat different from those of the "superstitious" experiments performed by Skinner and others. The relationship between stimulus,
reinforcer and response was investigated. The phenomenon observed was labeled "auto-shaping". The occurrence of relatively stable rates of pecking in the absence of differential reinforcement for successive approximations to the key peck response was reported. Only when the stimulus preceded the reinforcer (forward pairing) did pecking reliably occur. That is the key light was illuminated for a given period of time followed by several seconds of hopper presentation. Pecking did not reliably occur in the presence of a constant key light paired with intermittent food or to reverse pairings.

Other researchers have verified and extended the findings of Brown and Jenkins. Smith (1970) demonstrated a 3-key technique of auto-shaping and subsequent response chaining without ever having to hand-shape the behavior. Smith and Wilkes (1971) reported the successful automation of magazine approach behavior and subsequent auto-shaping of the key peck response without ever having to have the experimenter present. They discuss the procedure as a "... time-saving alternative to manual magazine training and key-pecking shaping (p. 375)." Additional data describing successful auto-shaping in pigeons are offered by Smith (1972); Smith (in press); and Fenner (1969).

Hitzing and Safar (1970) reported auto-shaping using procedures differing from those used by Brown and Jenkins.
(1968) in that a forward pairing of the light and hopper was not employed. Ten out of 12 birds pecked within 83 trials under conditions of variable time presentation of the stimulus light, having had hopper training during sessions on two previous days. To date this procedure has not been reported on elsewhere in the literature.

The auto-shaping phenomenon has been demonstrated in species other than the pigeon. Smith (1972), and Smith and Smith (1971) reported auto-shaping in dogs using lighted response bars. Squier (1969) reports successful auto-shaping in fish. Auto-shaping has also been reported in monkeys, Sidman and Fletcher (1968); and in rats, Powell, Saunders, and Thompson (1968); and Smith, Borgen, Davis, Pace (1971).

In the above cited research, interest has been focused upon those conditions under which an initial key peck is reliably occasioned without having had to hand shape the behavior. Actually the various authors contributing to the literature on auto-shaping have used a variety of procedures; varying kind and duration of the trial stimulus (key light) and the duration of the inter-trial-interval. However, all of the research reviewed here, with the exception of Hitzing and Safar (1970) have had in common the forward pairing of a stimulus (ranging from 3-8 seconds, most about 6-8 seconds) and the presentation of the food (2-5 seconds) immediately following the stimulus.
In no case was a key peck a requirement for food delivery. In most cases a key peck during the stimulus resulted in the termination of that stimulus and the immediate delivery of the reinforcer; also in general key pecks during the inter-trial-interval had no programmed consequences except possibly to extend the inter-trial-interval period as in a procedure described by Brown and Jenkins (1968). However, it is important to realize that auto-shaping is concerned with the occurrence of the first key peck and not with subsequent rates of responding in either the presence of contingent reinforcement or no food conditions.

A methodological and behavioral extension of auto-shaping is the set of procedures and the phenomenon of auto-maintenance. Auto-shaping usually refers to the occurrence of the first key peck under conditions of the forward pairing of a stimulus and reinforcer. Auto-maintenance, in distinction to this, refers to the continued occurrence of the behavior in the presence of the stimulus-reinforcer pairing despite the absence of programmed reinforcers for the behavior.

Brown and Jenkins (1968) describe a procedure which utilized a forward pairing of the light and hopper, but any key pecks while the key was lit had no programmed consequences. They reported that the procedure does not guarantee a high stable rate of performance but "... it is capable of generating a surprisingly high level of
maintained key pecking in a substantial percentage of cases (p. 6)." Williams and Williams (1969) extended this "auto-maintenance" procedure by instituting a negative contingency. That is, pecks during the stimulus presentation resulted in the light immediately going out and no food being delivered on that trial. If no pecks occurred the light remained on for its predetermined length of time followed by the hopper presentation. They reported that "Substantial responding clearly took place despite the negative relation between pecking and reinforcement (p. 512)." Performance under conditions of a negative contingency was explored further using an irrelevant key. When a second key (irrelevant), was paired with the negative contingency key in every respect, but had no programmed consequences associated with pecking it, pecking switched from the negative contingency key to the irrelevant key. When the irrelevant key was continuously lit as opposed to being correlated with the negative contingency key going on and off, pecking persisted on the negative contingency key even though such responding prevented food delivery. Hitzing and Safar (1970) used several procedures involving the presentation of light and food. There were no programmed reinforcement contingencies associated with pecking the lit key. Non-pairing sessions were conducted in which light and food were presented randomly with the arrangement that the key light
could never precede food by less than 15 seconds. Sustained responding did not develop under these conditions. However, when the light always preceded food delivery (forward pairing) the number of trials with pecks markedly increased. The auto-maintenance phenomenon has been reported by Gamzu and Williams (1971) using pairing procedures in which a probability of reinforcement via a random probability generator was associated with either the key light or both the key light and the inter-trial-interval. Under these conditions they reported that when the probability of food was differentially associated with the stimulus, pecking was maintained even though there were no programmed contingencies for pecking in the presence of the light and no precise relationship between the light and specific instances of food delivery. That is, the presentation of the hopper could occur at anytime during the stimulus light or not at all, depending upon the result of sampling a random probability generator at intervals during the stimulus presentation. When a probability of reinforcement was associated with the lit key and the inter-trial-interval period, pecking the key rapidly dropped and no pecking developed during the inter-trial-interval. Subjects under the no reinforcement condition displayed very little pecking. Subjects under the inter-trial-interval only condition did not peck at all. Subsequent shifts to the differential condition
resulted in sustained pecking. Schwartz (1972) replicated the Williams and Williams (1969) finding that pigeons continued to respond even when pecking prevented the delivery of food; and extended the Williams and Williams work on the irrelevant key conditions. Illumination was alternated between two keys; one was a negative contingency key, the other a yoked irrelevant key on which pecks had no consequences. Food was delivered subsequent to the irrelevant key only if the subject had not pecked on the previous negative contingency key condition. It was found that the subjects pecked the irrelevant key more often. On choice trials in which both keys were presented simultaneously without delivery of food, the irrelevant key was again more frequently pecked. A third procedure involved the use of a multiple schedule in which the frequency of reinforcement was varied in both plies. Pecking was observed during that ply which was associated with the more frequent reinforcement delivery. When frequency of reinforcement was made the same for both plies, pecking markedly decreased. That is, pecking occurred only when the change in key color was associated with a differential assignment of reinforcement probability.

The auto-maintenance phenomenon has been demonstrated in at least one species other than the pigeon. Gardner (1969) showed the occurrence of sustained pecking in bobwhite quail under conditions of the forward pairing of a
stimulus and a reinforcer when pecking had no programmed consequences.

At least one attempt to extend the generality of the effect of this stimulus-reinforcer relationship to another species has failed. Gamzu (1972) demonstrated auto-shaping in squirrel monkeys, but failed to get sustained key pressing under negative auto-maintenance conditions.

In the short period of time since Brown and Jenkins (1968) described their auto-shaping procedures there have been numerous replications and extensions of automated procedures to occasion pecking in pigeons and to extend the research to other species. Recently there has been an increased focus of attention on the auto-maintenance phenomenon.

The purpose of this research was to demonstrate the auto-maintenance phenomenon and to investigate the role that adventitious contingencies of primary and conditioned reinforcement may play in the maintenance of key pecking.

Staddon and Simmelhag (1971) have demonstrated that the non-contingent delivery of food to hungry pigeons engendered stereotyped and recurring patterns of behavior. Their analysis of response-dependent and response-independent food delivery led them to conclude that the terminal response (pecking) in both situations may be viewed as a discriminated operant. (However, they do not suggest that the Law of Effect can completely account for
acquisition. Nor do they accept as complete Skinner's (1948) analysis of "superstitious" responding as being the result of adventitious contingencies of reinforcement.)

It is in part the intent of this paper to view key pecking under conditions of non-contingent food delivery as an operant behavior. However, such behavior is examined within the same frame of reference that Skinner (1948) used to explain the occurrence of responding under response-independent schedules of food delivery. It seems reasonable to suggest that pecking in the auto-maintenance paradigm may be influenced by adventitious reinforcement contingencies. If such is the case, one might predict that an analysis of the distribution of responding during the stimulus presentation would disclose responding maximizing near the key light termination/food delivery. A scallop into the reinforcer might be anticipated. Although the occurrence of such response patterning would not necessarily confirm the presence of an adventitious contingency of reinforcement it would be suggestive of it. In addition this study considered the possibility of the offset of the stimulus light as functioning as a conditioned reinforcer subsequent to its being repeatedly darkened in temporal proximity with the food delivery. Herrnstein (1966) cites evidence which indicates that a stimulus in a discrimination procedure could come to function as a
conditioned reinforcer and consequently maintain super-
stitious responding due to an adventitious contingency of
reinforcement. Kelleher and Gollub (1962) cite evidence
which indicates that a stimulus may come to function as
a conditioned reinforcer as a result of simply being
paired with a primary reinforcer. In the negative auto-
maintenance procedure one might reasonably project that
because of the pairing of light offset with the delivery
of food (on all occasions when the subject does not peck),
that light offset might become a conditioned reinforcer.
If such is the case, one might expect that subjects would
respond to produce light offset when given the opportunity.

The present experiment explored these possibilities
using auto-maintenance, negative auto-maintenance, and
no food conditions. The auto-maintenance and negative
auto-maintenance conditions in this experiment were of
extended duration relative to most other studies in the
same area. The results are discussed in terms of other
relevant research and suggested hypotheses as to the
nature and function of stimulus-reinforcer relationships.
METHOD

Subjects

Eight white, naive carneau pigeons served as subjects. They were maintained at 80% of their free feeding body weight. Four of the birds were 3-5 months old and four were 5-8 months old at the beginning of the experiment.

Apparatus

The experimental chamber measured 12 x 16 1/4 x 14 in. Three of the walls were painted flat black, the fourth wall which constituted the response panel was 1/8 in. anodized black aluminum. The floor was constructed of stainless steel; the ceiling was translucent frosted glass. Entrance to the chamber was through a hinged wall (12 x 14 x 12 in.) which served as a door. Two keys each measuring 1 in. in diameter were located 4 11/16 in. from either end of the response panel and 9 1/2 in. above the floor. The hopper, an automated LeHigh Valley Magazine model #1347 was located 4 in. above the floor and centered between the two keys. Access to the hopper was through a 2 sq/ in. aperture in the response panel. The left key was transilluminated by a white light operated by 17 volts A.C. The hopper light was also white. The house light was located above the trans-
lucent glass ceiling, approximately 1 1/2 in. from the response panel and 9 in. from the entrance to the chamber. The chamber was vented by a fan, U 21 model #50748-D500 from Fasco Distributing Company. The vent hole was 2 1/2 in. in diameter and located in the wall opposite the response panel near the ceiling and adjacent to the wall opposite the entrance. The room in which the experimental chambers were located was constantly flooded with white noise from a speaker located in the center of the room approximately 8 ft. above the floor. Mixed grain was used in the hopper and for home cage feeding throughout the experiment. Water for the pigeons was vitamin treated.

Programming and recording equipment were located in a room separated from the experimental room. Programming was accomplished by appropriate electromechanical circuitry; recording was accomplished via digital and print-out counters, and an Esterline-Angus event recorder.

Procedure

All subjects were hand hopper trained prior to experimental manipulations. On the first day of hopper training the subject was placed in the darkened chamber for one hour of habituation. Throughout hopper training the key light remained darkened. On the second day, the subject was placed in the chamber with the hopper in the raised position, heaped with grain and the hopper
light on. The subject was observed for 15 minutes; if it did not eat within that amount of time it was force fed by being held with the left hand across the shoulders, its wings kept close to its body and guided so that its head was placed inside the hopper. After the subject pecked at the grain about 10 times the hand was slowly removed and the animal was shaped to feed out of the hopper in a training procedure which approximated the following schedule of hopper presentations, although the actual timing and delivery of presentations varied somewhat for each subject. The hopper remained up for 20 seconds after which it went down for 1 second. In the down position the hopper light was off. The hopper then came back up for 8 seconds and went down for 3 seconds; came up for 6 seconds and went down for 5 seconds; came up for 4 seconds and went down for 8 seconds; came up for 3 seconds and went down for 10 seconds 5 times; came up for 3 seconds and went down for 20 seconds 5 times; came up for 3 seconds and went down for 30 seconds 24 times. On the third day, 3 second hopper presentations were delivered on a variable time (VT) 30 second schedule independent of the subject's behavior. The subject was observed to see if it was eating the grain. If not, the hopper was held up for 10 seconds or until the animal pecked at the grain about 10 times. From that point the shaping procedure as described above was repeated.
Once the subject was consistently approaching the hopper and feeding on a VT 30 second schedule of hopper presentations, a VT 60 second schedule was introduced. All subjects met the criterion of approaching and feeding each time from the hopper presented 20 times on a VT 60 second schedule. Birds S-1, C-1, C-2, C-3, C-4, completed hopper training in four days; birds S-2, S-3, S-4 completed hopper training in five days. All birds began experimental sessions on the day following completion of hopper training. Experimental sessions were conducted daily except for Saturdays. Each session lasted approximately one hour and was composed of 50 food presentations delivered on a VT 60 second schedule.

Birds S-1, S-2, S-3, S-4 were exposed to an Auto-Maintenance condition in which, on a VT 60 second schedule, a key light (9 seconds duration) was presented and immediately followed by a 4 second hopper presentation. The longest inter-trial-interval was 260 seconds; the shortest inter-trial-interval was 1 second. Key pecks had no programmed consequences. The birds were exposed to the following numbers of such sessions: S-1 (38), S-2 (43), S-3 (43), S-4 (43). Following this S-1, S-2, S-3 were switched to a No Food condition in which the key light was presented on a VT 60 second schedule but was not followed by hopper presentations. Key pecks again had no programmed consequences. There were 11 such No
Food sessions. Following this, S-1, S-2, S-3 were returned to an Auto-Maintenance condition identical to that preceding the No Food condition for 13 sessions. After the first Auto-Maintenance condition, S-4 was exposed to a Negative Contingency Key Light Offset Loss of Food procedure. In this condition key light presentations were programmed on a VT 60 second schedule. If the subject did not peck the lit key, the key light remained on for 9 seconds and was immediately followed by food delivery (4 second hopper presentation). If the subject pecked the lit key, the light immediately went out and the hopper was not presented that trial. Pecks during the inter-trial-interval and hopper presentations had no programmed consequences. The number of sessions for S-4 under these conditions was 11. Following this, S-4 was reexposed to Auto-Maintenance conditions for 13 sessions.

Upon completion of hopper training, C-1, C-2, C-3 and C-4 were exposed to Negative Contingency Key Light Offset Loss of Food conditions for 27 sessions. Following this they were exposed to a No Food condition identical to the one described above. The birds were exposed to the following numbers of such sessions: C-1 (9), C-2 (9), C-3 (10), C-4 (8). After this the Negative Contingency Key Light Offset Loss of Food condition was reinstated for 13 sessions.
RESULTS

Figure 1* shows trials with pecks for two of the birds exposed to the Auto-Maintenance/No Food/Auto-Maintenance conditions and the one bird exposed to Auto-Maintenance/Negative Contingency Key Light Offset Loss of Food/Auto-Maintenance conditions. The data for S-3 are not graphed since that bird pecked only three times in 67 sessions. All of the subjects pecked the lighted key at least once during the first session. Subject S-1 pecked on 36 trials during the first session, and reached a high of 49 trials during session 7. The average number of trials with pecks for this subject for the first nine sessions was approximately 42. Thereafter responding rapidly decreased to a stable near zero rate. Trials with pecks for the first session of the No Food condition remained at zero. A small increase in responding was then observed, reaching seven trials with pecks during session 42. Responding again decreased to zero. With the reintroduction of Auto-Maintenance conditions responding increased to a relatively stable rate of about four trials with pecks per session. The performance of S-2 was similar to S-1 in that most of the responding occurred during the initial sessions of the first Auto-Maintenance condition; the

*Note: All figure legends, figures and tables appear in the Appendices on pages 32-44.
number of trials with pecks then decreased to zero. Subject S-2 showed very little responding during the return to Auto-Maintenance conditions. Subject S-4 did not resemble S-1 and S-3 in the level of trials with pecks throughout the first two conditions of the experiment. The number of trials with pecks per session rose during the first nine sessions to a mean of about 43 for the next 17 sessions. A reduction after session 23 was followed by a moderate recovery extending from session 29 through 37. There was a relatively reduced amount of responding during the remaining sessions of this condition. With the introduction of Negative Contingency Key Light Offset Loss of Food there was a recovery to approximately 25 trials with pecks per session for the next five sessions, followed by a gradual reduction of responding for five more sessions. The re-introduction of Auto-Maintenance conditions did not appreciably change the number of trials with pecks from that of the terminal sessions of the first Auto-Maintenance condition.

Figure 2 shows the total number of pecks averaged over sessions which occurred in each of six successive 1.5 second intra-stimulus intervals of the 9 second stimulus presentation. Data shown are for S-2 during the first Auto-Maintenance condition. The cross-hatched columns represent the percent of responding in any given interval.

During sessions 1-4, most of the pecking occurred in
the last 4.5 seconds of the stimulus presentation. There was no pecking of the lighted key during the first 1.5 seconds. Pecking began in the second interval and increased through the fifth and still represented a large percentage of responding in the sixth interval.

Sessions 10-13 depict a shift in the distribution of responding. Most of the pecking shifted to the early intra-stimulus intervals, the greatest percent of responding occurring in the 1.5 to 3.0 interval. Shortly thereafter, responding ceased for the remainder of this manipulation. This subject pecked only infrequently during No Food and the return to Auto-Maintenance conditions. These data are not shown; a clear trend in response distribution could not be determined.

Figures 3 and 4 show intra-stimulus interval data for S-1 and S-4. Again during the first four sessions most of the responding occurred during the last 4.5 seconds of the stimulus presentation. There was very little pecking during the initial 1.5 seconds. During sessions 8-11 for S-1 and 39-43 for S-4 pecking shifted to the middle and earlier intervals. The bottom graphs in Figures 3 and 4 display responding during the last several sessions of the second Auto-Maintenance condition. Most of the pecking occurred during the first 4.5 seconds, specifically the second and third intervals. Intra-stimulus interval data are not shown for the No Food condition for S-1.
due to the paucity of responding during this condition.

Figure 5 shows latency in seconds of pecks as measured from the beginning of each trial for S-4 during Negative Contingency Key Light Offset Loss of Food. Frequency of pecks is averaged over sessions. (It is to be noted that the first peck occurring during trials of Negative Contingency Key Light Offset Loss of Food conditions resulted in the termination of the light and the withholding of the hopper presentation that trial. Therefore, by definition only, one peck may have occurred per trial during Negative Contingency Key Light Offset Loss of Food unlike Auto-Maintenance conditions in which several pecks may have occurred during a given stimulus presentation.) The largest percentage of key pecks occurred with a latency of between 1.5-3.0 seconds; that is to say, relatively early in the 9 second stimulus presentation.

Figure 6 shows trials with pecks for birds C-1, C-2, C-3 and C-4. All of these subjects pecked on at least two of the trials during the first session. The first graph reveals very little responding for C-1 during the first manipulations of the experiment. In the second Negative Contingency Key Light Offset Loss of Food condition trials with pecks increased from two on the first trial, to 16 during the middle trials and then decreased to three trials with pecks on the last session of this manipulation.
The graph for subject C-2 reveals four trials with pecks during the first session. The rate of pecking did not increase beyond this for the next eight sessions. The number of trials with pecks then increased to 34 by session 15, followed by a steady reduction. There were four or less trials with pecks per session during the last seven sessions of this Negative Contingency Key Light Offset Loss of Food condition. The first two sessions of No Food showed a very slight increase in trials with pecks followed by an absence of responding until the return to Negative Contingency Key Light Offset Loss of Food.

Subject C-3 pecked on four trials during the first session of Negative Contingency Key Light Offset Loss of Food and showed a relatively constant rate of about 12 trials with pecks per session during the rest of this condition. With the introduction of No Food, trials with pecks dropped to approximately four per session. A re-introduction of Negative Contingency Key Light Offset Loss of Food resulted in the rate returning to its pre-No Food average.

Subject C-4 pecked on seven trials during the first session, increasing to 37 trials with pecks by session 9 and then decreased. The average number of trials with pecks was approximately nine during the last six trials of this Negative Contingency Key Light Offset Loss of Food condition. The average number of trials with pecks
dropped to approximately two during No Food conditions. The re-introduction of Negative Contingency Key Light Offset Loss of Food conditions resulted in an increase in trials with pecks which subsequently diminished to a low level. Figure 7 displays the latency in seconds of the first peck as measured from the beginning of each trial for representative sessions for C-4 during the first Negative Contingency Key Light Offset Loss of Food condition. Frequency of pecks is averaged over sessions. The largest percentage of pecks during sessions 1-4 occurred with latencies of 3.0-4.5 and 7.6-9.0 seconds. During sessions 8-11 there appeared to be a slight trend to peck earlier in the trial. Sessions 14-17 and 22-25 reveal a shift toward longer latencies again. Birds C-2 and C-3 showed similar shifts in peck latency (see Tables 1 and 2). Pecks during the initial sessions tended to occur after relatively long latencies; followed by a shift to shorter latencies. This in turn preceded a trend to again peck after longer latencies in the final sessions of this manipulation.

Figure 8 shows the same information about C-4 for representative portions of No Food and return to Negative Contingency Key Light Offset Loss of Food conditions. After the introduction of the No Food condition there was a marked tendency to peck with latencies approaching 9 seconds. This tendency was also observed after returning
to Negative Contingency Key Light Offset Loss of Food conditions. The above description generally applies to C-2 and C-3 although C-2 pecked less than C-3 or C-4 during No Food and return to Negative Contingency Key Light Offset Loss of Food conditions (see Tables 1 and 2).

In general, the subjects C-1, C-2, C-3 and C-4 displayed some inter-subject variability as to the frequencies of trials with pecks (see Figure 6). However, the distribution of latencies of pecks across trials for these same birds appeared to be consistent with respect to the conditions under which shifts in latencies occurred.
DISCUSSION

In general, the results of this experiment did not corroborate the predictions originally made based on hypotheses of adventitious reinforcement. In the Auto-Maintenance condition, responding was not sustained for two of the subjects, one did not respond and one responded at a relatively high level of trials with pecks. In addition, an analysis of response distribution for these subjects revealed that pecks did not occur in close, temporal proximity to the presentation of food, other than during the initial trials of the first Auto-Maintenance condition. Subsequently, there was the marked absence of a scallop into the food delivery. If pecking during Auto-Maintenance was controlled by adventitious consequences one might expect a reduction in responding during the No Food condition. For two of the subjects reported, responding increased with the introduction of the No Food condition, however, they had already been responding at a near zero rate. With the return to Auto-Maintenance conditions one might again expect pecking, if it was maintained by adventitious contingencies of reinforcement, to increase in rate; it did not. Subject S-4 went from Auto-Maintenance to Negative Contingency Key Light Offset Loss of Food and showed an increase in responding over the previous six sessions. However, the
increase in responding was nearly indistinguishable from variability observed during the Auto-Maintenance condition. The latency data for S-4 during Negative Contingency Key Light Offset Loss of Food was compatible with a conditioned reinforcement hypothesis that would predict responding to occur early in the stimulus interval. However, such a conclusion could not be made in view of responding maximizing in the early intervals of the stimulus presentation (away from light offset) during the Auto-Maintenance conditions.

The data from the group of subjects which was initially subjected to the Negative Contingency Key Light Offset Loss of Food condition offered only partial support for the prediction that a conditioned reinforcer would be operating. Three of the four subjects did peck during the first Negative Contingency Key Light Offset Loss of Food condition, one of them with a relatively stable rate. It was anticipated that an analysis of latency data would reveal short latencies for most pecks. The opposite was found. During the first Negative Contingency Key Light Offset Loss of Food condition the average peck latency was somewhat variable. Toward the end of this condition most of the responding occurred during the last half of the stimulus presentation. In the No Food condition one might have expected a decrease in behavior maintained by a conditioned reinforcer which
had been intermittently paired with food delivery during the previous condition. This was observed in three of the subjects. In two of them there was a gradual reduction in trials with pecks during the No Food condition. The other subject showed a momentary increase in trials with pecks during this condition followed by a cessation of responding. When conditions were returned to their former state, the number of trials with pecks increased. This again was compatible with a conditioned reinforcement hypothesis. However, latency data for both No Food and the second Negative Contingency Key Light Offset Loss of Food conditions revealed pecking with relatively long latencies. If a conditioned reinforcement hypothesis was accurate here, one would expect the subjects to terminate the light with short latencies, since light offset (the conditioned reinforcer) would be immediately presented. Such was not the case. These data indicated that the responding was apparently not under the operant control of a conditioned reinforcer.

Other research has addressed itself to the question of whether or not pecking during auto-maintenance is due to an adventitious contingency of reinforcement. Gamzu and Williams (1971) assigned a non-zero probability of food delivery to a light-off condition. In another procedure, they assigned an equal non-zero probability of food delivery to both light-on and light-off conditions.
Pecking occurred in the presence of the light when food delivery was differentially associated with the light, but it dropped to a low level with non-differential food delivery. This work was replicated and extended by Gamzu (1971). It was concluded that adventitious reinforcement of pecking probably was not operating to maintain pecking. If subjective case requires it were, pecking should have increased during the non-differential condition when the overall frequency of reinforcement was higher. Instead, pecking occurred only when the illumination of the key was associated with a change in the frequency of reinforcement. Gamzu and Schwartz (in press) performed a related experiment using multiple variable-time schedules in which different frequencies of reinforcement were associated with the schedule plies. Pecking, primarily occurred in the presence of the ply when it was associated with a differential frequency of reinforcement.

The role of conditioned reinforcement in Auto-Maintenance has been investigated and reported on elsewhere also. Schwartz (1972) hypothesized that if the stimulus light were to remain on until the end of hopper presentation, the light offset could not become a conditioned reinforcer and if anything, might become aversive. The procedures of the Schwartz experiment were such that one group of animals, pecks turned off the key light and prevented food delivery. For another group of animals,
pecks did not turn off the key light but no food was delivered. In both conditions if no pecks occurred, the light remained on through the end of food delivery. Under such conditions light offset would not be expected to maintain responding. It was found that neither of these conditions had a negative influence on key pecking. That is, under both conditions birds pecked at substantial rates. And they pecked at rates actually higher than those reported by Williams and Williams (1969) in whose study the negative contingency procedures involved light offset just prior to food delivery. Schwartz concluded that "... the response-produced offset of the key plays no role in maintaining key pecking (p. 4)." It seems unlikely that persistence of responding during negative Auto-Maintenance conditions is attributable to conditioned reinforcement properties of the light offset.

Yet research has shown that pigeons are sensitive to the response-reinforcer contingency in negative auto-
maintenance. Williams and Williams (1969) using a functionally irrelevant key along with the negative contingency key found that birds would peck the irrelevant key while rates of pecking the negative contingency key dropped to near zero. The two keys were different colors. When the functional significance of the colors was reversed, responding also reversed. When the irrelevant key was withdrawn, pecking the negative contingency key increased.
Reintroduction of the irrelevant key resulted in diverted pecking from the negative key to the irrelevant key. Schwartz (1972) extended this research using a yoked irrelevant key in such a way that the irrelevant key and the negative contingency key were matched for stimulus-reinforcer pairings but were different on the response-reinforcer dimension. Subjects responded on the irrelevant key demonstrating that they were "... sensitive to the negative contingency between pecking and reinforcement (p. 6)."

An explanation has been summarized by Gamzu (1972) to explain the persistence of responding during negative auto-maintenance. It involves the identification of two kinds of pecks: auto-pecks and operant pecks. Auto-peaks are short duration pecks, having a duration of 20 milliseconds or less. All longer duration pecks are termed operant pecks. It is suggested that these two classes of pecks are controlled by different processes. Auto-pecks are apparently controlled by antecedent events and are relatively insensitive to their consequences, even when reinforcement is dependent upon their occurrence (Schwartz, 1971). In shaping techniques tested, the initial responses were auto-pecks. In negative auto-maintenance conditions only short duration pecks were observed. Furthermore, Gamzu (1972) suggests that because pecking grain in a hungry pigeon is a phylogenetical-
ly determined response, auto-pecks reflect natural consum-
matory behavior and are produced by the association of
the key light with grain. It is argued that this state-
ment accurately appraises responding if it persists under
conditions of negative auto-maintenance.

Finally, Wasserman, Markman and Hearst (1971) discuss
data generated from procedures very similar to the auto-
maintenance procedures used in the present study. A
house light was not employed in either this or the Wasser-
man study. In most of the other studies cited a house
light was used. Wasserman, Markman and Hearst also failed
to get substantial pecking under auto-maintenance condi-
tions. They also reported the absence of anticipated
scalloping into the food delivery. Instead, responding
maximized in the early part of the stimulus presentation.
However, upon introducing a house light, responding
dramatically increased. They hypothesized that the house
light made the key light less salient and therefore re-
quired more orienting behavior to observe light changes.
When the house light was not on, the birds sometimes
showed "alerting" responses to the onset of the key light
even though their backs were to the key. They seldom
pecked under these conditions. Apparently when the stimu-
lus change was diffuse (could be detected from anywhere
in the chamber even without facing the key), attention
to the key and subsequent pecking were reduced. To test
this further, the key light was left on during the entire session and only feature changes of the key (presentation of vertical lines against the key) preceded food delivery. Under these conditions the birds readily pecked. It was concluded that pecking under auto-maintenance conditions "... represents a tendency on the part of organisms to get as close as they can to the conditioned appetitive stimuli (p. 3)." Pavlov (1934) has stated "When conditioned stimuli are elaborated out of various external agents . . . , the first reaction elicited by the established conditioned stimulus usually consists in a movement towards the stimulus, i.e., the animal turns to the place where the stimulus is to be found (p. 187)." Skinner (1948) in describing the effects of non-contingent food delivery has stated "The effect of the reinforcement was to condition the bird to respond to some aspect of the environment rather than merely to execute a series of movements (p. 169)."

In consideration of the results of the present experiment, and after reviewing portions of the relevant research, several summary statements can be made. It is apparent that there are aspects of operant and classical conditioning theory relevant to an explanation of the auto-maintenance phenomenon. It does not appear that persistence of responding in auto-maintenance can be completely explained in terms of the effects of adventitious contingencies
of reinforcement. Although under certain circumstances (in the presence of irrelevant keys) there is behavioral sensitivity to the negative contingency. It does appear that reference to classical conditioning may partially account for the phenomenon in view of the observed topographical differences in responding under classical vs. operant conditioning paradigms (auto-pecks vs. operant pecks). Also, it is suggested that informational qualities of the light in the auto-maintenance paradigm may account for the directedness of the responding. And in so far as the light serves as a discriminative cue for the delivery of food, it is plausible that there may be some influence of a conditioned reinforcer, although it is acknowledged that this research does not offer definitive evidence for such a notion.
TABLE 1

Frequency and Percent of Total pecks per 1.5 second latency interval for subject C-2. Pecks are averaged over sessions.

Latency in Seconds

<table>
<thead>
<tr>
<th>Sessions</th>
<th>0.0-1.5</th>
<th>1.5-3.0</th>
<th>3.0-4.5</th>
<th>4.5-6.0</th>
<th>6.0-7.5</th>
<th>7.5-9.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative Contingency Key Light Offset Loss of Food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4</td>
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<td>1</td>
<td>.3</td>
<td>.5</td>
<td>0</td>
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<tr>
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<td>44</td>
<td>11</td>
<td>22</td>
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<td>0</td>
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<tr>
<td></td>
<td>12.7</td>
<td>64.8</td>
<td>14.1</td>
<td>7</td>
<td>1.4</td>
<td>0</td>
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<tr>
<td>14-17</td>
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<td>8.3</td>
<td>9.8</td>
<td>4.3</td>
<td>3.5</td>
<td>1.5</td>
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<td></td>
<td>2.7</td>
<td>29.5</td>
<td>34.8</td>
<td>15.2</td>
<td>12.5</td>
<td>5.4</td>
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<td>33.3</td>
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<td>10</td>
<td>50</td>
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<td>10</td>
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<tr>
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<td>.3</td>
<td>.6</td>
<td>.5</td>
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<tr>
<td></td>
<td>0</td>
<td>9.1</td>
<td>18.2</td>
<td>36.4</td>
<td>27.3</td>
<td>9.1</td>
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</table>

Total
TABLE 2

Frequency and Percent of Total pecks per 1.5 second latency interval for subject C-3. Pecks are averaged over sessions.

<table>
<thead>
<tr>
<th>Latency in Seconds</th>
<th>Sessions</th>
<th>0.0-1.5</th>
<th>1.5-3.0</th>
<th>3.0-4.5</th>
<th>4.5-6.0</th>
<th>6.0-7.5</th>
<th>7.5-9.0</th>
<th>Freq</th>
<th>% Total</th>
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<tbody>
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<td>1.8</td>
<td>2.5</td>
<td>2</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>11.4</td>
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<td>22.9</td>
<td></td>
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</tr>
<tr>
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<td>8-11</td>
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<td>4</td>
<td>.8</td>
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<td>.8</td>
<td>1.3</td>
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<tr>
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<td>14-17</td>
<td>.8</td>
<td>3.8</td>
<td>4.3</td>
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<td>1.3</td>
<td>2.5</td>
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<td>4.5</td>
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<td>3.2</td>
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<td>6.7</td>
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<td></td>
<td>4.3</td>
<td>3.4</td>
<td>13.6</td>
<td>29.8</td>
<td>28.5</td>
<td>20.4</td>
<td></td>
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</tr>
<tr>
<td>Negative Contingency Key Light Offset Loss of Food</td>
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<td>.6</td>
<td>3.8</td>
<td>3.1</td>
<td>3.5</td>
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<td>2.2</td>
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<td>23</td>
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<td>21.2</td>
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<td>12.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
FIGURE 1
LEGEND
Trials with pecks as a function of sessions. Ordinate: number of trials in which peck(s) occurred. Abscissa: daily sessions. Condition changes are indicated by phrase insets and vertical lines.
FIGURE 1

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FIGURE 2
LEGEND

Total pecks and percent of total pecks as a function of intra-stimulus intervals. Left Ordinate: total number of pecks averaged over sessions per intra-stimulus interval. Right Ordinate: percent of total pecks averaged over sessions per intra-stimulus interval. Abscissa: successive 1.5 second intra-stimulus intervals.
FIGURE 2

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FIGURE 3
LEGEND

Total pecks and percent of total pecks as a function of intra-stimulus intervals. Left Ordinate: total number of pecks averaged over sessions per intra-stimulus interval. Right Ordinate: percent of total pecks averaged over sessions per intra-stimulus interval. Abscissa: successive 1.5 intra-stimulus intervals.
FIGURE 3
FIGURE 4

LEGEND

Total pecks and percent of total pecks as a function of intra-stimulus intervals. Left Ordinate: total number of pecks averaged over sessions per intra-stimulus interval. Right Ordinate: percent of total pecks averaged over sessions per intra-stimulus interval. Abscissa: successive 1.5 second intra-stimulus intervals.

40
Figure 4

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FIGURE 5
LEGEND

Frequency of pecks and percent of total pecks as a function of latency in seconds. Left Ordinate: frequency of pecks averaged over sessions per latency interval. Right Ordinate: percent of total pecks averaged over sessions per latency interval. Abscissa: successive 1.5 second latency intervals.

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Figure 5

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FIGURE 6
LEGEND
Trials with pecks as a function of sessions.
Ordinate: number of trials in which peck(s) occurred. Abscissa: daily sessions. Condition changes are indicated by phrase insets accompanying top graph and vertical lines.
FIGURE 6

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FIGURE 7
LEGEND

Frequency of pecks and percent of total pecks as a function of latency in seconds. Left Ordinate: frequency of pecks averaged over sessions per latency interval. Right Ordinate: percent of total pecks averaged over sessions per latency interval. Abscissa: successive 1.5 second latency intervals.
FIGURE 7
FIGURE 8
LEGEND

Frequency of pecks and percent of total pecks as a function of latency in seconds. Left Ordinate: frequency of pecks averaged over sessions per latency interval. Right Ordinate: percent of total pecks averaged over sessions per latency interval. Abscissa: successive 1.5 second latency intervals.
FIGURE 8

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REFERENCES


