Operant Aspects of Auto-Maintenance: Conditioned Reinforcement and Superstitious Behavior

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OPERANT ASPECTS OF AUTO-MAINTENANCE:
CONDITIONED REINFORCEMENT AND SUPERSTITIOUS BEHAVIOR

by

Michael B. Granat

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INTRODUCTION

For approximately 30 years, the initial responses in operant conditioning experiments were experimenter shaped by the method of successive approximation. Operants were arbitrary behaviors which affected the environment and in turn were affected by the environmentally produced consequences. An operant was controlled by the response-reinforcer relationship. Alternatively, respondents were reflexive behaviors, and were governed by the stimulus-reinforcer relationship. This general separation of operant and respondent conditioning and the relationships most important in their control was somewhat narrowed by Brown and Jenkins (1968). By presenting an automatic procedure for the shaping of an operant, the key-peck of the pigeon, they opened new fields of research—auto-shaping (A-S), and auto-maintenance (A-M). Questions concerning the nature of the operant, the interactions of the relationships controlling it, and the analysis of the pigeon's key-peck as an operant were brought to issue.

Brown and Jenkins' procedure was to illuminate a response-key for eight seconds and to immediately follow key-light offset with four seconds of grain availability. The forward key-light--food delivery pairing comprised
a trial, and trials were separated by a variable intertrial interval (ITI) averaging 60 seconds. A magazine trained subject was exposed to this procedure as follows: key-pecks during the ITI postponed key-light onset; a key-peck during the key illumination immediately turned the light off and was followed by hopper presentation. If no pecks occurred, the grain was presented non-contingently following key-light offset. The effectiveness of the procedure was judged in terms of number of trials to first key-peck, and the percentage of the total number of subjects emitting a peck within 160 trials (two sessions). The authors experimented with a variety of procedures; the forward pairing method proved to be the simplest and most effective means of auto-shaping. They concluded that the shaping of the key-peck resulted from a combination of the pigeon's species-specific tendency to peck at the objects it looks at and the temporal proximity of food paired with this orienting behavior.

Sidman and Fletcher (1968) extended Brown and Jenkins' procedure by investigating the applicability of the auto-shape procedure to monkeys. They were interested in whether the key-light and hopper tray must be illuminated and if A-S was feasible when the instrumental response was different from the consummatory response on the animal. They found that the monkeys could be auto-shaped
even though the shaped response was different from the hopper response, and that it was not necessary to light the hopper.

Rachlin (1969) listed three possible criteria for evidence of auto-shaping: 1) the subject must be shaped in a gradual approach to the key as a prerequisite to the first response; 2) the first peck must be a function of the stimulus-reinforcer relationship; 3) the procedure must be an automatic method of shaping and be at least as efficient as hand shaping. Rachlin made three changes in the A-S method. First, instead of food as the reinforcer, his procedure used shock intensity reduction as a negative reinforcer. Second, mounted on the response key was a hemispherical transparent plastic extension extending 1.3 cm into the interior of the chamber. Third, a peck in the absence of the key-light had the same effect as during the reduction of shock intensity. The A-S phenomena according to his criteria was weak. There was no gradual shaping to the first peck and only suggestive evidence that the first peck resulted from the stimulus-reinforcer pairing.

In the following years, the A-S procedure was studied using bobwhite quail (Gardner, 1969), fish (Squier, 1969), and dogs (Smith and Smith, 1971). Furthermore, the technique was expanded to a three key procedure for pigeons (Smith, 1970), to an automatic method for magazine
approach in the pigeon (Smith and Wilkes, 1971), to an automatic magazine and bar-press training procedure with rats (Smith, et. al., 1971), and to a three manipulanda technique for dogs (Smith and Smith, 1972).

In the preceding studies, the forward pairing of the key-light with food was considered a requisite condition for the emergence of the auto-shaped peck. Hitzing and Safar (1970) demonstrated that following two days of hopper presentations only, the aperiodic onset of the key-light alone was sufficient to engender the first peck. In Brown and Jenkins' "trials only" condition (Hitzing and Safar's "Key-light only") there was no pecking. The difference was accounted for by: 1) the absence of a house light in Hitzing and Safar's experiment and the possibility that the key-light onset was easier to discriminate; 2) Hitzing and Safar's subjects received 44 hopper presentations prior to shaping compared to 10 in Brown and Jenkins.

For the purposes of this paper, the following distinction between A-S and A-M is made. The A-S procedure is in effect until the first key-peck. The A-M procedure is in effect for all subsequent key-pecks.

The first A-M study was the forward pairing--fixed trial condition of Brown and Jenkins. The authors made the following observation: "The arrangement does not guarantee a stable performance, but it is capable of generating a surprisingly high level of maintained key-
pecking in a substantial percentage of cases, (page 6)."

Williams and Williams (1969) extended the method of A-S by instituting a negative response contingency and continuing the procedure for additional sessions. They found birds learned to peck an illuminated key even though pecks turned off the key-light and prevented food from being delivered for that trial. It was discovered that if another key was illuminated such that its onset and offset were controlled by the programming of the key with the negative response contingency, the subjects would peck at the functionally irrelevant key in preference to the key with the negative contingency. The authors stated that pecking on the irrelevant key "effectively demonstrated behavioral sensitivity to some aspect of the negative contingency, (page 517)."

Gamzu (1972) attempted to extend the negative contingency procedure to squirrel monkeys. He reported that the monkeys' responses were affected by the response-reinforcer contingency and that the subjects did not respond when the result was loss of food.

Gamzu and Williams' (1971) research questioned some basic assumptions: first, the precise relationship between the key-light and food presentation in terms of the p(food/key-light) which had always been equal to 1.0; second, the information provided by the differential delivery of food which had always been presented following the trial stimulus and never during the ITI. In the
presence of the key-light, access to four seconds of grain was programmed randomly, the probability was .03 at the start of each of the 8.6 seconds of key illumination. An average of 13 food presentations were made per 50 trials. Key-pecking was compared under a "differential condition"--p(food/key-light)=.03, p(food/ITI)=0, and a "nondifferential condition" in which the p(food) is equal during the ITI and key-light. Their results showed pecking during the differential condition, a decrease in pecking during the nondifferential condition, and if the differential condition was preceded by the nondifferential, a retardation in the development of pecking.

Schwartz (1972) was concerned with response-reinforcer contingencies and the determination of pecking. Specifically, he investigated the possibility that key-light offset (a stimulus change which precedes food) served as a conditioned reinforcer in the negative auto-maintenance procedure of Williams and Williams. The procedure employed was to keep the key illuminated until food delivery terminated, and to fix the length of the key-light. Thus, if the pigeon did not peck the key, food was available during last seconds of key-light. Key-pecking prevented food availability, but had no effect on light duration. The pigeons responded in more trials than those of Williams and Williams'. Schwartz concluded: The response-produced offset of the key plays no role in maintaining key-pecking, (page 4)." In his second
experiment, there were 50, eight second trials during which one of two keys was lighted (either red or white), and 10, six second trials during which both keys were lighted. In the presence of the red stimulus, an auto-maintenance negative contingency fixed trial (A-MNC) procedure was in effect. Key-pecks prevented food delivery following key-light offset but had no affect on key-light duration. In the presence of the white stimulus, key-pecks had no consequences and a trial ended with food only if the previous red-key trial had ended with food. In trials in which both keys were available, food was never delivered. The results showed that with measures of both responses per minute, and trials with pecks, the birds responded more on the white key. During the choice trials, the white key was pecked more often. Schwartz concluded that the pigeons are sensitive to the negative response contingency. He further stated that in the A-M phenomenon response-reinforcer relationships had some effect in eliminating key-pecking, while the stimulus-reinforcer pairings were of overriding importance in maintaining key-pecking.

Hitzing and Safar (1970) explained the difference between their results in their key-light only condition with Brown and Jenkins' results (trials only) with reference to the discriminability of the key-light onset. Hitzing and Safar did not use a house light and thus the
onset of the key-light in this contextual condition was different. This might contribute to the emergence of the first key-peck in the A-S procedure. The present experiment will extend the study of the A-M procedure without a house light by maintaining the procedure for more sessions than did Hitzing and Safar. This research will also employ the behavior resulting from A-M and Auto-Maintenance Negative Contingency as a baseline against which an "extinction" procedure will be compared.

Within the A-S, A-M procedure there is a combination of respondent and operant aspects. The possibility of adventitious reinforcement in maintaining pecking will be explored. An analysis of the temporal distribution of pecks in the trial stimulus will be reported under an AM, A-MNC, and No Food condition (similar to operant extinction). The A-MNC procedure will be utilized in an attempt to shed light on the possibility of adventitious conditioned reinforcement. At present there is no "micro-analysis" of pecking engendered by the procedures in question. The possibility of conditioned reinforcement has been investigated but there are some questions concerning the procedures. Since the field of research is only four years old, any descriptive information is valuable. The descriptive aspect of this research will be of primary concern.
METHOD

Subjects

Eight 3 to 5 month old, naive, white carneaux pigeons of mixed sex were deprived to 80% + grams of their free feeding weight. Water was continually available in the home cage.

Apparatus

The interior of the experimental chamber was 15" by 12" by 17 1/2". The walls were painted flat black. The two response keys were 10" above the floor of the chamber and were 5" apart; the grain hopper was centered between the two keys and was 4" above the floor. The chamber was housed in a wooden box which served to attenuate extraneous stimuli. A fan provided ventilation as well as masking noise. Additional masking noise was provided from a speaker hanging from the ceiling. Key-pecks were recorded on impulse counters, print counters and on an event recorder.

Procedure

On day one, all birds were placed in a chamber for one hour to habituate to it. On the second day, the hopper was up and grain was heaped into the bin, the only light available was the hopper light. If the bird
did not eat within 15 minutes, it was "coaxed" by the experimenter's hand, and once the bird began to eat, the hand was faded out. The presentation time of the hopper was decreased from 10 seconds to 3 seconds gradually as the interval between presentations increased from 1 second to 30 seconds. On the third day, the subjects were given approximately 25 hopper presentations, each of three seconds in duration and separated by a VT 30 seconds schedule. On the fourth day, they received five presentations on a VT 30 seconds and 20 on a VT 1 minute. Twenty presentations on a VT 1 minute comprised the fifth day. If the subject failed to eat at each presentation of the hopper on a session by session basis, the schedule was changed to the schedule that was just previously in effect, and if no recovery and subsequent progress was made, the bird was replaced. On the first day of auto-maintenance and thereafter, all sessions lasted for 50 trials. A trial consisted of nine seconds of key illumination immediately followed by three seconds access to grain accompanied only by the hopper light. The house light was never used. The intertrial interval averaged 1 minute and had a range from 1 second to 4 minutes 30 seconds. Key-pecks were recorded separately during the trial in six successive 1 1/2 second intervals, during hopper presentation, and during the intertrial interval.

Four pigeons were in Group R and four in B. Each
group was hopper trained as described above. Then the birds in Group R were exposed to an auto-shape procedure during which key-pecks had no effect on the key-light duration or hopper presentation schedule. Following the first peck, the procedure is referred to as Auto-Maintenance. This condition was changed to a No Food condition after "stabilization", a period in which no systematic trend was observed. The key-light came on, food was not delivered at its offset. After this phase, the group was returned to the A-M condition.

The birds in Group B were exposed to an auto-shape procedure in which a key-peck during key-light prevented the delivery of food for that trial but had no effect on the key-light duration. This procedure is referred to as Auto-Maintenance Negative Contingency (A-MNC), and it was changed to a No Food condition after stabilization. The A-MNC condition was reinstituted after key-pecking had stabilized. The experiment ended for both groups after each had stabilized.

Note: All figure legends and figures referred to in the next section appear in the Appendix on pages 24-34.
RESULTS

Figure 1A-E presents the entire experiment expressed in total trials with pecks and total pecks per session for Group R and Bl. Although the number of trials with pecks was variable for each subject in Group R, R1, R3, and R4 pecked at least once per trial over 50 percent of the time in the A-M condition. For the majority of sessions, R2 did not peck in more than 20 percent of the total trials and for this reason, was kept on the A-M condition throughout the experiment. On the first day of the No Food condition, R1 and R3 pecked (trials with pecks and total pecks) less than on the previous day; R4 pecked more. During the No Food condition each of the three birds gradually stopped pecking. When food was again presented following the key-light, R3 and R4's pecking quickly returned to the level at which it was during the previous A-M condition. Subject R1 resumed pecking (trials with pecks) at an elevated level relative to its last days of A-M. During the final phase of A-M, R3 and R4's probability of pecking (trials with pecks, and total pecks) was similar to that of the initial A-M condition; R1's total pecks per session were at their highest level and remained so for the duration of the experiment. For all birds in Group R, total pecks increased and decreased; between trial pecks occurred infrequently.
and were not related to the other response measures. The pattern of trials with pecks for Bl, Figure 1E, was similar to that of Group R in variability but not in percentage of trials pecked. Pecking did consistently occur despite the negative response contingency. Pecking gradually subsided in the No Food condition, increased upon reinstatement of the A-MNC condition, and decreased throughout the remainder of the A-MNC condition. Bird B2 pecked only during 13 of 50 sessions and never exceeded five trials with pecks. Bird B4 pecked in six of 50 sessions and never exceeded five trials with pecks. Due to an equipment failure, B3 was terminated as a subject after 20 sessions. For Bl, total pecks increased and decreased with trials with pecks; between trial pecks occurred infrequently.

All subjects in Group R, for the first four sessions, exhibited a within key-light pecking distribution in which the number of pecks increased as the trial stimulus progressed toward food delivery. This scallop-like pattern is shown in Figures 2A and 4A. Data for R3 was like that of R1 and R4. Figures 3A and 5A present data from the same session with respect to the latency of the first peck during the key-light. Figure 3A, for R1, shows that the first peck per trial usually occurred during the first half of the trial stimulus. Figure 5A, for R4, shows that first pecks per trial occurred in the second
half of the trial stimulus. In the sessions following, the distribution of key-light pecks shifted to the left (Figures 2B and C, 4B and C) as the number of short latencies increased (Figures 3B and C, 5B and C). This pattern continued until the No Food condition was instituted; it was exhibited by every bird in this group. In the No Food phase, there was a shift in the distribution of pecks toward the end of the trial (Figures 2D and 4D) and the absolute number of short latency pecks decreased more rapidly than the longer latency pecks (Figures 3D and 5D). This trend continued until pecking finally ceased. Figure 6 is a reconstructed cumulative record of the averaged trial-by-trial pecks over the four sessions previous to No Food, and a session-by-session record of pecks per trial in the first eight sessions of No Food. In the beginning of each of sessions 26-33, there was a greater number of pecks per trial relative to the end of the previous session. Under analogous conditions this is called spontaneous recovery. Following the No Food phase, the distribution of key-light pecks and latency to first peck recovered as it was during A-M sessions previous to the No Food stage.

Figures 7 and 8 present the temporal and latency distribution of key-pecks for B1. Before being removed from the experiment, B3's data were similar to that of B1. In the first sessions of A-MNC, B1 quickly developed a
scallop-like pattern of pecking and maintained this pattern throughout the duration of this condition. Subject Bl also showed longer latency first pecks than did the Group R birds. Unlike Group R during the No Food condition, the distribution of pecks did not change, the total number of pecks just gradually decreased. Pecks falling late in the trial still occurred in greater numbers than earlier pecks. Longer latency pecks also occurred in greater numbers than shorter latency pecks. After the A-MNC condition was reinstituted, pecking was reacquired as it was in the beginning of the experiment and during the last A-MNC sessions prior to No food.
DISCUSSION

Brown and Jenkins described their forward pairing of key-light and food procedure as capable of generating a high and persistent level of key-pecking but without stability of performance. As described earlier, three of four subjects (Group R) in the A-M condition typically pecked during at least 50 percent of the trials. The number of trials pecked and total pecks were affected by the absence of the house light in the present experiment. Wasserman, Markman, and Hearst (1971) reported that the number of trials with pecks for birds auto-shaped without a house light could be increased markedly by introducing a house light. This might also account for the low rates of responding for birds R2, B2, and B4 in the present experiment.

One of the primary issues in the A-M phenomena is whether or not adventitious reinforcement is operating to maintain key-pecking. Is the key-peck behavior superstitious? The two theories currently adopted in an attempt to evaluate key-pecking are those of Herrnstein (1966), and Staddon and Simmelhag (1971). Herrnstein has described reinforcement as blindly strengthening whatever behavior it follows. Staddon and Simmelhag have stated that reinforcement directly determines what
behavior precedes the reinforcer. They stated that the availability of food combined with a state of food deprivation, will induce a bird to peck. Furthermore, reinforcement will decrease the variability of the physical locus of the peck, rather than increase the overall rate of pecking. If a peck on the response-key is followed by noncontingent reinforcement, the loci of the pecks will converge to focus upon the key. While it is not possible to state which theory is of primary importance for the maintenance of the key-peck behavior in the present experiment, there are some data which are compatible with the effects of adventitious reinforcement. The gradual shift in key-pecking observed in Group R toward the onset of the key-light is amenable to Herrnstein's description of superstitious pecking. He stated that superstitious behavior can "drift". This drifting would be gradual and would not be because reinforcement is no longer effective, but because of the absence of contingencies of reinforcement. However, the fact that the drift in all four birds was so similar tempers the applicability of the explanation in terms of superstitious behavior. Additionally, during the No Food condition, as key-pecking subsided the last pecks to occur were closest to food delivery. The "spontaneous recovery" data presented suggest some form of reinforcement was operating previous to the No Food condition.
Another issue is whether or not key-light offset which immediately precedes food delivery, is a conditioned reinforcer. Schwartz (1972) concluded that it was not necessarily so, however, his experimental procedures were questionable. His method was to program the delivery of food in the last seconds of key-light so that key-light offset did not precede food presentation. Therefore, light offset occurred while the bird was eating with his head in the food magazine. For two pigeons, key-pecks turned off the key-light and prevented food, and for another two subjects, key-pecks prevented food but had no effect on key-light duration. He reported substantial key-pecking under both conditions. It is questioned whether or not these birds behaviorally came into contact with the programming sequence.

In the A-M procedure for this experiment, key-light offset reliably predicted grain presentation. During the No Food condition key-pecks occurred most persistently just before key-light offset; in the sessions before this, most pecks occurred early in the trial stimulus. The pattern of key-pecking changed substantially. In the A-MNC, key-light offset preceded food delivery only when no pecks occurred during the key-light. Not only did B1 peck, but a scallop-like pattern emerged. Since key-light offset was followed by food occasionally, as determined by B1's pecking behavior, it could function
as a conditioned reinforcer and adventitiously reinforce key-pecks. During the No Food condition, Bl's key-pecks were most persistent late in the key-light interval. Although the above is not conclusive evidence for the existence of conditioned reinforcers and adventitious conditioned reinforcement in A-M and A-MNC, it is compatible with such an interpretation.

Two of the puzzling issues brought forth by experiments in A-S and A-M are explanations concerning the emergence of the first key-peck and key pecking despite negative response-reinforcer relationships. Intermixed in these issues is the relationship of operant and respondent conditioning and the role each plays, and the effect of their combined influence.

The emergence of the first key-peck may be explained with reference to the findings of Staddon and Simmelhag. They employed the principle of stimulus substitution. Since grain is a stimulus that elicits pecking in pigeons, key-pecks preceding food presentation may demonstrate a susceptibility of consummatory responses to the stimulus substitution principle. Data from Smith (1972) lend support to this explanation. He reported that the topography of the key-peck is different when water presentation follows the key-light, as opposed to food delivery following the key-light. "For water the beak is closed at key contact, and certain characteristic
neck muscle movements which are observed only during drinking occur shortly after beak contact." With "food-based responding the beak is open, then closes and opens in rapid succession at key contact." Smith concluded by stating that there seemed to be some sort of elicited behavior in response to the key-light. Wolin (1968) has previously reported similar findings.

Staddon and Simmelhag also discussed the negative A-M findings of Williams and Williams within the context of their theory. Negative A-M is a condition during which key-pecks turn off the key-light and prevent food delivery. According to them, this condition is one in which the principles of reinforcement and variation operate in opposition to each other. The predictability of food delivery following key-light offset could be a condition in which key-pecking occurs due to the principle of stimulus substitution. However, when a key-peck does occur, the key-light turns off and food is not delivered and thus via the principles of reinforcement there is a reduction in the terminal response—key-pecking. This process continues until trials occur without pecks and then food is presented, and then by stimulus substitution, key-pecking ensues. The cyclic process continues. Staddon also predicted that if key-pecks prevent food but do not affect key-light duration, extinction would take place. This is in contrast with the findings of this experiment for bird Bl.
Schwartz (1971) and Schwartz and Williams (1972) reported that there were two kinds of key-pecks in the A-S and A-M procedure. Key-pecks of 20 sec or less in duration were termed "auto-pecks" and key-pecks of longer duration were called "operant pecks". Gamzu (1972) extended these findings. Auto-pecks were said to be controlled by antecedent events (S-SR). It was discovered that in the shaping techniques, initial responses were auto-pecks, and in negative A-M, only short duration pecks were observed. Auto-pecks were not effected by consequent events even if specific contingencies for reinforcement were programmed. When response-reinforcer contingencies were arranged, operant pecks predominated. Gamzu termed behaviors like auto-pecks "minimal units". They may be observed in normal animals prior to operant conditioning and are said to be species-specific. Minimal units may be evoked by exteroceptive and interoceptive stimuli or by a combination of both. In the case of auto-pecks they are said to be related to the consummatory behavior of pigeons. Given this analysis, key-pecking in the A-S and A-M procedures is affected by both antecedent and consequent events. In order to determine the nature of the response, negative A-M must be employed because then the stimulus-reinforcer contingency may be shown to dominate the response-reinforcer contingency in controlling behavior.
Another explanation of why the pigeon key-pecks in the A-S procedure was first offered by Brown and Jenkins. They suggested that the informational properties of the key-light affected the behavior of the pigeon. Hitzing and Safar used no house light and flat black interior walls in order to make key-light onset easy to discriminate. They stated that this would enhance the A-S phenomenon and had supporting data. Wasserman et. al. found greater key-pecking with the use of a house light. Their results were explained by suggesting that the birds could detect key-light onset regardless of their position in the chamber if no house light was used. It was not necessary for the birds to attend to the response-key in order to discriminate when food delivery would occur. Schwartz (1972) commented that the response-key becomes a target for the peck because it is a differential signal for food presentation. Gamzu and Schwartz (1972) also stated that the response-key becomes the target of the pigeon's peck because the key is a signal for food delivery. In summary, if the general illumination of the chamber interior, rather than the key-light illumination, is sufficient to signal food, then the pigeon will peck the key less frequently.

Given the present development of the theory and research in A-S and A-M, perhaps the most salient remarks were those of Schwartz and Williams (1971). "The fact
that pecking is involved in operant, collateral, and consummatory behavior complicates both an analysis of the important relationships in the present situation and in cross-species comparisons, (page 159)."
FIGURE 1

LEGEND

Effects of Auto-Maintenance, Auto-Maintenance Negative Contingency, and No Food on trials with pecks, and total pecks. Abscissa: daily sessions of 50 trials. Left Ordinate: trials with pecks (range of 0-50 trials). Right Ordinate: total key-pecks per session. Vertical hash lines separate the different experimental conditions.
Figure 1
Effects of Auto-Maintenance, and No Food on the intrastimulus key-peck distribution for subject Rl. Abscissa: intrastimulus intervals in 6, 1 1/2 second bins. Left Ordinate: frequency of key-pecks averaged over 4 sessions. Right Ordinate: percent of total key-pecks averaged over 4 sessions.
Figure 2
FIGURE 3

LEGEND

Effects of Auto-Maintenance, and No Food on latency to first key-peck for subject Rl.
Abscissa: latency (sec) to first key-peck in presence of key-light in 6, 1 1/2 second bins. Left Ordinate: absolute total key-pecks over 4 sessions. Right Ordinate: absolute percent of total key-peck over 4 sessions.
Figure 3

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FIGURE 4
LEGEND

Effects of Auto-Maintenance, and No Food on the intrastimulus key-peck distribution for subject R4. Abscissa: intrastimulus intervals in 6, 1 1/2 second bins. Left Ordinate: frequency of key-pecks averaged over 4 sessions. Right Ordinate: percent of total key-pecks averaged over 4 sessions.
Figure 4

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FIGURE 5

LEGEND

Effects of Auto-Maintenance, and No Food on latency to first key-peck for subject R4. Abscissa: latency (sec) to first key-peck in presence of key-light in 6, 1 1/2 second bins. Left Ordinate: absolute total key-pecks over 4 sessions. Right Ordinate: absolute percent of total key-pecks over 4 sessions.
Figure 5

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FIGURE 6
LEGEND

Effects of No Food on cumulative responses per session for subject R4. Abscissa: trials 1-50. Ordinate: cumulative responses (key pecks) in key-light per session. Sessions 22-25 cumulative key-pecks are averaged over the 4 sessions trial-by-trial. Sessions 26-33 cumulative key-pecks trial-by-trial per each session.
LEGEND

Effects of Auto-Maintenance Negative Contingency, and No Food on intrastimulus key-peck distribution for subject Bl. Abscissa: intrastimulus intervals in 6, 1 1/2 second bins. Left Ordinate: frequency of key-pecks averaged over 4 sessions. Right Ordinate: percent of total key-pecks averaged over 4 sessions.
Figure 7

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FIGURE 8
LEGEND

Effects of Auto-Maintenance Negative Contingency, and No Food on latency to first key-peck for subject Bl. Abscissa: latency (sec) to first key-peck in the presence of the key-light in 6, 1 1/2 second bins. Left Ordinate: absolute total key-pecks over 4 sessions. Right Ordinate: absolute percent of total key-pecks over 4 sessions.
Figure 8
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