AUTOSHAPING, RANDOM CONTROL, AND OMISSION TRAINING IN THE RAT¹

CHARLES LOCURTO, H. S. TERRACE, AND JOHN GIBBON

COLUMBIA UNIVERSITY AND
THE NEW YORK STATE PSYCHIATRIC INSTITUTE

The role of the stimulus-reinforcer contingency in the development and maintenance of lever contact responding was studied in hooded rats. In Experiment I, three groups of experimentally naive rats were trained either on autoshaping, omission training, or a random-control procedure. Subjects trained by the autoshaping procedure responded more consistently than did either random-control or omission-trained subjects. The probability of at least one lever contact per trial was slightly higher in subjects trained by the omission procedure than by the random-control procedure. However, these differences were not maintained during extended training, nor were they evident in total lever-contact frequencies. When omission and random-control subjects were switched to the autoshaping condition, lever contacts increased in all animals, but a pronounced retardation was observed in omission subjects relative to the random-control subjects. In addition, subjects originally exposed to the random-control procedure, and later switched to autoshaping, acquired more rapidly than naive subjects that were exposed only on the autoshaping procedure. In Experiment II, subjects originally trained by an autoshaping procedure were exposed either to an omission, a random-control, or an extinction procedure. No differences were observed among the groups either in the rate at which lever contacts decreased or in the frequency of lever contacts at the end of training. These data implicate prior experience in the interpretation of omission-training effects and suggest limitations in the influence of stimulus-reinforcer relations in autoshaping.

Key words: autoshaping, omission training, random-control training, lever contacts, lever presses, rats

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In a now classic experiment, Brown and Jenkins (1968) demonstrated that pigeons will peck at a brief visual signal so long as that signal is followed reliably by food. This phenomenon, termed autoshaping, is theoretically significant for a number of reasons. First, food follows the offset of the signal whether or not pecking to the signal has occurred. Accordingly, one must ask whether a response-reinforcer contingency (R-S*) is necessary for the acquisition of a conditioned key peck. A second basis for interest in autoshaped behavior is the demonstration that such behavior persists in the face of contingencies that would be expected to eliminate responding controlled primarily by R-S* relationships. Williams and Williams (1969) used an omission-training

(negative automaintenance) procedure in which food occurred only on those trials in which pecking did not occur. In this experiment, in which there was a positive contingency between a signal and food (S-S*) and a negative contingency between pecking and food ($\bar{R}$ -S*), pecking was maintained at substantial frequencies. Williams and Williams' experiment prompted numerous attempts (most of which have used pigeons) to define the role of S-S* relationships in the development and maintenance of conditioned behavior (*e.g.*, Herrnstein and Loveland, 1972; Schwartz, 1972; Schwartz and Williams, 1972*a,b*).

Omission training, in which R and S* are negatively correlated, is but one of a family of

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procedures that allows one to assess the influence of a positive correlation of S and S* in the autoshaping paradigm. The rationale of the omission-training procedure is made clear by considering the possible contribution of adventitious R-S* pairings in autoshaping (Brown and Jenkins, 1968; Hearst and Jenkins, 1974). While an autoshaping paradigm calls for a positive S-S* relationship, it does not eliminate the possibility of close temporal pairings between responses and reinforcers. Persistent responding in the face of an omission procedure is grounds for rejecting the adventitious reinforcement explanation.

A second procedure relevant to the evaluation of S-S* contingencies in autoshaping is the "random-control" procedure (*cf.* Rescorla, 1967). This procedure, in which signals and reinforcers are delivered independently of one another, allows one to specify whether the correlation between stimuli and reinforcers is necessary for the occurrence of autoshaping. Without such a control, one cannot evaluate the contribution of nonassociative factors, such as pseudoconditioning.

The two experiments reported here evaluated the role of S-S* associations on both the acquisition and maintenance of autoshaped behavior in rats, an organism that has received relatively little attention in the rapidly expanding literature on autoshaping. Following the first systematic demonstration of autoshaping in the rat (Peterson, Ackil, Frommer, and Hearst, 1972), there appears to have been only one attempt (Stiers and Silberberg, 1974) to evaluate systematically the effects of omission training and a random-control procedure on the autoshaped behavior of this organism. In the Stiers and Silberberg study, two retractable levers were programmed independently to protrude into the experimental chamber at the end of an intertrial interval whose average value, in each case, was 90 sec. One lever was "neutral", in the sense that it was not predictive of food. The second lever was either "positive" or "negative". When "positive", food would be delivered at the end of a trial whether or not the rat made contact with the lever (*i.e.*, autoshaping). When "negative", contacts with the second lever cancelled delivery of food at the end of the trial (*i.e.*, omission training). Different groups of rats were exposed to one of two different training sequences: (1) positive (and neutral) levers →

negative (and neutral) levers; or, (2) negative (and neutral) levers → positive (and neutral) levers.

Stiers and Silberberg observed that the frequency of contacts on both the positive and negative levers was generally higher than the frequency of contacts on the random-control lever. More important, these authors found that omission training was effective in educating responding in naive subjects and in maintaining responding in subjects with prior autoshaping training. Specifically, they concluded that omission training did not retard subsequent responding under an autoshaping procedure, and, that the effectiveness of omission training in maintaining responding was not influenced by prior autoshaping training. These data were interpreted as strong evidence of the influence of Pavlovian S-S* relationships in autoshaping with rats.

Stiers and Silberberg's results pose certain problems of interpretation. It is well known that performance on simple schedules differs from that engendered by concurrent schedules (*cf.* Catania, 1966; Herrnstein, 1970). In Stiers and Silberberg's study, the random-control procedure was administered *concurrently* either with the positive or with the omission lever. Responding might well be influenced by the availability of the random-control lever. Similarly, responding on the random-control lever may also be influenced by the availability of an alternative lever. It is reasonable to expect some differences between response levels under concurrent procedures and one in which only one contingency is in effect at a time. The latter is the procedure followed in the present experiments.

A second and more important interpretive problem concerns Stiers and Silberberg's finding of no sequential effects. For example, in shifting from autoshaping to omission training, Stiers and Silberberg found decrements in responding in all subjects. These authors concluded, however, that under omission training, responding was still maintained at substantial levels, as compared to the responding engendered during prior autoshaping training.

One wonders what the effects of omission training would be as assessed against reference levels other than prior autoshaping. One might specify, for example, a baseline level of responding as measured under a random-control procedure. How different would be the re-

sponse reduction following the shift from auto-shaping to a random-control procedure? In the present study, we evaluated both sequences: autoshaping → omission training, autoshaping → random control. We also compared these to the sequence: autoshaping → extinction.

A similar question concerning the baseline appropriate for assessing sequential effects arises when one considers response probability in subjects that received autoshaping following omission training. Following omission training, Stiers and Silberberg noted, terminal auto-shaping levels were, in some cases, lower than those observed in subjects given training only on an autoshaping procedure. This is not the only comparison of interest. One may also compare response probability during auto-shaping that follows random-control training.

Experiment I studied the acquisition of responding under autoshaping, omission training, or a random-control procedure. In addition, we sought to clarify the sequential effects of random-control and omission training on the subsequent acquisition of an auto-shaped response. Experiment II studied the relative efficacy of extinction, random-control, and omission procedures in eliminating auto-shaped behavior.

EXPERIMENT I

METHOD

Subjects

Twelve male, hooded rats, approximately 125 days old at the start of training, were maintained at 80% of free-feeding weights throughout the experiment. These 80% weights were readjusted weekly to take into account weight gains observed in a control group that continued on free feeding for the duration of the experiment. To maintain their 80% weights, experimental subjects received supplementary food in their home cages after each session.

Apparatus

The test chamber for all experiments was a modified Coleman ice chest (80-quart capacity). The subjects' portion of the chamber was 24 cm wide, 29.5 cm long, and 34 cm high. A feeder dish was located in the middle of the test panel at floor level. A retractable lever (Scientific Prototype) was housed 4 cm above

the floor and 7 cm to the right of the feeder dish. Upon insertion, it protruded 1.59 cm into the test chamber. Approximately 35 g (0.35 N) of force was necessary to depress the lever sufficiently to operate a microswitch and register a press. A small cue lamp (Lehigh Valley) was placed 8 cm above the lever. Contacts with the lever were also recorded, through the use of a drinkometer circuit. The reinforcer was the delivery of a 45.0-mg Noyes food pellet into the feeder dish. A houselight (10 W) located on the ceiling opposite the test panel provided constant illumination. White masking noise was continuously present during each session.

Procedure

All experimentally naive subjects were first trained to eat reliably from the feeder dish. Feeder training was conducted on two consecutive days, during which 50 food pellets were delivered following intervals whose average value was 15 sec. These and other variable-time (VT) schedules were constructed from the Fleshler-Hoffman (1962) formula. During the first session, each subject was given several experimenter-delivered pellets on an approximate VT 5-sec schedule. Once consistent eating was observed, pellets were delivered on the VT 15-sec schedule.

On the day following the second feeder-training session, all subjects were given the first of seven operant-level sessions. Each session consisted of 25 presentations of the lever (trials). By definition, no pellets were given during the operant-level sessions. A trial was defined as insertion of the lever accompanied by illumination of the cue lamp for 15 sec. Trials were arranged to occur on a VT 90-sec schedule.

On the day after the last operant-level session, each subject was assigned to one of the following three experimental groups for 40 training sessions. With infrequent exceptions, sessions were conducted daily. Each session was terminated after 25 trials.

1. *Autoshaping* (Subjects 138, 139, 140, 141): a reinforcer was delivered at the end of each trial, independently of a subject's behavior during the trial. The intertrial interval was determined by a VT 90-sec schedule.

2. *Omission training* (Subjects 134, 135, 136, 137): reinforcement was scheduled at the end of each trial. Reinforcement was cancelled on each trial in which the lever was contacted.

The intertrial interval was determined by a VT 90-sec schedule.

3. *Random control* (Subjects 127, 131, 132, 133): trials and reinforcers were scheduled independently on two separate VT 90-sec tapes. Either event could occur at any time during a session.

On the day following the last session (Session 40), all subjects of the omission-training and random-control groups were given 20 sessions of autoshaping training.

RESULTS

Initial Training

The autoshaping procedure generated lever contacts to a far greater extent than did either omission training or the random-control procedure. Omission training was more effective than the random-control procedure in establishing and maintaining contact behavior early in training. However, this difference disappeared with extended training. In agreement with Peterson *et al.* (1972), contacts were found to be much more frequent than lever presses.

The effects of the three procedures were evaluated by measuring the probabilities, frequencies, and latencies of both lever contacts and presses during each session. Response probability was expressed as the proportion of trials with at least one contact.

The probability of a lever contact of each subject in each group is shown in Figure 1. Throughout most sessions, three of the four subjects in the autoshaping group produced

lever contacts on more than 20 of the 25 trials. This level of responding was not achieved by any of the subjects in the omission-training or random-control groups. The greater tendency of the autoshaping subjects to contact the lever can also be seen by the virtual absence of overlap of the group medians.

Statistical analyses² revealed that the probability of contacts of the autoshaping group exceeded that of both the omission-training and random-control groups ($0.05 < p < 0.10$). The comparison of contact probability for omission training and the random-control procedure indicated that the higher probability of contacts observed under the omission-training procedure was limited to the first 20 sessions ($p < 0.05$). Over the last 20 sessions, there were no differences between the random-control and omission-training groups. Contact probabilities of omission subjects were lower during the last 20 sessions than they were during the first half of training ($0.05 < p < 0.10$). The reverse was true of the subjects of the random-control group. These subjects exhibited an increase in contact probability ($0.05 < p < 0.10$) during the final 20 sessions.

The total frequency of contacts per session made by the subjects of each group is shown in Figure 2. In evaluating these data, the reader should bear in mind that all groups

²Comparisons between groups were conducted using the Randomization test while within-group changes were assessed with the Randomization test for matched pairs (Siegel, 1956).

Fig. 1. Proportion of trials with at least one contact during each session. Points to the left of Session 1 in each panel, labelled "OP", indicate mean performance for each subject during the last five operant-level sessions.

had an equal opportunity to respond. The frequency of contacts made by the autoshaping group vastly exceeded that of the other two groups ($p < 0.05$). No systematic differences in contact frequency could be observed in comparing omission-training and random-control subjects.

Systematic observations, which were limited to the first phase of Experiment I, revealed that the behavior of the three experimental groups could also be distinguished by response topography. Autoshaping subjects tended to gnaw and lick the lever, often keeping their paws on the top of the lever during the entire trial (*cf.* Stiers and Silberberg, 1974: Table 1, p. 504). Omission subjects tended to make a single movement toward the lever, occasionally touching it once or twice. When near the lever, omission subjects engaged in a number of easily discernible patterns of behavior. These included: (1) revolving their heads around the lever several times; (2) gnawing at the grid directly below the lever and alternately moving to the food cup and back to the grid; or, (3) extending on their hind legs above the lever to the right corner of the cage, sniffing and gnawing at the corner of the test panel. These patterns occurred whether or not the lever was contacted.

The behavior of random-control subjects

during lever insertions was composed of two distinct patterns: (1) no apparent directed movements toward the lever during a trial—if a contact occurred, it appeared to be a function of general exploratory activity; (2) on a small fraction of trials, directed movements toward the lever occurred and were followed by multiple contacts similar in topography to those of the autoshaping group, although contact with the lever seldom extended throughout the entire trial.

Latencies of contact were variable although, in general, the rank-ordering of the groups mirrored the probability data. For the last 20 sessions, group mean contact latencies for trials with at least one contact were as follows: autoshaping, 3.49 sec; omission training, 4.35 sec; random control, 5.67 sec. Autoshaping subjects produced shorter latencies than either omission-training or random-control subjects ($p < 0.05$). The latencies of omission subjects were significantly shorter ($p < 0.05$) than those of random-control subjects.

Few lever presses were recorded during any portion of training. No subject in either the omission training or random-control group pressed with a probability of more than 0.10 for more than one session. Of the autoshaping subjects, only #140 pressed with a probability exceeding 0.10 throughout the 40 sessions.

Fig. 2. Total contacts during each session. Points to the left of Session 1 in each panel, labelled "OP", indicate mean performance for each subject during the last five operant-level sessions.

Autoshaping Following Omission or Random-Control Training

When switched to the autoshaping procedure, subjects that had experienced omission training produced lever contacts at consistently lower levels than did subjects originally exposed to the random-control procedure. Contrary to expectation, the random-control → autoshaping group exceeded the naive autoshaping group on all measures.

Figure 3 presents individual and group functions of contact probability for both the omission-training → autoshaping → and the random-control → autoshaping groups. All four subjects of the random-control → autoshaping group contacted the lever on virtually all trials after the sixth day of autoshaping training. In contrast, three of the four former omission-training subjects did not substantially exceed their previous lever contact performance until the latter stages of autoshaping

Fig. 3. Proportion of trials with at least one contact during each autoshaping session. Points to the left of Session 1 in each panel, labelled "B" (baseline), indicate mean performance for each subject during the last five sessions before autoshaping.

training. During the 20 sessions, the contact probability of the former random-control subjects exceeded that of the former omission subjects ($p < 0.05$). Figure 1 showed that subjects of the naive autoshaping group contacted the lever during most trials of a given session. One autoshaping subject reached this level of performance during the fifth session (140); another during the eighth session (141). The third did not reach this level until the twenty-second session (138). Thus, acquisition appeared faster for random-control $\rightarrow$ autoshaping subjects than for naive autoshaping subjects.

The total frequency of contacts for each subject of the omission training $\rightarrow$ autoshaping and random-control $\rightarrow$ autoshaping groups is shown in Figure 4. Not only was the overall frequency of contacts higher for the subjects whose training began with the random-control procedure ($p < 0.05$), but by the end of training, there was little overlap between the random-control $\rightarrow$ autoshaping and the omission-training $\rightarrow$ autoshaping groups in total contacts. It should also be noted that the rise in contact frequency was faster for random-control $\rightarrow$ autoshaping subjects. It was also the case that the rate of increase and asymptote of contact frequency of the random-control $\rightarrow$ autoshaping subjects was greater than those of the naive autoshaping group (*cf.* left panel of Figure 2).

Differences in contact latencies were in the same direction as differences in contact probability and frequency. Throughout training, the former random-control subjects produced lever-contacts with significantly shorter latencies ($p < 0.05$) than did the former omission subjects. During the last five sessions, group mean latencies on trials occasioning a contact were as follows: omission training $\rightarrow$ autoshaping, 3.45 sec; random-control $\rightarrow$ autoshaping, 1.99 sec. It is also interesting to note that the latencies of the subjects exposed to only the autoshaping procedure were longer than those of the random-control $\rightarrow$ autoshaping group.

Substantial lever pressing was also observed in the random-control $\rightarrow$ autoshaping subjects. Each of these four subjects pressed the lever with a probability exceeding 0.30 during at least one five-session block of autoshaping training. Two random-control $\rightarrow$ autoshaping subjects (127, 132) lever pressed on 0.90 of the trials during at least one five-session period.

The probability of lever pressing of three of the four random-control $\rightarrow$ autoshaping subjects decreased with extended training. On the other hand, only one of the former omission subjects (134) produced any lever presses.

The data obtained during both phases of this study question the effectiveness of omission training to maintain responding in rats. Prolonged exposure to the procedure produced clear decrements in lever contacts. Also, subjects given omission training were retarded in their subsequent autoshaping performance as compared to subjects trained under a random-control procedure before autoshaping. Experiment II examined the ability of an omission-training procedure to maintain responding in subjects with a prior history of autoshaping training.

EXPERIMENT II

METHOD

Subjects

Twelve male, hooded rats were maintained on the same feeding schedule used in Experiment I. The range of ages was 130 to 185 days. Nine of the subjects had served in Experiment I.

Table 1

Previous experimental histories of subjects in Experiment II.

Group	Subject	History	Group Mean Number of Auto-shaping Sessions
Autoshaping $\rightarrow$ Omission Training	R-115	AS(35)	25
	R-118	AS(25)	
	R-132*	RC(40) $\rightarrow$ AS(20)	
	R-136*	OT(40) $\rightarrow$ AS(20)	
Autoshaping $\rightarrow$ Random Control	R-116	AS(20)	25
	R-141*	AS(40)	
	R-133*	RC(40) $\rightarrow$ AS(20)	
	R-137*	OT(40) $\rightarrow$ AS(20)	
Autoshaping $\rightarrow$ Extinction	R-139	AS(40)	30
	R-140*	AS(40)	
	R-127*	RC(40) $\rightarrow$ AS(20)	
	R-134*	OT(40) $\rightarrow$ AS(20)	

*Served in Experiment I.

Fig. 4. Total contacts during each autoshaping session. Points to the left of Session 1 in each panel, labelled "B" (baseline), indicate mean performance for each subject during the last five sessions before autoshaping.

ment I. Subjects' histories are shown in Table 1. Before this study, all subjects had experienced at least 20 autoshaping sessions. In each group, two subjects had been given only autoshaping training, while two others had been exposed either to random-control or to omission training, respectively, prior to autoshaping.

Apparatus

The same as used in Experiment I.

Procedure

Four subjects each were assigned to omission training, random control, or extinction for 25 sessions. The omission and random-control procedures were identical to those in Experiment I. Under the extinction procedure, the lever was inserted on a VT 90-sec schedule but was never followed by food. The groups were matched in terms of the mean number of previous autoshaping sessions and response probability during the last five autoshaping sessions. The first session for each subject followed its last autoshaping session.

RESULTS

All three procedures were effective in reducing contact responding. No systematic differences in lever contact performance were observed among the groups either in the rate of reduction or in their responding at the end of 25 sessions. Lever pressing was virtually

eliminated for those subjects in each group that had previously produced some lever presses. By the end of training, no subject pressed the lever with a probability exceeding 0.05.

Figure 5 shows the probability of making a contact during each of the 25 training sessions of each procedure. After 25 sessions, none of the procedures reduced the probability of a contact response to zero. At no point during training could the three experimental groups be distinguished on the basis of response probability.

A similar picture emerged from the data concerning total contact frequency. These are shown in Figure 6. Contact frequency appeared to be most rapidly reduced by omission training. After 25 sessions of omission training, none of the four subjects produced more than 22 contacts per session. In contrast, two of the random-control subjects were still producing lever contacts quite frequently on the last session (R-133, 66 contacts; R-141, 160 contacts). This was also true of one extinction subject (R-140, 102 contacts). However, none of the differences among these groups proved significant.

Contact latencies increased relative to their autoshaping baseline as a function of training for all subjects. Over the last five sessions, the group mean latencies on trials occasioning at least one contact were as follows: autoshaping → omission training, 5.51 sec; autoshaping →

Fig. 5. Proportion of trials with at least one contact during each session. Points to the left of Session 1 in each panel, labelled "B" (baseline), indicate mean performance for each subject during the last five autoshaping sessions.

random control, 6.33 sec; autoshaping → extinction, 6.07 sec. No significant differences on this measure were observed among the groups.

DISCUSSION

Theoretical analyses of autoshaping (e.g., Gamzu and Schwam, 1974; Hearst and Jenkins, 1974; Moore, 1973; Schwartz and Williams, 1972a; Schwartz and Gamzu, *in press*) and conditioning (Rescorla, 1967) have cited both omission and random-control procedures as important techniques for evaluating the effects of R-S* and S-S* contingencies. Some studies of the effects of omission training on pigeons' key pecking have concluded that certain responses, particularly responses established by an autoshaping procedure, are insensitive to their consequences (cf. Williams and Williams, 1969). While these apparent exceptions to the Law of Effect have not been consistently confirmed by other experiments (e.g., Griffin and Rashotte, 1973; Hursh, Navarick, and Fantino, 1974) they are sufficiently pervasive to warrant serious concern. Studies employing a random-control procedure have provided impressive evidence that the correlation between a stimulus and a reinforcer is necessary both to engender and main-

tain pigeons' key pecking (cf. Gamzu and Williams, 1971).

Our data question the generality of both conclusions. Lever contacts in rats were engendered and maintained under the random-control procedure in which there was no programmed correlation between lever insertions and food delivery. Our data on omission training suggest that S-S* relationships *per se* have but a limited ability to maintain auto-shaped lever contacts.

The effectiveness of the random-control procedure in supporting responding was evident in both experiments. Occasionally, relatively high response levels were maintained, both in naive subjects (Experiment I: R-127) and in subjects that had previously experienced autoshaping (Experiment II: R-133; R-141). Moreover, the frequency of responding of all four of the naive random-control subjects increased with extended training. This increase in response frequency was not evident in earlier work with rats using a concurrent random-control procedure (cf. Stiers and Silberberg, 1974).

Earlier research on random-control procedures does not suggest a second feature of our results. This was the rapid acquisition and high level of lever contacts during the auto-

Fig. 6. Total contacts during each session. Points to the left of Session 1 in each panel, labelled "B" (baseline), indicate mean performance for each subject during the last five autoshaping sessions.

shaping sessions that followed random-control training. The general finding in a variety of earlier studies was a retardation in acquisition following random-control training (*e.g.*, Bilbry and Winokur, 1973; Enberg, Hansen, Welker, and Thomas, 1972; Gamzu and Williams, 1971; Hearst and Jenkins, 1974). The many procedural and species differences between this study and past research preclude a systematic comparison. However, the present data do show that under some conditions, exposure to a random-control treatment facilitates subsequent acquisition.

The degree to which omission training supports responding above the level expected during random-control training was shown to be limited to experimentally naive subjects, and even in this instance, to the early portions of training. Thereafter, strong negative effects of omission training were evident, including significant response decrements with extended training and a retardation in responding when omission-training subjects were switched to autoshaping (*cf.* Barrera, 1974; Hursh, *et al.*, 1974, for similar results with pigeons). Moreover, in Experiment II, omission training did not maintain responding above the level supported either by random-control or extinction procedures in subjects that first experienced autoshaping (see Gamzu and Schwam, 1974, for similar data on squirrel monkeys. Also see Powell and Kelly, 1976, for similar data comparing crows and pigeons).

To account for the fact that performance during omission training is more successful (*i.e.*, responses do not occur to the signal) in experienced than in naive animals, it is helpful to consider what a subject might be learning during omission training and how exposure to autoshaping facilitates that learning. Basically, the subject must learn that responses to the signal cancel food. The task is made difficult by the presence of two competing factors that interact within the omission paradigm: a positive S-S* relationship, which engenders signal-directed responding; *versus*, the negative response contingency ($\bar{R}$ -S*), which should eliminate responding. Assuming that both relationships are potentially effective, the relative influence of either relationship may depend simply on the proportion of each type of relationship a subject experiences during omission training. By this account, significant responding is engendered in naive subjects by

the predominance of S-S* relationships early in training. As responding develops, the relative proportions change and the negative response relationship ($\bar{R}$ -S*) is sampled to a much larger degree. On the other hand, experienced subjects (which are responding at high probabilities when placed on omission training) sample the negative response contingency ($\bar{R}$ -S*) almost exclusively at the beginning of omission training.

An additional assumption is needed to account for the fact that responding does not recover during the latter portions of omission training when reinforcement probability is increased through nonresponding. For example, both naive omission subjects (Experiment I) and experienced omission subjects (Experiment II) were receiving food on nearly 70% of the trials by the end of omission training. Yet, responding showed no signs of recovery. Perhaps once response probability has been reduced (that is, once the $\bar{R}$ -S* contingency has been adequately sampled), S-S* relationships may be relatively ineffective in supporting responding.

This analysis of omission training, which focuses on the effectiveness of both S-S* and $\bar{R}$ -S* relationships, may be compared with interpretations that have emphasized primarily the Pavlovian aspects of autoshaping (Moore, 1973; Schwartz and Williams, 1972a). Among the important conclusions that Pavlovian analyses of autoshaping have developed are the following: 1. responses engendered by omission training are insensitive to their consequences (Williams and Williams, 1969; Schwartz and Williams, 1972b); 2. the level of responding supported by omission training is unaffected by prior autoshaping training (Stiers and Silberberg, 1974); 3. omission training may serve as the assay of S-S* control of skeletal response systems (Gamzu and Schwam, 1974); 4. autoshaping may be characterized as a "... simple Pavlovian process" (Moore, 1973, p. 164).

Each of these conclusions derives from the assumption that omission training is effective in maintaining responding. To the extent that this conclusion has been questioned by previous studies using pigeons (*e.g.*, Barrera, 1974; Hursh, *et al.*, 1974), crows (Powell and Kelly, 1976), and by the present study using rats, one must also question autoshaping as a simple Pavlovian process.

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