

AVERSIVE PROPERTIES OF THE NEGATIVE STIMULUS IN A SUCCESSIVE DISCRIMINATION¹

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Experiment I sought to determine if the stimulus correlated with extinction in a successive discrimination was an aversive stimulus. An escape response provided an index of aversive control. Two groups of pigeons were exposed to a multiple variable-interval 30-sec extinction schedule. For the experimental group, a single peck on a second key produced a timeout during which all lights in the chamber were dark. For the control group, pecks on the second key had no contingency. The rate of responding on the timeout key during extinction for the experimental group was higher than that of the control group during all sessions of discrimination training except the first. In Exp. II, green was correlated with variable interval 30-sec and red was correlated with variable-interval 5-min. Timeouts were obtained from variable-interval 5-min. There were more timeouts from extinction in Exp. I than from variable-interval 5-min in Exp. II. Experiment III showed that not presenting the positive stimulus reduced the number of timeouts from the negative stimulus for the two birds from Exp. I that had the highest rate of timeouts from extinction, but had little effect on the two birds that had the lowest rate of timeouts. These results suggest that in a multiple schedule, the stimulus correlated with extinction, or the lower response rate, functions as a conditioned aversive stimulus. Explanations of the timeout response in terms of extinction produced variability, displaced aggression, and stimulus change, were considered but found inadequate.

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Discussion

Several theorists have assumed that the negative stimulus, S⁻, which is correlated with extinction in a successive discrimination, actively controls the behavior of not responding. The negative stimulus has been interpreted as inhibitory (Pavlov, 1927; Spence, 1937), frustrative (Amsel, 1962), or aversive (Terrace, 1966a). Terrace (1966a) found gross differences

in the behavior of pigeons following discrimination learning with and without errors. Following discrimination learning with errors, photographs of the pigeons showed that "S⁻ evokes various emotional responses such as wing flapping and turning away from the key (Terrace, 1966a, p. 316)." Following discrimination learning without errors, the pigeon sat passively during S⁻. Terrace (1966a) concluded that when a successive discrimination is established with responses to S⁻, the negative stimulus becomes a conditioned aversive stimulus due to frustration or emotional behavior produced by nonreinforced responding.

The behavior of the animal during S⁺, the stimulus correlated with reinforcement, also depends on whether the discrimination was trained with or without errors. When a discrimination was trained with errors, behavioral contrast, an increase in the response rate in S⁺ occurred when the response rate in S⁻ decreased. Terrace (1963, 1964) found that when a discrimination was trained without errors, behavioral contrast did not occur.

The present experiments extended an experiment by Terrace (1966b) in which behavioral contrast was observed early in discrimination training, but gradually decreased

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during 60 sessions of extended discrimination training. According to Terrace, behavioral contrast is a byproduct of frustration or similar emotional responses. These responses adapt out after prolonged exposure to the discriminative stimuli, which may account for the decrease in behavioral contrast with extended discrimination training.

In Terrace's experiments, the aversive properties of S- were inferred rather than measured independently. The present experiments employed a procedure in which the animal was given an opportunity to produce a timeout from the discriminative stimuli. A multiple schedule in which S+ alternated with S- was arranged on one key. A peck on a second key produced a timeout during which the box was dark and the contingencies on the multiple schedule were removed. As Leitenberg (1965) pointed out, some of the previous studies of timeout behavior were designed so that the timeout response in conjunction with behavior on the food key increased the frequency of positive reinforcement. To avoid the confounding of timeouts from S- with the frequency of reinforcement in S+, the present procedure was designed so that timeouts during S- had no effect on the reinforcement frequency during S+. To determine if the timeout response was controlled by its consequences, a control group was given the same multiple schedule as the experimental group, but pecks on the timeout key had no scheduled consequences. The purpose of these experiments was to determine if a timeout response was an escape response from an aversive stimulus and therefore provided a quantitative index of aversive control.

EXPERIMENT I

In Exp. I, S+ was correlated with VI 30-sec and S- was correlated with extinction. Experiment I sought to determine if a response could be reinforced by a timeout during the extinction component of a successive discrimination. The experiment also permitted a comparison between the rate of responding to S+ and timeout behavior from S-.

METHOD

Subjects

Ten experimentally naive, adult White Carneaux pigeons were maintained at 80% of

their free-feeding weights throughout the experiment. Four birds were in the experimental group and six in the control group.

Apparatus

A three-key pigeon chamber, specifications described in Rilling (1967), was used.

Procedure

The procedure for the experimental group was as follows. After the pecking response was conditioned, responses on the right-hand key were reinforced on a variable-interval 30-sec schedule (VI 30-sec). Red and green keylights, S+, were correlated with reinforcement and were presented alternately on the right key. The duration of the stimuli was gradually increased from 30 to 240 sec during Sessions 1 to 4. The right key, center key, and houselights were darkened for 5 sec between stimulus presentations and an amber pilot light at the rear of the box was illuminated. The variable-interval tape did not run during the 5-sec intertrial interval and responses on the dark key were not reinforced. This intertrial interval insured that during subsequent discrimination sessions, a response to S- would never be immediately followed by the appearance of S+. The session was terminated after each stimulus was presented five times.

During the fifth session of VI training, the center key was illuminated with a white light. A single peck on the center key produced a 30-sec timeout during which all lights in the box were off and pecks on the keys had no effect. A timeout during S- terminated the stimulus correlated with extinction and the houselights. A timeout during S+ terminated the stimulus correlated with the VI schedule and the houselights. The VI tape did not run during timeouts from S+. At the end of the timeout, the lights came on again and the contingencies on the keys were reinstated. The timer controlling the duration of the right keylight continued to run during the timeout. If a timeout occurred when there was less than 30 sec remaining for the stimulus on the right key, the timeout was terminated when the interval elapsed by the onset of the amber light. This was to assure that during the subsequent sessions of discrimination training, timeouts during S- would have no effect on the reinforcement frequency during S+.

Discrimination training was begun after 20 sessions on VI 30-sec. During discrimination training, green, S+, was correlated with reinforcement and red, S-, was correlated with extinction. The session was terminated after each stimulus was presented 10 times. During the discrimination sessions, the length of the session was doubled in order to hold the number of reinforcements per session constant. Therefore, there were twice as many opportunities to produce timeouts as in the pre-discrimination sessions. The maximum possible number of timeouts per session was 80. Discrimination training was continued for 60 sessions, after which S+ and S- were reversed. Green was now correlated with extinction and red was correlated with reinforcement. Reversal training was continued for 60 sessions.

The procedure for the control group was the same as the experimental group with the following exceptions. During the fifth session of VI training, the center key was illuminated with a white light. Pecks on the center key were counted, but had no effect on the contingencies on the white key or the multiple-schedule key and the houselights remained on. The white light remained on for the 4 min of both S+ and S-. After 20 sessions on VI 30-sec, the control group was given 60 sessions of discrimination training in which green was correlated with reinforcement and red was correlated with extinction. Reversal training was omitted.

RESULTS

The left-hand section of Fig. 1 shows the number of timeouts from the S+ stimuli for each subject during the last 15 sessions of pre-discrimination training. The right-hand section of Fig. 1 shows the number of timeouts from S+ and S- during the 60 sessions of discrimination training and the 60 sessions of discrimination reversal. The closed-point curves show the timeouts during the discrimination sessions and the open-point curves show the timeouts during the discrimination-reversal sessions. The circles show the timeouts from S- and the triangles show timeouts from S+. Timeouts from S- increased rapidly for each subject during the early sessions of discrimination training. For Birds 133, 4294, and 375, after reaching a peak, timeouts from S- declined with extended discrimination training. The exception was Bird 4859, whose timeout

behavior was maintained at a substantially higher rate than that of the other three birds throughout extended discrimination training. After 60 sessions of discrimination training, timeouts from S- still occurred for each subject, so some timeout behavior from S- was a characteristic of the final discrimination performance. The timeout data show substantial variability within and between the individual birds. A notable unexplained example of extreme variability for Bird 4859 was Session 25 in which only two timeouts from S- occurred.

The discrimination reversal sessions also demonstrated timeouts from S- for each subject, but the data were less consistent than during original discrimination training. Birds 133 and 4294 showed fewer timeouts during the reversal sessions than original training; reversal data for Bird 4859 essentially replicated the original discrimination sessions. Bird 375's timeout behavior from S- did not begin until reversal session 18, after which timeout behavior increased moderately through the remaining reversal sessions.

Three of the birds produced very few timeouts from S+, but in Session 45 of discrimination training, Bird 133 began consistently to obtain timeouts from S+. During the remaining sessions of discrimination training, Bird 133 produced about as many timeouts from S+ as S- and this pattern of behavior continued throughout reversal training.

In order to determine how the timeouts from S- were distributed within the 4 min of extinction, the timeouts from S- for Sessions 40 to 60 of the discrimination training sessions were divided into eight class intervals of 30 sec each, and the number of timeouts produced during each class interval was determined. Sessions 40 to 60, rather than the earlier sessions, were selected for this analysis on the assumption that the pattern of timeout behavior had stabilized by Session 40. Figure 2 shows the distribution of timeouts from S- for each subject as a function of the amount of time that the animal had been exposed to S-. More responses that produced a timeout from S- occurred during the first half of S- than during the last half. The smallest number of timeouts from S- occurred during the last minute of S-. The distribution peaked during the first class interval for Birds 4859 and 4294, the second class interval for Bird 133, and the fifth class interval for Bird 375.

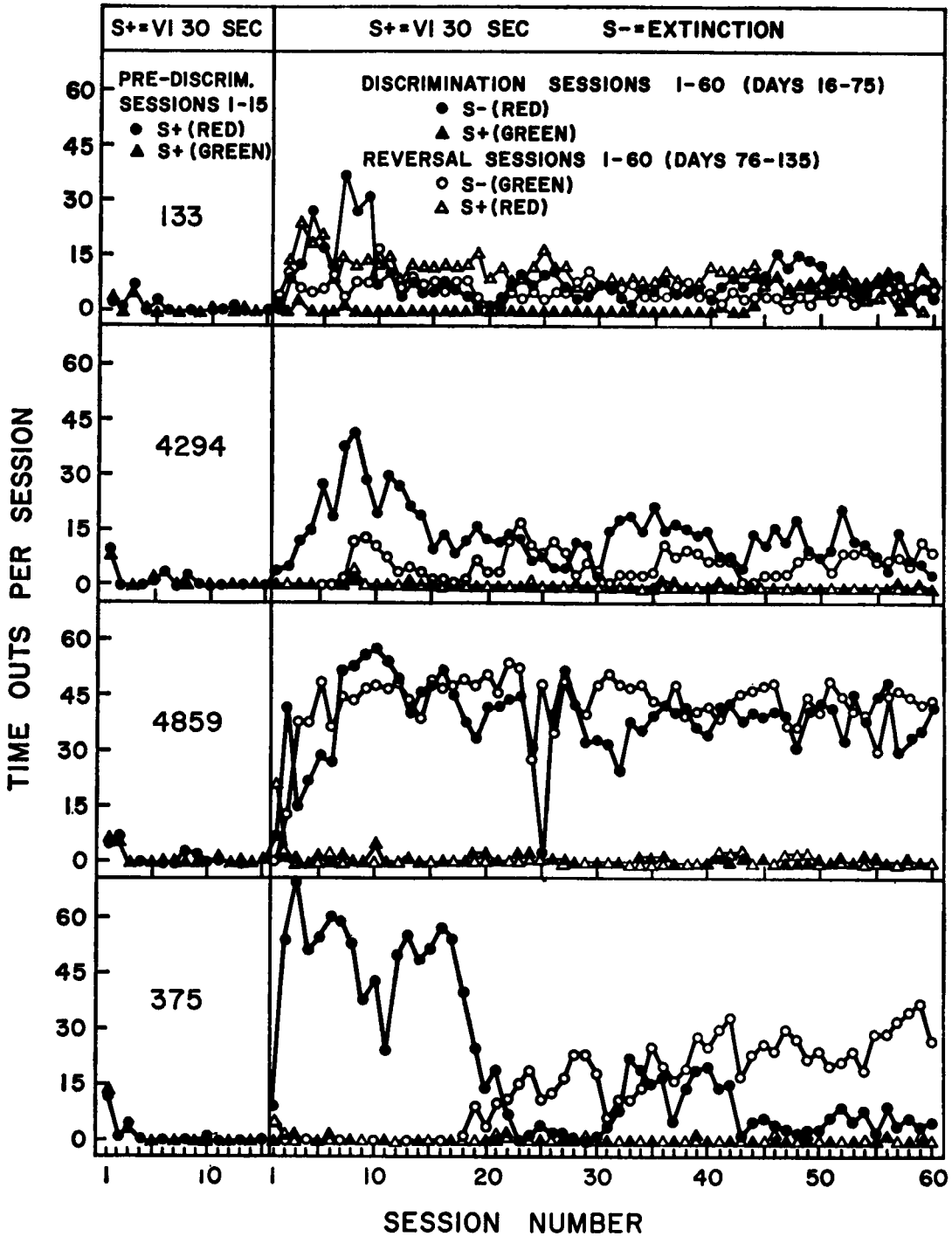


Fig. 1. The left-hand section shows each subject's timeouts from the two S+ stimuli during the prediscrimination sessions. The right-hand section shows each subject's timeouts from S+ and S- during discrimination training and discrimination reversal.

In order to determine how the timeouts from S+ were distributed within the 4-min S+ interval for Bird 133, the timeouts from

S+ for Sessions 40 to 60 of discrimination training were divided into class intervals of 60 sec each. The timeouts from S+ were dis-

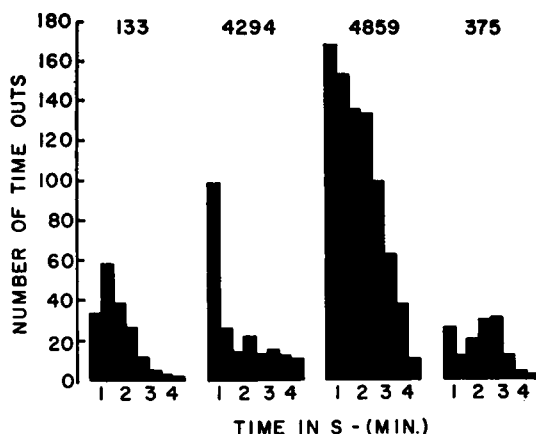


Fig. 2. Number of timeouts from S- during sessions 40 to 60 of discrimination training for each subject in class intervals of 30 sec.

tributed within the four class intervals as follows: 1,24; 2,35; 3,37; and 4,22. A comparison of the S+ distribution with the S- distributions for Bird 133 demonstrates that the S- distribution was skewed toward the beginning of S- although there was no basis for rejecting the hypothesis that the S+ distribution was rectangular.

Figure 3 shows the response rates during S+ and S- for the corresponding sessions of Fig. 1. The response rates in Fig. 3 were computed by dividing the number of responses in red and green by the actual duration of the red and green stimuli respectively. The response rate to S+ increased at the onset of discrimination training for each subject, but the amount of behavioral contrast was quite small for Bird 4859. Only Bird 133 showed a consistent decrease in the amount of behavioral contrast with extended discrimination training: the response rate to S+ during discrimination sessions 40 to 60 was lower than the response rate during discrimination sessions 1 to 20. Extended discrimination training did not attenuate the magnitude of behavioral contrast for Bird 4294 during either the discrimination or the reversal sessions. Attenuation of behavioral contrast cannot be assessed for Bird 4859 because the magnitude of the initial contrast effect was so small. Bird 375 showed substantial behavioral contrast during discrimination sessions 1 to 18 which decreased during Sessions 36 to 45, but behavioral contrast increased again during Sessions 46 to 60. In the reversal condition, Bird 375 shows sub-

stantial variability in the response rate to S+, but the trend in Sessions 20 to 60 was a slight increase.

Several comparisons can be made between the timeout data in Fig. 1 and the response rate data in Fig. 3. The Pearson product moment correlations between the number of timeouts from S- and the response rate to S+ over the 60 sessions of discrimination training for Birds 133, 4294, 4859, and 375 were 0.126, 0.093, 0.001, and 0.403 respectively. Therefore, the response rate to S+ is a poor predictor of timeouts from S- and vice versa. However, both behavioral contrast and timeouts from S- occur during the early sessions of discrimination training.

It is difficult to compare the number of responses during S- with the number of timeouts from S- because a timeout shortened the duration that S- was actually presented. Figure 3 shows that the response rate to S- was virtually zero by Session 10 for all the subjects, yet Fig. 1 shows that timeouts from S- continued to occur throughout the 60 sessions of discrimination training. These results suggest that factors other than the number of responses to S- are responsible for maintaining timeouts from S-.

Figure 3 shows that during the early sessions of discrimination reversal for Birds 4294 and 375, the response rates in both S+ and S- were virtually zero. Figure 1 shows that timeouts from S- were also absent during the early reversal sessions for these birds. Timeouts from S- did not occur until responding to S+ resumed. This suggests that reinforced responding in S+ was one of the factors that maintained timeouts from S-.

In order to compare the results of the experimental group, where each response on the white key produced a timeout, with the results of the control group, where responses on the center key had no effect, the mean response rate for each session during S- was computed for each group. The response rate for the experimental group was computed by dividing the number of timeouts per session by the time the white key was illuminated during S-; the response rate for the control group was computed by dividing the number of responses on the white key by the S- duration of 40 min. For the control group, Fig. 4 shows that the first day of extinction of responding on the red key produced the highest

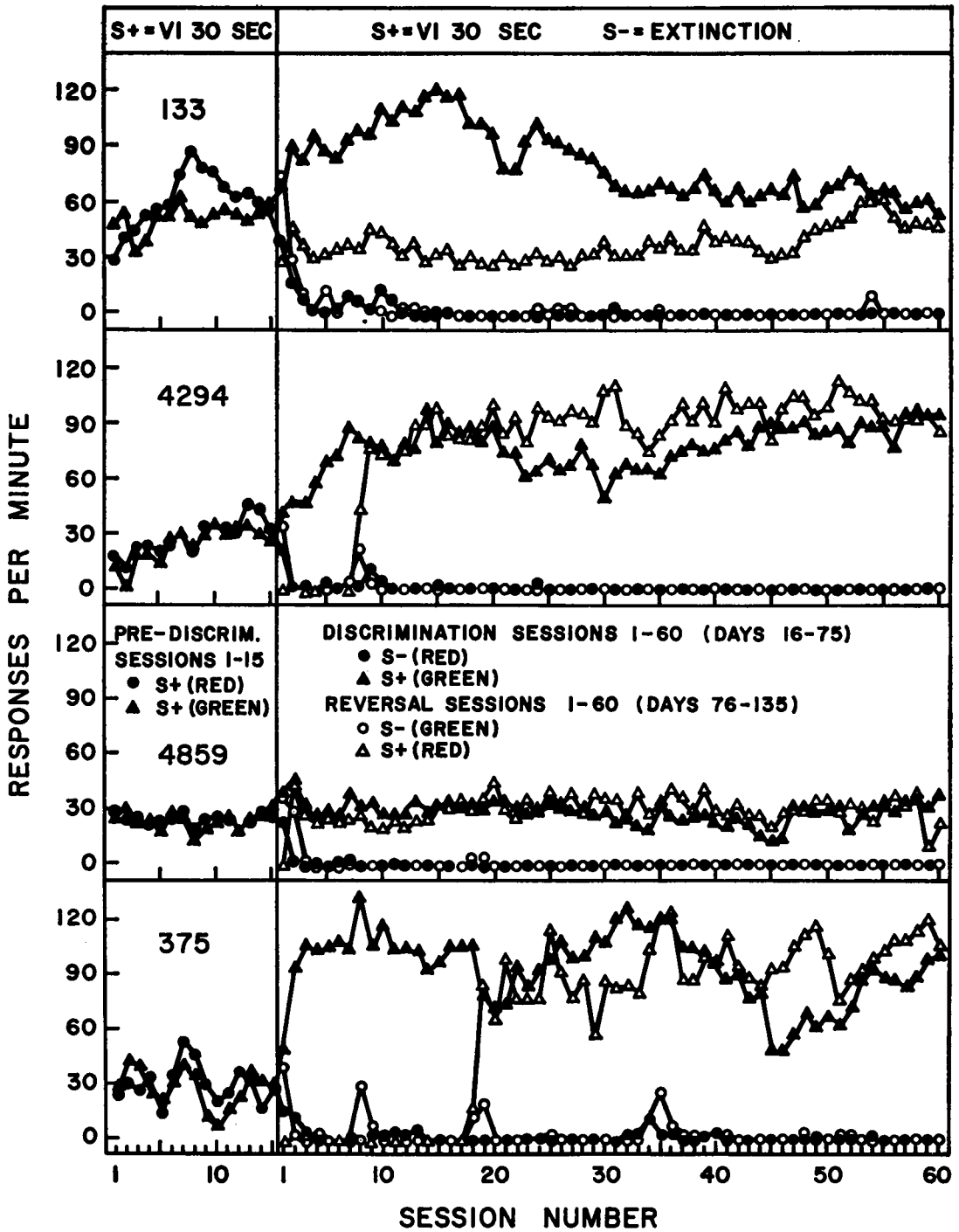


Fig. 3. The left-hand section shows each subject's response rates to the two S+ stimuli during the prediscrimination sessions. The right-hand section shows each subject's response rates to S+ and S- during discrimination training and discrimination reversal.

rate of responding on the white key. Extended discrimination training of the control group reduced the response rate on the center key to

a very low level. For the experimental group, Fig. 4 shows that the mean timeout rate increased during Sessions 1 to 3, fluctuated be-

tween a rate of 1.34 and 2.85 responses per minute during Sessions 4 to 17, and dropped to a lower rate which fluctuated between 0.16 and 1.00 responses per minute during Sessions 18 to 60. Each of the six control birds pecked the white key. Session 1 of discrimination training produced responses on the white key for five of the six subjects in the control group. The averaged data for the control group were fairly typical of the behavior of a majority of the individual subjects.

Figure 4 shows that the control group had a higher rate of responding on the white key than the experimental group during Session 1; during Session 2, the rates for the two groups were about the same, so the timeout behavior of the experimental group during these sessions may not have been due to the timeout contingency. However, the virtual disappearance of responses on the center key

for the control group with extended discrimination, in contrast with the maintenance of timeout behavior by the experimental group, indicated that the timeout responses during Sessions 3 to 60 were reinforced by their consequences.

EXPERIMENT II

While a successive discrimination is usually established by correlating one stimulus with reinforcement (S+) and another stimulus with extinction (S-), a discrimination can also be established by correlating two different stimuli, S1 and S2, with different values of a schedule of reinforcement. In an experiment by Guttman (1959), S1 was correlated with VI 1-min and S2 was correlated with VI 5-min. In a generalization test after discrimination training, the peak of the gradient was shifted away

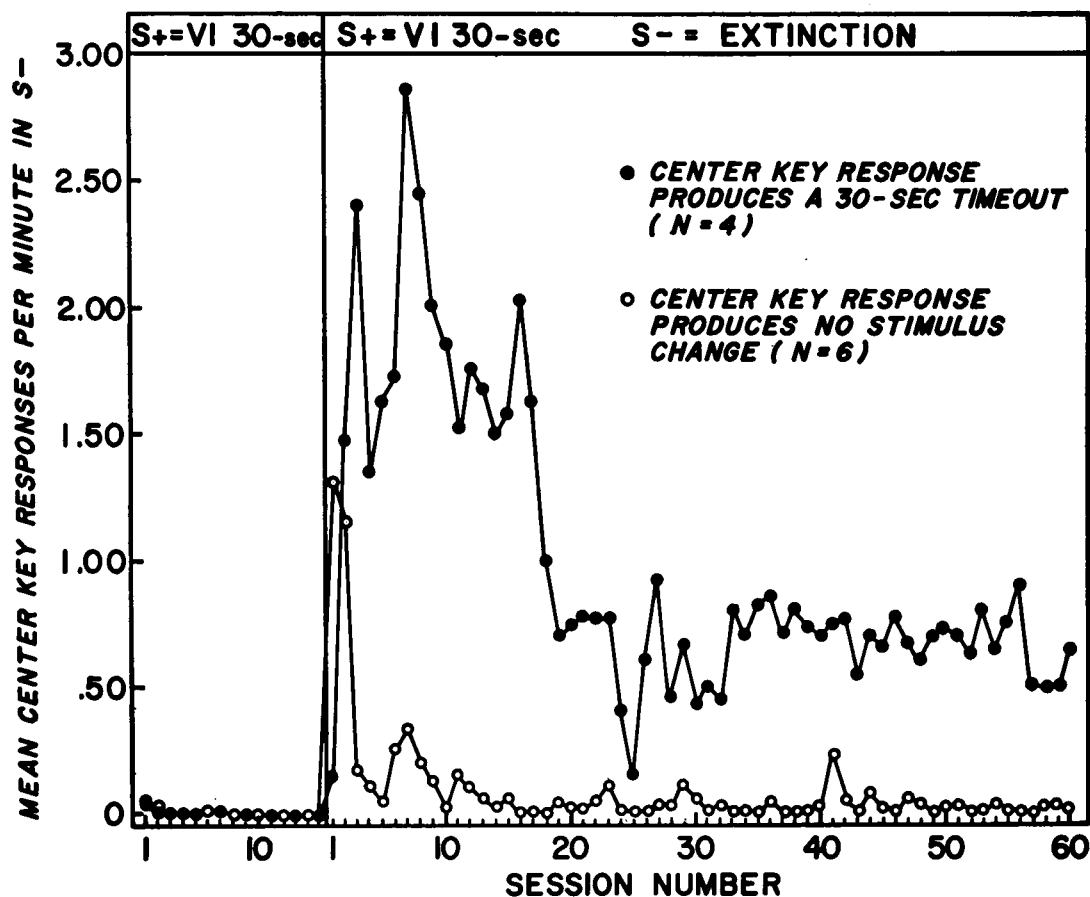


Fig. 4. The left-hand section shows the experimental and control groups' average response rate on the center key during S+ for the prediscrimination sessions. The right-hand section shows the experimental and control groups' average response rate on the center key during S- for the discrimination sessions.

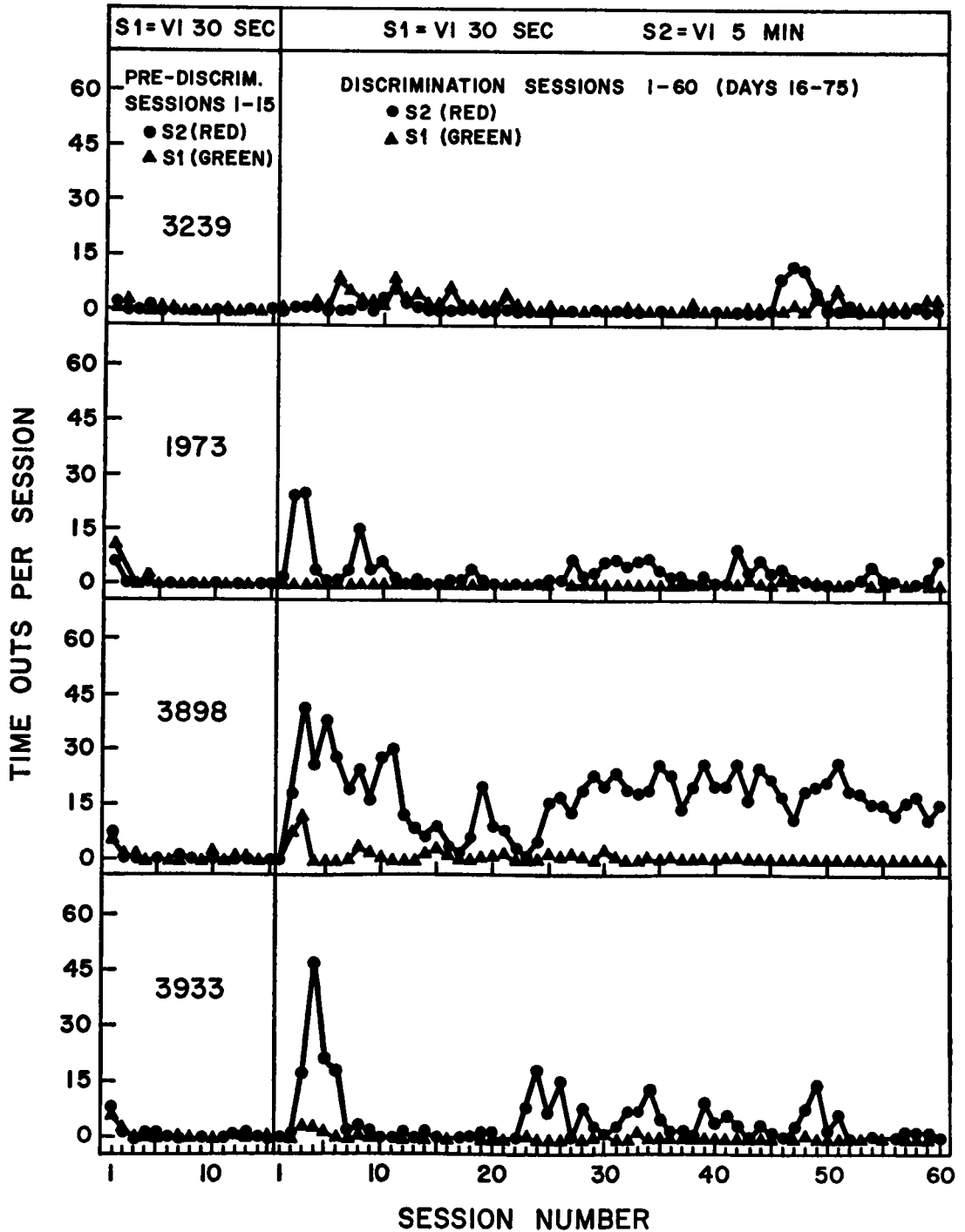


Fig. 5. The left-hand section shows each subject's timeouts from the two S+ stimuli during the prediscrimination sessions. The right-hand section shows each subject's timeouts from S+ and S- during discrimination training.

from the stimulus correlated with the VI 5-min schedule. Guttman concluded that a stimulus correlated with a relatively low reinforcement density was inhibitory and functionally negative. The Guttman experiment demonstrated that a stimulus correlated with VI 5-min shares some of the properties of a stimulus correlated with extinction. Since Exp. I demonstrated timeouts from a stimulus correlated with the extinction component of a multiple schedule, the purpose of Exp. II was to determine if timeouts could be obtained also from a stimulus correlated with the VI 5-min component of multiple VI 30-sec, VI 5-min.

METHOD

Subjects

Four experimentally naive, adult White Carneaux pigeons were maintained at 80% of their free-feeding weights throughout the experiment.

Procedure

The procedure was identical with Exp. 1, except that at the onset of discrimination training, the schedule of reinforcement in red, S2, was changed from VI 30-sec to VI 5-min. The reversal sessions were omitted.

RESULTS

The left-hand section of Fig. 5 shows timeouts from S1 and S2 for each subject during the last 15 sessions of prediscrimination training on VI 30-sec. In the right-hand section of Fig. 5, the circles show timeouts from VI 5-min, S2, and the triangles show timeouts from VI 30-sec, S1, during the 60 sessions of discrimination training. During Sessions 1 to 10 of discrimination training, timeouts from S2 increased over the prediscrimination baseline for all of the birds except 3239. The pattern of timeout behavior during the 60 sessions of discrimination training differed in detail from pigeon to pigeon. Timeouts from S2 were virtually absent for Bird 3239 except for Sessions 46 to 49 when a few timeouts occurred. For Bird 1973, some timeouts occurred during Sessions 1 to 10, but timeouts were at a very low level during Sessions 11 to 60. Only Bird 3898 showed a moderate number of timeouts during the 60 sessions of extended discrimination training, but the number of timeouts fluctuated from session to session. Bird 3933

also showed fluctuations in timeout behavior during extended discrimination training. An occasional timeout from S1 also occurred, but this behavior was weak in comparison with the number of timeouts from S2.

In order to determine how the timeouts from S2 were distributed within the 4 min of VI 5, the timeouts from S2 for Sessions 40 to 60 of the discrimination training sessions were divided into eight class intervals of 30 sec each, and the number of timeouts produced during each class interval was determined. Figure 6 shows the distribution of timeouts from S2 for each subject as a function of the amount of time that the animal had been exposed to S2. More responses that produced timeout from S2 occurred during the first half of S2 than during the last half. The smallest number of timeouts from S2 occurred during the last minute of S2. The peak of the distribution occurred during the first class interval for Birds 3239 and 3933, the second class interval for Bird 3898 and the third class interval for Bird 1973. The distribution of timeouts within the 4 min of VI 5 shown in Fig. 6 is remarkably similar to the distribution within the 4 min of extinction shown in Fig. 2, except that the absolute number of responses was smaller.

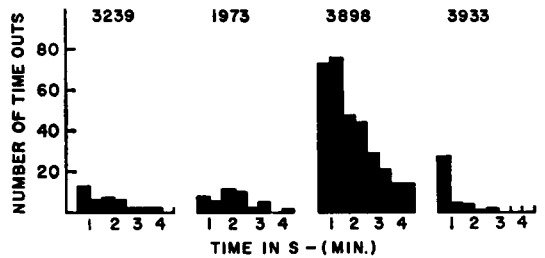


Fig. 6. Number of timeouts from S2 during Sessions 40 to 60 of discrimination learning in class intervals of 30 sec.

In Fig. 7, the triangles show the response rates to S1 and the circles show the response rates to S2 during the 15 prediscrimination and the 60 discrimination sessions. All birds showed behavioral contrast at the beginning of discrimination training. After 60 sessions of discrimination training, the rate of responding to S1 remained above the baseline rate during the final sessions of prediscrimination training for Birds 3239, 1973, and 3933. The exception was Bird 3898, whose response rate to S1 during Sessions 55 to 60 of discrimina-

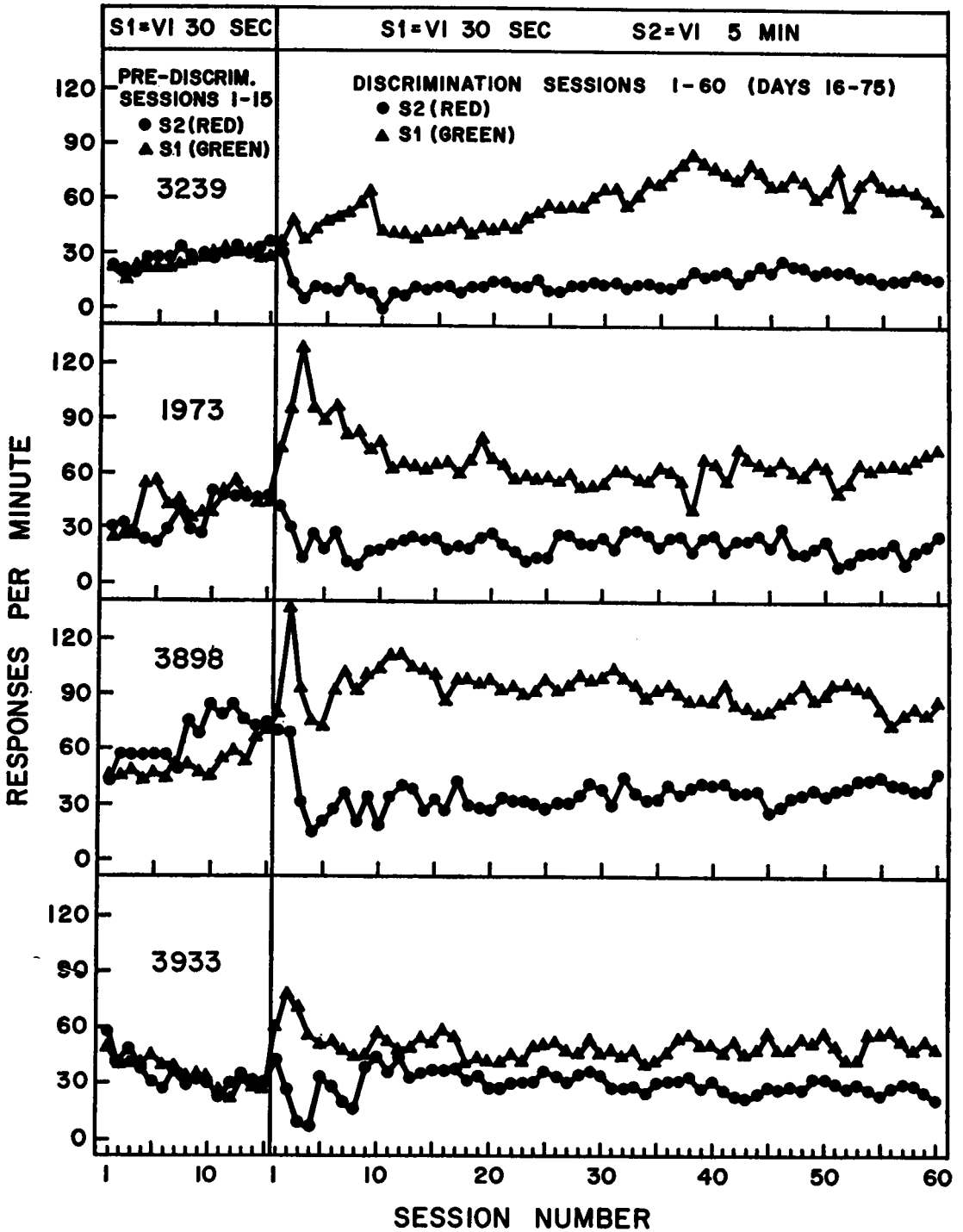


Fig. 7. The left-hand section shows each subject's response rates to the two S+ stimuli during the prediscrimination sessions. The right-hand section shows each subject's response rates to S+ and S- during discrimination training.

tion training was virtually the same as the response rate during the last session of prediscrimination training.

The pattern of responding to S1 across the 60 sessions of discrimination training differed in detail from bird to bird. For Bird 3239, the peak rate to S1 occurred in Session 38 which was atypically late in discrimination training. Birds 1973, 3898, and 3933 showed three stages of behavioral contrast mentioned by Bloomfield (1966) during Sessions 1 to 10. During the first stage the response rate to S1 increased, the peak occurred during the second stage, and during the third stage the rate fell. After Session 10, the response rate to S1 was relatively constant for Birds 1973 and 3933; Bird 3898 showed a gradual decrease.

The response rate to S2 dropped when the schedule of reinforcement was changed from VI 30-sec to VI 5-min and the response rate to S2 remained below that to S1 throughout the 60 sessions of discrimination training.

In order to compare the pattern of timeout behavior from the red stimulus, which was correlated with extinction in Exp. I and with VI 5-min in Exp. II, the data for each group were averaged. In Fig. 8, the filled circles show the average number of timeouts for the four birds whose individual data were presented in Fig. 1. The open circles in Fig. 8 show the average number of timeouts for the four birds whose individual data were presented in Fig. 5. More timeouts from the red stimulus occurred when it was correlated with extinction than when it was correlated with VI 5-min. Both functions showed a rapid increase in timeout behavior over the low rate during the prediscrimination sessions during the first few sessions of discrimination training. After reaching a peak, both functions dropped before Session 30. In Sessions 30 to 60, the mean number of timeouts for both groups remained relatively constant in comparison with the first 30 sessions.

In order to compare the effects of extinction in Exp. I and VI 5-min in Exp. II during the red component, on the rate of responding during the green component, the data for each group of birds were averaged. In Fig. 9, the left-hand section shows the response rate to green during the last 15 sessions of prediscrimination training and the right-hand section shows the response rate to green during the 60 sessions of discrimination training. Green

was correlated with VI 30-sec during all these sessions. The filled circles show the average response rate to S+ of the four birds in Fig. 3, where S- was correlated with extinction. The open circles show the average response rate to S1 of the four birds in Fig. 7, where S2 was correlated with VI 5-min. For both groups, behavioral contrast occurred at the beginning of discrimination training. During Sessions 20 to 60 of discrimination training, the response rate to S+ for both groups was remarkably constant. After 60 sessions of discrimination training, the response rate to green for both groups remained considerably above the prediscrimination baseline. The group that underwent a transition from VI 30-sec to VI 5-min in S2 showed about the same amount of behavioral contrast as the one undergoing a transition from VI 30-sec to extinction in S-.

A comparison of Fig. 8 and 9 shows that the shapes of the timeout functions are clearly different from the shapes of the behavioral contrast functions. However, both behavioral contrast and timeouts from S- and S2 are behavioral processes that usually began to occur during the first few sessions of discrimination training. In both Exp. I and II, the greatest changes in the amount of timeout behavior and behavioral contrast occurred during the first 30 sessions of discrimination training. In both experiments, discrimination training produced behavioral contrast and timeouts from S- or S2 in most subjects.

EXPERIMENT III

In Exp. I, timeouts from extinction occurred under a procedure in which a period of food reinforcement alternated with a period of extinction. The purpose of this experiment was to determine the effect on timeouts from the period of extinction of not presenting the period of food reinforcement. If the VI 30-sec contingencies of reinforcement which maintained responding for food also control timeouts from extinction, then not presenting the period of food reinforcement should reduce the number of timeouts from the period of extinction.

METHOD

Subjects

The four birds from the experimental group in Exp. I served.

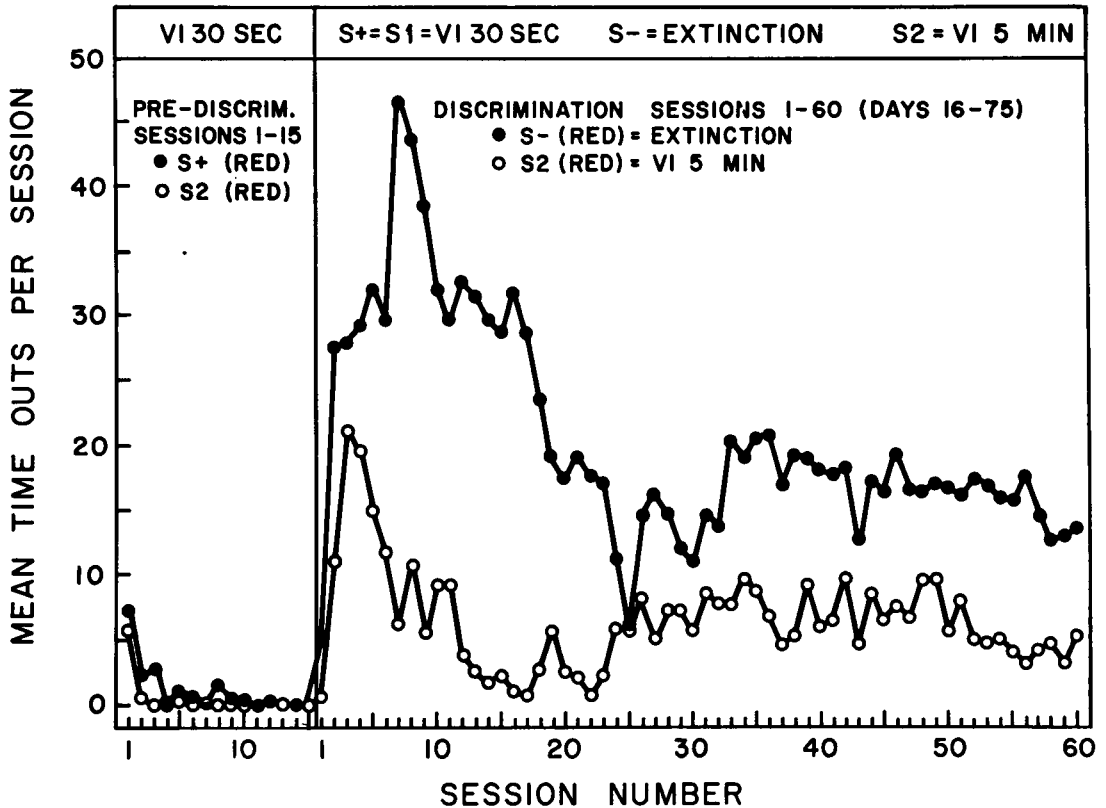


Fig. 8. Mean timeouts from extinction for the four birds in Exp. I are compared with mean timeouts from VI 5-min for the four birds in Exp. II.

Procedure

Sessions 45 to 60 of the reversal sessions of Exp. I were arbitrarily selected as the first 15 sessions of Exp. III. After reversal session 60, Day 135 in Fig. 1, S+ was not presented for 30 days. Green, S-, was presented for 4 min. Each presentation of S- was separated by the 5-sec intertrial interval. Each session was terminated after S- was presented 20 times. In order to facilitate comparison with the sessions in which S- was presented 10 times, the arbitrarily selected dependent variable was the number of timeouts during the 10 even trials. After 30 sessions of extinction during S-, S+ and S- were again alternated every 4 min with VI 30-sec reinforcement in S+ and extinction in S-.

RESULTS

The results of Exp. III are presented in Fig. 10. Birds 4859 and 375 showed the highest number of timeouts during the 15 sessions prior to not presenting S+. For Birds 4859 and

375, not presenting S+ for 30 sessions substantially reduced the number of timeouts from S-, and reintroducing S+ increased the number of timeouts from S- over the rate that prevailed when S+ was not presented. For these two birds, timeouts from S- were facilitated by alternating S+ with S-. Birds 133 and 4294 showed the lowest number of timeouts during the 15 sessions prior to not presenting S+; not presenting S- did not reduce timeout behavior. The failure to find a reduction in timeout behavior for Birds 133 and 4294 may be accounted for by the low baseline number of timeouts from S- for these birds before S+ was removed. The lack of sensitivity of the timeout response of two birds leads to the view that the reduction of timeout behavior may not be general, but the sensitivity of the timeout response of the other two birds to the withdrawal of the S+ condition leads to the view that positive reinforcement may be, at least in part, responsible for timeouts from S-.

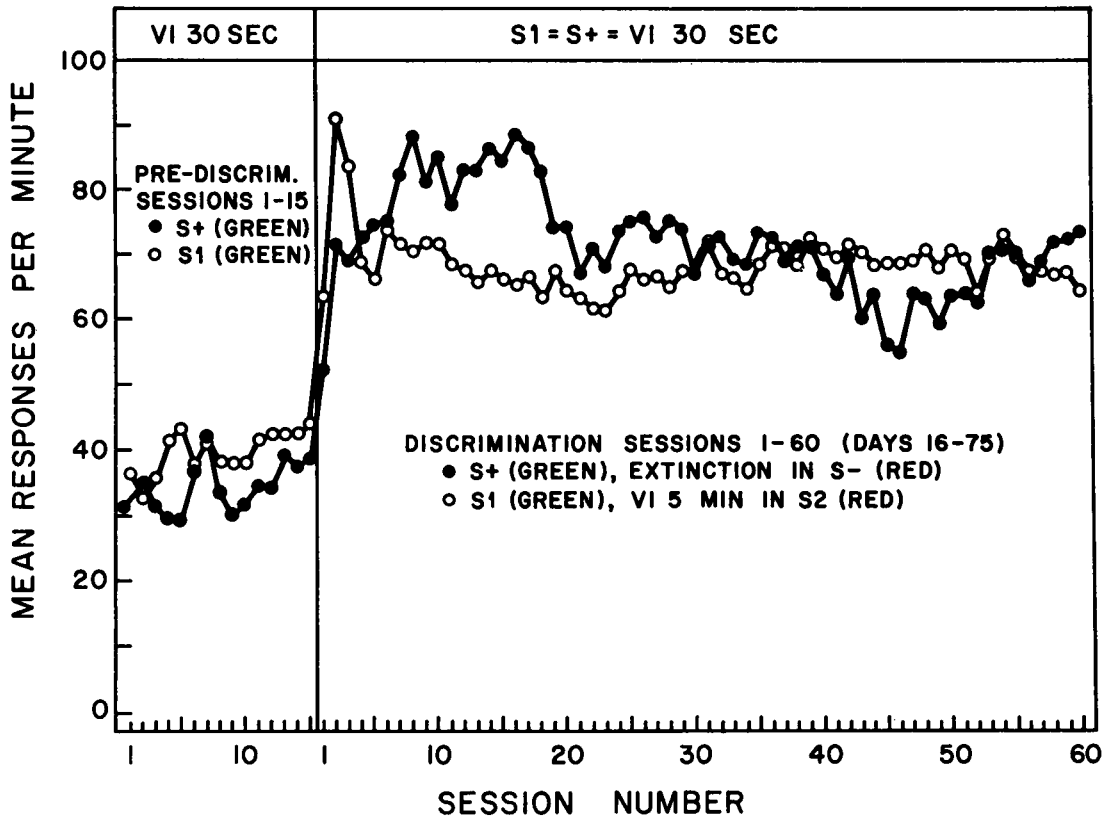


Fig. 9. Mean rates of responding during S+ for the four birds in Exp. I are compared with the mean rates of responding during S+ for the four birds in Exp. II.

DISCUSSION

The results of Exp. I demonstrated timeouts from the extinction component of multiple VI 30-sec extinction. Experiment II showed timeouts from the VI 5-min component of multiple VI 30-sec VI 5-min. For some birds, the timeout behavior was extremely weak and substantial individual differences were present, but each experimental animal demonstrated timeout behavior. In multiple VI 30-sec extinction, the timeout response removed one stimulus correlated with extinction and substituted another in its place; in multiple VI 30-sec VI 5-min, the timeout response removed a stimulus correlated with VI 5-min in exchange for a stimulus correlated with extinction. Some timeouts from S+ were also observed and in Exp. I one bird removed S+ at least as often as S- during the later discrimination sessions.

The major theoretical question is to account for the occurrence of the timeout response. At least four alternative interpretations could be

given: (1) Extinction increases the variability of behavior, *e.g.*, Antonitis (1951), so the occurrence of timeouts on the center key could be attributed to the increased variability in responding due to extinction of responding on the right key. (2) Azrin, Hutchinson, and Hake (1966) alternated periods of food reinforcement with periods of extinction and observed aggression against a nearby pigeon at the onset of the extinction periods. According to an aggression interpretation, extinction of responding on the right key during S- elicits aggression against an inanimate object, the center key. (3) Appel (1963) argued that the stimulus change produced by the timeout response is a positive rather than a negative reinforcer. (4) Finally, as suggested by Terrace (1966a), the timeout response could be an escape response from a conditioned aversive stimulus.

An interpretation of the timeout response in terms of increased variability or aggression implies that the timeout response is not controlled by its consequences. In Exp. I, a com-

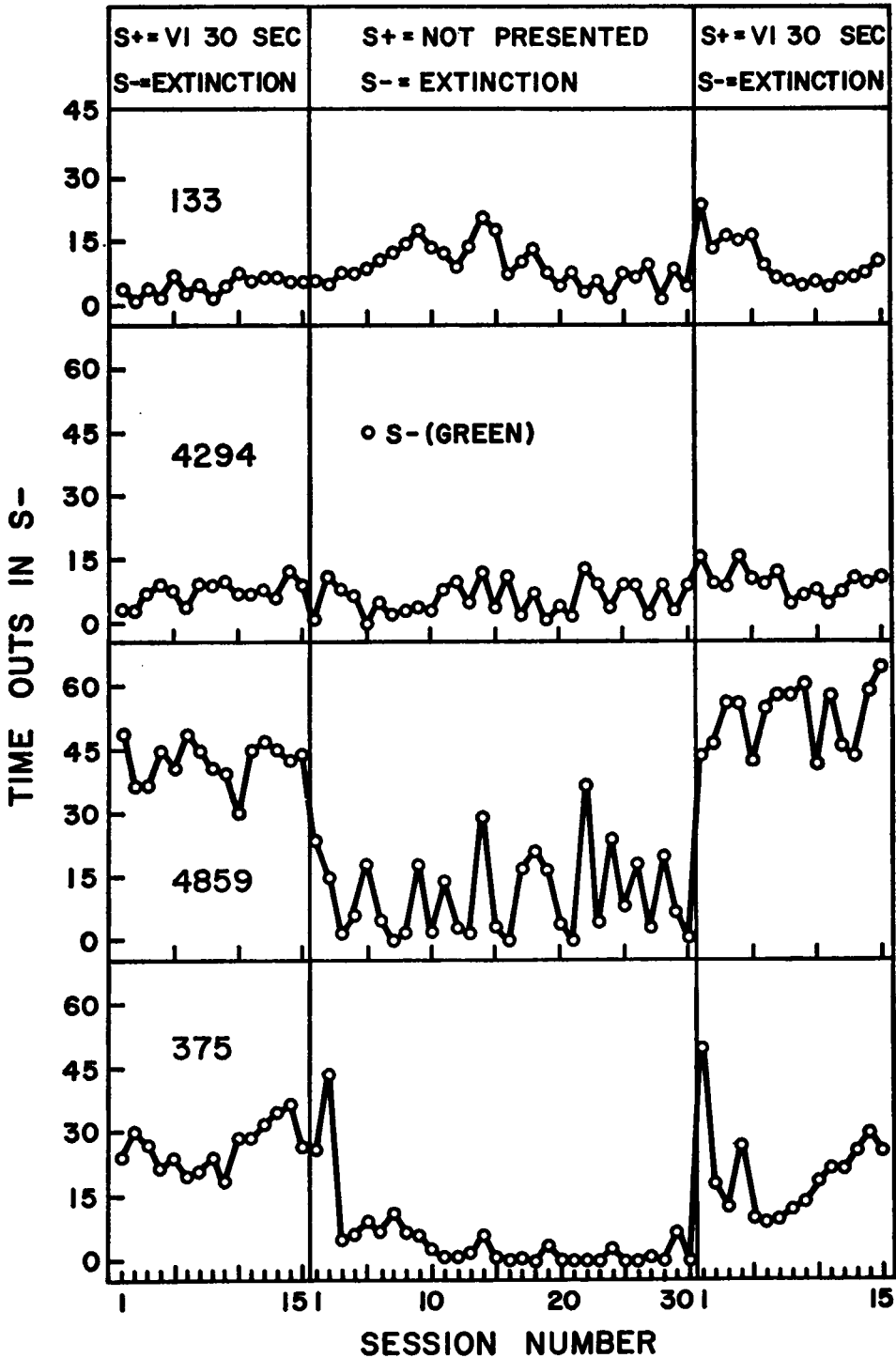


Fig. 10. The left-hand section shows the number of timeouts from S- for the 15 sessions before S+ was omitted. The center section shows the number of timeouts from S- during the 30 sessions in which S+ was not presented. The right-hand section shows the number of timeouts from S- during the 15 days after S+ was reintroduced.

parison of the control group, where responses on the white key had no contingency, with the experimental group, where a response produced a 30-sec timeout, showed a higher rate of timeout behavior for the experimental group for all but the first session of discrimination training. After Session 1, the 30-sec timeout increased the rate of responding on the white key. This increased rate of responding supports the interpretation that the timeout response was controlled by its consequences. The results of the control group suggest that increased variability of behavior or displaced aggression increased the operant level of responding on the center key during the first few sessions of discrimination training and that when this response terminated S—, it increased in frequency because of the reinforcing effects of escape from S—.

The stimulus-change interpretation cannot be dismissed unequivocally because the termination of an aversive stimulus, as required by the escape paradigm, must involve a stimulus change. However, stimulus change, *per se*, could not be the only factor responsible for the timeout behavior in the present experiments because the timeout response was affected by the contingencies of reinforcement on the food key. The pattern of timeout behavior during the 4 min of extinction observed in Exp. I holds up in Exp. II during the 4 min of VI 5. The major difference is that the absolute number of timeouts is smaller in Exp. II. Of the eight animals employed in the two experimental groups, six showed the highest frequency of timeout behavior during the first minute after the onset of S— and all subjects obtained at least half of their timeouts during the first 2 min of the 4-min period of red. An interpretation that stimulus change *per se* is reinforcing would not predict a distribution of timeouts skewed toward the beginning of S— because most of the timeouts would be in close proximity to the stimulus change resulting from the alternation of the components of the schedule.

Azrin, *et al.* (1966) found a high probability of attack during the first 30 to 60 sec after the transition from continuous reinforcement to extinction which decreased as a function of time from the onset of extinction. Attack is generally elicited by unconditioned aversive stimuli such as electric shock. However Azrin, *et al.* (1966) showed that the observation of

attack can be used to detect the presence of conditioned aversive stimuli. Their findings provide strong evidence that in eliciting attack, extinction is functionally similar to aversive stimulation and that the transition from continuous reinforcement to extinction is an aversive event. For a majority of the subjects in the present experiment, the distribution of timeouts paralleled the distribution of attacks reported by Azrin, *et al.* While the generality of the phenomenon is limited, these distributions suggest for some subjects at least, the transition from VI 30-sec to extinction or VI 5-min may be considered an aversive event.

The following results support the interpretation that the timeout response was an escape response from an aversive stimulus. Pecks on the center key were controlled by their consequences, which included termination of the red stimulus on the right key. Timeout behavior from the red stimulus was conditioned during the transition from VI 30-sec to extinction or VI 5-min. While the necessary and sufficient conditions for producing timeout behavior remain to be determined, the present data showed that a reduction in the reinforcement frequency and the response rate in the presence of red were associated with an increase in timeout behavior. With the exception of Bird 133, timeouts were rare during green when the reinforcement frequency and response rate were relatively high, but did occur during red when the reinforcement frequency and response rate were relatively low. More timeouts from red occurred when it was correlated with extinction than VI 5-min. While the generality of the phenomenon does not extend to all of the subjects, most of these data are consistent with the assertion that the stimulus in a successive discrimination which is correlated with a relatively low response rate functions as an aversive stimulus. The results of Exp. II, where timeouts from VI 5-min were observed, provide direct support for Guttman's (1959) interpretation that a stimulus correlated with relatively weak reinforcement can become functionally negative. Given the relatively small number of timeouts from S+ and the substantial individual differences in this behavior, speculation about the factors that produce timeouts from S+ seems unwarranted.

Terrace (1966b) found that behavioral contrast disappeared during extended discrimination training. In contrast with Terrace's re-

sults, the present results showed that for Sessions 20 to 60 of discrimination training the response rate to S+ for the group average was remarkably constant and the prediscrimination response rate to S+ was not recovered. Some birds showed a decreased rate of responding to S+ with extended discrimination training; for others the rate increased and for some the rate remained constant. One major difference between the two experiments was Terrace's use of a correction procedure in which each response to S- delayed the termination of the current S- for 30 sec. Bloomfield (1966) compared the amount of behavioral contrast produced by correction and noncorrection procedures. With a noncorrection procedure, the response rate to S+ showed a steady increase while the correction procedure produced a high peak rate to S+ which declined with further training. These data suggest that the disappearance of behavioral contrast in Terrace's experiments may be related to his use of a correction procedure.

One of the unexpected findings of Exp. I was that during the reversal sessions, timeouts from S- did not begin until responding to S+ had been reinforced. The results of Exp. III, although of limited generality, also point to the alternation of S+ with S- as one of the factors that may be responsible for timeouts from S-. Several procedures in addition to that of Exp. III could be used to examine the relationship between the response rate to S+ and the occurrence of timeouts from S-. One alternative would be to alternate red and green throughout the experiment. First S+ - S- training would be given followed by S- - S- training. This would not only allow a determination of whether timeouts from S- are affected by the alternation of S+ with S-, but would also demonstrate whether timeouts from S- would occur in the presence of the stimulus that previously functioned as S+. Further analysis of these procedures would indicate the extent to which an interpretation of timeout behavior from S- should incorporate the contingencies of reinforcement during S+ as one of the factors that may produce timeouts from S-.

Azrin (1961) found that timeouts from a fixed-ratio schedule typically occurred during the pause after reinforcement and were a function of the size of the fixed ratio. Similar results have been obtained by other investi-

gators; see Leitenberg (1965) for a critical review. In order to determine if timeouts from fixed-ratio schedules of reinforcement are controlled by their consequences, control conditions where a response on a second key has no contingency should be compared with conditions where responses produce timeouts. The present findings do not diminish the possibility that simple schedules of positive reinforcement have aversive properties as well.

REFERENCES

- Amsel, A. Frustrative nonreward in partial reinforcement and discrimination learning: Some recent history and a theoretical extension. *Psychological Review*, 1962, **69**, 306-328.
- Antonitis, J. J. Response variability in the white rat during conditioning, extinction, and reconditioning. *Journal of Experimental Psychology*, 1951, **42**, 273-281.
- Appel, J. B. Aversive aspects of a schedule of positive reinforcement. *Journal of the Experimental Analysis of Behavior*, 1963, **6**, 423-428.
- Azrin, N. H. Time-out from positive reinforcement. *Science*, 1961, **133**, 382-383.
- Azrin, N. H., Hutchinson, R. R., and Hake, D. F. Extinction-induced aggression. *Journal of the Experimental Analysis of Behavior*, 1966, **9**, 191-204.
- Bloomfield, T. M. Two types of behavioral contrast in discrimination learning. *Journal of the Experimental Analysis of Behavior*, 1966, **9**, 155-161.
- Guttman, N. Generalization gradients around stimuli associated with different reinforcement schedules. *Journal of Experimental Psychology*, 1959, **58**, 335-340.
- Leitenberg, H. Is time-out from reinforcement an aversive event? A review of the experimental evidence. *Psychological Bulletin*, 1965, **64**, 428-441.
- Pavlov, I. P. *Conditioned Reflexes*. (Translated by G. V. Anrep) London and New York: Oxford University Press, 1927.
- Rilling, M. Number of responses as a stimulus in fixed interval and fixed ratio schedules. *Journal of Comparative and Physiological Psychology*, 1967, **63**, 60-65.
- Spence, K. W. The differential response in animals to stimuli varying within a single dimension. *Psychological Review*, 1937, **44**, 430-444.
- Terrace, H. S. Discrimination learning with and without "errors". *Journal of the Experimental Analysis of Behavior*, 1963, **6**, 1-27.
- Terrace, H. S. Wavelength generalization after discrimination learning with and without errors. *Science*, 1964, **144**, 78-80.
- Terrace, H. S. Stimulus control. In W. K. Honig (Ed.), *Operant behavior: areas of research and application*. New York: Appleton-Century-Crofts, 1966. Pp. 271-344. (a)
- Terrace, H. S. Behavioral contrast and the peak shift: effects of extended discrimination training. *Journal of the Experimental Analysis of Behavior*, 1966, **9**, 613-617. (b)

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