STIMULUS-PRODUCING RESPONSES IN CHIMPANZEES[1]

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Recent analyses of discrimination learning have emphasized a distinction between responses which are instrumental in obtaining food and responses which result in exposure to the discriminative stimuli (2, 9, 11). These responses will be classified in terms of their contingencies; that is, a response of the former type will be referred to as a food-producing response (Rf), and a response of the latter type will be referred to as a stimulus-producing response (Rs).

Most analyses have dealt with Rs as a theoretical construct to be inferred from Rf performance (2, 9). On the other hand, Wyckoff (11) developed a technique for dealing with Rs directly. He used pigeons as Ss in a free-operant situation. The Rf was pecking a translucent key; the Rs was pressing a pedal on the floor of the experimental enclosure. Periods in which Rf was reinforced on a 1/2-minute, fixed-interval schedule (positive periods) alternated randomly with the periods in which there was no possibility of reinforcement (negative periods). The key remained white throughout both positive and negative periods unless Rf occurred; in this case, the key changed from white to red or green. One of these colors was correlated with positive periods and the other with negative periods. Although Rs did not alter the probability of reinforcement, it did enable the bird to discriminate between the two conditions. As long as the pedal was held down, the discriminative stimuli remained on, but the bird had to leave the pedal to eat. The durations of the pedal-pressing responses increased as the discrimination developed, but decreased when the positive and negative stimuli were reversed or made nondifferential.

The Wyckoff technique had the disadvantage that the pedal-pressing response had a very high operant level, and frequently the Rs rates were high despite poor discriminations. Wyckoff inferred the strength of Rs from the duration of the response. A temporal response measure makes it difficult to assess the frequency of a response or to schedule the appearance of the stimuli which are contingent upon the response.

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The purpose of the present experiments was to investigate variables determining the frequency of stimulus-producing responses and their relationships to discrimination performance.

METHOD

Subjects — Chimpanzee No. 125, 6-year-old male; experimental history: visual deprivation (6), spatial discrimination (7), play (10).
Chimpanzee No. 160, 5-year-old female; experimental history: visual deprivation (6), play (10). [3] Food deprivation: 80 to 85% of body weight at start of experiments. Reinforcements: 8-gram pieces Purina Lab Chow. Diet supplement: vitamins, oranges, skim milk.

Apparatus — Experimental chamber: 24- by 36- by 38-inch concrete cubicle, plywood door, expanded metal floor; 24- by 38-inch panel of 1/4-inch aluminum mounted in one wall. Manipulanda: two telephone keys, 3 inches apart on 5- by 8-inch plexiglas window in panel. Stimuli: 60-watt overhead lamp, audible click as "feedback" for depression of either key, doorbell chime accompanying operation of food magazine, red and blue lamps behind telephone keys. Sound mask: continuous white noise. The procedures were automatically programmed and results automatically recorded (3).

Procedure — Session length: 7 hours (2 hours in Experiment I) or 60 food reinforcements. All stimuli off for 1-minute time out (4) following each food reinforcement, and off indefinitely to terminate each session. After key-pressing was "shaped up" (8), 30 successive responses were reinforced. Then, a 1/2-minute fixed interval (FI 1/2) of food reinforcement was instituted on one key and the other was disconnected. This schedule was shifted from one key to the other at random (changing only at reinforcement). Each S received three sessions under this procedure, and low and equal rates of responding (about 0.75 per minute) developed on each key. The red and blue lamps were not illuminated during this preliminary training.

EXPERIMENT I

The purpose of this experiment was to develop a stimulus-producing-response technique for use with chimpanzees, and to determine suitable parameters for further experiments.

Method

Pressing the left key was Rf, and pressing the right key was Rs. As in the Wyckoff procedure, positive and negative periods alternated randomly. During the negative periods, extinction was in effect on the left key (Rf ext); there was no possibility of food reinforcement. The lamps behind the keys remained dark throughout both positive and negative periods unless Rs occurred, in which case the window was illuminated by the red or blue lamps. These colors were correlated with FI 1/2 and ext, respectively. Following every Rs, the current stimulus was displayed for a specified interval of time (St). If the positive and negative periods alternated during this interval, the stimulus color changed accordingly. Over Sessions 1-22,

[3] In previous experiments from these laboratories, these animals were designated Chow and Margo, respectively.

St was 3 minutes; over Sessions 23-26, St was 1 minute; over Sessions 27-35, St was 1/2 minute. The mean duration of positive and negative periods was 3 minutes, with a range of 1/2 minute to 5 1/2 minutes. After Session 16, the procedure was modified so that Rf could not result in reinforcement if it occurred within 3 seconds of a preceding Rs. For example, if Rs occurred just as a food reinforcement was "set up" by the FI schedule, the availability of this reinforcement was postponed for 3 seconds. The occurrence of Rs did not alter programming of the positive and negative periods or the possibility of food reinforcements. S could "choose" between mixed (no exteroceptive stimuli) and multiple (exteroceptive stimulus for each component) schedules of reinforcement (5).

The dependent variables were the Rs rate, the Rf rate, and the discrimination ratio (DR). The latter value is obtained by computing the ratio of the rate of responding in Rf ext to the rate of responding in FI 1/2, and then taking the complement of this ratio (1). If the rates in positive and negative periods are equal, DR will be 0.00; if responding occurs only in positive periods (FI 1/2), DR will be 1.00. The DR provides an index of the level of discrimination, which is relatively independent of absolute rates of responding.

Results

By the 11th session, both Ss had developed clear discriminations (DRs were more than 0.90). Throughout the experiment, Rf rates in the positive periods were highly variable, and ranged from 1.46-11.46 per minute for No. 125 and from 1.61-11.10 per minute for No. 160. By Session 15, both Ss had developed very high Rs rates (more than 2 responses per minute), although an Rs rate of 0.33 response per minute would keep the discriminative stimuli continuously visible. When the procedure was changed in Session 16, the Rs rates dropped precipitously. Over Sessions 16-22, mean Rs rates for No. 125 and No. 160 were 0.45 and 0.68 per minute, respectively. The median DRs over the same sessions were 0.98 and 0.93 for No. 125 and 160, respectively. Comparable DRs were maintained at each value of St. Rs rates were also quite variable both within and between sessions at each value of St; however, the most stable Rs rates were obtained when St was 1/2 minute.

EXPERIMENT II

In this experiment, Rf was reinforced by food on a 100-response, variable-ratio schedule (VR 100), and Rs was reinforced by the onset of the discriminative stimuli on fixed-ratio (FR) schedules. The intermittent reinforcement of Rs should make possible a more sensitive analysis of the reinforcing effect of the discriminative stimuli.

Method

The Ss had been on free feeding for 6 weeks following Experiment I, but were reduced to the body weight of Experiment I before this experiment. During the positive periods, VR 100 (range: 1 to 200) was in effect on the left key. During the nega- periods, ext was in effect; St was 1/2 minute. The durations of the alternating VR 100 and ext periods varied randomly from 1/2 minute to 10 minutes (mean, 4 minutes). These values were held constant throughout this experiment. During the preliminary training period of 3 days, the discriminative stimuli were on continuously. The discriminative stimulus was displayed after each Rs for Sessions 1 to 7; that is, Rs was continuously reinforced (Rs crf). For the remainder of the experiment, Rs had to occur a specified number of times to produce the discriminative

stimulus; that is, Rs was reinforced on a fixed-ratio schedule (Rs FR). For example, in Session 8, every tenth Rs resulted in the appearance of the current discriminative stimulus for 1/2 minute (Rs FR 10). Both Ss received 11 sessions at Rs FR 10 and 8 sessions at each of the following: Rs FR 20, Rs FR 30, and Rs FR 60, in that order, followed by one session of Rs ext (the discriminative stimuli could not appear). Beginning with the last session on Rs FR 30, the frequency with which both keys were pressed simultaneously was recorded. This record indicated the frequency with which S used both hands simultaneously.

Results

During the preliminary training, high stable Rf rates developed in VR 100. Table 1 presents the median Rf rates in VR 100 and median DRs for each value of the Rs schedule.

TABLE 1

Median Responses per Minute in Positive Periods (Rf VR 100) and DRs

Rs Schedule	No. 125		No. 160	
	Rf VR 100	DR	Rf VR 100	DR
crf	80.86	0.97	76.25	0.99
FR 10	90.53	0.99	92.07	0.99
FR 20	104.37	0.99	84.87	0.99
FR 30	107.95	0.99	63.03	0.98
FR 60	97.64	0.99	82.10	0.98

Representative Rf performances are shown in the upper records of Fig. 1 and 2. The segments labelled 1 and 2 in each figure correspond to VR 100 and ext periods, respectively. During Rf VR 100, both Ss have over-all rates of about 1.50 responses per second; during Rf ext, the rates are close to zero. With few exceptions, the positive and negative periods can be easily distinguished on the basis of the Ss' behavior. Long pauses in the record of No. 160 did occur often, and almost invariably began in Rf ext periods. Rs performances, shown in the lower records, were recorded concurrently with the Rf curves. Some segments are labelled with the same numbers and letters to facilitate comparison. It should be noted that the cumulative recorders continued to run while the discriminative stimuli were visible (during St), but not during time outs.

During the segment labelled 1 in Fig. 1, a very high Rf rate was maintained; however, the Rs rate was just high enough to keep the red light on throughout the period. In the segment labelled 2, the Rf rate was zero, and the Rs rate was higher than in Segment 1; however, the responses occurred in bursts and the blue light was off for some of the period. In another negative segment labelled 3, the darkened portions of the Rf curve approximate the times that the blue light was on, and the small arrows on the Rs curve indicate the response or responses which brought it on. Throughout the experiment, both Ss tended to pause (on both keys) following the appearance of the blue light. The short pauses which occasionally occurred on the Rf curve during positive periods correspond to momentarily high Rs rates (as at a and c) or to a pause on the Rs curve during which the red light disappeared (as at b). At this stage of training, both Ss showed a zero Rf rate when neither discriminative stimulus was displayed.

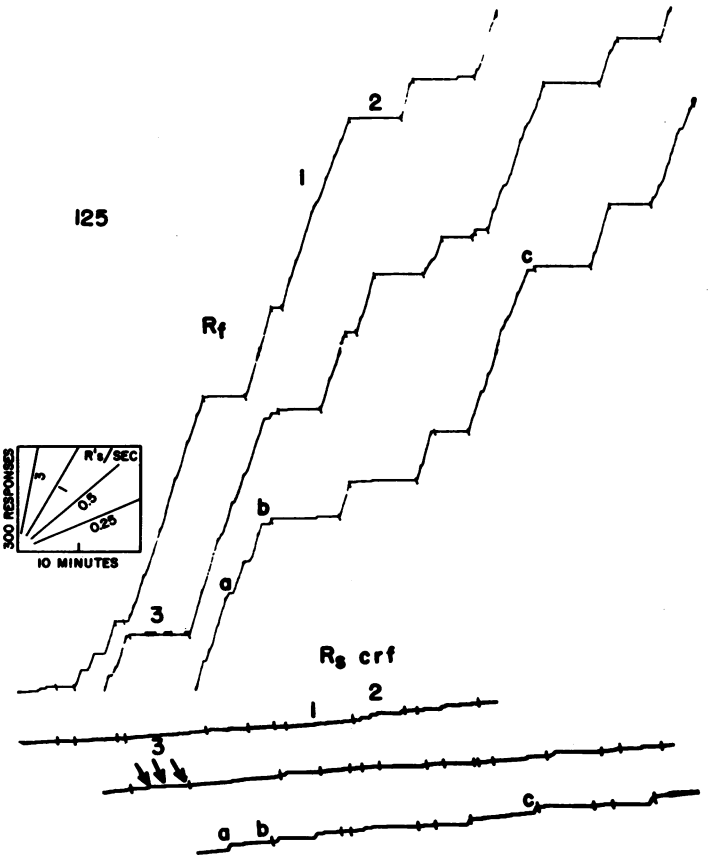

Fig. 1. Representative cumulative-response records for No. 125 at Rs crf. Each alternation of positive and negative periods is marked by a pip. Food reinforcements are not shown.

In Fig. 2, the lower record shows the performance of No. 160 on Rs FR 20. Under this schedule, both Ss developed local Rs rates of approximately 3 responses per second. The segments labelled 1 and 2 show representative performances during positive and negative periods, respectively. The small arrows indicate bursts of responding on the Rs curves and the corresponding brief pauses on the Rf curve. In Segment 2, the Rf rate dropped to zero, but the bursts on the Rs curve continued. During both segments, the Rs rate dropped to zero when the discriminative stimuli were displayed (that is, during St). In the negative segment labelled 3, two bursts of 20 responses on the Rs key were followed by a prolonged pause on both keys. The Rs pause was terminated by a burst of 20 responses in the negative segment just before a, followed by a short pause through a 30-second positive period and a longer burst of responding in the next negative segment at a. In the next positive segment, characteristic performances emerged. Both the Rs and Rf rates dropped to zero in the positive period at b; however, the Rs rate near the end of the segment was unusually prolonged. Sustained high Rs rates accompanied by zero Rs rates appeared at c and d during a positive period.

Figure 3 contains representative Rs FR 30 and FR 60 curves for No. 125. The pauses at a and b occurred during negative periods following the appearance of the

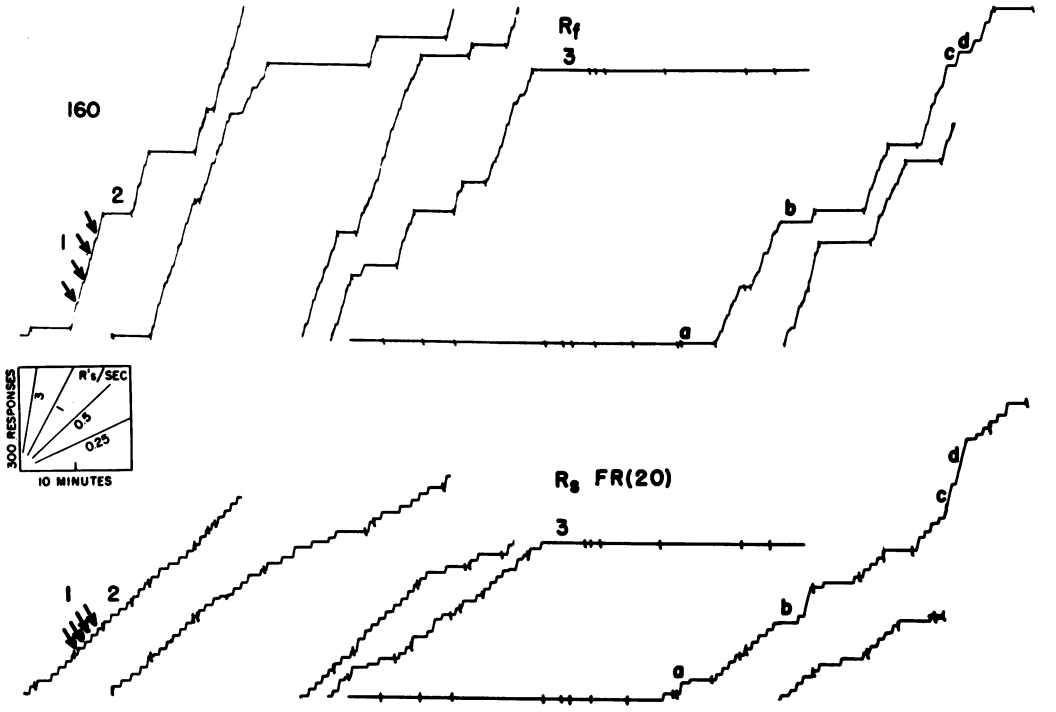

Fig. 2. Representative cumulative-response records for No. 160 at Rs FR 20.

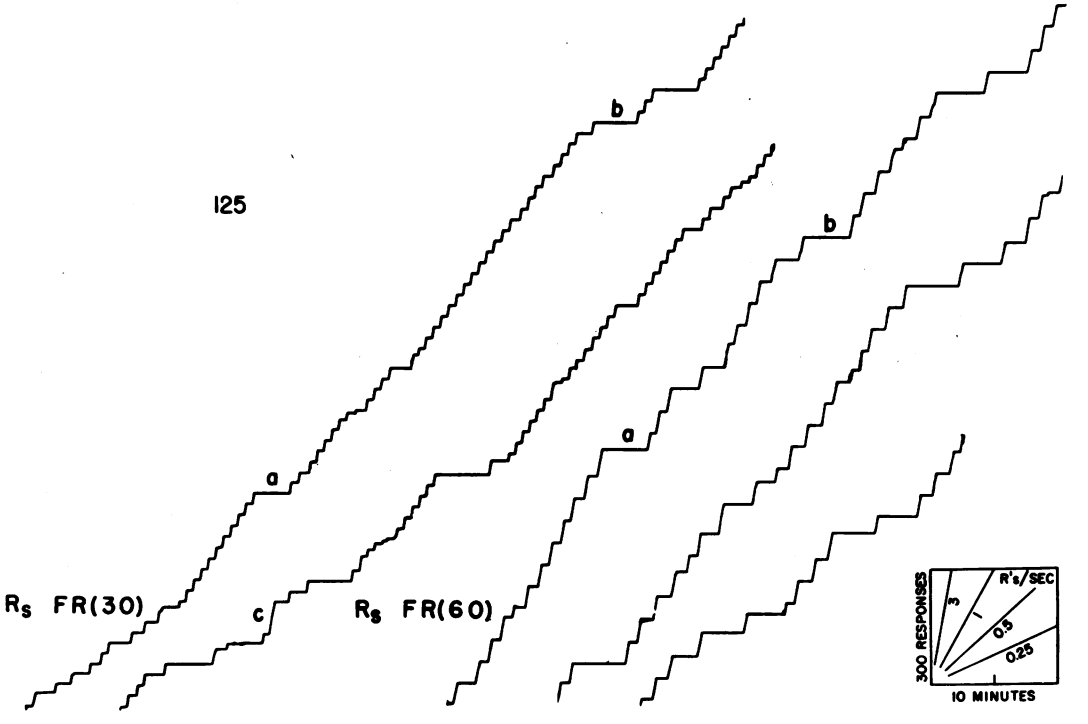

Fig. 3. Representative cumulative-response records for No. 125 at Rs FR 30 and Rs FR 60.

blue light. These pauses were frequent but never prolonged. Sustained bursts of responding (as at c) occasionally occurred during positive periods. The curves of No. 160 contained longer pauses than those of No. 125.

The median Rs rates for positive (solid lines) and negative (dotted lines) periods at each Rs schedule of Experiment II are shown in Fig. 4. The cross-hatched and dashed lines present comparable functions from Experiment III. (See below.)

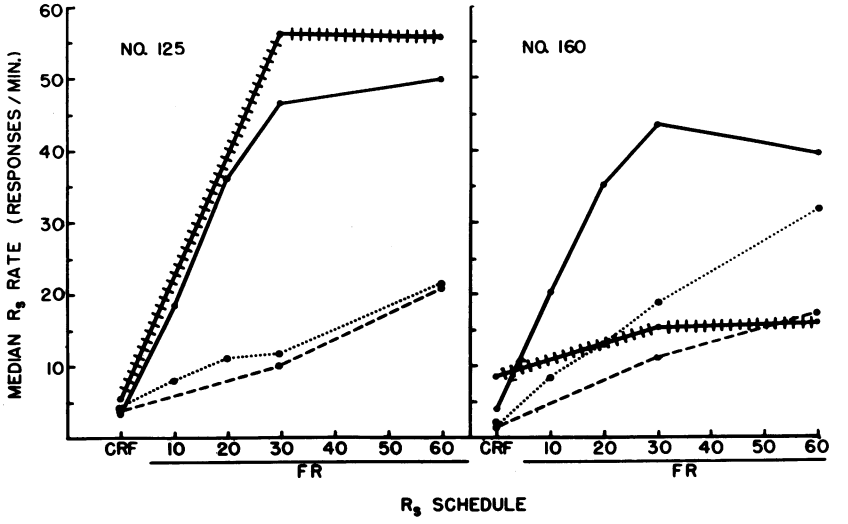

Fig. 4. Median Rs rates at each Rs schedule in Experiments II and III. The first session at each value was omitted in computing these medians. Solid lines represent positive periods and dotted lines represent negative periods of Experiment II. Cross-hatched lines represent positive periods and dashed lines represent negative periods of Experiment III.

The functions for both Ss are similar. After Rs crf, the rates during the positive periods were consistently higher than those during the negative periods. The rates during the positive periods increased to Rs FR 30, but then remained the same or fell off at Rs FR 60.

Analysis of the cumulative-response records indicated that the lower Rs rates during negative periods resulted from the tendency of both Ss to initiate pauses on both keys. Although DRs remained high, it is important to note that Rf rates were usually zero in the absence of the red or blue stimuli. At Rs FR 30 and FR 60, No. 160 began to show intermediate Rf rates in the absence of the discriminative stimuli; therefore, the DR values were lowered for this S. Observation of No. 160 indicated that S was using both hands simultaneously on the two keys; No. 160 showed 30 such responses in the last session at Rs FR 30 and hundreds of simultaneous responses at Rs FR 60. However, no simultaneous responses were recorded for No. 125.

The positive and negative periods can no longer be distinguished on the basis of the response patterns of either S on Rs ext (Fig. 5). Discriminations of both Ss were abolished in this extinction session (DRs were zero). The lettered Rf curves show pauses intermingled with intermediate and high Rf rates. The Rf rates of No. 160 were erratic, but high, and S received 60 reinforcements. No. 125 showed low over-all Rf rates and responded only sporadically in the hours of the session

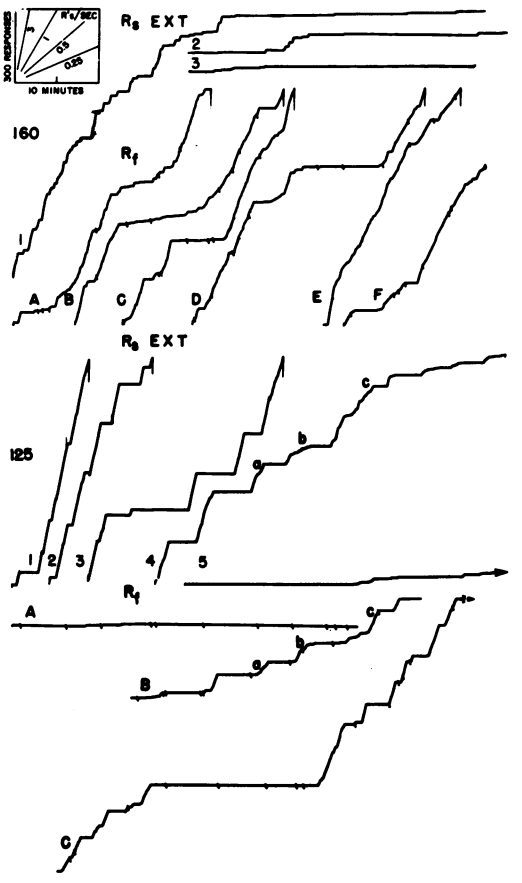

Fig. 5. The cumulative Rs (numbered) and Rf (lettered) records of both Ss in Rs ext. Pips on Rf curves indicate alternation of positive and negative periods.

remaining after the arrow which terminates the curve. The negatively accelerated Rs ext curves were sizable (No. 160: 1341 responses; No. 125: 3112 responses). The earlier portions of these curves tended to be bi-valued, but some intermediate rates did occur as the asymptote was approached. During Rs ext, 4 and 27 simultaneous responses were recorded for No. 160 and 125, respectively. The segments at a, b, and c in the Rf and Rs records of No. 125 are corresponding, and these probably were the segments in which S used both hands.

EXPERIMENT III

The purpose of this experiment was to re-determine the functions obtained at some of the Rs schedules used in Experiment II. Both Ss received four sessions at each of the following Rs schedules: crf, FR 30, and FR 60. These were followed by one session of Rs ext.

The median Rs rates in positive (cross-hatched lines) and negative (dashed lines) periods at each Rs schedule of Experiment III are shown in Fig. 4. Again, the first session at each value was omitted in computing the median. The median Rs rates and DRs for No. 125 were little changed. However, the rates of No. 160 at Rs FR 30

and FR 60 were considerably lower than in the determinations of Experiment I, and the function is flatter. The median DRs of No. 160 dropped to 0.90 and 0.95 at Rs FR 30 and FR 60, respectively. This drop resulted from frequent responding in the absence of the discriminative stimuli.

Many simultaneous responses (ranging from 6 to 67) were recorded for No. 160 over these sessions. This S's frequent use of both hands was not related in any consistent way to an Rs schedule. No simultaneous responses were recorded for No. 125 in these sessions.

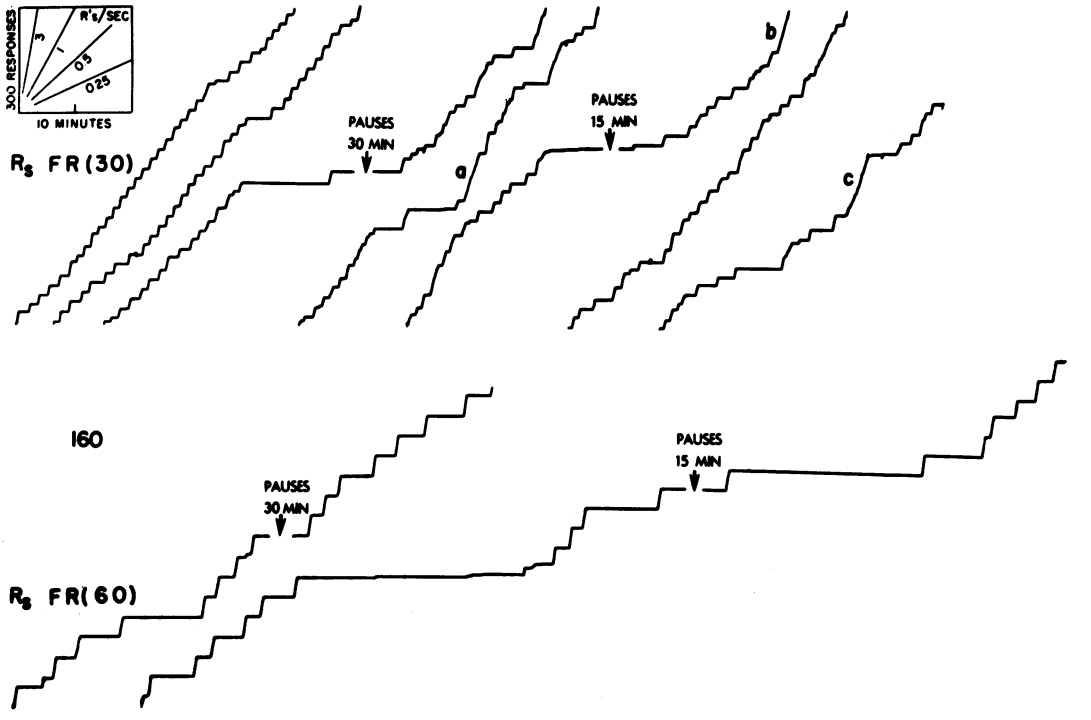

Fig. 6. Representative cumulative-response records for No. 160 at Rs FR 30 and Rs FR 60.

The local rates of responding at Rs FR 30 and FR 60 (Fig. 6) remained stable at about 3 responses per second. Thus, the changes in the over-all Rs rates of this S were primarily due to the frequency and duration of pauses. The broken segments indicate sections of the curve in which S was pausing and have been omitted for convenience in presentation. Corresponding pauses occurred in the Rf records (as in Fig. 2). The pauses were still initiated in negative periods. Prolonged bursts of responding (as at a, b, and c) occurred frequently in both positive and negative periods. Both Ss continued to show high Rf rates. In the absence of the discriminative stimuli, No. 125 sometimes had low Rf rates, and No. 160 had some high Rf rates. The sessions of Rs ext which directly followed Rs FR 60 are shown in Fig. 7 and 8. Again, the DRs were close to zero for both animals. The Rf curve of No. 125 (Fig. 7) was low for about the first 30 minutes of the session, but then became high and sustained. The Rs ext curve contained 1715 responses. Although

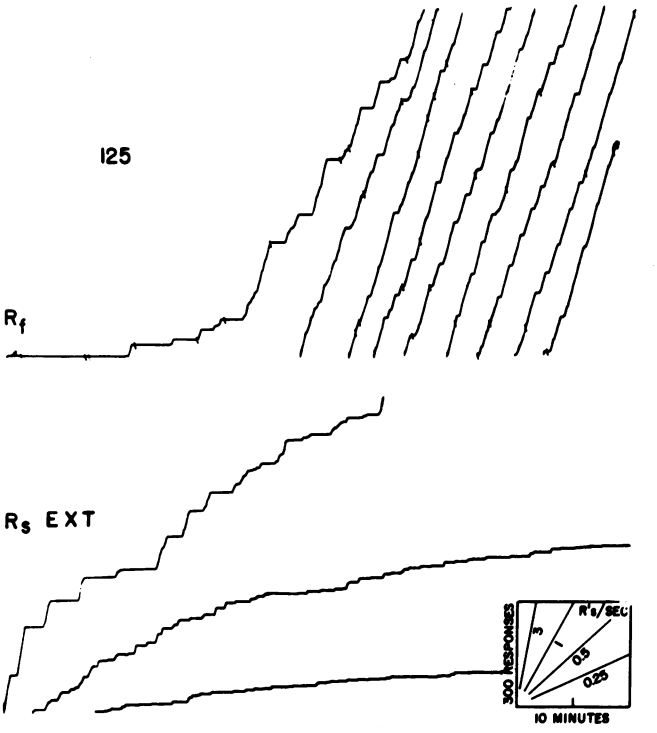

Fig. 7. The cumulative Rf and Rs records of No. 125 in Rs ext. Pips on Rf curves indicate alternation of positive and negative periods.

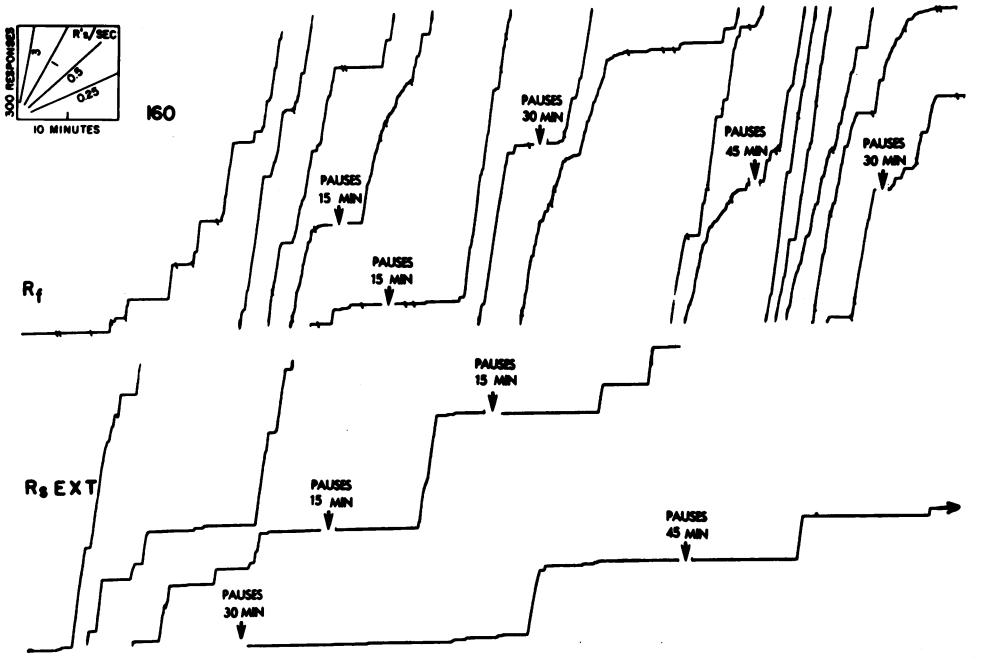

Fig. 8. The cumulative Rf and Rs records of No. 160 in Rs ext.

this extinction curve was smaller than the preceding one, it showed the same general characteristics; that is, bi-valued rates of responding gave way to some intermediate rates and over-all negative acceleration. In this Rs ext session, 34 simultaneous responses were recorded for No. 125.

The Rf curve of No. 160 (Fig. 8) was characterized by an initial portion which was highly similar to that of No. 125. For the remainder of the session, however, prolonged bursts of responding alternated with pauses ranging from a few minutes to more than 45 minutes. The Rs ext curve of No. 160 contained 3576 responses. The over-all curve again showed negative acceleration; however, the initial portion was steeper and more prolonged than the previous Rs ext curve. Large bursts of responding still occurred late in the session, and intermediate rates were infrequent. For No. 160, 15 simultaneous responses were recorded on Rs ext.

EXPERIMENT IV

The purpose of this experiment was to determine the effects of eliminating the discriminative function of the stimuli by making them nondifferential with respect to positive and negative periods.

Method

The system of alternation of positive and negative periods was the same as in Experiments II and III, and St was again 1/2 minute. Periods in which either the red or blue lights would appear following Rs also continued to alternate randomly; however, this schedule of alternation was independent of the alternation of positive and negative periods; that is, the red and blue lights were no longer correlated with either type of period exclusively. The Rs schedule was FR 60 for Sessions 1-19. Over Sessions 20-24, the stimuli remained on continuously even when the Rs rate was zero. Over Sessions 25-31, the stimuli were again discriminative and remained on continuously. The DRs were still computed on the basis of rates of responding in positive and negative periods rather than the presence of the red or blue stimulus.

Results

The DRs remained close to zero throughout the sessions in which the stimuli were nondiscriminative; therefore, the Rf rates for both positive and negative periods will be combined. The Rs rates will also be combined since they no longer differed with respect to positive and negative periods. By the third session, the Rf rates had fallen to low values (1.14 and 10.52 responses per minute for No. 125 and 160, respectively). These rates subsequently recovered, and median Rf rates over Sessions 13-19 were 73.27 and 34.23 responses per minute for No. 125 and 160, respectively.

The daily Rs rates for both Ss are shown in Fig. 9. The curves fall slowly and there are several reversals. The rates of No. 125 (solid line) remained close to zero over Sessions 13-19, while those of No. 160 (dashed line) stabilized at about 3.5 responses per minute. Figure 10 shows a portion of the cumulative record of No. 160 from Session 2. The Rf records are characterized by bursts of responding alternating with pauses. At this stage of the experiment, the Rs records of No. 160 differed little from those of the previous experiment (Fig. 6). The Rs rates of No. 125 were lower during this session than in the previous experiment. For most of this session, the Ss' rates were still under the control of the red and blue lights

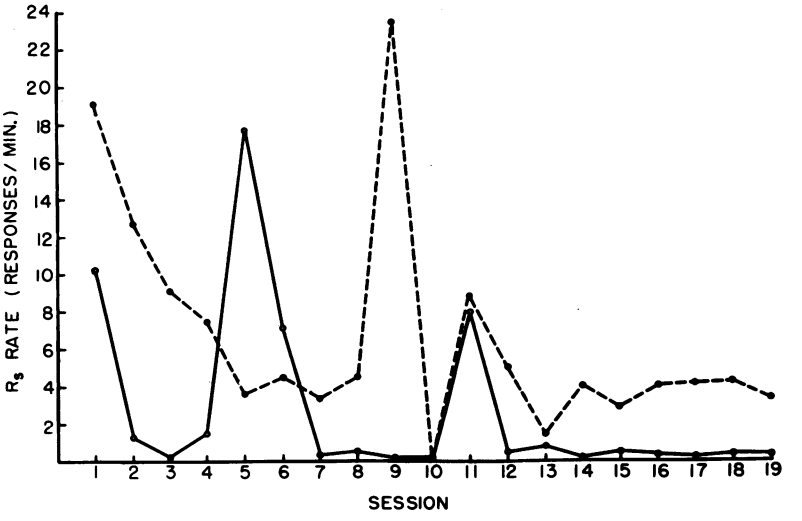

Fig. 9. The daily over-all Rs rates for No. 125 (solid line) and No. 160 (dashed line) in Experiment IV.

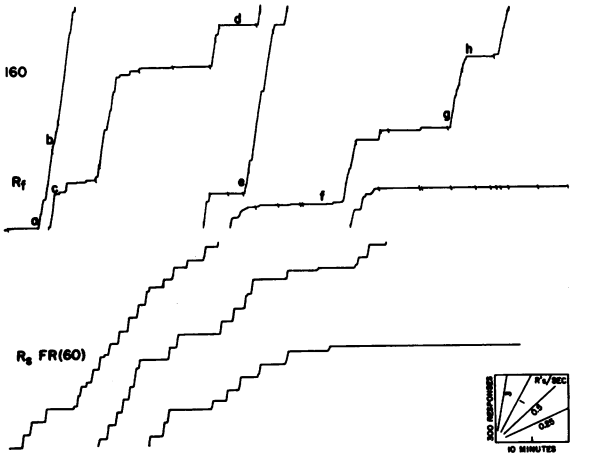

Fig. 10. Cumulative Rf and Rs records of No. 160 from Session 2 in Experiment IV. Pips on Rf curves indicate alternation of positive and negative periods.

even though these were no longer discriminative stimuli. The first segment in the Rf record of Fig. 10 was a negative period. When the red light appeared at a, a high rate developed immediately; however, this rate was sustained through a positive period (at b) although the blue light was on during the segment. Shifts from high rates during the red light to low rates at the appearance of the blue light are shown at c and h. Both of these periods were negative. Positive periods in which zero rates accompanied the blue light followed by negative periods in which high rates accompanied the red light are shown at d and e. Positive periods in which the red light was on are shown at f and g. There was only slight attenuation of stimulus control in this session.

No. 160 emitted 20 simultaneous responses in Session 2, 15 in Session 3, 19 in Session 11, and 11 in Session 12. No. 125 showed only 1 simultaneous response over the first 3 sessions. In Session 4, 131 simultaneous responses were recorded; and, in Session 5, 12 simultaneous responses were recorded. After Session 5, however, such responses were very infrequent for No. 125.

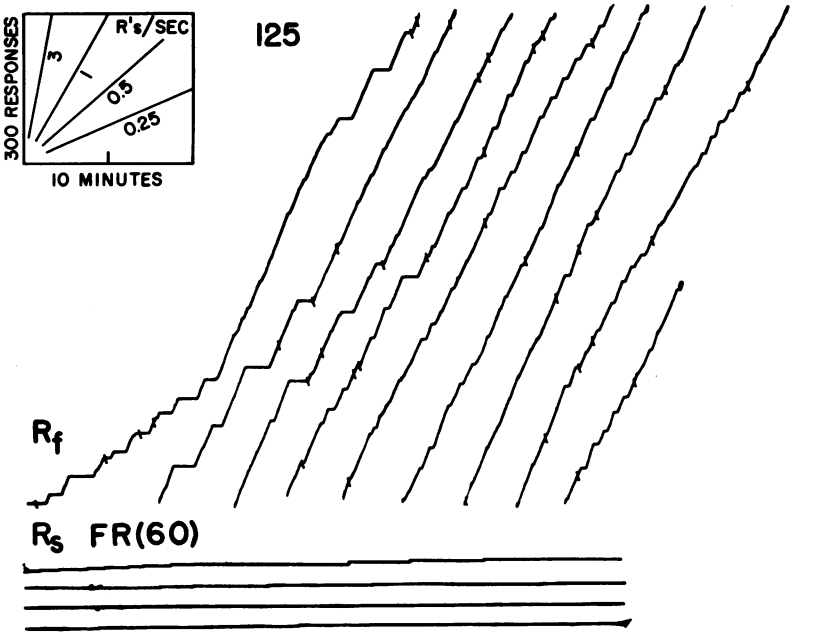

Fig. 11. Cumulative Rf and Rs records of No. 125 from Session 19 in Experiment IV. Pips on Rf curves indicate alternation of positive and negative periods.

Figure 11 is the cumulative-response record of No. 125 from Session 19. The over-all Rf rate remained high throughout both positive and negative periods. The over-all Rs rate was close to zero, and the stimuli did not appear since 60 responses were not emitted in the session. The Rs rate of No. 160 was still high enough at this stage of the experiment to produce the discriminative stimulus occasionally.

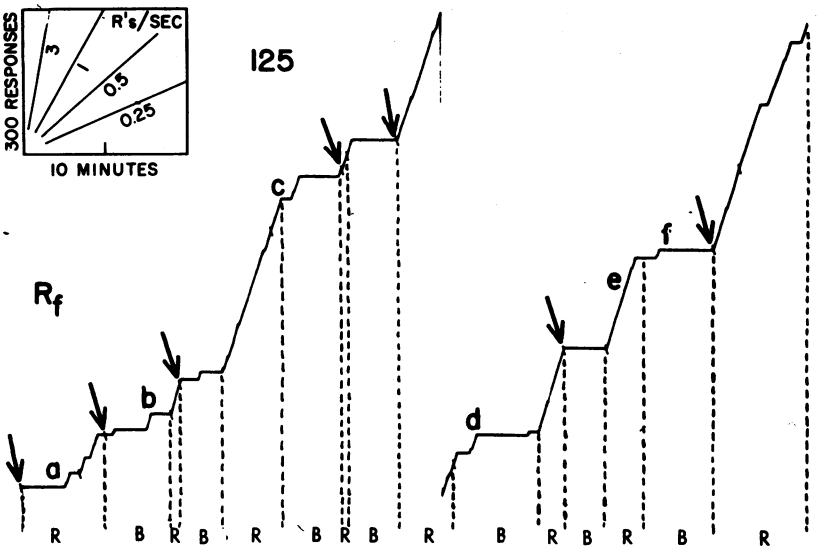

Fig. 12. Cumulative Rf record of No. 125 from Session 20 in Experiment IV. Pips indicate alternation of positive and negative periods. Periods of red (R) and blue (B) lights are marked by dashed lines.

Figure 12 contains a portion of the cumulative-response record of No. 125 from Session 20 in which the stimuli remained on continuously. In general, high rates of responding still prevailed in the red light (as at e); however, pauses did occur occasionally (as at a). When the color changed to blue, there was still a tendency to pause, but short bursts of responding were frequent in the blue light (as at b, c, d, and f). The figure shows that stimulus control remained strong in this session. By Session 22, the response rates had become equal in both colors. Rs rates remained close to zero throughout these sessions.

For Sessions 25 to 31, the stimuli were again correlated with the respective schedules of reinforcement and were on continuously. The DRs of No. 160 rose rapidly, and the median DR over Sessions 29-31 was 0.97. No. 160 recovered the discrimination more slowly; the median DR over the last three sessions was 0.75.

DISCUSSION

The results of Experiment I confirm Wyckoff's finding that discriminations can be developed under conditions where the appearance of the discriminative stimulus is dependent upon Ss' behavior (11). The results also show that Rs rates can be sustained at the three values of St used. Unfortunately, there was much variability in both Rf and Rs rates. Under an FI schedule, the passage of time during Rs responding increases the probability that Rf will be reinforced. Thus, an Rf following a series of Rs's is likely to be reinforced and a chain of responding develops. Observation of Ss suggested that this factor was responsible for the high Rs rates which developed under the first procedure when St was 3 minutes. When the procedure was changed to militate against the development of such a chain (Method, Experiment I), the Rs rates dropped precipitously. The new procedure did change the characteristics of the FI schedule, however, and may have increased the variability in Rf rates. This finding suggested the desirability of using a schedule of food

reinforcement which is not programmed by time. It should be noted that Wyckoff's procedure involved an FI schedule, which may have influenced his results.

Experiments II and III demonstrate that substantial Rs rates can be sustained at FR schedules ranging up to 60. The Rs FR performances of both Ss had the same characteristics as FR schedules of food reinforcement (5). The over-all Rs rates apparently reached an asymptote at about Rs FR 30 at the Rs schedules used here.

The over-all Rs rates of No. 160 were quite low in Experiment III. The difference in Ss' performances in Experiment II may have resulted from No. 160's starting to respond with both hands simultaneously before the Rs ext session. The Rf rate of No. 125 remained very low in Rs ext, and few food reinforcements were received in the absence of the discriminative stimuli. On the other hand, No. 160 maintained high Rf rates in Rs ext and received many food reinforcements in the absence of the discriminative stimuli. Probably because of this experience in Experiment II, No. 160 showed some high Rf rates in the absence of the discriminative stimuli in Experiment III. The cumulative records of No. 160 from Experiment III show that the discrimination was not at all attenuated in the presence of the discriminative stimuli; thus, the lowered DRs resulted from responding in the absence of these stimuli.

The pauses following the appearance of the blue stimulus which resulted in the lower Rs rates during negative periods suggest that the conditioned-reinforcing effect of the negative stimulus was lower than that of the positive stimulus.

The Rs ext sessions provide one control for artifacts; that is, the only change in the programming equipment was the disconnection of the red and blue lamps. The fact that the DRs fell to zero indicates that these colored lights provided the only discriminative stimuli. The Rs ext curves are similar to those obtained in the extinction of FR schedules of food reinforcement. Clearly, the appearance of the discriminative stimuli maintained the Rs performance. The possibility remained, however, that their appearance rather than their function as discriminative stimuli provided the reinforcing effect.

The results of Experiment IV demonstrate that the discriminative function of the stimuli is necessary if they are to function as conditioned reinforcers. However, the Rs rates extinguished far more rapidly when the stimuli did not appear at all. In the early portions of Experiment IV, the Rf rate remained high in the formerly positive (red) stimulus and remained close to zero in the formerly negative (blue) stimulus. Thus, almost all food reinforcements still occurred in the formerly positive stimulus; however, the reinforcements occurred only half as frequently, and Ss often emitted hundreds of responses when the formerly positive stimulus was displayed (Fig. 10) without receiving a reinforcement. With extensive exposure to this condition, the stimuli lost their effectiveness as conditioned reinforcers and the Rs rates fell to very low values. At the same time, a high Rf rate developed and was maintained throughout each session (Fig. 11).

Simultaneous responses on both keys were recorded for both Ss in the Rs ext sessions and in the earlier sessions of Experiment IV. In both cases the experimental operations eventually resulted in extinction of Rs rates. Further study would be necessary to specify the factors involved in such simultaneous responding.

When the stimuli were on continuously in Session 20 of Experiment IV, there was a "spontaneous recovery" of the stimulus control (Fig. 12). This occurred

despite the fact that the Rs rates had been maintained at very low values for about seven sessions. This finding suggests that the number of responses necessary to produce the discriminative stimulus (the Rs schedule) may be critical.

The technique used in these experiments could prove to be invaluable in assessing the effects of many variables upon discrimination performance (for example, aversive stimuli, brain lesions, drugs). If S will respond to produce the discriminative stimuli, we can assume that it is "attending" to these stimuli; the Rs rates could serve as an operational index of "attention." Investigators sometimes indicate that they are not subjectively sure whether a discrimination was really lost or whether S just stopped "attending" to the stimuli. The present objective technique might enable us to make a useful distinction between these possibilities.

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