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DISCRIMINATED TIME-OUT AVOIDANCE IN PIGEONS[1]

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Performances of two pigeons were studied on a concurrent discriminated TO avoidance-VR schedule. Each avoidance response postponed a TO from a VR 140 for a specified RS interval. The warning stimulus on the TO avoidance schedule was a discontinuous clock which consisted of a series of discrete color changes that varied systematically with the RS interval. Experimental manipulations established that the avoidance behavior was under the control of the avoidance schedule and the discontinuous clock. Five-min TOs maintained higher avoidance rates than shorter TO durations; a 15-min TO maintained less avoidance responding than the 5-min TO. Chlorpromazine hydrochloride increased TO avoidance behavior and decreased concurrent VR behavior.

Morse and Herrnstein (1956) demonstrated that nondiscriminated avoidance behavior which postponed a time-out (TO) from positive reinforcement could be maintained with pigeons. Subsequent studies have established and maintained nondiscriminated TO avoidance with several other species. Ferster (1958) studied TO avoidance with chimpanzees. Baer, using small children as subjects, was able to maintain nondiscriminated avoidance behavior that postponed an interruption of ongoing cartoons (1960) and that postponed withdrawal of the social reinforcer of "attention" (1962). A multiple schedule of nondiscriminated TO avoidance has been demonstrated with monkeys by Zimmerman (1963). These studies have established that TO avoidance behavior has many of the properties of avoidance behavior maintained by primary negative reinforcers, such as electric shock.

In a discriminated avoidance procedure, a warning stimulus appears a fixed interval of time before the occurrence of a negative reinforcer. Appropriate responding terminates the warning stimulus and postpones or avoids the negative reinforcer. It is possible for more than a single stimulus to precede the negative reinforcer. A series of stimulus changes can be programmed, each progressively closer in time to the occurrence of the negative reinforcer. Findley (1963) maintained TO avoidance behavior in a chimpanzee under the exteroceptive stimulus control of a meter pointer whose position was correlated with the RS interval.

The present experiments investigated TO avoidance behavior with pigeons under the control of warning stimuli consisting of a series of discrete color changes that varied systematically with the time by which a response postponed a TO (RS interval).

METHOD

Subjects

Two adult White Carneaux pigeons were maintained at about 80% of their free-feeding weights. They had a history of experience on various reinforcement schedules.

Apparatus

A Foringer pigeon chamber contained two response keys mounted 2¾ in. apart in one wall. The keys could be illuminated by any of several different colored 115-v ac, 7-w key lights located behind them. A food magazine was located directly below and between the response keys. The chamber was illuminated

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during sessions by two 125-v ac, 6-w houselights located on the wall opposite the response key. The key lights and the houselights went off simultaneously with the operation and illumination of the food magazine. Programming was accomplished by a system of switching relays and timers. Data were automatically recorded on counters and cumulative recorders.

General Procedure

Experimental sessions were run daily except when apparatus failures occurred. Each session lasted for 40 reinforcements or 4 hr, whichever occurred first. A reinforcement consisted of a 4-sec access to the food tray.

The basic procedure was a concurrent VR-TO avoidance schedule. A variable ratio schedule with a mean ratio of 140 was programmed on the right response key. The actual ratios varied from 1 to 400 responses. The TO avoidance schedule was programmed on the left key concurrently with the VR 140. A response on the avoidance key postponed the occurrence of a 5-min TO from the VR schedule for a specified RS interval. The TO period consisted of a "blackout" condition which involved turning off all lights in the chamber. A 3.5-sec delay interval was programmed as a control procedure between a response on the avoidance key and the possibility of a response on the VR key producing a reinforcement.

EXPERIMENT I

Procedure. Each response on the avoidance key postponed a 5-min TO from the VR 140 for a 60-sec RS interval. The avoidance key was illuminated with a green key light. The VR key was illuminated with four different colored key lights, each of which was on for 15 sec and appeared in the same sequential order. The four colored key lights on the VR key were correlated with the timing of the RS interval. During successive 15 sec of the RS interval the VR key was illuminated by blue, red, white, and yellow key lights. If no response occurred on the avoidance key during the total 60-sec RS interval, the 5-min TO occurred. Each response on the avoidance key reset the 60-sec RS timer and reinstated the blue key light. The avoidance schedule is a discriminated avoidance schedule in which the warning stimulus is a discontinuous clock (Ferster and Skinner, 1957) consisting of a series of discrete color changes. After avoidance behavior had been maintained for 24 sessions for T2 and 20 sessions for T8, 16 control sessions for T2 and 11 control sessions for T8 were run with no TOs programmed.

Results. Avoidance responding was established during the first several sessions of the concurrent VR-TO avoidance schedule. The mean avoidance rate for T2, based on the last three sessions, was 3.1 responses per min. T8's avoidance rate was 3.4 responses per min. T2 had a mean VR rate of 122.2 responses per min; T8 143.6 responses per min. The highest frequency of avoidance responses occurred during the last 15-sec stimulus interval, just preceding the TO. Figure 1 C and H show cumulative response records of TO avoidance for both subjects. The pips indicate TO occurrences, during which the paper drive was disconnected. When TOs were no longer programmed, responding on the avoidance key dropped to zero in eight sessions for T2 and in five sessions for T8.

These results show that discriminated TO avoidance can be established and maintained concurrently with a VR schedule with pigeons and that such avoidance behavior is under control of TO occurrences.

EXPERIMENT II

This investigated the stimulus control of the TO avoidance behavior. The experimental manipulations involved the temporal and exteroceptive stimulus variables.

Procedure. After the avoidance schedule was reinstated concurrently with the VR, the 60-sec RS interval with four 15-sec stimuli was changed to a 120-sec RS interval with four 30-sec stimuli. After performances stabilized, a 20-sec RS interval was programmed with four 5-sec stimuli. The 20-sec RS interval was then kept in effect, but the exteroceptive stimuli were reduced from four to two. During the first 10 sec of the 20-sec RS interval, a blue key light was on; during the second 10 sec a yellow key light was on. Reducing stimuli from four to two with the same RS interval separated the temporal control of the avoidance behavior from the exteroceptive stimulus control. After a brief return to the original baseline, the schedule was changed so that only a blue key

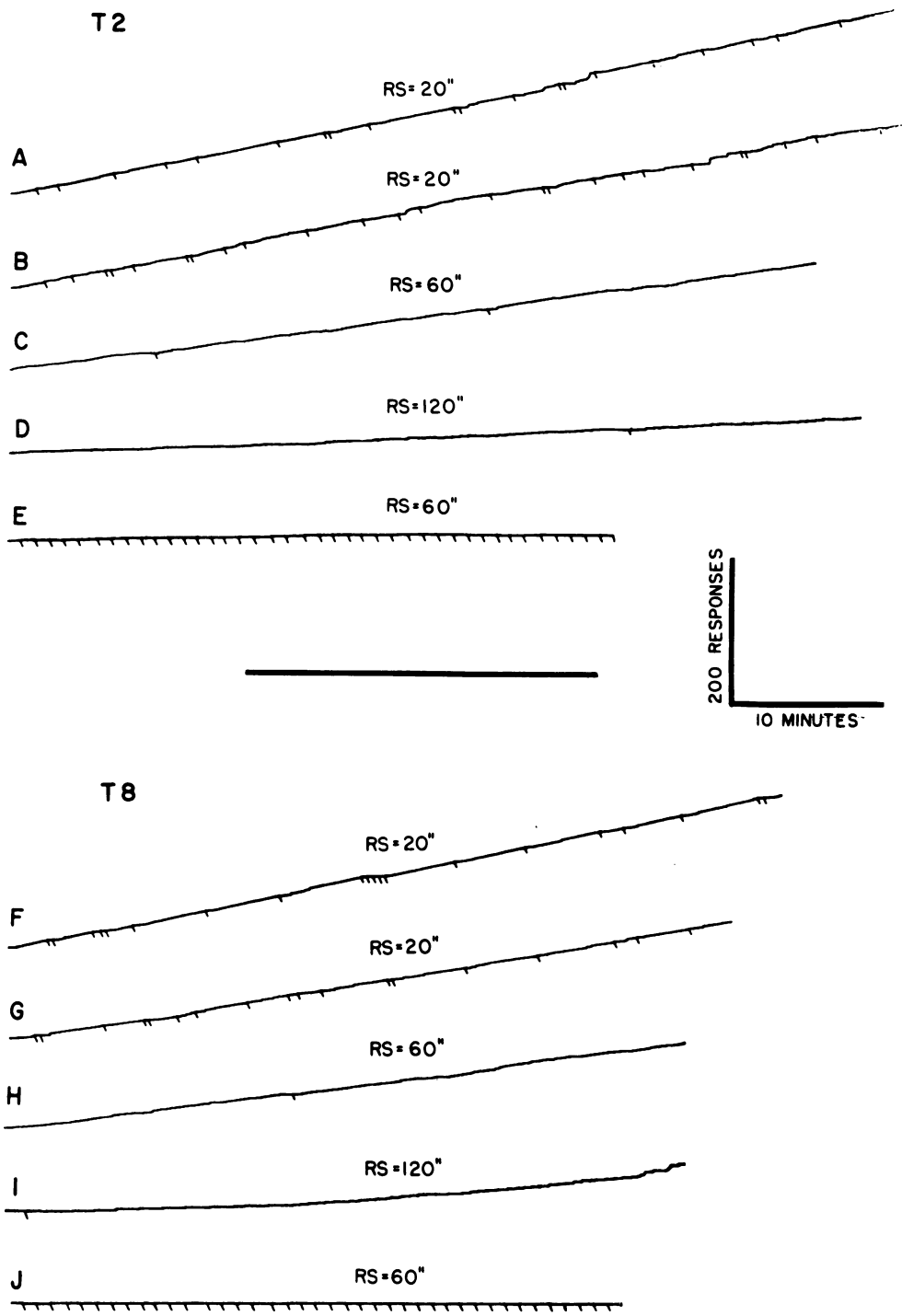

Fig. 1. Performances of the two subjects on each of the TO avoidance schedules programmed concurrently with the VR schedule. The pips indicate TO occurrences, during which the recorder motor was disconnected. Records B, C, and D for T2 and G, H, and I for T8 show performances with a discriminated avoidance schedule when the RS interval contained four exteroceptive stimuli, each on for one quarter of the interval. Records A and F show performances on a discriminated avoidance schedule when the RS interval contained two exteroceptive stimuli, each on for one half of the interval. Records E and J show performances with a nondiscriminated avoidance schedule.

light illuminated the VR key during the entire 60-sec RS interval. This converted the program to a nondiscriminated avoidance procedure. During all of the above manipulations, the VR 140 schedule remained on the right response key.

Results. The results of the stimulus manipulations can be seen in Fig. 1 and 2. When the RS interval was increased to 120 sec with four 30-sec stimuli, T2's mean avoidance rate fell from 3.1 to 1.5 responses per min. T8's mean avoidance rate fell from 3.4 to 1.8 responses per min. Cumulative records of avoidance performances on the schedule are shown in Fig. 1 D and I. During reduction of the RS interval to 20 sec with four 5-sec stimuli, T2's avoidance rate went to 4.4 responses per min and T8's to 3.4 responses per min. Records B and G in Fig. 1 show performances on that schedule.

Figure 2 shows avoidance response distributions for the different sequential stimuli within the RS interval. As many more opportunities existed for an avoidance response in the early stimulus intervals than in the later ones following a preceding avoidance response, responses are plotted as responses per opportunity. The numbers on the abscissa represent the serial position of the stimuli within the RS interval. Figure 2 D and H show avoidance response distributions for both subjects when the RS interval was 60 sec with four 15-sec stimuli. The highest avoidance frequency occurs during the last stimulus preceding the TO. The second highest frequency occurs during the second stimulus (15 to 30 sec). When the RS interval was increased to 120 sec with four 30-sec stimuli (Fig. 2 B and F) the highest avoidance frequency was again in the last

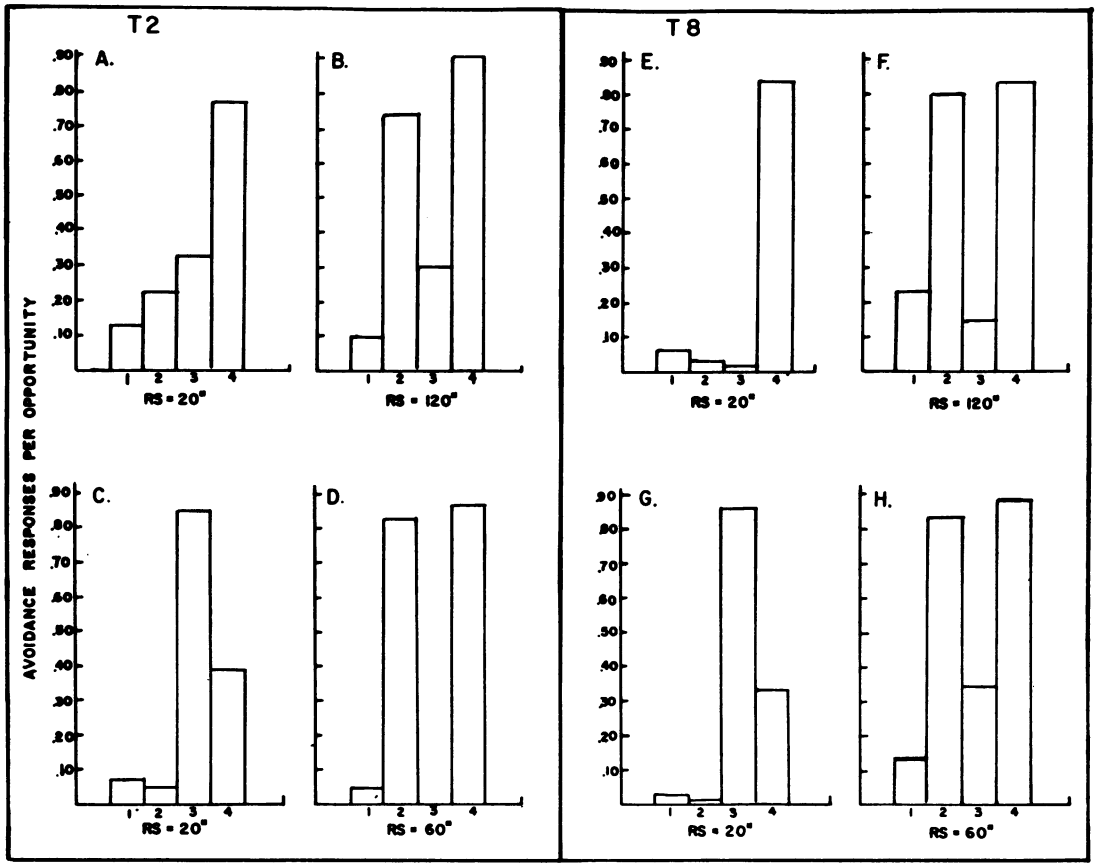

Fig. 2. Avoidance response distributions of the two subjects for the different sequential stimuli within an RS interval. Avoidance responses are plotted on the ordinate as responses per opportunity. The numbers on the abscissa represent successive quarters of the RS interval. For all response distributions except those labeled C and G, the RS interval contained four extroceptive stimuli, each lasting for one quarter of the interval. In response distributions C and G the RS interval contained two exteroceptive stimuli, each on for one half of the interval.

stimulus interval. The second highest was again in the second stimulus position. When the RS interval was 20 sec with four 5-sec stimuli, the overall highest avoidance frequency appeared during the last 5-sec stimulus (Fig. 2 A and E).

The mean avoidance rate of T2 increased to 4.8 responses per min and T8's to 4.6 responses per min when the RS interval was kept at 20 sec but with only two stimuli programmed (each for 10 sec of the interval). Records A and F in Fig. 1 show performances on that schedule. Figure 2 C and G show the avoidance response distributions. The highest avoidance response frequency is at the onset of the second stimulus (third recorded interval position) which is the terminal stimulus in this case. In Fig. 2, a comparison between A and C separates the temporal control and the exteroceptive stimulus control of the warning stimuli over T2's avoidance behavior. A comparison between E and G in Fig. 2 can be made also for T8. The shift in the highest response frequency from the terminal 5-sec interval to the third 5-sec interval accounts for the increase in the avoidance rate.

When the RS interval was 60 sec, with only one stimulus present during the entire RS interval, avoidance rates for both subjects dropped to near zero. Records for performances on the nondiscriminated avoidance schedule are shown in Fig. 1 E and J.

The VR performances during several of the above manipulations for T2 are presented in Fig. 3. The cumulative records, A through E, are the VR performances obtained concurrently with the avoidance records for T2, A to E, shown in Fig. 1. The occasional pauses seen in the records usually occur during the final stimulus interval. The pauses are particularly evident in record B, a VR record from the schedule in which the RS interval was 20 sec with four 5-sec stimuli. The very high and constant VR performance in Fig. 3 E was obtained concurrently with the nondiscriminated avoidance procedure. In general, for both subjects, the VR rate in each of the four sequential stimulus intervals was inversely related to the avoidance frequency in that interval.

These results show that the TO avoidance behavior was under the control of the parameters of the avoidance schedule and the discontinuous clock.

EXPERIMENT III

During the programming of the two longer RS intervals in Exp II, the second highest avoidance response frequency occurred during the second stimulus interval (Fig. 2 B, D, F, and H). The temporal response distribution could have been produced by the schedule control or by the red key light. The source of control was investigated by separating color from temporal position. A number of experimental manipulations reversed or switched the serial position of the four exteroceptive stimuli.

Procedure. All manipulations were performed with a 60-sec RS interval and a 5-min TO. The schedule on the right key remained at VR 140. The order of the four stimuli in the original baseline condition was: blue, red, white, and yellow. In the first manipulation the two middle stimuli were reversed so that the order of stimuli was: blue, white, red, and yellow. After a brief return to the baseline conditions, the first two colors were reversed so that the order of stimuli was: red, blue, white, and yellow. The final manipulation involved a return to the original baseline.

Results. Figure 2 D and H show the avoidance response distribution of the baseline condition. The resulting avoidance response distribution when the two middle stimuli were reversed is shown in Fig. 4 A and D. The second highest avoidance response frequency for T2 remained at the second temporal interval, although the stimulus associated with the interval was now white rather than red. For T8, the second highest response frequency stayed with the red stimulus and shifted to the third temporal interval position. The response distributions that resulted when the first two colors were reversed are shown in Fig. 4 B and E. The second highest response frequency of T2, although much lower, remained at the second temporal position. T8's highest avoidance response frequency, also much lower, again followed the red stimulus to the first temporal position. The return to the original baseline order of stimuli produced the results shown in Fig. 4 C and F. The second highest response frequency remained at the second temporal position for T2. In the final baseline, T8's highest avoidance response frequency was at the second position, and the second highest response frequency was

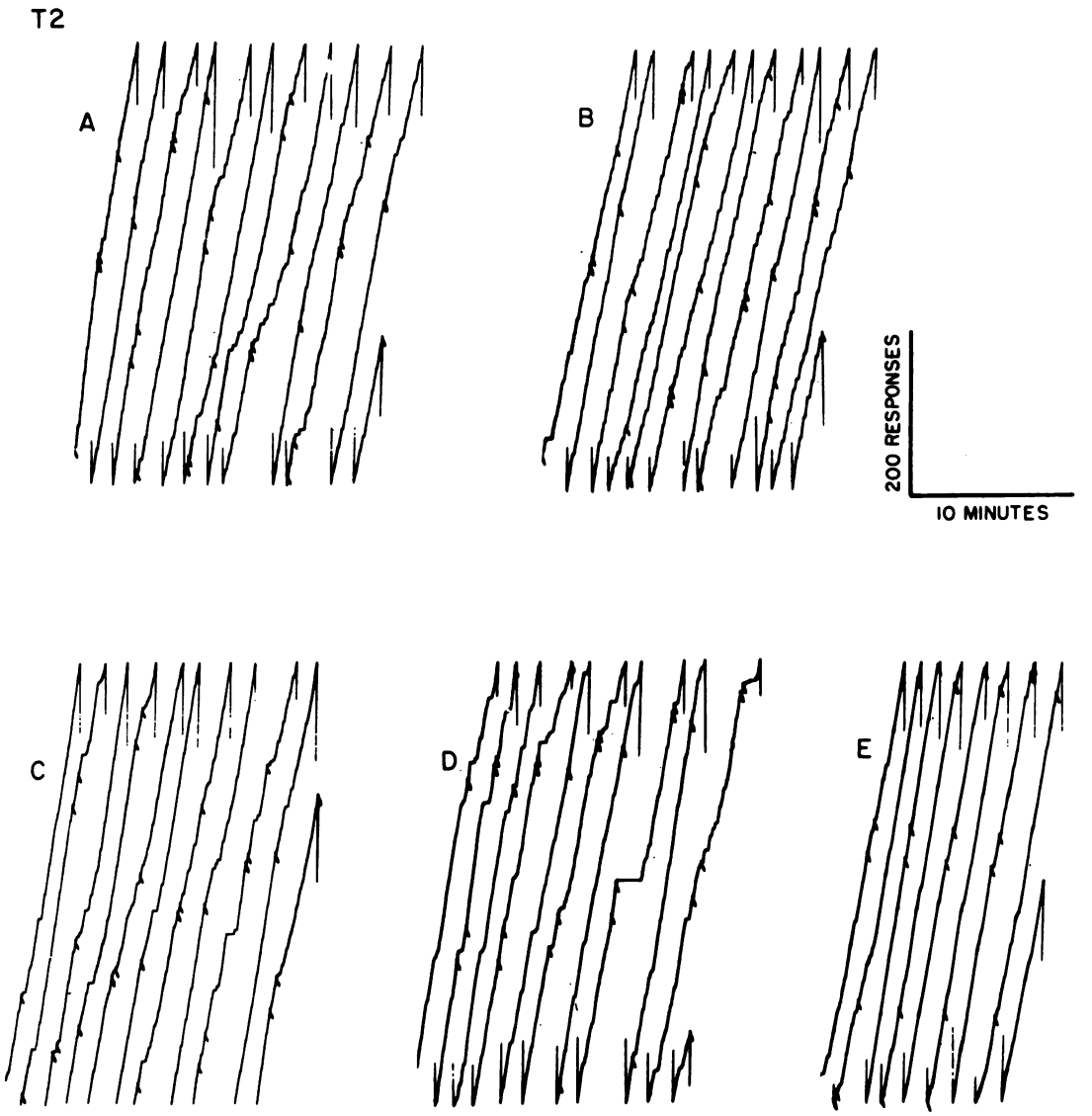

Fig. 3. Variable ratio performances of T2 obtained concurrently with several TO avoidance schedules. The pips indicate food reinforcements. Records A through E are performances obtained concurrently with the TO avoidance records for T2 presented in Fig. 1, records A through E.

at the last temporal position. These results suggest that T2's avoidance response distribution was under the schedule control and that T8's was controlled by the red key light.

EXPERIMENT IV

This studied the effect of TO duration on the discriminated TO avoidance behavior.

Procedure. The RS interval remained at 60 sec, divided into four 15-sec stimulus intervals, and the schedule on the right key remained at VR 140. Four values of TO duration were investigated: 0.5, 2, 5, and 15 min.

Results. The effect of TO duration on the avoidance behavior is shown in Fig. 5. Each point is the mean of the last three sessions at a given TO duration. Both subjects showed essentially the same effect. The highest avoidance rate occurred when TO duration was 5 min. The longest TO duration maintained less avoidance responding than the shorter TO durations. The concurrent VR performances of T2 remained fairly stable across all TO

durations, except at the longest. At the longest duration, T2's VR performance was strained, and the VR rates dropped to their lowest values in the entire study (105.7 responses per min). T8's VR rates remained stable during all TO durations (approximately 140 responses per min).

EXPERIMENT V

The effects of chlorpromazine hydrochloride on TO avoidance behavior were investigated.

Procedure. The effects of doses of chlorpromazine hydrochloride, ranging from 2.5 to 30 mg/kg, were determined for both subjects. All injections were made intramuscularly 30 min after the start of a session in volumes of 0.1 ml/100 g of body weight from an appropriate solution in 0.9% NaCl. A session in which saline was administered always preceded a drug session and served as a control for drug effects. The TO avoidance schedule contained a 60-sec RS interval divided into four 15-sec

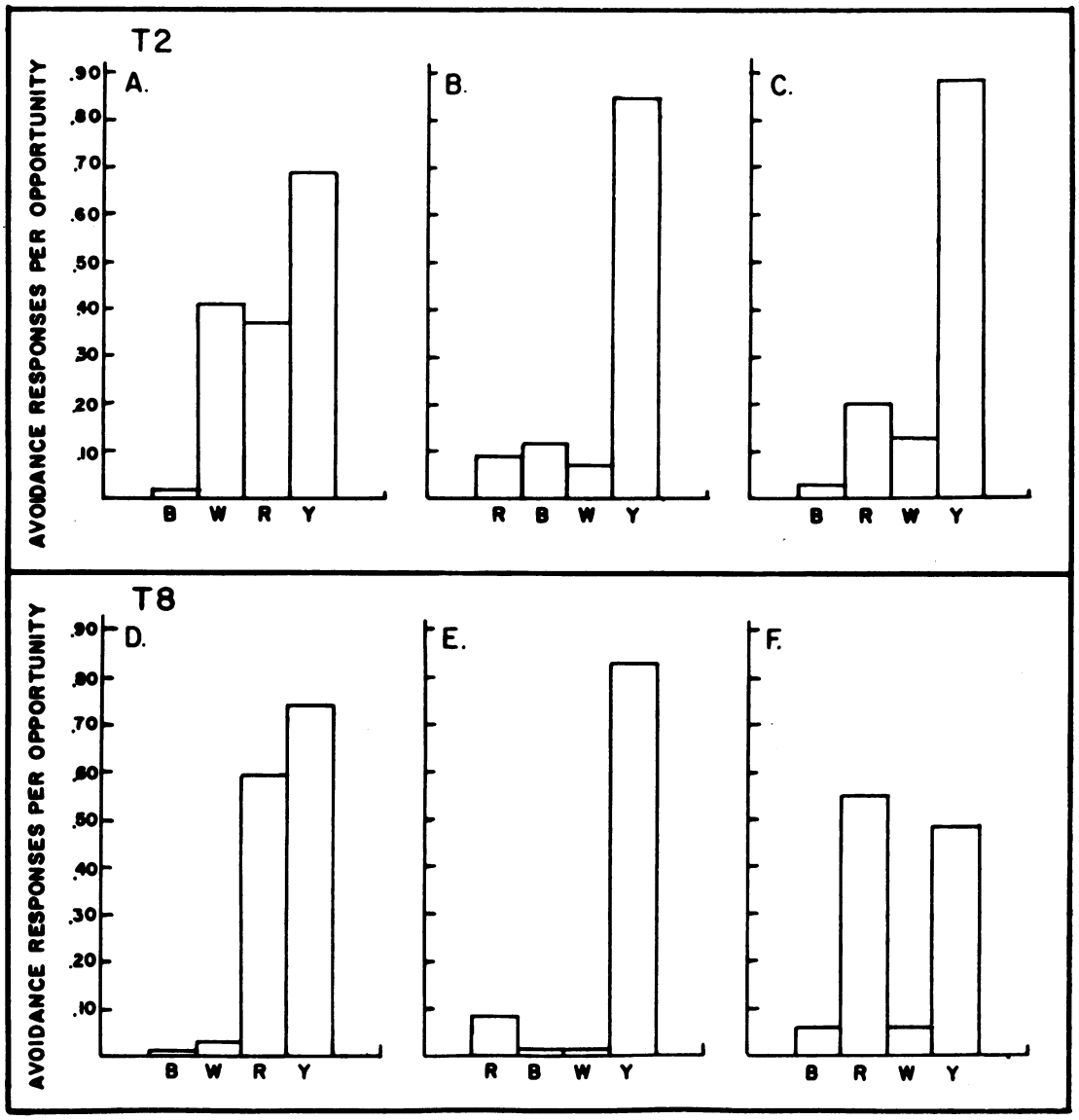

Fig. 4. Avoidance response distributions of the two subjects during manipulation of the serial position of the four exteroceptive stimuli within an RS interval. Avoidance responses are plotted on the ordinate as responses per opportunity. The letters on the abscissa represent the color of the stimuli associated with each interval. Each stimulus was on for one quarter of a 60-sec RS interval.

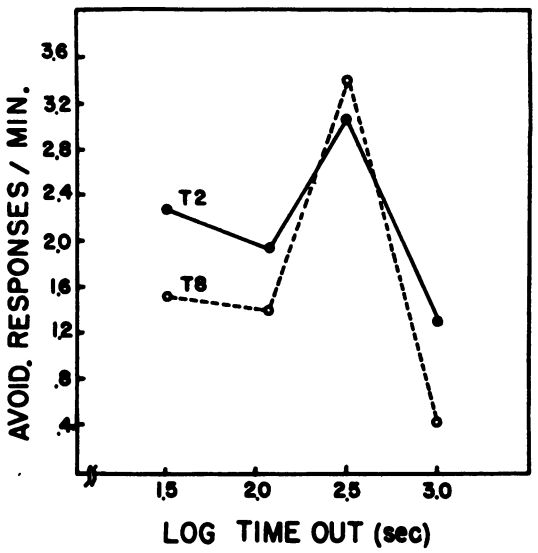

Fig. 5. Effects of four values of TO duration on TO avoidance response rates for both subjects. Time-out duration is expressed in seconds and is plotted on a logarithmic scale.

stimulus intervals. The VR 140 remained in effect concurrently on the right response key.

Results. Figure 6 presents the dose-response relationship for both subjects. The changes in TO avoidance behavior and VR behavior are expressed by the "output ratio" (Dews, 1955), which is the ratio of the rate during the drug session to the rate during the preceding saline control session. The solid lines indicate avoidance performances, and the dotted lines VR performances. Both subjects showed an increasing behavioral output on the avoidance schedule, followed by a declining output, as a function of dose. Both decreased output in VR performance over the entire dose range. The largest increase in avoidance behavior (over nine times control rates) occurred at 5 mg/kg for T2. The largest increase in avoidance behavior for T8 was at 20 mg/kg. Figure 7 shows the effects of the dose range of 2.5 to 20 mg/kg on TO avoidance behavior of T2. In general, all doses of chlorpromazine increased TO avoidance rates above control values and decreased VR rates below control values.

DISCUSSION

Substantial behavior that avoided a TO from positive reinforcement was maintained in the present study. The discriminated TO avoidance procedure produced a high degree of control over occurrence of avoidance behavior. The control by the warning stimuli in

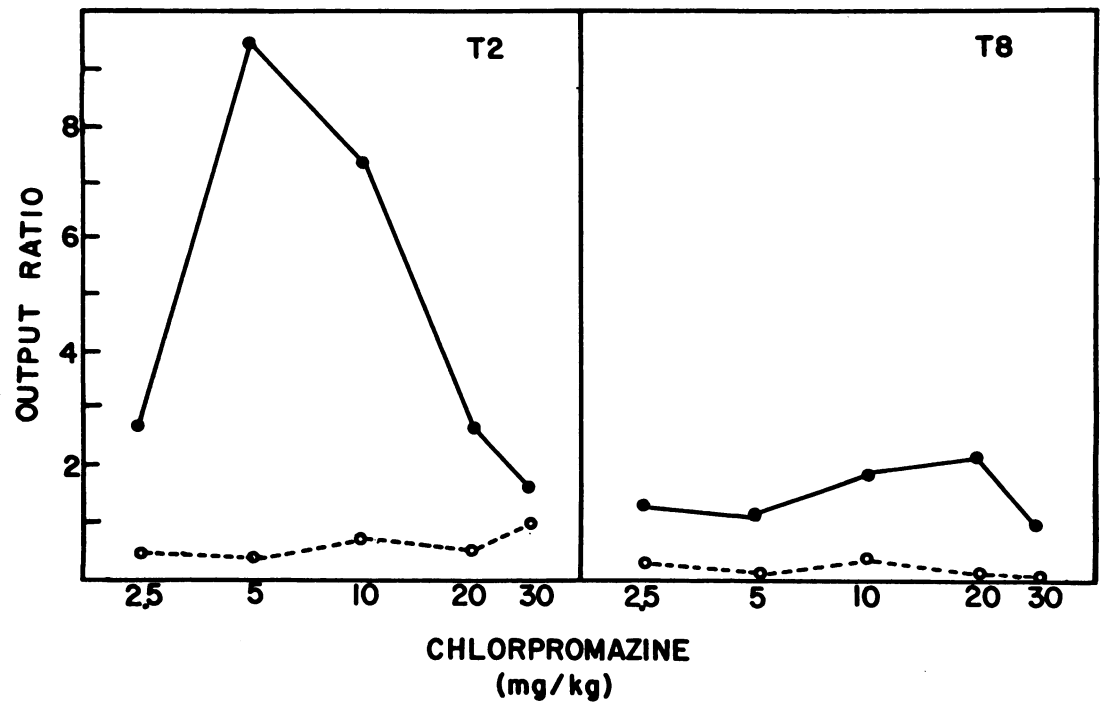

Fig. 6. The effects of five doses of chlorpromazine hydrochloride on discriminated TO avoidance (solid lines) and VR (dotted lines) performances for both subjects.

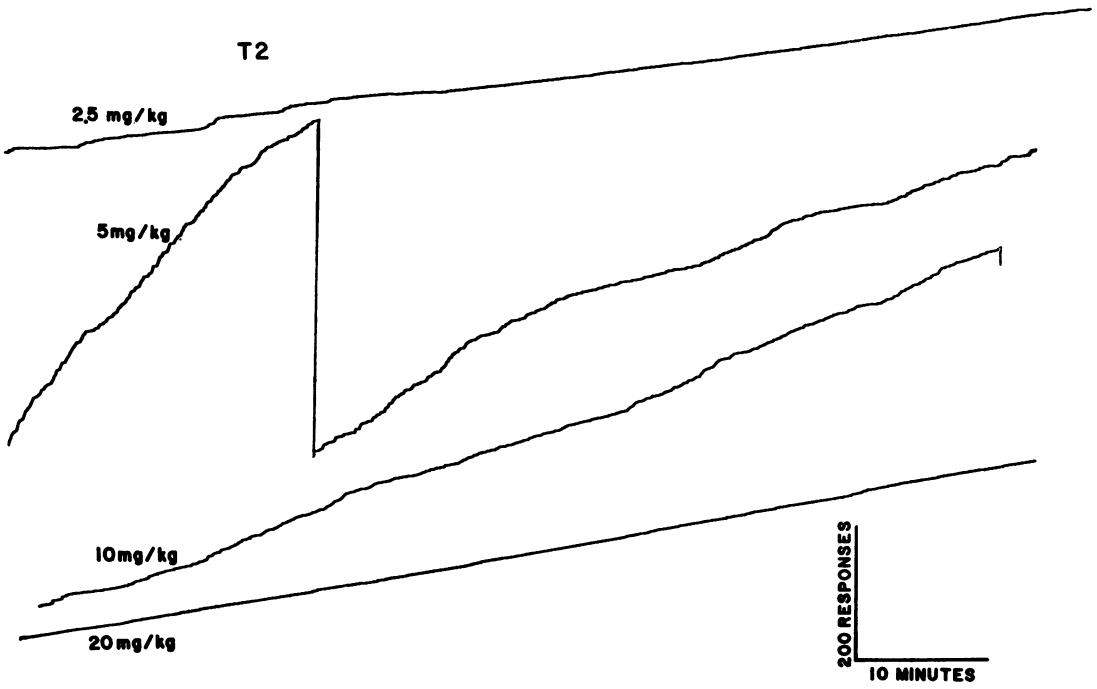

Fig. 7. The effects of several doses of chlorpromazine hydrochloride on discriminated TO avoidance performances of T2.

the present study has many of the properties of stimulus control in electric shock avoidance studies (Sidman 1955; Ulrich, Holz, and Azrin, 1964).

Loss of control over avoidance behavior occurred in Exp II when a nondiscriminated avoidance schedule was programmed. The loss of control with the nondiscriminated schedule is at variance with the literature which shows that nondiscriminated TO avoidance can be well maintained concurrently with a positive reinforcement schedule (Ferster, 1958; Morse and Herrnstein, 1956; Zimmerman, 1963). The reason for the discrepancy is not apparent. An important variable in the discriminated avoidance procedure appears to be the immediate stimulus change that occurs after an avoidance response, *i.e.* the reinstatement of the stimulus associated with the beginning of the RS interval. This stimulus defines a safe period from TO occurrences. Studies employing electric shock have shown that such a safe period must be made contingent upon a specific response and that the safe period be associated with the absence of negative reinforcers (Azrin, Holz, Hake, and Ayllon, 1963; Ulrich *et al.*, 1964).

In Exp IV, 5-min TOs were found to maintain higher avoidance rates with the same avoidance program than shorter TO durations. The longest TO duration employed (15 min) did not maintain as much TO avoidance behavior as the 5-min TO. The VR rate of T2 was also decreased at the longest TO duration. The disruptive effect of the longer TO duration was probably on the subjects' overall disposition to respond. A similar behavioral relationship with TO duration has been found with the matching to sample procedure (Ferster and Appel, 1961; Zimmerman and Baydan, 1963; Zimmerman and Ferster, 1963). Increasing TO durations usually increases matching accuracy, but with still longer durations S^D rates, and often matching accuracy, become disrupted.

The increase in TO avoidance rates produced by chlorpromazine is of particular interest. The literature shows almost uniformly that shock avoidance behavior is depressed by chlorpromazine. The increase in avoidance in the present study is not part of a generalized increase in responding. The rates on the concurrent VR schedule were consistently decreased across the entire dose range. The increase in rates produced by chlorpromazine is specific to the TO avoidance behavior. The in-

crease in avoidance and decrease in VR behavior is similar to the effects of chlorpromazine on observing responses (Cook and Kelleher, 1962; Kelleher, Riddle, and Cook, 1962). Increasing doses of chlorpromazine increased observing responses while food-producing responses were decreased.

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