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CHOICE OF TIMEOUT DURING RESPONSE-INDEPENDENT FOOD SCHEDULES

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Rats' lever pressing terminated visual or auditory stimuli associated with fixed-time or variable-time schedules of food delivery and produced a timeout period during which food delivery could not occur. Lever pressing during a timeout period reinstated the food-associated stimuli and again permitted food delivery according to the fixed-time or variable-time schedules. The mean interfood interval ranged from 1 minute to 16 minutes (variable-time schedules) or 32 minutes (fixed-time schedules); the timer controlling schedule intervals did not stop during timeout periods. The percentage of session time spent in timeout increased when the mean interfood intervals were lengthened and decreased when the mean interfood intervals were shortened. Timeouts were initiated most frequently about half way between successive food deliveries (fixed-time schedules) or after 15 seconds or more had lapsed since the last food delivery (variable-time schedules). Elimination of food delivery increased the percentage of session time spent in timeout, and elimination of the timeout contingency decreased lever press rates. When timeout was produced only when the lever was held in the depressed position, little time was spent in timeout. The main determinants of timeout initiation and termination appeared to be the rate of food delivery, freedom of movement during timeout, and the stimulus change associated with initiation and termination of timeout.

Key words: schedule-induced timeout, fixed-time schedules, variable-time schedules, extinction, lever press, lever hold-down, rats

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Azrin (1961) found that pigeons responding to produce food on fixed-ratio (FR) schedules would adopt a second response which resulted in a stimulus change and a timeout period during which food could not be obtained. Responses that produced timeout typically occurred during the interval between delivery of food and the first response on the schedule. With few exceptions, this general effect has been replicated with FR (Appel, 1963; Pliskoff & Tolliver, 1960; Thomas & Sherman, 1965; Thompson, 1964, 1965; Zimmerman & Ferster, 1964), progressive-ratio (PR) (Dardano, 1973, 1974), and fixed-interval (FI) (Brown & Flory, 1972) schedules of reinforcement.

Some disagreement exists regarding the relationship between characteristics of the schedule and the proportion of session time spent in timeout. Usually, as the size of the ratio was made larger, an increasing proportion of time was spent in timeout (e.g., Appel, 1963; Azrin, 1961; Dardano, 1973; Thompson, 1964). However, for some subjects, session time spent in timeout increased as the FI was lengthened (Brown & Flory, 1972) or the FR was made larger (Thomas & Sherman, 1965), up to a point, and then decreased with further enlargement of the schedule.

A number of interpretations have been proposed for the finding that subjects will respond to produce timeout. For example, several researchers suggested that schedules of positive reinforcement possess properties that are, in some way, aversive, with timeout initiation serving an escape function (e.g., Azrin, 1961; Dardano, 1973; Thompson, 1964). Alternatively, Zimmerman and Ferster (1964) suggested that timeout initiation occurred when there was a momentary loss of control by the schedule over the response required for reinforcement. A third interpretation emphasizes the abrupt transition from reinforcement to nonreinforcement, with the period of time im-

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mediately after the transition viewed as aversive (Brown & Flory, 1972; Hutchinson & Emley, 1972); again, timeout would serve an escape function. A fourth interpretation is that the stimulus change associated with timeout is, by itself, reinforcing (Appel, 1963; Coughlin, 1973).

In view of the lack of agreement regarding the determinants of initiation and termination of a stimulus change associated with timeout, additional information seems necessary. The present series of experiments further examined timeout from reinforcement by studying schedules that delivered food independently of responding. These schedules permitted the study of timeout in the absence of interactions between responses required for food presentation and responses that produce timeout. This seems important because the behavior controlled by previously studied response-dependent schedules may have influenced both the time spent in timeout and the temporal distribution of timeout initiation and termination.

GENERAL METHOD

Subjects

Twenty-three male Long-Evans hooded rats ranging in age from 6 mo to 10 mo were used. Rats R1, R2, and R3 had prior training on a variety of procedures in an undergraduate laboratory. The remaining rats were experimentally naive. Rats were maintained at about 80% of their free-feeding weights.

Apparatus

Three Plexiglas and aluminum experimental chambers of similar construction were used. Each was 30.5 cm long, 24.0 cm wide, and 24.0 cm high. A rat lever (BRS/LVE RCL-001), mounted 7.5 cm above the floor and 4.0 cm from the right wall (the chamber used with R24 and R26 in Experiment IV) or 4.0 cm from the left wall (used with all other rats), required a minimum force of about .13 *N* for operation. A receptacle for 45-mg Noyes rat pellets was centered on the wall containing the lever and was 2.0 cm above the floor. Chamber illumination was provided by two houselights (GE 1829 bulbs covered by white Plexiglas) mounted on the wall opposite the lever, 5.0 cm from each side and 1.0 cm from the top and, in addition, for R1, R2, and R3, by a light (Sylvania 28ESB bulb) mounted 6.0 cm above the lever and covered by a white lens. A 1-kHz 80-dB tone could be presented through a speaker located behind the lever. Each chamber was located in a ventilated sound-attenuating enclosure. A BRS/LVE solid state system (Experiment 2) and standard electromechanical components (all other experiments) controlled chamber events and recorded data.

Procedure

For all experimentally naive rats other than those in Experiment 4, the lever press response was shaped while the chambers were illuminated. During the next session, 30 consecutive lever presses were each reinforced by a 45-mg food pellet. In Experiments 1 and 3, sessions were preceded and followed by 10 min during which the chamber was dark and no food was presented. In Experiments 2 and 4, such delays were not used.

After the above preliminary training, procedures involving timeout were begun. When the chamber was illuminated, a food pellet was presented at regular intervals of time independently of responding (FT; fixed-time schedule) in Experiments 1, 2, and 3, and at irregular intervals of time independently of responding (VT; variable-time schedule) in Experiment 4. The VT schedules were prepared according to the Fleshler and Hoffman (1962) technique and consisted of mixed sequences of 12 intervals.

When FT or VT schedules were in effect, timeout could be initiated by depressing the lever. Three different procedures for initiating timeout were studied. In the first two procedures, one lever press (R22, R25, and all rats in Experiments 2 and 4) or two lever presses (R1, R2, and R3) turned off the chamber lights. During this timeout period, food was not delivered. When timeout was in effect, one lever press (R22, R25, and all rats in Experiments 2 and 4) or two lever presses (R1, R2, and R3) reinstituted chamber illumination and food delivery resumed according to the FT or VT schedule. In the third procedure, used in Experiment 3, depressing the lever produced timeout and releasing the lever ended timeout. Thus, the chamber was dark and food was not delivered for the duration that the lever was held down. In all experiments, the timer controlling the schedule continued to operate during timeout until the end of

the interval; the timer stopped if food delivery was set up during timeout. To protect against fortuitous reinforcement of responses that ended timeout, a 6-sec changeover delay occurred between termination of timeout and food delivery. Thus, food pellets scheduled for delivery during timeout or during the 6 sec immediately after the end of timeout were delivered 6 sec after the end of timeout; timeout could be initiated during the 6-sec delay.

In Experiments 2, 3, and 4, several control conditions were studied to establish that responding was controlled by the timeout contingency. Under one control condition, Food + No Timeout, food pellets were presented on FT or VT schedules, but lever pressing did not produce timeout. Food pellets were not presented for 6 sec after a response; lever pressing during this period restarted the 6-sec interval. Under a second control condition, No Food + Timeout, pellets were not delivered, but responses successively turned the houselights off and on. Under a third control condition, No Food + No Timeout, pellets were not delivered and lever pressing did not produce the stimulus change associated with timeout. It should be noted that the term *timeout* is used to describe a response-produced stimulus change during conditions that were not associated with food delivery; this was done to facilitate discussion and is consistent with the terminology of other reports (e.g., Coughlin, 1973; Rilling, Askew, Ahlskog, & Kramer, 1969).

All timeout conditions were continued until performances were stable from session to session. Stability was assumed when the mean percentage of session time spent in timeout in each of two consecutive blocks of three sessions was within 3% (Experiments 1 and 2), 2% (Experiment 4), or 1% (Experiment 3) of the combined six-session mean. In addition, under all conditions it was necessary that the mean number of responses in each of two consecutive blocks of three sessions be within one (Experiment 3) or two (all other experiments) responses of the six-session mean. In several cases, further training was given within a condition if the number of timeouts per session or the location of timeouts between food deliveries were variable. On VT schedules, sessions were terminated after 60 (VT 1-min), 30 (VT 2-min), 15 (VT 4-min), 8 (VT 8-min), or 4 (VT 16-min) food pellets, or 90 min, whichever occurred first. On FT schedules, sessions were terminated after 50 food pellets or upon delivery of the first food pellet after sessions had exceeded 1 hr. Sessions without food delivery lasted 1 hr. With few exceptions, sessions were conducted daily.

EXPERIMENT 1
TIMEOUT FROM FIXED-TIME SCHEDULES

The first experiment studied timeout initiation and termination during a series of FT schedules that were accompanied by either visual or auditory stimuli. Of special interest was the relationship between the proportion of session time spent in timeout and FT length, and the question of where, in the interfood interval, timeout would be initiated and terminated.

Procedure

Because of prior training, R1, R2, and R3 were initially trained for 18 sessions on an FT 1-min schedule during which food pellets were delivered every min independently of responding. During training, the chamber was illuminated and lever pressing had no effect. For the rest of the study, timeout and darkening of the chamber could be produced and terminated by two lever presses. The effects of the timeout contingency were studied using an ascending and descending sequence of FT schedules that ranged from 1 min to 32 min. In a subsequent condition, the stimuli associated with food and timeout were reversed. Thus, food delivery on FT 1-min occurred when the chamber was dark. Two lever presses turned on the chamber lights and initiated the timeout period. During the timeout period, two lever presses turned off the lights and again permitted food delivery on the FT 1-min schedule. Other procedural details were as described in the General Method section.

Two additional rats (R22 and R25) were trained on procedures generally similar to those for R1, R2, and R3, except that termination of a tone rather than illumination accompanied timeout. The chamber was illuminated continuously during sessions, and a single lever press produced timeout associated with termination of a tone and the FT schedule. If timeout was in effect, a single lever press reinstated the tone and the FT schedule.

Table 1

The sequence of schedules and the number of sessions of training for each rat in Experiment 1.

	Subject				
Schedule	*R1*	*R2*	*R3*	*R22*	*R25*
FT 1	27	30	14	21	20
FT 2	24	20	31	—	—
FT 4	35	16	24	11	8
FT 8	13	18	24	—	—
FT 16	22	20	14	8	6
FT 32	6	13	7	—	—
FT 16	13	10	12	—	—
FT 8	7	11	18	—	—
FT 4	10	16	7	12	6
FT 2	6	18	14	—	—
FT 1	8	10	28	8	6
FT 1 reversal	15	11	22	—	—
FT 1	17	19	27	—	—

Table 1 shows the sequence of conditions and the number of sessions of training for the five rats used in Experiment 1.

Results

Because of their prior histories, R1, R2, and R3 responded at relatively high rates at the beginning of the experiment. The initial training on an FT 1-min schedule without the timeout contingency decreased response rates to about two per min.

All rats responded to produce and terminate timeout throughout the ascending and descending sequence of FT schedules. It should be noted that despite the 6-sec changeover delay, the actual times between food pellets were usually close to the scheduled times. Figure 1 shows the mean percentage of session time and the range of times spent in timeout during the last six sessions on FT schedules for R1, R2, and R3, trained with the procedure in which timeout was associated with visual change. For R1 and R3, the timeout percentage increased regularly as the interval of the FT was lengthened. The only exception was a decrease in timeout percentage at FT 32-min for R3. The timeout percentage then decreased as the FT intervals were shortened. Rat R2 had a higher timeout percentage on FT 1-min and FT 2-min than on FT 4-min schedules on the ascending sequence of FT schedules; at longer FTs, the timeout percentage increased. The timeout percentage by R2 also was irregular on the descending FT sequence but showed an overall decrease.

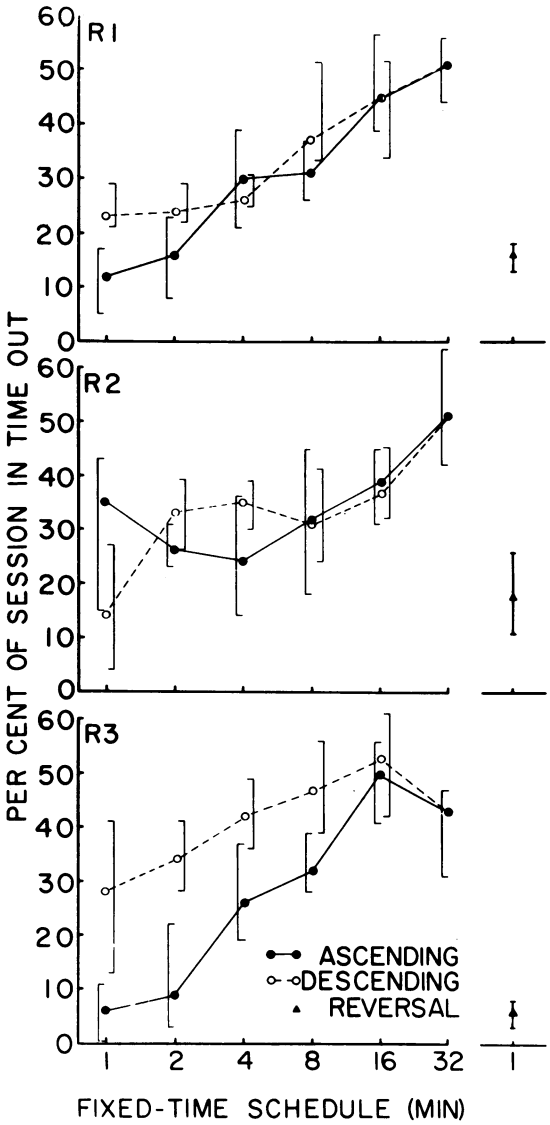

Fig. 1. Percentage of total session time spent in timeout and the ranges of timeouts during the last six sessions on each FT schedule for R1, R2, and R3 in Experiment 1. Brackets open to the right indicate the range of values during the terminal sessions on the ascending sequence and brackets open to the left indicate the range of values on the descending sequence. Unconnected triangles represent the reversal condition during which timeout was associated with an illuminated chamber.

When the stimuli were reversed for R1, R2, and R3, such that FT 1-min was in effect when the chamber was dark and timeout was associated with an illuminated chamber, all three rats increased the time spent in the absence of chamber illumination. The timeout percent-

age during the terminal sessions under this condition (triangle, in Figure 1) was about the same as on the immediately preceding and following FT 1-min conditions when timeout was associated with a dark chamber.

Manipulation of FT intervals had a consistent effect on the duration of timeouts (i.e., time between the initiating response and the terminating response). On FT 1-min schedules, the most common duration of timeouts was 2 sec or less. As the FT intervals were lengthened, brief timeout durations (i.e., 4 sec or less) decreased in frequency and longer timeout durations (i.e., 20 sec or longer) increased in frequency. This effect was reversed on the descending FT schedules.

Figure 2 shows the timeout percentage when termination of a tone was associated with timeout (R22 and R25). As before, the timeout percentage increased as the FT intervals were lengthened and decreased as the intervals were shortened. There were no obvious differences between outcomes when responding turned off a tone or turned off chamber illumination.

Another aspect of performance concerned the point during interfood intervals when timeouts were initiated. Figure 3 shows, for R1, R2, and R3, the percentage of timeouts initiated during successive quarters of FT intervals (i.e., 15-sec quarters on FT 1-min, 30-sec quarters on FT 2-min, etc.) during the terminal sessions on each FT schedule. Also shown above each bar is the actual number of timeouts produced. At FT 1-min to FT 4-min schedules, the modal location of timeout initiation was usually in the first or second quarter. At FT 8-min and longer schedules, the distributions tended to flatten and, in several cases, contained modes in the third or fourth quarters. The total number of timeouts was variable across FT schedules for individual rats and also across rats. Although the total number of timeouts generally increased on the ascending sequence, there does not seem to be any consistent relationship between FT interval and the total number of timeouts on the descending sequence. Distributions were not determined for R22 and R25, the rats studied with tone rather than light, but event records suggested a similar pattern of results.

Figure 4 shows for R1, R2, and R3, a parallel analysis of the point at which timeouts were terminated, again in relation to successive

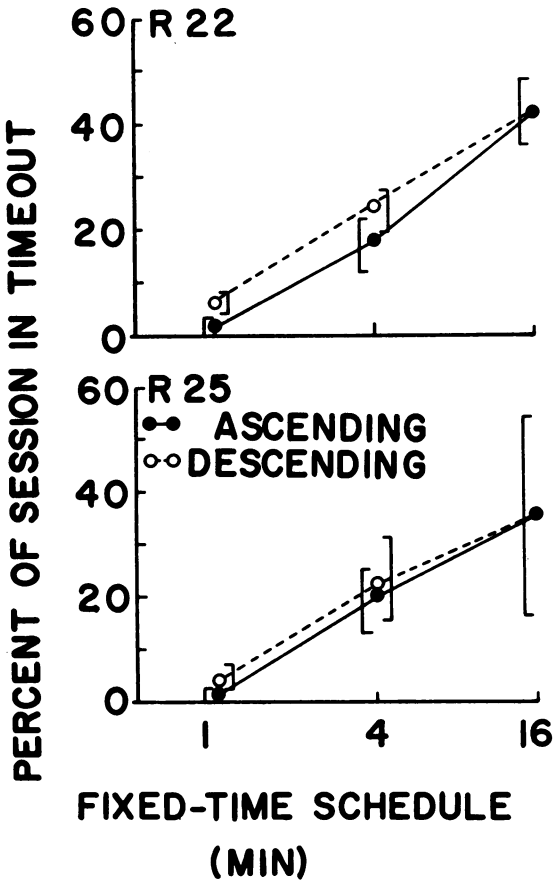

Fig. 2. Percentage of total session time spent in timeout and the ranges of timeouts during the last six sessions on each FT schedule for R22 and R25 in Experiment 1. Brackets open to the right indicate the ranges on the ascending sequence and brackets open to the left indicate ranges on the descending sequence.

quarters of the FT intervals. Combining all subjects, 22 of the 36 panels show modes in the third quarter. Exceptions were usually on the longest FT schedules for R1 and R3, and on the shortest FT schedules for R2. Event records suggested similar results with R22 and R25. Since timeout termination did not occur predominantly in the fourth quarter, the terminating response was probably not directly maintained by food presentation.

EXPERIMENT 2
EFFECT OF ELIMINATING FIXED-TIME FOOD DELIVERY AND/OR THE TIMEOUT CONTINGENCY

Experiment 1 showed that timeout was initiated and terminated when intermittent food

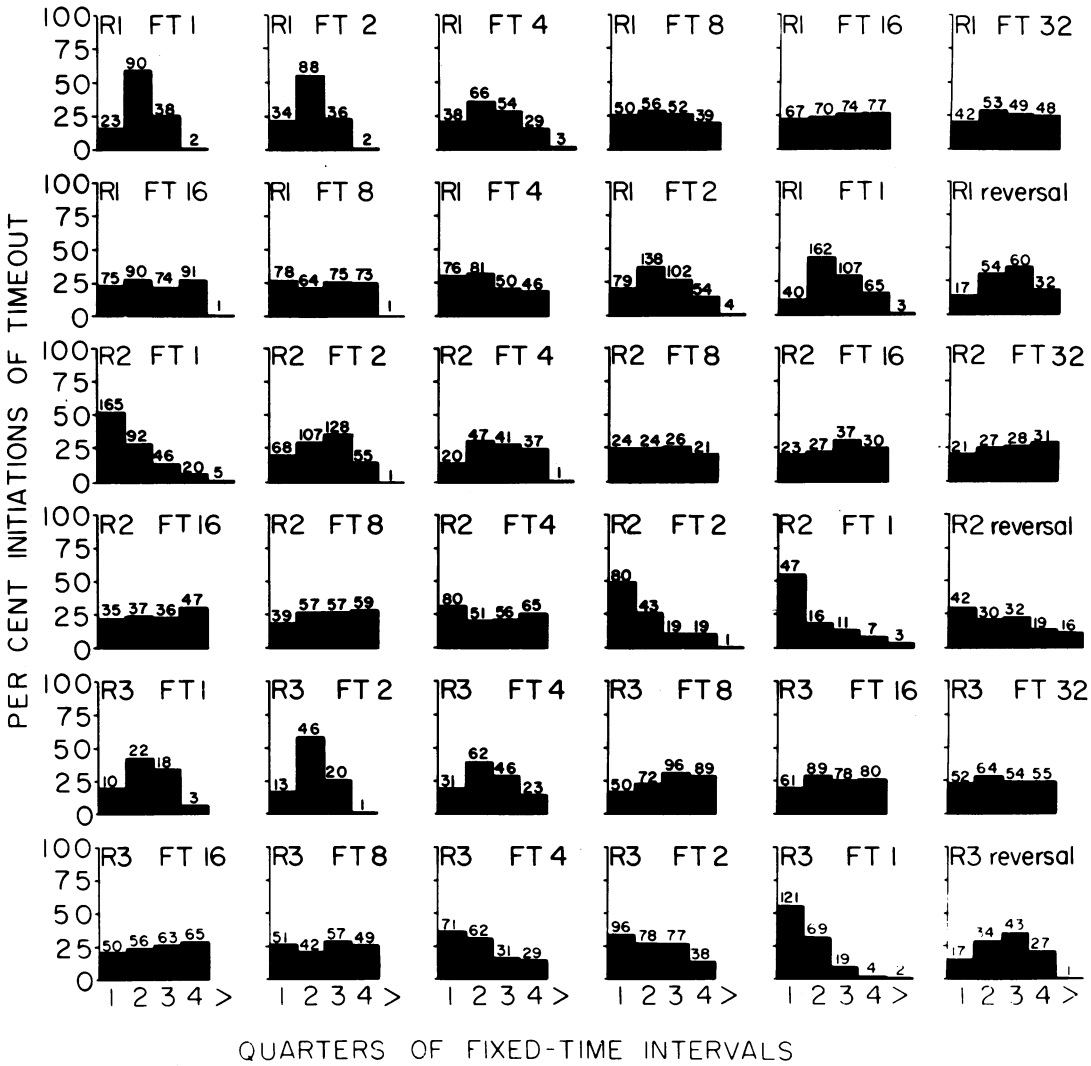

Fig. 3. Percentage of total timeouts initiated within successive quarters of FT schedules and during 6-sec delays following the end of FT intervals for R1, R2, and R3 in Experiment 1. Relative values are plotted on the ordinate with the absolute numbers shown above each bar. Data are from the last six sessions on the schedules.

was delivered independently of responding, and that timeout was controlled by the rate of food delivery. Experiment 2 further explored the extent to which two major components of the procedure, rate of food delivery and stimulus change, contributed to the control of responding. Three changes in the procedure were studied: elimination of the timeout contingency during FT schedules of food delivery; omission of food, but with lever presses still producing the stimulus change associated with timeout; and, elimination of both food delivery and the stimulus change contingency.

Procedure

Preliminary training as described in the General Method section was followed by training when responding terminated and reinstated FT schedules of food delivery and associated stimuli. Nine rats were randomly assigned to three FT schedules: FT 1-min (R31, R32, R33), FT 4-min (R34, R35, R36), or FT 16-min (R37, R38, R39). The sequence of conditions and number of sessions of training are shown in Table 2. The Food + Timeout condition, and all other conditions with a timeout contingency, required a single re-

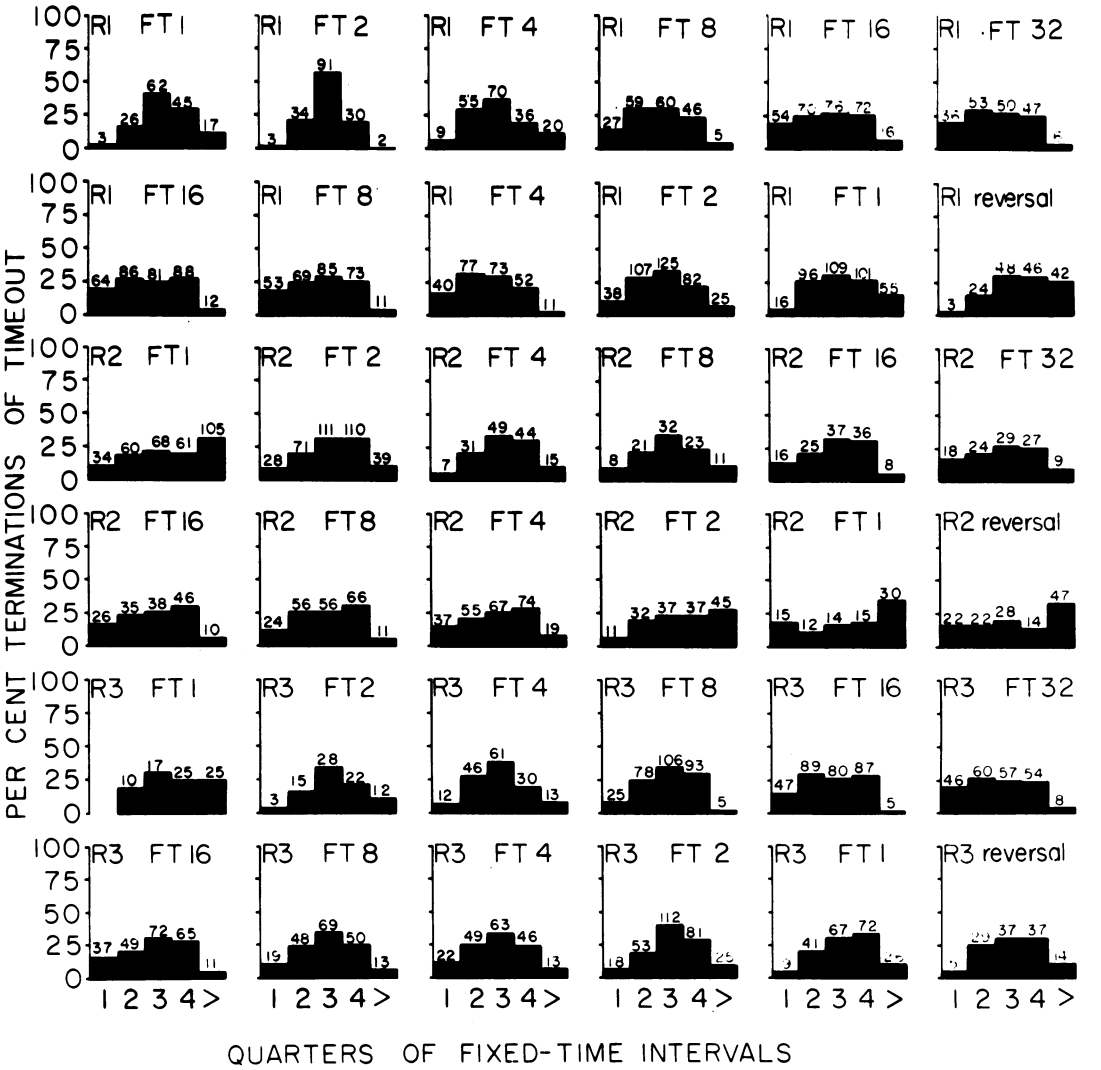

Fig. 4. Percentage of total timeouts terminated within successive quarters of FT schedules and following the end of FT intervals for R1, R2, and R3 in Experiment 1. Relative values are plotted on the ordinate with the absolute numbers shown above each bar. The data are from the last six sessions on the schedules.

sponse to terminate the FT schedule and/or the houselights as well as to reinstate the FT schedules and/or houselights. The Food + Timeout condition, the standard procedure used in Experiment 1, preceded and followed all other conditions. The remaining conditions were Food + No Timeout, No Food + Timeout, and No Food + No Timeout, as described in the General Method section.

Results

All rats pressed the lever during each of the conditions studied. Figure 5 shows the percentage of time spent in timeout (open bars), the rate of lever pressing per min (closed bars), and the ranges during the last six sessions of each condition for individual rats. The sequence of conditions is shown from left to right in each panel and, where applicable, timeout percentage and rate of lever pressing for each condition are shown as adjacent bars; only the rate of lever pressing is shown for those conditions, in which timeout could not be produced, Food + No Timeout and No Food + No Timeout.

Figure 5 shows that timeout percentages during baseline conditions (Food + Timeout) were comparable to or slightly lower than per-

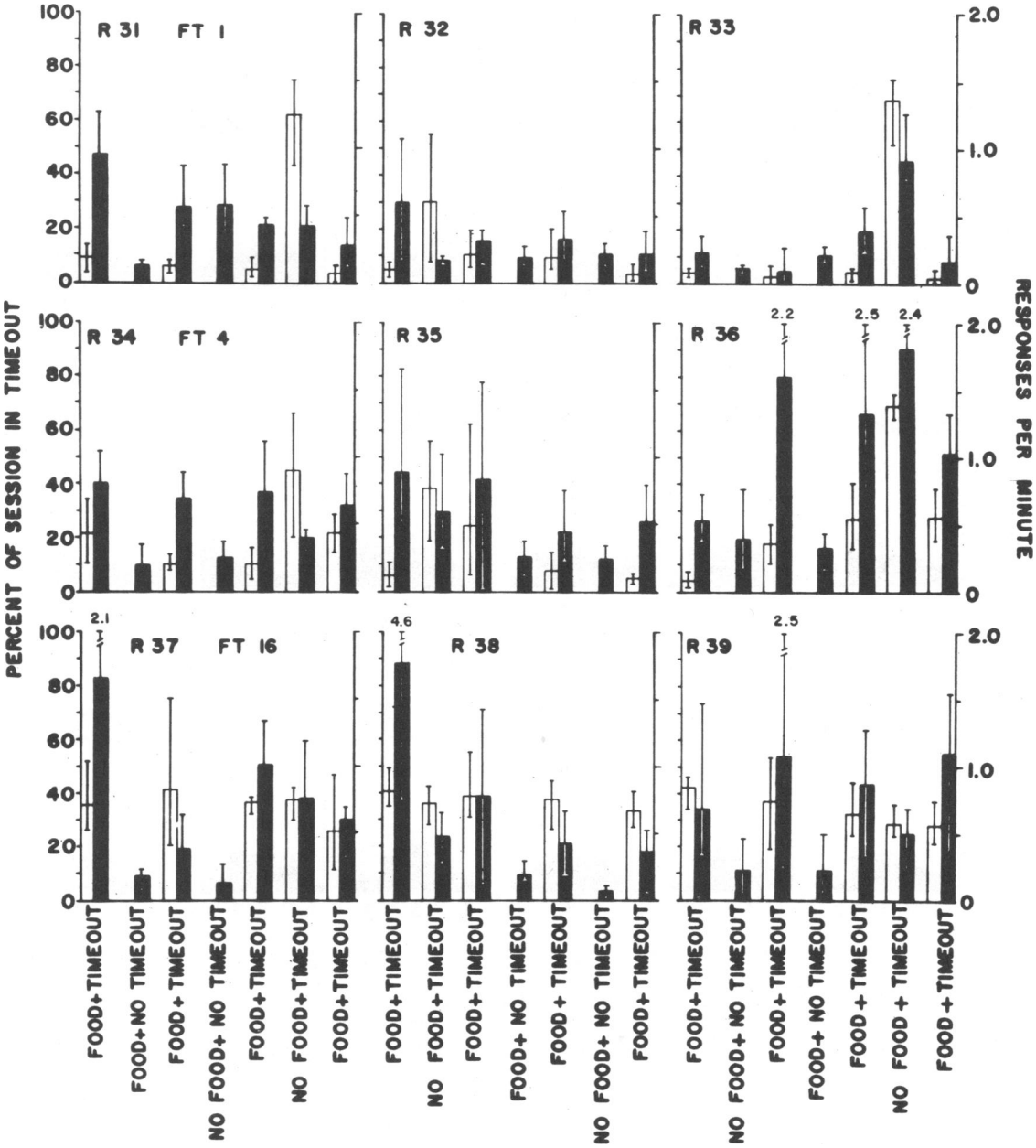

Fig. 5. Percentage of total session time spent in timeout (open bars) and the rate of lever pressing per min (closed bars) during the last six sessions of each condition in Experiment 2. Ranges of the terminal sessions are shown as vertical lines. Data in each panel are presented, from left to right, according to the sequence of conditions to which each subject was exposed.

centages obtained in Experiment 1 with equivalent FT schedules, as was also the case with regard to rates of lever pressing. When food was discontinued (No Food + Timeout), the timeout percentage increased substantially for R31, R32, and R33 trained with the FT 1-min schedules and for R34, R35, and R36 trained with the FT 4-min schedule. For example, R31 spent 62% of the session time in timeout, as compared to 5% and 3%, respectively, on the preceding and following Food + Timeout conditions. For R37, R38, and R39, trained with the FT 16-min schedule, there were no systematic differences in timeout

Table 2

The sequence of conditions and the number of sessions of training for each rat in Experiment 2.

Condition	Schedule FT 1 min	FT 4 min	FT 16 min
	Subject R31	*Subject R34*	*Subject R37*
Food + Timeout	20	24	18
Food + No Timeout	22	12	20
Food + Timeout	17	7	16
No Food + No Timeout	6	11	11
Food + Timeout	6	9	8
No Food + Timeout	6	16	9
Food + Timeout	9	6	7
	Subject R32	*Subject R35*	*Subject R38*
Food + Timeout	22	18	9
No Food + Timeout	22	21	8
Food + Timeout	6	6	15
Food + No Timeout	6	17	25
Food + Timeout	6	6	11
No Food + No Timeout	8	10	8
Food + Timeout	6	7	14
	Subject R33	*Subject R36*	*Subject R39*
Food + Timeout	20	15	18
No Food + No Timeout	13	13	7
Food + Timeout	8	10	6
Food + No Timeout	15	13	8
Food + Timeout	6	14	19
No Food + Timeout	9	10	10
Food + Timeout	7	7	7

percentages between the Food + Timeout and No Food + Timeout conditions. Thus, FT 16 min and no food had approximately equivalent effects. Although there was considerable variability across subjects, it appears that there was a ceiling of roughly 50% on timeout percentage. There were no systematic response rate changes when food was omitted in the No Food + Timeout condition; the rates increased on No Food + Timeout for R33 and R36, decreased for R32, R34, R35, R38, and R39, and showed little change for R31 and R37.

In the remaining two conditions, the timeout lever was made ineffective, regardless of whether or not food was available (Food + No Timeout and No Food + No Timeout). Lever pressing continued in both conditions, but usually at lower rates than during adjacent Food + Timeout conditions. For example, for R34 the number of responses per min on Food + No Timeout was .2, as compared to .8 and .7, respectively, on preceding and following Food + Timeout conditions. Similarly, the number of responses per min on No Food + No Timeout for R34 was .3, as compared to .7 on both preceding and following Food + Timeout conditions.

Data on the points at which timeouts were initiated and terminated during interfood intervals are not shown because of difficulties with the recording apparatus. However, an examination of partial data did not reveal any notable differences in the form of the distributions from the data reported for Experiment 1.

EXPERIMENT 3
HOLDING THE LEVER IN A DEPRESSED POSITION TO PRODUCE TIMEOUT DURING FIXED-TIME SCHEDULES

Other investigators (e.g., Brown & Flory, 1972; Falk, 1971; Staddon, 1977) have described a number of similarities between responding to produce timeout from schedules of food delivery and more widely studied schedule-induced behaviors, such as aggression and polydipsia. However, there are some difficulties in comparing responding to produce timeout with the behaviors involved in aggression and polydipsia. Notably, aggression and polydipsia consist of repetitive sequences of behavior that usually are measured in terms of either response rate or time engaged in the behavior without pausing. In contrast, responding to produce timeout usually is measured in terms of time spent in a timeout, but without any measure of behavior occurring during the timeout period itself. In view of the systematic patterns of behavior that occur between deliveries of food (e.g., Killeen, 1975; Staddon & Simmelhag, 1971), the role played by various behaviors during timeout may be important. Two ways to study the role of behaviors during the timeout period are either to record such behaviors or to restrict them. The present experiment took the latter approach. Subjects could produce timeout, but only for the duration that the lever was held in a depressed position. Not only did this procedure greatly limit activity during timeout, but it also provided a measure of behavior during timeout (duration of holding down on a lever) comparable to other measures of in-

duced behavior (e.g., duration of an attack or drinking episode).

Procedure

Five rats (R4, R6, R8, R13, and R14) were trained to lever press as described in the General Method section. Training for R13 and R14 was started about 2 mo after the others and involved the following additional procedures after acquisition of the lever press response. To produce food the lever had to be held in the depressed position for a minimum period of time, and then released. Whenever the lever was held down the houselights were turned off. The minimum duration required for each food pellet was increased across sessions from .5 sec to 5.0 sec for R14 and to 10.0 sec for R13. When 50% or more of all responses on three successive sessions met the criterion, R13 and R14 were trained with the same procedures used from the start with R4, R6, and R8; timeout was in effect only as long as the lever was held down (see General Method for details).

Table 3 shows the FT schedules studied and the sequence of training. Holding down the lever to produce timeout was first studied on the FT schedules shown as Phase 1. Next, during Phase 2, R4, R6, and R8 were trained on an ascending and descending sequence of FT schedules during which holding the lever in a depressed position did not produce timeout. As in Phase 1, there was a 6-sec delay between releasing the lever and the next possible food delivery; no food could be delivered when the lever was in a depressed position. Finally, during Phase 3, the following conditions were studied: Food + Timeout, No Food + Timeout, and No Food + No Timeout. During Food + Timeout, a different FT schedule was in effect for each rat: FT 1-min for R4, FT 4-min for R6, and FT 16-min for R8.

Table 3

The sequence of conditions and the number of sessions of training for each rat in Experiment 3. During Phase 3 a different FT was in effect for each rat in Food + Timeout conditions: FT 1-min (R4); FT 4-min (R6); FT 16-min (R8).

		Subject				
Phase	*Condition*	*R4*	*R6*	*R8*	*R13*	*R14*
1	FT 1 + Timeout	18	7	8	16	27
	FT 2 + Timeout	6	6	6	–	–
	FT 4 + Timeout	6	6	6	10	14
	FT 8 + Timeout	6	6	6	–	–
	FT 16 + Timeout	6	6	6	6	6
	FT 4 + Timeout	6	6	6	6	7
	FT 1 + Timeout	6	6	8	6	6
	FT 4 + Timeout	–	–	–	6	6
	FT 16 + Timeout	–	–	–	6	6
	FT 4 + Timeout	–	–	–	6	6
	FT 1 + Timeout	–	–	–	6	6
2	FT 1 + No Timeout	6	6	8	–	–
	FT 2 + No Timeout	6	6	6	–	–
	FT 4 + No Timeout	6	6	6	–	–
	FT 8 + No Timeout	6	6	6	–	–
	FT 16 + No Timeout	6	6	6	–	–
	FT 4 + No Timeout	6	6	6	–	–
	FT 1 + No Timeout	6	6	6	–	–
3	Food + Timeout	8	6	8	–	–
	No Food + Timeout	18	12	6	–	–
	Food + Timeout	6	13	6	–	–
	No Food + No Timeout	6	11	6	–	–
	Food + Timeout	6	6	7	–	–

Results

Figure 6 shows the percentage of session time spent in timeout (circles), the number of responses per min (triangles), and the ranges during the last six sessions by R4, R6, and R8 during Phase 1. The timeout percentage was low on all schedules, with the six-session mean never exceeding 3%. Further, there was no clear relationship between FT interval and timeout percentage. Thus, holding the lever down was not an effective timeout-producing response. Figure 6 also shows the absence of systematic differences in response rate across FT schedules. The range of mean durations that the lever was held down during each of the last six sessions was 1.7 sec to 2.4 sec (R4), 1.9 sec to 3.1 sec (R6), and 2.0 sec to 2.8 sec (R8). The modal number of timeout initiations for the schedules with the shortest interfood intervals was in the second or third quarters. At longer FT intervals, the distributions of timeout initiations flattened, with a majority tending to occur in the last two quarters.

Figure 7 shows that, when lever pressing did not produce timeout (R4, R6, and R8 in Phase 2), the percentage of session time spent with the lever held down was always low. Response rates were variable, but tended to be higher on intermediate FTs than on long or short FT intervals. The range of mean durations that the lever was held down during the last six sessions was 1.7 sec to 3.3 sec (R4), 1.9 sec to 2.6 sec (R6), and 2.2 sec to 3.3 sec (R8).

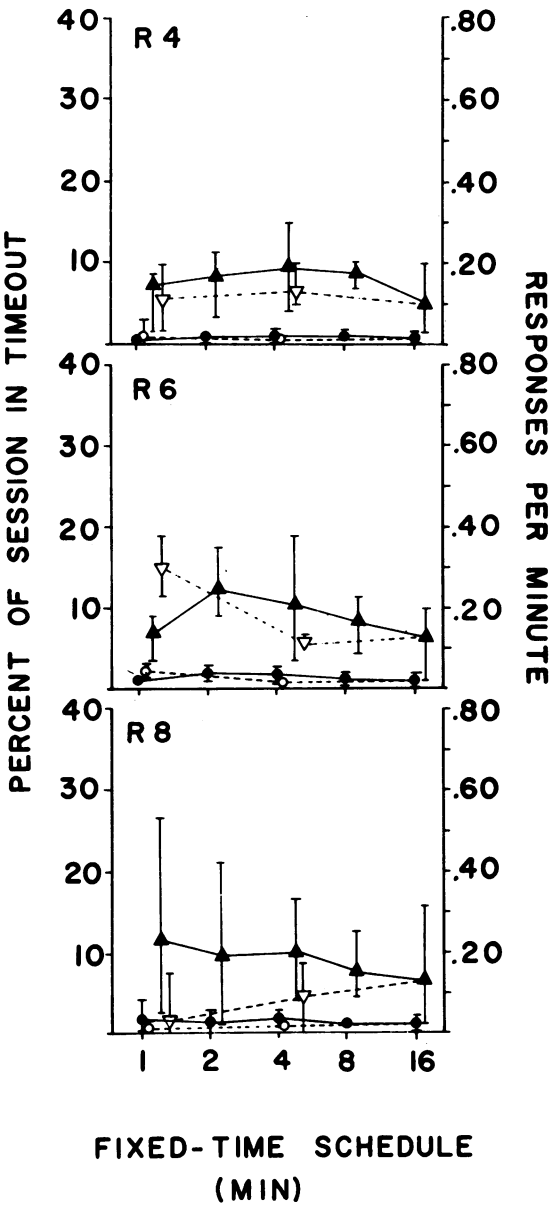

Fig. 6. Percentage of total session time spent in timeout is represented by circles (left ordinate) and the rate of responses (timeouts) per min is represented by triangles (right ordinate). Filled data points show the ascending sequence of schedules, and open data points show the descending sequence. For clarity, some data points are offset slightly to the right. Data are from the last six sessions of Phase 1 for R4, R6, and R8 in Experiment 3. Ranges of the terminal sessions are shown as vertical lines.

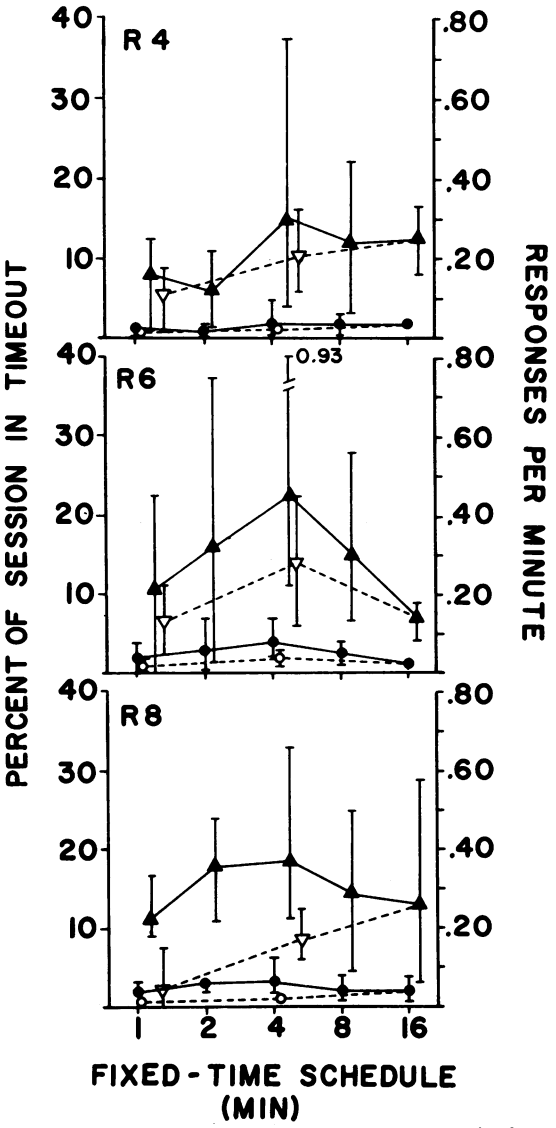

Fig. 7. Percentage of total session time with the lever held down is represented by circles (left ordinate) and the rate of responses (lever hold-downs) per min is represented by triangles (right ordinate). Filled data points show the ascending sequence of schedules, and open data points show the descending sequence. For clarity, some data points are offset slightly to the right. Data are from the last six sessions of Phase 2 for R4, R6, and R8 in Experiment 3. Ranges of the terminal sessions are shown as vertical lines.

Again, the modal number of lever presses occurred in the second or third quarters of interfood intervals on the FT 1-min and FT 2-min schedules, followed by a general flattening of the distributions as the FTs were lengthened. Overall, performances were similar whether or not timeout could be produced. Also, the distributions of timeout initiations generally were similar to those obtained when

a simple lever press produced timeout (Experiments 1 and 2).

When food was discontinued during Phase 3, the number of responses per min during the last six sessions under the No Food + Timeout condition and the No Food + No Timeout condition was .4 and .2 for R4; 0 and .1 for R6; and .1 and .1 for R8. Responses per min, combined for the last six sessions under the three Food + Timeout conditions were .1 (R4), .2 (R6), and .1 (R8). Thus, the response rates were similar among all Phase 3 conditions.

For the two subjects specifically trained to hold the lever down (R13 and R14), the first two schedules produced relatively high timeout percentages—as much as 16% on FT 1-min for R13. However, by the second ascending series of FT schedules, the timeout percentage was always low, never exceeding 3% for either rat. Thus, holding down on the lever was not an effective timeout response even after prior training to hold the lever in a depressed position. No other measures were taken of the performances of R13 and R14.

EXPERIMENT 4
TIMEOUT FROM VARIABLE-TIME SCHEDULES

Responding to produce timeout has commonly been studied with schedules that share the property of making food available in some regular way. The most direct information regarding timeout from irregular schedules of food delivery has come from a number of studies using multiple schedules with variable-interval (VI) reinforcement in one component and extinction schedules in the other (e.g., Coughlin, 1973; Hittesdorf & Richards, 1975; Rilling et al., 1969; Rilling, Kramer, & Richards, 1973; Terrace, 1971; von Sturmer, Beale, & Davison, 1975). In general, appreciable responding to produce timeout occurred in the extinction component, but not during the VI component. Rilling et al. (1969) also reported responding to produce timeout during the VI 5-min component of a multiple VI 30-sec VI 5-min schedule. However, few of these experiments studied simple VI schedules, and none systematically manipulated the interval. In the present experiment, rats could initiate and terminate timeout from response-independent variable-time (VT) schedules that ranged from 1 min to 16 min.

Procedure

Four rats (R23, R24, R26, and R29), without prior lever-press training, were used. In Phase 1, a single lever press prevented the delivery of food according to various VT schedules and turned off the houselights. A single lever press also reinstated the VT schedule and turned on the houselights. The General Method section gives details of the procedure. The VT schedules studied and the sequence of training are shown in Table 4.

After a lapse of about 1 mo during which no training took place, R23, R26, and R29 were observed under a series of control conditions that constituted Phase 2 (R24 had died). In one condition, Food + No Timeout, food was delivered on a VT schedule, but lever pressing did not turn off the houselights. In a second condition, No Food + Timeout, food was not available, but lever presses successively turned the houselights off and on. In a third condition, No Food + No Timeout, food was not available and lever presses did not produce a stimulus change. Each of the above conditions was preceded and followed by baseline conditions identical to those used in Phase 1 (Food + Timeout). During Food + Timeout and Food + No Timeout, a different VT schedule was in effect for each rat: VT 1-min for R23, VT 4-min for R29, and VT 16 for

Table 4

Order of training and number of sessions under each condition for individual rats. During Phase 2, a different VT schedule was in effect for each rat during Food + Timeout and Food + No Timeout conditions: VT 1-min for R23, VT 16-min for R26, and VT 4-min for R29.

		Subject			
Phase	*Condition*	*R23*	*R24*	*R26*	*R29*
1	VT 1 + Timeout	20	20	22	20
	VT 2 + Timeout	6	6	6	6
	VT 4 + Timeout	11	6	6	6
	VT 8 + Timeout	6	8	7	6
	VT 16 + Timeout	6	10	6	6
	VT 4 + Timeout	6	6	6	7
	VT 1 + Timeout	6	6	7	6
2	Food + Timeout	9	–	14	9
	Food + No Timeout	13	–	10	7
	Food + Timeout	7	–	9	11
	No Food + Timeout	14	–	9	7
	Food + Timeout	9	–	6	6
	No Food + No Timeout	7	–	13	11
	Food + Timeout	7	–	6	7

R26. The stability criterion described in the General Method section was not applied to the first condition of Phase 1 until 20 sessions had been conducted.

Results

Responding that produced and terminated timeout was acquired by all rats without any preliminary lever press training, thereby eliminating the possibility that a prior history of food-reinforced responding was partly responsible for continued responding under the VT schedules (e.g., Neuringer, 1970). Rat R29 responded regularly by the third session, while all other rats responded during the first session. The early sessions were characterized by brief bursts of responses. As training continued, such bursts became less frequent and tended to be largely limited to the beginning of sessions.

Figure 8 shows the percentage of session time spent in timeout during the last six sessions on the ascending and descending sequence of VT schedules (Phase 1). The percentage increased for all rats as the schedules were lengthened to VT 4-min (R26) or VT 8-min (all other rats). Further lengthening of the mean time between food pellets had little additional effect on timeout percentage. The timeout percentage decreased on the two VTs of the descending sequence.

The rate at which timeouts were produced ranged from .1 to 2.7 per min both across conditions and rats. Generally, the lowest rate occurred with the VT 1-min schedule, and there were no systematic differences among the other VT schedules. Timeouts were usually of brief duration. From about a quarter to half of the timeouts on all schedules did not exceed 2 sec for R23, R24, and R26, or 4 sec for R29. There was a general tendency for timeout durations to lengthen as the mean time between food deliveries increased.

Figure 9 shows the percentage of timeouts that were initiated within successive 15-sec bins after delivery of a food pellet. Generally, as the VT schedules were lengthened the mode of the distributions became increasingly distant from food delivery. At the longer VT schedules, especially VT 8-min and VT 16-min, the distributions flattened, with most timeouts beginning more than 300 sec after food delivery. With the exception of the performance of R24 on VT 1-min schedules, the modal number of timeout initiations never occurred during the first 15-sec bin after food delivery.

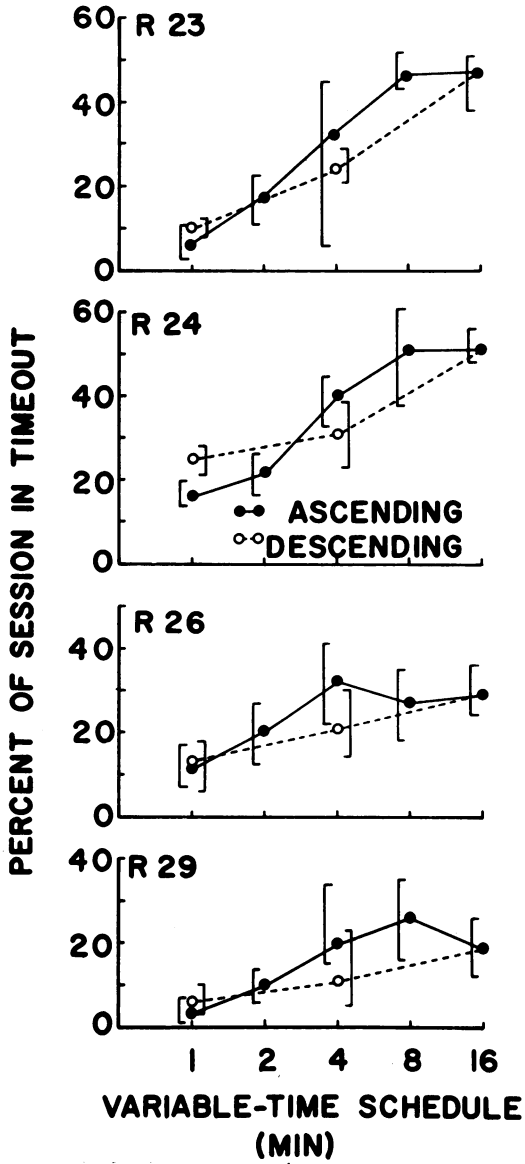

Fig. 8. Percentage of total session time spent in timeout and the ranges of timeouts during the last six sessions for each subject on VT schedules in Experiment 4. Brackets open to the right indicate the range of values on the ascending sequence and brackets open to the left indicate the range of values on the descending sequence.

The results of the control conditions of Phase 2 are summarized in Table 5. The percentage of total session time spent in timeout during Food + Timeout baseline conditions was comparable to that obtained in Phase 1 on

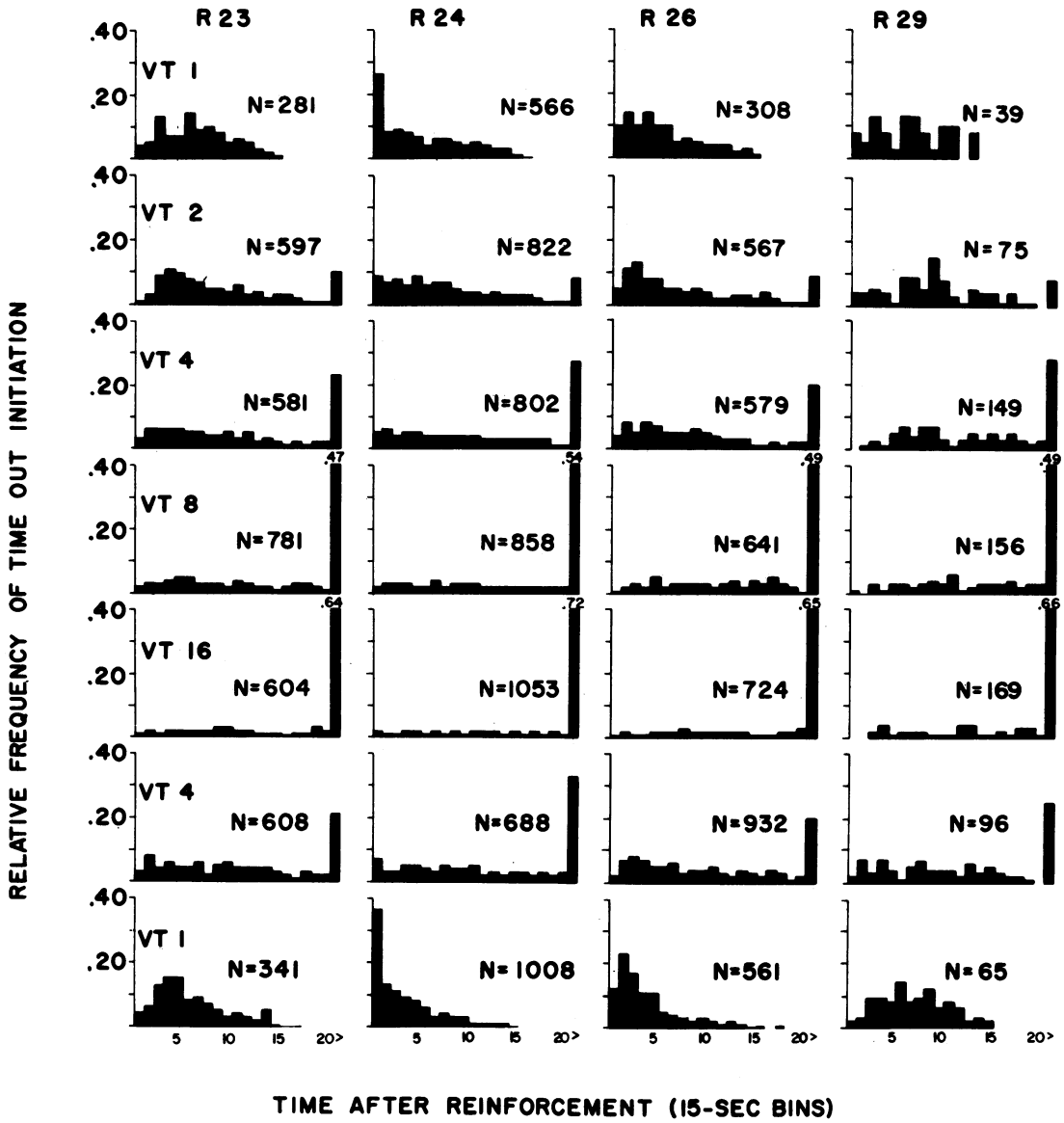

Fig. 9. Relative frequency of total timeout initiations within successive 15-sec bins after food delivery during the last six sessions for each subject on VT schedules in Experiment 4. Relative frequencies that exceed .40 are shown above columns. The total number of timeouts are shown in each panel.

the same condition. When food was discontinued during No Food + Timeout, the percentage of session time spent in timeout increased by 39% (R23), 37% (R26), and 21% (R29) from adjacent Food + Timeout conditions. The increase in timeout percentage was due more to an increase in the duration of timeouts than to increases in the rate of timeout initiation. On Food + No Timeout the rate of lever pressing was lower than on any other condition. When food was not available and timeout could not be produced (No Food + No Timeout), the rate of lever pressing was lower than on adjacent Food + Timeout conditions.

GENERAL DISCUSSION

The results of the present experiments have relevance for several interpretations of schedule-induced responding that produces timeout. One view is that timeout initiation represents

Table 5

Percentage of total session time spent in timeout and lever presses per min for each rat during the last six sessions of Phase 2 of Experiment 4; ranges are shown in parentheses. In conditions where timeout could be produced, the rate of timeouts equals half of the lever press rate. A different VT schedule was in effect for each rat during Food + Timeout and Food + No Timeout conditions: VT 1-min for R23, VT 16-min for R26, and VT 4-min for R29.

	Subject					
	R23		*R26*		*R29*	
Condition	*Percent of session time in timeout*	*Lever presses per min*	*Percent of session time in timeout*	*Lever presses per min*	*Percent of session time in timeout*	*Lever presses per min*
Food + Timeout	7% (4%-9%)	.6 (.3-.7)	26% (8%-44%)	1.0 (.5-1.8)	13% (6%-22%)	.9 (.5-1.2)
Food + No Timeout	—	.1 (.0-.1)	—	.3 (.2-.4)	—	.2 (.2-.4)
Food + Timeout	4% (2%-6%)	.4 (.2-.7)	25% (11%-41%)	.9 (.5-1.8)	14% (5%-27%)	.8 (.4-1.3)
No Food + Timeout	45% (24%-57%	.7 (.4-.9)	62% (41%-79%)	.4 (.3-.6)	35% (31%-41%)	.4 (.1-.7)
Food + Timeout	6% (4%-9%)	.8 (.6-1.2)	40% (30%-52%)	1.0 (.7-1.4)	11% (6%-14%)	.9 (.5-1.1)
No Food + No Timeout	—	.1 (.0-.2)	—	.4 (.2-.5)	—	.6 (.4-.9)
Food + Timeout	6% (3%-7%)	.6 (.4-.9)	32% (25%-39%)	1.1 (.8-1.3)	11% (4%-16%)	.8 (.6-1.2)

escape from aversive stimuli associated with required schedule performances (e.g., Azrin, 1961; Dardano, 1973; Thompson, 1964). For example, increases in the number of responses required for reinforcement presumably increase the aversive aspects of the schedule and, therefore, should produce an increase in the proportion of session time spent in timeout. The results with ratio schedules have been consistent with this view. However, this interpretation cannot account for the present data because FT and VT schedules do not impose any response requirement. Although responses required for reinforcement may contribute to responding to produce timeout, some other variable must be the main determinant of schedule-induced timeout.

Zimmerman and Ferster (1964) suggested that timeout was initiated when there was a loss of control over behavior required for reinforcement. Presumably, the postreinforcement pause on FR schedules is a time when control normally is absent and this is where timeouts usually are initiated. However, this interpretation again does not account for initiation of timeout from FT or VT schedules that require no behaviors over which control could be lost.

The suggestion by Brown and Flory (1972) that timeout initiation serves the function of allowing escape from aversive aspects of the abrupt transition from reinforcement to nonreinforcement also is inconsistent with the present data. Their interpretation seems to be based in part on the finding that timeout initiation often occurs shortly after reinforcement on FR and FI schedules. However, in the present experiments, timeout initiation on the longer FT and VT schedules often occurred after a considerable lapse of time since food delivery. Instances of long delays between food delivery and timeout initiation also can be seen on cumulative and event records of prior studies (e.g., Brown & Flory, 1972; Dardano, 1973).

Closely related to Brown and Flory's (1972) view is the possibility that timeout initiation allows escape from stimuli associated with extinction. For example, responding to produce timeout has predominated during the extinc-

tion component of multiple VI extinction schedules (e.g., Rilling et al., 1969; Terrace, 1971; von Sturmer et al., 1975). Similarly, on regular reinforcement schedules such as FR and FI, the time period immediately after food delivery is readily discriminable as a period when food is not available; it is the time shortly after reinforcement when timeout initiation often occurs.

It is not clear that the present results are amenable to an escape-from-extinction interpretation. On FT schedules, escape should occur immediately after food delivery. However, as mentioned earlier, timeout often was initiated a considerable period of time after the last food delivery. Similarly, the fact that VT schedules do not have periods of time with notably lower probability of food delivery than at other times (e.g., Catania & Reynolds, 1968), argues against interpretations in terms of escape from extinction.

Another difficulty with the escape view can be illustrated by the following example. When no food is available, as during No Food + Timeout conditions in Experiment 2, subjects spent approximately half of the total session time in timeout. This result follows if the nonavailability of food was highly aversive, but also if there was an absence of preference between the two stimulus conditions (i.e., light off versus light on). Similarly, as the rate of food delivery was increased by shortening the FT interval in Experiment 1, the timeout percentage decreased. This result follows if increasing the rate of food delivery decreased schedule aversiveness, but also if higher food delivery rates increased preference for stimuli associated with food or increased avoidance of timeout. Thus, the present data do not lead convincingly to the conclusion that responding to produce timeout necessarily was reinforced by escape from periods of nonreinforcement.

Appel (1963) found that pigeons responded to produce a stimulus change even when FR schedules remained in effect. He suggested that reinforcing properties of the stimulus change (cf. Kish, 1966) could be a primary determinant of timeout initiation and termination. The present data do not discount the importance of stimulus change. However, given that responding to produce and terminate timeout was sensitive to changes in the rate of food delivery, an account solely in terms of stimulus change seems insufficient. If stimulus change represented an important source of reinforcement, then performances should have been characterized by rapid responding which would produce a high rate of stimulus change. The present results suggest that occasional production of a series of short-duration timeouts, most common on shorter FT and VT schedules and early during sessions on all schedules, were reinforced by stimulus change, whereas production of timeouts of longer durations reflected control by some other variable.

A major determinant of responding to produce timeout was the rate of food delivery. Experiments 1, 2, and 4 showed a strong inverse relationship between the rate of food delivery and the percentage of session time spent in timeout. A reinforcement rate interpretation also is consistent with the results from most prior studies that used ratio schedules; although not reported, the reinforcement rate undoubtedly decreased with increasing ratio size. The reason for the occasional decrease in timeout percentage on schedules having very low reinforcement rates (e.g., Brown & Flory, 1972; Thomas & Sherman, 1965) remains to be determined. Other variables that may be involved include the operant level of responding to the lever associated with timeout initiation and termination, schedule-induced aggression directed at the lever, and superstitious response sequences (Dardano, 1973).

A final determinant of responding to produce and terminate timeout relates to the ineffectiveness of lever holding as the timeout-producing response. Because holding a lever in a depressed position greatly restricts movement, it is possible that behaviors that occur during timeout play an important part in the control of timeout initiation and termination. A suggestion by Green and Rachlin (1977) in a different experimental context may be applicable to the present results. They found that, in the presence of subject-produced stimuli associated with intermittent reinforcement, pigeons primarily engaged in interim behaviors associated with nonreinforcement when food delivery was distant in time, followed by an increase in terminal behaviors associated with reinforcement as food delivery neared. However, in the presence of subject-produced stimuli associated with nonreinforcement, pigeons engaged only in interim behaviors. Thus, exteroceptive stimuli associated with nonreinforcement may have exerted discrim-

inative control over the occurrence of interim activity. In a similar way, timeout in the present study was a subject-produced stimulus associated with nonreinforcement. Rats in Experiments 1, 2, and 4 may have engaged primarily in interim behaviors during timeout. However, rats in Experiment 3 could not engage in interim behaviors during timeout because the lever had to be held in a depressed position. Therefore, control over responding that produces timeout may occur only if an opportunity to engage in interim behaviors exists during timeout. Put differently, low probability lever pressing that initiates timeout may be reinforced by discriminative stimuli that signal the opportunity to engage in higher probability interim behaviors (cf. Premack, 1959). Conversely, if interim behaviors cannot occur during timeout, the lever press that produces timeout is not reinforced and remains at a low level.

To summarize our interpretation of timeout from response-independent food delivery, there appear to be two types of timeout, each controlled by different variables. Brief-duration timeouts seem to be controlled by the reinforcing properties of stimulus change, and long-duration timeouts seem to be reinforced by presentation of discriminative stimuli associated with interim behavior; the degree to which the opportunity to engage in interim behavior is reinforcing is a function of the rate of food delivery.

A final issue concerns the appropriateness of using the term *timeout* to describe the present procedures. On the interval schedules used in these experiments and by Brown and Flory (1972), food delivery was prevented during timeout, but the timing of VT, FT, and FI intervals did not stop unless food became available during timeout periods. Thus, timeout periods often did not result in either a delay or a reduction in the rate of food delivery. In contrast, during ratio schedules, responses during timeout were prevented from accumulating toward the number required for reinforcement, thereby decreasing the rate of food delivery (e.g., Azrin, 1961; Dardano, 1973; Thompson, 1964). However, even with ratio schedules, it has not been determined that timeout periods strongly affect the rate of food delivery. For example, it is possible that timeouts are often contained entirely within the postreinforcement pause during ratio schedules, a period when food-dependent responding does not occur. In any case, the present procedures appear to satisfy the essential requirement that food was not available for the duration of the timeout (Leitenberg, 1965). The extent to which timeout periods also served to delay or decrease the rate of food delivery depended on the duration of timeouts and the point during interfood intervals when timeouts were initiated and terminated.

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