SELF-IMPOSED TIMEOUTS UNDER INCREASING RESPONSE REQUIREMENTS¹

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Self-imposed timeouts by pigeons working under a progressive-ratio food schedule were studied under different conditions. The main findings were (1) continued production of timeouts over an extended series of sessions, (2) more frequent responding on the key with the timeout consequence than on a key having no consequence, (3) an inverse relationship between number of timeouts and level of body weight, (4) production of timeouts when the timeout duration was brief, lengthy, or controlled by the pigeon, and (5) dependence of self-imposed timeouts on variables controlling responding under the progressive-ratio schedule. Under all experimental conditions, with the exception of performances at the high body weight, timeouts were more frequent during the longer progressive-ratio steps and usually were localized in the post-reinforcement pause or the early part of the step. The timeout behavior could be interpreted as either an escape from aversive stimuli generated by the progressive-ratio schedule or as a response reinforced by the consequent stimulus change.

In human affairs, a commonly used punitive measure for asocial behavior is the temporary suspension of preferred activities. This practice has a counterpart in laboratory experimentation termed "timeout from positive reinforcement" (Ferster and Skinner, 1957). As an experimental operation, timeout has involved different manipulations but the various procedures usually include elimination of the opportunity for reinforcement correlated with a gross stimulus change (Leitenberg, 1965). Several studies have demonstrated that timeout from positive reinforcement functions as an aversive event either by showing that subjects prevented or terminated a timeout from positively reinforced activity (Baer, 1960; Baron and Kaufman, 1966; D'Andrea, 1971; Ferster, 1957, 1958) or by showing that a timeout following certain behavior reduced the rate of that behavior (Baer, 1962; Ferster and Appel, 1961; Holz, Azrin, and Ayllon, 1963; Miller and Zimmerman, 1966; Zimmerman and Bayden, 1963; Zimmerman and Ferster, 1963). This evidence embraces several differ-

ent procedures and types of subjects and also is in agreement with the general social view of the role of timeouts.

However, the generalization that a timeout from positive reinforcement acts as an aversive event has been complicated by investigations reporting that timeouts appeared to function as positive reinforcers, rather than aversive events, when the ongoing behavior was maintained by fixed-ratio reinforcement schedules which require a given number of responses for reinforcement. In the reference study by Azrin (1961), pigeons under various fixed-ratio food reinforcement schedules responded on a second key to initiate and terminate a timeout period identified by a gross change in illumination. The total duration of the self-imposed timeouts in a session was directly related to size of the fixed ratio, and timeouts typically occurred during the pause following reinforcement. Later studies have corroborated and extended these findings. Thompson (1964) reported that rats produced a 30-sec timeout as a function of ratio size, that timeouts were localized in the post-reinforcement pause, that loci of timeouts were displaced under a mixed fixed-ratio schedule, and that the self-imposed timeouts did not reflect an operant level of responding on the timeout lever. A later study, which replicated these results with pigeons, also showed that session duration based on either number of reinforcements or time had

¹Research supported by National Aeronautics and Space Agency Grants NSG 189-61 to the University of Maryland and NGR 21-001-069 to the Johns Hopkins University, and report preparation, in part, by MCHS Grant No. 917. Assistance of E. Taylor and student aides in conducting the study is acknowledged. Reprints may be obtained from the author, The John F. Kennedy Institute, Division of Psychology, 707 N. Broadway, Baltimore, Maryland 21205.

no effect on the timeout performances (Thompson, 1965). An increasing monotonic function between number of responses on the timeout key and ratio size was reported by Appel (1963); however, total duration of timeouts in a session was not related to ratio size under one of the two timeout conditions. Also, the pigeons responded as much on the timeout key when only stimulus change resulted as when a stimulus change was correlated with suspension of the reinforcement schedule.

The predominant occurrence of self-imposed timeouts during the post-reinforcement pause and their relation to number of responses required for reinforcement has led to the interpretation that such timeouts represent an escape response from the aversive properties of the fixed-ratio schedule. Stimuli present after reinforcement become aversive from their correlation with the maximum amount of work or time preceding the next reinforcement (Azrin, 1961; Thompson, 1964). This interpretation has been questioned by Zimmerman and Ferster (1964), who surveyed several variables that might influence responding on a timeout key and noted the complexity of factors controlling a switching response of this kind. They suggested that the timeout response might be related to the temporary loss of control by the positive reinforcement schedule. Appel (1963) proposed that stimulus change was a sufficient explanation of timeout key responding. Despite the ambiguity about the critical determinants of self-imposed timeout from positive reinforcement, experimental work has demonstrated that timeout does not have a single function and that its role is related to the conditions of reinforcement.

The present study further analyzed conditions controlling self-imposed timeouts from a schedule of positive reinforcement. Food-reinforced responding of pigeons was maintained by a progressive-ratio reinforcement schedule under which the number of responses required for successive reinforcements increased by a fixed number or multiple. Besides extending the study of self-imposed timeouts to another type of reinforcement schedule, use of the progressive-ratio schedule provided a focus on the main finding of earlier studies that the occurrence of self-imposed timeouts depended on the size of the response requirement. Within each session under this schedule, the number of responses required for reinforcement starts at a

minimum value and increases in discrete steps to a value that can result in an extremely strained performance or the cessation of responding (Hodos, 1961; 1963). The first part of the study dealt with the development and stability of self-imposed timeouts having a fixed duration of 3 min. Later parts of the study examined timeout behavior when the fixed duration of timeouts was decreased to 5 sec or increased to 9 min, when the pigeon controlled the duration of the timeout period, when deprivation level of the pigeons was varied, and when an inconsequential third key was added and/or the timeout key had no consequence.

PROCEDURE

Subjects

Three male, White Carneaux pigeons, 3- to 5-yr old, were housed in individual compartments with continuous access to grit and water. Weights were maintained at 80% of free-feeding weight except in Part V of the study. Each pigeon previously had extended training under a fixed-ratio 50 grain reinforcement schedule, and B-10 had participated in a study involving electric shock punishment during fixed-ratio performance.

Apparatus

A 13 by 15 by 13 in. (33 by 38 by 33 cm) experimental chamber was equipped with a speaker for masking noise, a relay providing response feedback click, three translucent response keys (Gerbrands) requiring an approximate operating force of 18 g (0.18 N), two 7.5-w houselights, and a grain dispenser (Lehigh Valley). The response keys were mounted behind a 0.75 in. (1.9 cm) aperture, 10 in. (25.4 cm) above the grid floor, and 2.5 in. (6.3 cm) apart center-to-center. The "food" key was centered on the front panel and transilluminated by a white light; the "timeout" key was to the right and transilluminated by a red light; the "dummy" key was to the left, transilluminated by a green light. Two bulbs, type GE 313, were mounted behind each key. A key was made unavailable by inserting a shield over the panel aperture. A rectangular opening, centered below the food key and 3 in. (7.6 cm) above the grid floor, permitted access to the raised grain feeder tray. Reinforcement was a 4-sec presentation of a grain mixture during

which time all chamber lights were extinguished and the magazine light illuminated.

Procedure

Some aspects of the procedure were common to all parts of the study: a single peck on the timeout key produced the timeout condition, all chamber lights were extinguished and response keys were inoperative during the timeout period, the food reinforcement schedule was a progressive-ratio 50 (PR 50) under which the first reinforcement required 50 responses and each succeeding reinforcement required an additional 50 responses (50, 100, 150, *etc.*), and session duration was approximately 2 hr. Extended breaks in responding typically occurred during the later part of the session. If the pigeon was responding on the food key at a high and regular rate, the session was not ended until the step was completed. The pi-

geons were studied daily in Part I and six days per week in the remaining parts of the study. The additional procedures in each part of the study are described below and summarized in Table 1. Unless stated otherwise, each experimental condition was scheduled for a minimum of 20 sessions and until the number of timeouts exhibited no obvious trends over 10 consecutive sessions.

I. Development and stability of timeout performance. Each pigeon was studied under the PR 50 schedule with only the food key available until the number of reinforcements in a session and the temporal pattern of responding appeared stable over 20 consecutive sessions. The timeout key then was uncovered and a 3-min timeout scheduled for each response on the timeout key. The pigeons could respond on either key at any time, but during the timeout period, responses on either key were inconsequential. This condition was scheduled for more than 130 sessions. After approximately the fortieth and the eightieth sessions, the timeout key was covered for several sessions to determine the dependence of the progressive-ratio performance on the concurrent timeout condition. These two sets of interpolated sessions were terminated when the performances were similar over a few sessions. Following the final session with the timeout option, several sessions were scheduled with the timeout key covered; then, the pigeons remained in their home cages for approximately two months.

II. Different fixed durations of the timeout period. Before this experimental condition, several sessions were scheduled under the PR 50 schedule with the timeout key covered, followed by several sessions with the timeout key uncovered and the 3-min timeout period in effect. When the performances of each pigeon resembled the final performances in Part I, the new timeout durations were introduced. All conditions were the same as in Part I except for the duration of the timeout period. Either the 5-sec or the 9-min fixed-duration timeout period was scheduled, depending on the pigeon. After the final session under a given timeout duration, several sessions were scheduled with the timeout key covered. The procedure was repeated with the alternate timeout duration scheduled for each pigeon.

III. Subject control of timeout duration All aspects of the procedure were the same as in

Table 1

Summary of procedure showing order of experimental conditions and number of sessions under each condition. Timeout duration is in minutes if not otherwise indicated. Numbers in parentheses denote order of conditions when different for different subjects. Abbreviations: PR-progressive-ratio, TO-timeout, w/o-without.

<i>Experimental Condition</i>	<i>B-10</i>	<i>B-17</i>	<i>B-32</i>
I Development and stability of timeout performance			
PR 50	61	52	51
PR 50 + TO 3	137	132	132
PR 50	11	7	15
II Different fixed durations of the timeout period			
PR 50 + TO 15 sec	31 (1)	34 (2)	43 (2)
PR 50	7	4	5
PR 50 + TO 9	34 (2)	27 (1)	25 (1)
PR 50	4	7	13
III Subject control of timeout duration			
PR 50 + TO	48	57	44
PR 50	6	7	7
IV Reinforcing effect of timeout			
PR 50 + TO key w/o TO	34	22	23
PR 50 + dummy key	23	22	34
PR 50 + dummy key + TO key w/o TO	21	14	31
PR 50 + TO 3 + dummy key	29	36	30
TO 3 + dummy key, no food key	36	24	21
V Level of food deprivation			
PR 50 + TO 3, high body weight	37 (2)	36 (2)	25 (1)
PR 50 + TO 3, low body weight	31 (1)	39 (1)	27 (2)

the preceding parts of the study, except for two changes in the properties of the timeout period. A single peck on the timeout key initiated the timeout period, which remained in effect until the pigeon pecked the timeout key a second time. During the timeout period, one of the two red keylights behind the timeout key remained illuminated. This was the only part of the study in which the timeout condition did not include a total blackout.

IV. Reinforcing effect of timeout. This part of the study included five experimental manipulations that varied the availability of the response keys and the consequences of responding on the key. Otherwise, the conditions were similar to those in Part I. First, the food key and the timeout key were available but responding on the timeout key did not result in a timeout (PR 50 + TO key w/o TO). This operation was extinction of timeout responding. Under the second condition, the timeout key was covered and the food key and the dummy key were available (PR 50 + dummy key). This was the first time in the study that the dummy key was available. The third condition included the exposure of all keys, but responses on the timeout key did not produce timeouts (PR 50 + dummy key + TO key w/o TO). This marked the first time in the study that all keys were simultaneously available to the pigeon. Under the fourth condition, all keys were available and a 3-min timeout period followed a response on the timeout key (PR 50 + TO 3 + dummy key). The experimental conditions were identical to those of Part I, except for the presence of the dummy key. Under the fifth condition, the food key was covered for the first and only time in the study. The dummy key and the timeout key were available and a 3-min timeout period was scheduled on each response on the timeout key (TO 3 + dummy key, no food key).

V. Level of food deprivation. In this part of the study, all three keys were available with a 3-min timeout scheduled for a timeout key response. Except for the different body weight, the conditions were identical to those of Part IV, fourth set of conditions, and except for the different body weight and presence of the dummy key, identical to the conditions in Part I. No sessions were scheduled while each pigeon's weight was adjusted downward by reduced daily feeding. When body weight approached 75% of free-feeding weight, sessions

were resumed. The weight reduction was considered sufficient if the pigeon consistently completed more progressive-ratio steps in a session compared to the number completed at the 80% body weight in Part IV, fourth condition. Final weights were 77% for B-10 and 75% for B-17 and B-32.

After the final session at the low weight, pigeons remained in their home cages and their weights adjusted upward by a larger daily feeding. Sessions were rescheduled when weights approached 90% of free-feeding weight. Each pigeon's weight was raised further until the number of progressive-ratio steps completed in a session was consistently lower than the number completed in Part IV, fourth condition. Final weights were 97% for B-10 and B-17, and 95% for B-32.

RESULTS

I. Development and stability of timeout performance. The final performances under the progressive-ratio schedule before the timeout key was available showed the temporal properties characteristically generated by this schedule: a high rate of responding during each step, generally longer durations of post-reinforcement pauses as size of the steps increased, and breaks in responding during the early part of the longer progressive-ratio steps. The number of completed steps gradually declined from a peak of 15 or more in the first session. Over the final 10 sessions, before the timeout condition was added, the mean number of completed steps was 8.0 for B-10, 7.7 for B-17, and 6.4 for B-32.

In the first session with the timeout key available, all pigeons responded immediately and frequently on the timeout key, producing at least 30 timeouts in the session. Thereafter, the overall trend of timeout responding over successive sessions was irregular. Intersession variability was high, and the general level of timeout responding shifted abruptly after a series of sessions. After more than 100 sessions, the number of timeouts in a session appeared to stabilize, ranging around the same general level. Mean number of timeouts over the final 20 sessions was 6.5 (range 1 to 13) for B-10, 5.2 (range 1 to 10) for B-17, and 11.9 (range 7 to 19) for B-32.

The number of reinforcements (completed progressive-ratio steps) in a session with the

Fig. 1. The upper graph shows the mean number of 3-min timeouts in a session as a function of the successive progressive-ratio steps; the lower graph shows the relative number of sessions in which a timeout occurred in each progressive-ratio step. With the notation for progressive-ratio steps on the abscissa of each graph, the final completed step is denoted by "N", the preceding step by "N-1", etc. The last point, which is unconnected, and denoted by "N+1", is the number of timeouts occurring during the remainder of the session. The data in both graphs are based on the final 20 sessions. The dashed line is the average of the individual functions.

timeout option available increased for B-32 and decreased for B-10 and B-17 relative to session reinforcements before the timeout option was introduced. The mean number of reinforcements over the final 10 sessions was 4.3 for B-10, 5.9 for B-17 and 7.6 for B-32. During the series of sessions with the timeout condition, the number of reinforcements in a session exhibited long-term transitions.

During the two interpolated sets of sessions when the timeout key was covered, the performances showed transitory changes. In the first session without the timeout key in each series, more progressive-ratio steps were completed relative to the preceding session in five of the six cases. When the timeout key was uncovered again, all pigeons produced more timeouts relative to the number in the last previous session with the timeout key.

Within a session, the number of timeouts during a progressive-ratio step was directly related to the size of the step. This relation is shown in Figure 1 for two indexes of timeout performance. The upper graph shows the mean number of timeouts in a session as a function of the progressive-ratio step; the lower graph shows the relative number of sessions in which a timeout occurred at each step. The notation for the progressive-ratio steps on the abscissa uses the last completed step in a session as the reference, denoted as "N", with the preceding steps becoming "N-1", "N-2", etc. This reverse ordering was used because of the differences in number of completed steps in the sessions and the rarity of timeouts in the early steps. The pigeons never produced a timeout during the first progressive-ratio step and rarely during the second step, averaging 0.08 per session for the group.

The timeouts usually occurred during the post-reinforcement pause or during the early part of the progressive-ratio step. This localization of timeouts early in the step can be seen in the cumulative records of B-17 and B-32 shown in Figure 2. The performances of B-10 were similar to those of B-17. A record of the progressive-ratio performance before the timeout condition was added also is included for each pigeon. The record segments at the bottom of the figure illustrate the production of timeouts throughout a progressive-ratio step, a pattern that occurred infrequently.

II. Different fixed durations of the timeout period. Self-imposed timeouts consistently oc-

curred in each session when the timeout period was as short as 5 sec or as long as 9 min. Figure 3 shows the number of timeouts in a session and also the per cent of the session in timeout as a function of the duration of the timeout period. Data for the 3-min timeout period were taken from the preceding part of the study. For each pigeon, the mean number of timeouts in a session was inversely related to the duration of the timeout period, and the per cent of the session in timeout was directly related to duration of the timeout period. As a group, the pigeons averaged nearly 45% of the session in timeout when the 9-min timeout period was scheduled.

The comparative number of timeouts under the three timeout durations was biased by the difference in the time available for timeout responses in the session. The maximum number of timeouts in the 120-min session was 1440 under the 5-sec timeout duration, 40 under the 3-min duration, and 13.3 under the 9-min duration. This bias can be circumvented by expressing timeouts as a proportion of the maximum number possible. The right side ordinate in Figure 3, "per cent of session in timeout", also can be read as per cent of maximum number of timeouts. With this dependent variable, the functions in Figure 3 show that the number of possible timeouts increased as the duration of the timeout period increased.

Another measure that corrects for the bias of differences in time available for timeouts under the three timeout durations is the rate of timeout responses when rate is calculated from session time minus total duration of timeouts in the session. This measure does not show a consistent relationship for the pigeons. The rates of timeout responding (responses per hour) under the 5-sec, 3-min, and 9-min timeout periods respectively were 8.9, 3.0, and 3.6 for B-10; 3.5, 3.6, and 3.1 for B-17; and 14.2, 8.6, and 13.0 for B-32.

With both the 5-sec and the 9-min timeout periods, timeouts were more frequent as the size of the progressive-ratio step increased during the session. Figure 4 shows these functions and also the function for the 3-min timeout period. During these sessions, none of the pigeons produced a timeout during the first progressive-ratio step, and the only timeouts during the second step were two 5-sec timeouts by B-32. The data for the 5-sec timeout period

Fig. 2. Cumulative response records for B-17 and B-32 illustrating the progressive-ratio performance before availability of the timeout option, labelled "no TO", and a final performance with the 3-min timeout option scheduled, labelled "TO 3". Reinforcements are indicated by the momentary downward deflection of the response pen with a dot added below the deflection. The response pen remained deflected for the 3-min duration of the timeout period. Complete sessions are shown. The segments at the bottom of the figure illustrate the production of timeouts throughout a progressive-ratio step by B-10 and B-32.

show the most deviation from a generally increasing monotonic trend.

A further similarity of the performances under the different timeout durations was the predominant occurrence of timeouts in the early part of the progressive-ratio step. Figure 5 includes a cumulative response record for each pigeon under the 5-sec timeout duration

and a record for B-17 and B-32 under the 9-min timeout duration. The performances of B-10 resembled those of B-17 under the 9-min period. The records of B-32 illustrate the occurrences of timeouts in the last half of the longer progressive-ratio steps, which had become a common feature of this pigeon's performance. For all pigeons, the expiration of the timeout

Fig. 3. The number of timeouts in a session (solid circles and left ordinate) and the per cent of the session spent in timeout (open circles and right ordinate) as a function of the duration of the timeout period. The number of timeouts in each of the final 10 sessions under each timeout duration are plotted and the means connected. Each point for the per cent of the session in timeout is the mean of the values over the final 10 sessions. The lowest graph presents the average of the individual functions.

period was followed by a pause before responding, with the exception of some 5-sec timeouts by B-32 in the latter part of the progressive-ratio step.

III. Subject control of timeout duration.

Fig. 4. The mean number of timeouts in a session as a function of successive progressive-ratio steps for each of the timeout durations. Each point is the mean of the values for the final 10 sessions. The lowest graph presents the average functions for each of the timeout durations. The notation on the abscissa is the same as in Figure 1.

When the duration of each timeout period was controlled by the pigeon, the performances showed the same general features found under the fixed-duration timeout procedure: timeouts were produced in all sessions, frequency of timeouts was related to size of the progressive-ratio step, and timeouts were produced

Fig. 5. Cumulative response records illustrating the performances under the 5-sec and the 9-min timeout durations. Complete sessions are shown. Reinforcements and timeouts indicated as in Figure 2.

predominantly in the early part of the progressive-ratio step. Table 2 lists some descriptive measures of the performances. Two pigeons, B-10 and B-32, produced more timeouts and remained in timeout longer under this timeout condition than under any of the fixed duration timeout conditions. The frequencies of timeouts by each pigeon showed the same rank found under all earlier conditions: B-32 responded most often on the timeout key and B-17, least often.

Figure 6 shows four indexes of the timeout performance as a function of size of the progressive-ratio step. The upper-left graph shows that, on the average, the likelihood of a timeout during a step increased as the size of the step increased. One pigeon, B-32 produced at least one timeout during each of the three highest progressive-ratio steps in all 10 sessions. The infrequent timeouts by B-17, an average of 2.6 per session, were more likely during the two longer steps.

Fig. 6. Four measures of timeout performance when the duration of the timeout period was controlled by the pigeon. The upper-left graph shows the relative number of sessions in which a timeout occurred in each progressive-ratio step. The upper-right graph presents the mean number of timeouts in each progressive-ratio step during a session. In the lower-left graph, the total time spent in timeout in each of the progressive-ratio steps during a session is shown. The lower-right graph shows the mean duration of a timeout in each progressive-ratio step during a session. All points were calculated from the final 10 sessions. The dashed line in each graph is the average of the individual functions.

The average function in the upper-right graph shows that the number of timeouts during a progressive-ratio step increased with the size of the step. A clearly increasing gradient was absent for B-17; however, the mean number of timeouts was highest during the longest step. The pigeons never produced a timeout during the first step. During the second step, B-10 produced one timeout and B-32, five timeouts.

The lower-left graph presents the total timeout duration during each progressive-ratio

step. This index exhibits the most orderly functions for the pigeons, including B-17, which produced few timeouts. The group average shows a sharply increasing monotonic function, and none of the individual functions show any marked reversals in the increasing trends.

The lower-right graph presents the mean duration of a timeout during each progressive-ratio step. The average function shows that the mean duration of each timeout period increased as the size of the progressive-ratio step

Table 2

The mean and range (shown in parentheses) of some performance measures when timeout duration was controlled by the pigeon. Entries refer to a session and are based on the final 10 sessions.

	B-10	B-17	B-32
Number of timeouts	9.8 (5-18)	2.6 (1-5)	21.5 (11-28)
Total duration of timeouts (min)	75.2 (43-107)	8.9 (0.02-34.6)	81.3 (60.7-101.9)
Mean duration of timeout (min)	8.6 (4.3-16.4)	3.8 (0.02-13.2)	4.3 (2.4-9.3)
Number of Reinforcements	5.6 (4-7)	7.0 (5-8)	7.4 (6-9)

increased. The individual functions show the same general trend except for the single point at N-2 for B-10, which reflected the influence of two timeouts, each lasting approximately 20 min. Summarizing the results of these four indexes of timeout performance, a longer progressive-ratio step generally was associated with a greater likelihood of a timeout, a greater number of timeouts, more total time spent in

timeout during the step, and a longer mean duration of each timeout.

Figure 7 includes a cumulative record for each of the pigeons. Characteristics of the performances common to all pigeons illustrated by these records include: (1) the immediate initiation of responding on the food key when the session began, (2) the predominant occurrence of timeouts during the post-reinforcement pause or during the early part of the progressive-ratio step, (3) the infrequent timeouts during the initial steps of the progressive-ratio schedule, and (4) the extended length of time spent under the longer progressive-ratio steps. Pigeon B-32 continued to produce timeouts in the latter part of some longer progressive-ratio steps. The durations of these timeouts were brief.

IV. Reinforcing effect of timeout. The results of the five experimental manipulations assessing the reinforcing effect of the timeout consequences are summarized in Figure 8. The results from the first condition, under which responses on the timeout key were not followed by a 3-min timeout period, are shown in the

Fig. 7. Cumulative response records illustrating the performances when pigeons controlled the duration of the timeout period. Complete sessions are shown. Timeouts and reinforcements indicated as in Figure 2.

Fig. 8. The number of responses on the timeout key (solid circles) and/or the dummy key (open circles) under five experimental conditions. The number in parentheses after a point is its exact value. The coded description of each condition, listed at the top of each panel, is described in the text.

first section of Figure 8, headed "TO key (no TO)". All pigeons eventually responded less frequently on the timeout key than they did when the timeout consequence had been scheduled in earlier parts of the study. The mean number of timeout key responses over the final 10 sessions was 1.8 for B-10, 0.6 for B-17, and 5.6 for B-32. In the first session, B-10 and B-32 responded excessively on the timeout key; in the fifth and tenth sessions, B-17, which had produced few timeouts in the preceding part of the study, showed two isolated instances of frequent timeout key responding.

The results from the second condition, under which the timeout key was covered and the dummy key was exposed, are in the second panel of the graphs in Figure 8, headed "dummy key". In the early sessions, all pigeons responded frequently on this novel, inconsequential key. Pigeon B-17, which was least active on the timeout key throughout the study, responded 626 times in the first session. The dummy key responses by each pigeon in a session declined to the approximate level of timeout key responses in the preceding condition. The mean frequency of dummy key responses over the final 10 sessions was 1.1 for B-10, 1.6 for B-17, and 4.3 for B-32. The results from the first two experimental manipulations showed that, over a series of sessions, pigeons will continue to respond occasionally on an added inconsequential key that had been associated with timeouts or an added key never associated with scheduled consequences, but the frequency of responding in both cases is less than on a key resulting in timeouts.

Under the third experimental condition, responding on the timeout key with no timeout consequence and the dummy key was compared directly. These data are in the third panel of the graphs in Figure 8, headed "TO key (no TO) & dummy key". Over the final 10 sessions, the number of responses on the timeout key and the dummy key were similar and infrequent for B-10 (1.4 timeout and 0.7 dummy) and B-17 (0.5 timeout and 0.3 dummy), but dissimilar for B-32 (1.7 timeout and 6.8 dummy). These results show no common tendency by the pigeons to respond more frequently on the key previously associated with timeouts nor to favor a key having a particular color and/or location.

Under the fourth experimental condition, both dummy key and timeout key were avail-

able and the 3-min timeout was reinstated for timeout key responses. These data are in the fourth panel of each graph, headed "TO key (3' TO) + dummy key". All pigeons responded more frequently on the timeout key than on the dummy key. The mean response frequencies over the final 10 sessions on the timeout and dummy keys respectively were: B-10, 5.1 and 0.9; B-17, 2.3 and 0.6; B-32, 22.2 and 2.7. The timeout key responding by each pigeon also was more frequent compared to responding on this key in the previous three conditions when no timeout consequence was scheduled. Frequency of responding on the timeout key increased over the early sessions in the series, whereas dummy key responses maintained the same general level throughout the series of sessions. Although dummy key responses were infrequent, they did persist for all pigeons. Regarding individual performances, rescheduling the timeout consequence immediately reduced the high frequency of dummy key responses by B-32; also, B-17 again responded very frequently on the dummy key in two of the sessions.

In the final experimental condition assessing the dependence of timeout key responding on responding under the PR 50 food schedule, the food key was covered and the dummy key and timeout key with the 3-min timeout consequence were available. These results are shown in the last panel of the graphs in Figure 8, headed "no food key TO key (3' TO) & dummy key". The frequency of timeout responses and dummy key responses by all pigeons declined to low levels. Mean frequencies over the final 10 sessions were: B-17, 0.2 timeout and 0 dummy; B-32, 0.4 timeout and 0.1 dummy. No responses on either key were made by B-10. Introduction of this condition resulted in frequent responding on the timeout and/or dummy keys by all pigeons. During the transition to the final values, responses on the timeout key usually were more frequent than responses on the dummy key. Note the unusually high number of dummy key responses by B-10 in the first and second sessions.

V. Level of food deprivation. Figure 9 presents the number of reinforcements and the number of 3-min timeouts in each of the last 10 sessions at the high and low body weights and also these data at an intermediate weight, which were taken from the fourth condition of the preceding part of the study. The func-

Fig. 9. The number of timeouts (solid circles and left ordinate) and the number of reinforcements (open circles and right ordinate) in each of the final 10 sessions at three different body weights. The means of each set of 10 values are connected. The lower graph is the average of the individual functions.

tions for all pigeons show that number of timeouts was inversely related to body weight or, correspondingly, directed related to the number of completed progressive-ratio steps. Note that the reduction of body weight increased the frequency of timeouts by B-17,

which had diminished to a low level in preceding parts of the study. Dummy key responses by the pigeons were infrequent and were not consistently related to a high or low body weight. The mean frequency of dummy key responses over the last 10 sessions at both weights was 2 for B-10, 0.2 for B-17, and 0.3 for B-32. The value for B-10 includes the influence of 18 dummy key responses in a single session at the low weight.

Figure 10 shows the mean number of timeouts and the relative number of sessions with a timeout as a function of the progressive-ratio step for each of the three body weights. At low body weights, all pigeons showed definitive, increasing gradients for both indexes of timeout performance. The pigeons continued to produce timeouts during the shorter progressive-ratio steps, as in earlier parts of the study, which resulted in a wide range of steps containing timeouts. For example, B-10 which averaged 12 completed steps in a session, produced timeouts as early as the third progressive-ratio step. The functions for the relative number of sessions in which a timeout occurred in each step at the low body weight appear less regular because two of the pigeons, B-10 and B-32, reached the maximum value before the final completed step. They produced a timeout in every session during the fourth longest completed step.

At the intermediate body weight, a clearly increasing gradient was absent for two pigeons. These functions lack the regularity of those shown in Figure 1, which represented performances under the same experimental conditions except for the absence of the dummy key. Relative to the earlier data, however, the present functions are based on one-half the number of sessions; also, the number of timeouts in a session by B-10 and B-17 were much less frequent. Although lacking regularly increasing gradients, the present functions indicate the dependence of timeouts on size of the progressive-ratio step by the predominance of timeouts in the final two steps for all pigeons.

At the high body weight, there was no general relationship between timeouts and size of the progressive-ratio step. The infrequent timeouts did not exhibit a common pattern for either index of timeout performance. Due to the infrequency of timeouts, the average values in the graphs were strongly influenced by a

Fig. 10. The graphs on the left side present the mean number of timeouts in each progressive-ratio step for each of three body weights; the graphs on the right show the relative number of sessions in which a timeout occurred in each progressive-ratio step at the different body weights. Notation for the abscissa is described in Figure 1. Each point is the mean of the values from the final 10 sessions.

discrepant value entering into the calculations. A common feature of the timeout performances at all body weights was the absence of

any timeouts during the first step of the progressive-ratio schedule.

The cumulative response records in Figure

Fig. 11. Cumulative response records illustrating the performances at high and low body weights. Complete sessions are shown. Reinforcements and timeouts indicated as in Figure 2. Circled numbers and arrows indicate the number and location of dummy key responses.

11 illustrate some temporal characteristics of the performances at the high and low body weights. The performances of B-17, not shown, were similar to those of B-10. At the low body weight, a high and regular response rate persisted throughout the progressive-ratio steps. The only irregularities were occasional long breaks in the early part of the step. The pigeons were responding on the food key or were in timeout during most of the session when working at the low weight. Timeouts were localized in the early part of the progressive-ratio step and the post-reinforcement pause for B-10 and B-17. However, B-32 continued to produce timeouts later in the step. Occasionally, during the longer progressive-ratio steps, B-32 alternated between a series of responses on the food key and a response on the timeout

key. This pattern is illustrated by the low weight record in Figure 11.

At the high weight, the pigeons were inactive during most of the session. The performances at the high weight included the only instances during the entire study of a long delay preceding responding on the food key at the beginning of the session.

DISCUSSION

The main findings can be summarized as follows. Pigeons produced timeouts having a fixed duration of 5 sec, 3 min, or 9 min, or having a duration controlled by the pigeon. The frequency of self-imposed timeouts was directly related to the number of responses required for reinforcement, increasing as the pi-

geon entered longer progressive-ratio steps, and occurring largely during the early part of each step. Frequency of timeouts also was related to the control of the progressive-ratio schedule: timeouts were most frequent when more progressive-ratio steps were completed at a low body weight, less frequent when few steps were completed at a high body weight, and absent or infrequent when pigeons were prevented from working under the positive reinforcement schedule. Infrequent and sporadic responding on an added, inconsequential key occurred under the progressive-ratio schedule but to a lesser degree than responding on the key with the timeout consequence scheduled, identifying a reinforcing effect of the timeout condition.

Some of these results parallel those reported when responding was maintained by a fixed-ratio positive reinforcement schedule. Frequency and duration of self-imposed timeouts were related to size of the progressive-ratio step in the same manner that they were related to size of the fixed-ratio schedule. Timeouts were not localized in the post-reinforcement pause as they were under fixed-ratio schedules; however, they were largely limited to the early part of the progressive-ratio step. Also, a lower level of responding on an inconsequential added key relative to a key followed by timeout under the progressive-ratio schedule has been reported for fixed-ratio positive reinforcement schedules.

The greater variability in the locus of self-imposed timeouts during a reinforced response sequence under the progressive-ratio schedule might be due to the weaker control exerted by this schedule relative to the control by fixed-ratio schedules. Responding under a progressive-ratio schedule inevitably becomes severely strained as the subject continues responding through the successively longer steps. This characteristic of progressive-ratio performance has led to the use of the index termed "breaking point" to describe the upper limit of behavior (Hodos, 1961; Thompson, 1972). Also, the invariant relationship between number of responses and reinforcement, which defines the fixed-ratio schedule, makes accumulated response count during the reinforced response sequence a more potent controlling stimulus compared to its control in progressive-ratio schedules. Another possible source of the greater irregularity of timeout behavior

under progressive-ratio schedules is the nature of the dependence between the timeout and positively reinforced behaviors. The response increment in successive progressive-ratio steps increases the likelihood of a self-imposed timeout, but the increasing response requirement also results in a weaker control over the food-reinforced operant by the progressive-ratio schedule. Further, a self-imposed timeout from positive reinforcement appears to depend on a modicum of control by the progressive-reinforcement schedule because the stimuli controlling the timeout response are generated by the performance under the positive reinforcement schedule. Accordingly, the frequency of timeouts increases as the control by the schedule weakens until the schedule no longer can maintain behavior, at which point timeout behavior also is lost. This total loss of control would be illustrated by instances in which the pigeons were observed to roost throughout the later part of a session.

Two parts of the study were pertinent to the reinforcing effect of timeout from the progressive-ratio schedule. The series of manipulations in Part IV explored the possibility that responding on the timeout key was only one of the behaviors that could occur under local conditions of the reinforcement schedule, rather than being controlled by the scheduled timeout consequence. The results demonstrated a reinforcing effect of the timeout consequence, with this effect dependent on working under the positive reinforcement schedule. However, the finding that sporadic responding occurred on a key having no scheduled consequence suggests the influence of other variables and recommends the addition of such a control condition in studies of this type.

That part of the study dealing with different durations of the timeout period is also relevant to a reinforcing effect of the timeout condition. The duration of the timeout period should be a critical determinant of timeout responding. At one extreme, an excessively long timeout period would curtail the time available for working under the positive reinforcement schedule. At the other extreme, an extremely brief timeout period would resemble a momentary stimulus change, rather than providing time away from the conditions of positive reinforcement. The timeout durations used apparently were within these limits. With both the 5-sec and the 9-min timeout dura-

tions, the pigeons produced timeouts, and the timeouts bore the same general relationships to the progressive-ratio performance as the 3-min timeout period. The question of one of these timeout durations being more effective for generating timeout responses than the other durations could not be ascertained from the data. Judging from the timeout performances in that part of the study where the pigeons controlled the timeout duration, this question is inappropriate because the mean duration of a timeout during each progressive-ratio step was generally longer as the size of the step increased. Accordingly, an optimum fixed duration of timeout would vary with the number of responses required for reinforcement.

None of the present results contradicts the interpretation of self-imposed timeouts as an escape response reinforced by the removal of unfavorable reinforcement conditions, although some details of the performances reflect either a weak control and/or operation of other controlling variables. For example, there were instances of extended post-reinforcement pauses without a timeout; also, the first timeout during a progressive-ratio step often followed an appreciable amount of responding within the step. The timeout data also can be explained by a reinforcing effect of stimulus change on timeout key responses. As a weak reinforcer, stimulus change would be influential during times when the positive reinforcement schedule exerted minimal control. In the case of the 5-sec timeout, stimulus change as the critical consequence of timeout responding appears to be a more suitable explanation of the timeout performances. This timeout duration appears rather brief to function as an effective escape period from aversive conditions of the positive reinforcement schedule.

As noted by Appel (1963), explanations of self-imposed timeouts from positive reinforcement do not apply to the reinstatement of the timeout conditions when the experimental procedure allows the subject to control timeout duration. The termination of the timeout condition can be viewed as a switching response that is prerequisite to working under the positive reinforcement schedule and that is reinforced by presentation of the stimulus conditions associated with the reinforcement schedule. This interpretation assumes the continued control over behavior by the schedule of positive reinforcement. The question re-

mains why local conditions of the reinforcement schedule can act as a negative reinforcer at one time and as a positive reinforcer at a later time. The changed function must involve time-dependent processes acting during the timeout period, such as the following: (1) the effect of conditions controlling the timeout behavior weaken during their absence under the timeout, (2) a timeout condition that does not permit working under the positive reinforcement schedule becomes less favorable than the timeout condition under which responding under the schedule is optional, (3) the conditions generating timeout behavior also control a low probability of responding under the positive reinforcement schedule which, over time, will eventually result in a response, and termination of the timeout is a prerequisite for this response. Another possibility is that termination of the timeout period is controlled by the same factor responsible for production of the timeout period; namely, the reinforcing effect of stimulus change.

Two general comments can be made about the phenomenon of self-imposed timeouts. First, timeout key responding can be considered as one of several classes of behavior having a low probability of occurrence, all of which compete with the behavior maintained by the positive reinforcement schedule. A timeout key response would depend on a period of weak control by the positive reinforcement schedule. Hence, conditions favorable to timeout key responses would feature weak reinforcing stimuli. Second, separate instances of timeout key responding might be due to different controlling variables, rather than to the same controlling condition. Besides the reinforcing effect of stimulus change and schedule-induced escape, timeout key responding could reflect, on some occasions, schedule-induced aggression (Gentry, 1968), an operant level of key pecking, or a superstitious behavior involving response sequences on available operanda (Herrnstein, 1966).

REFERENCES

- Appel, J. B. Aversive aspects of a schedule of positive reinforcement. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 423-428.
- Azrin, N. H. Time-out from positive reinforcement. *Science*, 1961, 133, 382-383.
- Baer, D. M. Escape and avoidance responses of preschool children to two schedules of reinforcement

- withdrawal. *Journal of the Experimental Analysis of Behavior*, 1960, 3, 155-160.
- Baer, D. M. Laboratory control of thumbsucking by withdrawal and re-presentation of reinforcement. *Journal of the Experimental Analysis of Behavior*, 1962, 5, 525-528.
- Baron, A. and Kaufman, A. Human, free-operant avoidance of "time out" from monetary reinforcement. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 557-565.
- D'Andrea, T. Avoidance of timeout from response-independent reinforcement. *Journal of the Experimental Analysis of Behavior*, 1971, 15, 319-325.
- Ferster, C. B. Withdrawal of positive reinforcement as punishment. *Science*, 1957, 126, 509.
- Ferster, C. B. Control over behavior in chimpanzees and pigeons by time-out from positive reinforcement. *Psychological Monographs*, 1958, 72 (8, Whole no. 461).
- Ferster, C. B. and Appel, J. B. Punishment of S_Δ responding in matching to sample by time out from positive reinforcement. *Journal of the Experimental Analysis of Behavior*, 1961, 4, 45-56.
- Ferster, C. B. and Skinner, B. F. *Schedules of reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Gentry, W. D. Fixed-ratio schedule-induced aggression. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 813-817.
- Herrnstein, R. J. Superstition: a corollary of the principles of operant conditioning. In W. K. Honig (Ed.), *Operant behavior: areas of research and application*. New York: Appleton-Century-Crofts, 1966. Pp. 33-51.
- Hodos, W. Progressive-ratio as a measure of reward strength. *Science*, 1961, 134, 943-944.
- Hodos W. and Kalman, G. Effects of increment size and reinforcer volume on progressive-ratio performance. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 387-392.
- Holz, W. C., Azrin, N. H., and Ayllon, T. Elimination of behavior of mental patients by response-produced extinction. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 407-412.
- Leitenberg, H. Is time-out from positive reinforcement an aversive event? *Psychological Bulletin*, 1965, 64, 428-441.
- Miller, N. and Zimmerman, J. The effects of pre-timeout stimulus on matching-to-sample of humans. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 487-499.
- Thompson, D. M. Escape from S^D associated with fixed-ratio reinforcement. *Journal of the Experimental Analysis of Behavior*, 1964, 7, 1-8.
- Thompson, D. M. Time-out from fixed ratio reinforcement: a systematic replication. *Psychonomic Science*, 1965, 2, 109-110.
- Thompson, D. M. Enhancement of progressive-ratio performance by chlordiazepoxide and phenobarbital. *Journal of the Experimental Analysis of Behavior*, 1972, 17, 287-292.
- Zimmerman, J. and Bayden, N. Punishment of S_Δ responding in humans in conditional matching-to-sample by timeout. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 589-597.
- Zimmerman, J. and Ferster, C. B. Intermittent punishment of S_Δ responding in matching-to-sample. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 349-356.
- Zimmerman, J. and Ferster, C. B. Some notes on time-out from reinforcement. *Journal of the Experimental Analysis of Behavior*, 1964, 7, 13-19.

Received: 12 June 1972.

(Final Acceptance: 29 September 1972.)