AVOIDANCE OF TIMEOUT FROM RESPONSE-INDEPENDENT REINFORCEMENT¹

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Responses on a lever by rats postponed scheduled timeouts, or periods during which the delivery of response-independent food was withheld. The effects of a number of experimental variables were examined and the conclusions drawn are that the functional relations describing free-operant avoidance of timeout from response-independent reinforcement are similar to those for avoidance of electric shock and that both phenomena are sensitive to the same parametric manipulations. Results suggest that high frequency of food delivery in timein maintains a higher rate of timeout avoidance than low frequency. The evidence argues against an interpretation in terms of adventitious food-reinforcement of the timeout avoidance response. Finally, the effects of scheduling timeouts independently of responding and of omitting timeouts confirm the view that timeouts can be aversive and may act as punishment for responding.

A number of studies have shown that withholding the opportunity to obtain reinforcement may be aversive, or more accurately, the stimulus conditions obtaining during periods of nonreinforcement may acquire aversive properties (Baron and Kaufman, 1968; Ferster, 1958; McMillan, 1967; Morse and Herrnstein, 1956; Thomas, 1964). Typically, these studies employed a procedure in which a response was maintained by positive reinforcement under certain stimulus conditions (timein). Reinforcement never occurred as a consequence of the response when some other stimulus was present (timeout).

The purpose of many of these studies was to compare the effects of timeout from positive reinforcement with those of unconditioned aversive stimuli (*e.g.*, electric shock). The latter have been studied in some detail and knowl-

edge about the similarities and differences in the function of conditioned and unconditioned aversive events is of systematic and practical interest. With three exceptions (Baer, 1960; Kaufman and Baron, 1966; Thomas, 1965a), all of the studies have imposed timeouts on a schedule of response-dependent positive reinforcement. Baer (1960) studied avoidance of interruptions of cartoons by children. No behavior was required of the children to "earn" the viewing of the cartoons; responses served only to postpone the next scheduled interruption of the cartoons. Thomas (1965a) reported experiments in which grain was occasionally delivered independently of responding, except during timeout periods. The pigeons could postpone the next timeout by pecking a green disc on the wall of the experimental chamber. During the timeout periods, the disc was illuminated by a red light. Thomas argued that the procedure he and Baer employed is "operationally more comparable" to those that maintain behavior solely by avoidance of unconditioned noxious events than procedures confounded by concurrent interruption of ongoing positively reinforced behavior (Thomas, 1965a, p. 217).

The present experiment attempted to investigate several specific problems concerned with avoidance of a stimulus correlated with withholding of response-independent food from a deprived animal. The free-operant avoidance procedure developed by Sidman

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(1953a) was used except that the animal's task was to avoid timeouts instead of electric shock. In free-operant avoidance, unsignalled shocks are delivered at fixed periods of time unless the animal responds. Responses postpone the next scheduled shock. In the present experiment, periods of time during which food was never delivered to the animal were scheduled to occur unless the animal responded and postponed the next timeout period.

METHOD

Subjects

Three Sprague-Dawley male rats (7, A4, and A6) from the Holtzman Company, Madison, Wisconsin, had all served previously in an operant conditioning experiment in an undergraduate learning course. The animals were about six months old at the start of the present experiments and were maintained at 85% of free-feeding weight with water available at all times in the individual home cages.

Apparatus

The apparatus consisted of an operant conditioning chamber 4.75 by 9.5 by 9.5 in. (11.9 by 24.8 by 24.8 cm) high, containing a lever, 6-w stimulus light, and food cup located on one wall. A force of approximately 20 g (0.18 N) on the lever was required to actuate the micro-switch. White noise of 80-db sound level was delivered from a speaker mounted next to the chamber. All scheduling and recording equipment was located in an adjoining room.

Procedure

Food pellets (45-mg Noyes) were delivered at variable intervals of time, independent of the behavior of the animal, during timein periods. The stimulus light was on during timein periods and off during timeout. No food was delivered during timeout and each timeout lasted 1 min. The duration of the timein period was determined by two independent clocks. Termination of timeout (or the beginning of an experimental session) activated the first clock and initiated timein. Upon completion of the interval of time set on the first clock, and if no lever press occurred during timein, a timeout began. A response on the lever during timein disabled the first clock and activated the second, thus postponing the onset of the next scheduled timeout by the interval of time set

on the second clock. Each further response in timein reset the second clock and postponed the next timeout by the interval of time set on it. Responses during timeout had no scheduled effect except that they were counted. Sessions were usually conducted daily for about 1 hr.

The following criteria of stability were used to determine when the schedule parameters were changed: (a) the animal must have had at least four sessions on that condition, and either, (b) the response rates during timein of three consecutive sessions had to fall within $\pm 10\%$ of the mean of these rates, or (c) the rates during timein of three consecutive sessions had to be less than 0.5 responses per minute.

1. The effects of varying temporal parameters and frequency of food delivery. All rats began with the first clock set at 15 sec and the second clock at 45 sec. Thus, the interval between successive timeouts was 15 sec if no response was emitted during timein. Each response in timein postponed the next scheduled timeout by 45 sec. A food pellet was delivered on the average of four per minute during timein by means of a tape puller. After 6.5 hr (6.5 sessions), the setting on the first clock was reduced to 7.5 sec for Subject 7 because the response rate had decreased steadily since the start of experimentation. This meant that the interval between successive timeouts was only 7.5 sec if the animal did not respond during timein. Response rate increased after 1.5 hr at the new setting and criterion (b) of stability was reached upon completion of 18 hr exposure to the schedule. The animal was then run through the settings indicated in Table 1. For Rats A4 and A6, food delivery was reduced to two pellets per minute after 2.5 hr (two sessions). Food delivery was further reduced to one pellet per minute for Rat A6 after 8 hr at two pellets per minute. With these procedures in effect, A4 reached criterion (b) in 19 hr and A6 in 15 hr. The amount of time by which a response during timein postponed timeout was then varied through the following descending and ascending series of intervals: 15, 7.5, 3.75, 7.5, 15, and 45 sec. The frequency of food delivery was then changed to one pellet per minute for Rat A4, which was run at 45, 15, 7.5, 15, and then 45 sec, in that order. Rate of food delivery was changed to two pellets per minute for Rat A6, which was

Table 1

Clock settings at which Rat 7 was run. Numbers in each cell indicate the order of exposure to the values.

<i>R-TO Values (Seconds) (Time by Which Response during Timein Postponed Timeout)</i>	<i>TO-TO Values (Seconds) (Time between Successive Timeouts if No Response Emitted during Timein)</i>				
	3.75	7.5	15	30	60
3.75	13	5	11	—	—
7.5	17	15	7	3, 22	—
15	4	12	16	6, 19	14, 20
45	—	1	10, 24	2, 23	18
100	—	—	—	9, 21	8

NOTE: Cells with two entries denote values that were studied twice because the first determination was so far out of line from the other points that its validity was questionable.

run at 45, 15, 7.5, and 3.75 sec. Finally, A6 was run at a rate of four pellets per minute and 45 sec.

2. *The effect of imposing a delay between responding and food delivery.* After reaching criterion at the final settings indicated in Table 1, Rat 7 continued on the same temporal values for 37 sessions. A 3-sec delay was then imposed to eliminate adventitious food-reinforcement of responding. Instead of delivering a food pellet each time the microswitch arm of the tape puller dropped into a hole in the tape, a clock was operated and a food pellet was delivered after 3 sec had elapsed. Each response during this 3-sec interval reset the clock and delayed food delivery by 3 sec. The tape puller was adjusted to maintain the same frequency of food delivery during timein (approximately 4 per minute). Sixty one sessions were given with the 3-sec delay in effect. The 3-sec delay was then removed and 11 more sessions were conducted. For the rest of the experiment, the criteria adopted above were abandoned. By this time, the behavior was very stable and judgments about the likelihood of further changes in the rate could be made confidently.

3. *The effects of scheduling timeouts independently of responding and of omitting timeouts.* Following the last 11 sessions described in the above paragraph, timeouts were scheduled to occur every 15 sec independently of responding; responses did not postpone the next scheduled timeout. After this, conditions were changed so that timeouts were omitted altogether, regardless of whether the animal responded or not. The order of conditions and the number of sessions at each condition are given in Table 2.

Table 2

Conditions and number of sessions in each condition for Rat 7 during the last phase of the experiment. The conditions were presented in the order listed in the table. Abbreviations in parentheses refer to symbols used in Fig. 3.

<i>Condition</i>	<i>Number of Sessions</i>
Timeout independent of response (EXT)	20
Resume timeout avoidance (BL)	6
Timeouts omitted (O)	30
Resume timeout avoidance (BL)	6
Timeouts omitted (O)	7
Resume timeout avoidance (BL)	6
Timeout independent of response (EXT)	16

RESULTS

The results of varying the temporal parameters for Rat 7 are shown in Fig. 1. For a given setting of the first clock (the TO-TO interval or the time between successive timeouts if no response occurred), response rates increased to a maximum and then decreased gradually as a function of the increase in time by which a response postponed timeout (the R-TO interval on the abscissa of Fig. 1). Responding during timeout periods was infrequent relative to responding maintained by timeout postponement, and systematic relations between variations of the temporal parameters and responding during the timeout periods were not evident.

For Rats A4 and A6, response rate increased rapidly to a maximum, followed by a gradual decrease as the interval by which a response postponed timeout was lengthened (see Fig. 2). For A4, no systematic sequence effects were observed in the ascending and descending

Figure 1. Response rate of Rat 7 maintained by the schedule of timeout postponement as a function of the amount of time by which a response postponed the next scheduled timeout (the R-TO interval). The parameter is the interval between successive timeouts if no response occurred (the TO-TO interval). Each point is the average of the last three sessions at each pair of values. In cases where points were redetermined (see Table 1), the second determination is plotted.

series of intervals used in the experiment and so, where two determinations were made, the average of both is plotted in Fig. 2. Again, responding during timeout was found to be infrequent and declined over the course of the experiment to the point where it rarely occurred.

Only the data from the first descending series collected from A6 are shown in Fig. 2. From the time A6 achieved criterion (c) at the leftmost point in Fig. 2, and for 53 more sessions, response rate maintained by the schedule of timeout postponement was generally below 0.5 responses per minute despite the wide range of parameter values to which it was exposed (see Procedure). Responses during timeout for A6 showed the same pattern of decline in frequency over the course of the experiment as for A4. In terms of rate, responding during timeout for the last 53 sessions was about equal to that maintained by timeout postponement.

There is a suggestion that the overall height of the curves in Fig. 2 may be a function of the amount of food delivery during timeout. For A4, two of the three points plotted for one pellet per minute are considerably below the corresponding points for two pellets per minute.

The mean response rate for Rat 7 for the last five sessions before the 3-sec response-food delay was instituted was 3.8 responses per minute. The mean response rate for the last

Fig. 2. Response rates of Rats A4 and A6 on the schedule of timeout postponement as a function of the interval by which a response postponed timeout with rate of food delivery during timeout as the parameter. Points are the averages of the last three sessions at each value, except for Subject A4 where the points representing two pellets per minute, R-TO values of 7.5, 15, and 45 sec, and one pellet per minute, R-TO values of 15 and 45 sec are the averages of both determinations, thus six sessions (see Procedure and Results).

five sessions with the 3-sec delay in effect was 3.8 responses per minute. Removal of the delay resulted in a mean response rate over the final five sessions of 3.9. No disruptive effects were noted when the response-food delay was imposed. The large number of sessions ($N = 61$) with the delay contingency in effect was given specifically to detect any slow drift of the behavior.

Results from Rat 7 of the final experimental manipulations are shown in Fig. 3. When responses were no longer effective in postponing timeouts, the EXT condition in Fig. 3, response rate was lowered dramatically from the baseline (BL) rate. For comparison, the rate of responding during timeout periods is also depicted in Fig. 3. Response rate during timeout during sessions when timeouts were scheduled independently of responding was also lower, on the average, than timeout rates during baseline sessions. Omitting timeouts resulted in rates lower than those of the baseline sessions but higher than those of the extinction sessions.

Fig. 3. Response rates of Rat 7 during timein (TI) and timeout (TO) for the last phase of the experiment (see Table 2). Points are the averages of the last five sessions in each condition and vertical lines through the tops of the bars represent the range of values. Sessions in which timeout postponement was in effect are labelled BL for baseline. The condition in which timeouts were scheduled independently of responding are abbreviated EXT and the condition where timeouts were omitted is denoted by 0. The leftmost points represent the last five sessions given after removal of the response-food delay, before the first exposure to the schedule where responses no longer resulted in timeout postponement.

DISCUSSION

Leitenberg (1965) reviewed the literature and discussed the study of timeout in five different experimental contexts: avoidance, escape, punishment, conditioned negative reinforcement, and the conditioned emotional response. A recent paper by Wagner (1969) shows this phenomenon to be relevant to theories of motivation. The present experiments make possible more direct comparisons of the effects of timeout from positive reinforcement and those of unconditioned aversive events.

The similarity of Fig. 1 of this study to Fig. 1A-C reported by Sidman (1953b) for the shock-avoidance case is apparent; the general features of Sidman's functions were obtained here for avoidance of timeout from response-independent food reinforcement. The conclusions drawn from these results are that the functional relations describing free-operant avoidance of timeout from food are similar to

those for avoidance of electric shock, and both phenomena are sensitive to the same parametric manipulations. The data from Rats A4 and A6 serve as a "systematic replication" (Sidman, 1960) of those collected from Rat 7 and further support these conclusions. They also suggest that frequency of food delivery in timein is an important variable. The results were opposite to those reported by Thomas (1964, 1965b). He showed that fewer timeouts were avoided when the average rate of food delivery (response-dependent) was high than when it was low. Pigeons pecked one disc to produce food, and responses on a second disc postponed timeout. When responses on the food disc were reinforced on the average of once every 9 min, the bird emitted about 2.5 responses per minute on the avoidance disc. Response rate on the avoidance disc dropped to zero when responses on the food disc were reinforced on the average of once per minute. Responding resumed on the avoidance disc, however, when extinction was scheduled on the food disc (Thomas, 1964). Thomas (1965a) reported that this result also holds in the case of free food during timein. Responses on a single disc served only to postpone timeouts; food was delivered independently of the bird's behavior during timein. Higher rates of responding were maintained when the food was delivered on the average of once per 3 min than when it came on the average of once every minute. Thomas points out a difficulty in interpretation of the results of his latter experiment, however, because of the procedure he used for arranging response-reinforcement delays. Every response added 4 sec to the time to the next scheduled food presentation, thus reducing the overall frequency of food presentation during a session. When the response-food delay was imposed in the present study, only responses within 3 sec of a scheduled food delivery postponed delivery (by 3 sec) and care was taken to ensure that the average rate of food delivery did not decrease. In any case, Thomas' results are curious, as Leitenberg (1965, p. 430) pointed out. In a discussion of the sensitivity of schedules with high reinforcement frequency to the effects of timeout, Ferster (1960, p. 152) remarked, ". . . timeouts from the more reinforcing schedules would be expected to be the most aversive." There is evidence to support this expectation. For example, it is difficult to reconcile the re-

relationship of timeout avoidance to frequency of food delivery that Thomas reported with the results of studies on chained reinforcement schedules. In the chained reinforcement schedule, the animal is required to respond in the presence of one stimulus in order to produce a second stimulus, during which responding results in unconditioned reinforcement. The results of these studies clearly show that the higher the frequency of food delivery in the second component of the chained schedule, the higher the response rate in the first component (Autor, 1960; Findley, 1962). In other words, the more frequently food is delivered in the presence of a stimulus, the more (faster) the animal will respond to produce that stimulus. The present results are consistent with this analysis.

The absence of any effect as a consequence of imposing the response-reinforcement delay argues against the possibility of adventitious food reinforcement of responding. It is difficult to see how the case of adventitious maintenance of the behavior (Herrnstein, 1966) could be sustained without clumsy additional assumptions in view of the systematic relationships shown in Fig. 1 and 2. Features of the data shown in Fig. 3 are also in conflict with an account of these results in terms of adventitious maintenance of the behavior.

The last phase of the experiment explored the effect of removing the timeout avoidance schedule by (a) subjecting the animal to timeout periods regardless of how often it responded (extinction) or by (b) omitting the timeout periods altogether, making it unnecessary for the animal to respond at all, since no timeouts occurred. These two conditions resulted in clearly different response rates (see Fig. 3). Scheduling timeouts independently of responding generated lower rates than did omitting the timeouts altogether. The fact that omitting timeouts controlled lower rates than did the baseline condition of timeout postponement is further evidence that superstitious responding was not being maintained by accidental food reinforcement. Note also that when timeouts were omitted, response rate was close to the rate during timeout during baseline sessions.

Sidman (1953b) offered an explanation of the decrease in response rate that occurs when the R-S interval is short relative to the S-S interval for the shock-avoidance case that could

also give a plausible account of the results obtained by scheduling timeouts independently of responding and omitting timeouts from the schedule. The interpretation centers around a gradient-of-punishment notion. Briefly, the argument is that when timeouts occur independently of responding (or when the interval by which a response postpones a timeout is short relative to the interval between successive timeouts if no response occurs) some responses will be closely followed by timeouts, which results in suppression of the rate due to punishment. It is known that timeout can serve as an effective punishment (Ferster and Appel, 1961). That the rate resulting from scheduling timeouts independently of responding was considerably lower than that when timeouts were omitted is strong evidence for this view. The punishment hypothesis might also clear up the anomalous performance of Rat A6, where complete suppression was observed after the first exposure to the shortest postponement interval. There are occasional cases in the literature where punishment resulted in prolonged suppression of behavior under certain conditions (Storms, Boroczi, and Broen, 1962; Holz, Azrin, and Ayllon, 1963), but it is not very satisfying to invoke these as explanations for the behavior of A6.

REFERENCES

- Autor, S. M. *The strength of conditioned reinforcers as a function of the frequency and probability of reinforcement*. Unpublished doctoral dissertation, Harvard University, 1960.
- Baer, D. M. Escape and avoidance response of pre-school children to two schedules of reinforcement withdrawal. *Journal of the Experimental Analysis of Behavior*, 1960, 3, 155-158.
- Baron, A. and Kaufman, A. Facilitation and suppression of human loss-avoidance by signaled, unavoidable loss. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 177-185.
- Ferster, C. B. Control of behavior in chimpanzees and pigeons by time-out from positive reinforcement. *Psychological Monographs*, 1958, 72, No. 8 (Whole No. 461).
- Ferster, C. B. Suppression of a performance under differential reinforcement of low rates by a pre-time-out stimulus. *Journal of the Experimental Analysis of Behavior*, 1960, 3, 143-153.
- Ferster, C. B. and Appel, J. B. Punishment of S-delta responding in matching to sample by time-out from positive reinforcement. *Journal of the Experimental Analysis of Behavior*, 1961, 4, 45-56.
- Findley, J. D. An experimental outline for building and exploring multi-operant behavior repertoires.

- Journal of the Experimental Analysis of Behavior*, 1962, 5, 113-166.
- 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.
- Holz, W. C., Azrin, N. H., and Ayllon, T. A comparison of several procedures for eliminating behavior. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 407-412.
- Kaufman, A. and Baron, A. Use of withdrawal of reinforcement with the escape-avoidance paradigm. *Psychological Reports*, 1966, 19, 959-965.
- Leitenberg, H. Is time-out from positive reinforcement an aversive event? A review of the experimental evidence. *Psychological Bulletin*, 1965, 64, 428-441.
- McMillan, D. E. A comparison of the punishing effects of response-produced shock and response-produced timeout. *Journal of the Experimental Analysis of Behavior*, 1967, 10, 439-449.
- Morse, W. H. and Herrnstein, R. J. The maintenance of avoidance behavior using the removal of a conditioned positive reinforcer as the aversive stimulus. *American Psychologist*, 1956, 11, 430.
- Sidman, M. Avoidance conditioning with brief shock and no exteroceptive warning signal. *Science*, 1953, 118, 157-158. (a)
- Sidman, M. Two temporal parameters of the maintenance of avoidance behavior by the white rat. *Journal of Comparative and Physiological Psychology*, 1953, 46, 253-261. (b)
- Sidman, M. *Tactics of scientific research*. New York: Basic Books, 1960.
- Storms, L. H., Boroczi, B., and Broen, W. E. Punishment inhibits an instrumental response in hooded rats. *Science*, 1962, 135, 1133-1134.
- Thomas, J. R. Avoidance of time-out from two VI schedules of positive reinforcement. *Journal of the Experimental Analysis of Behavior*, 1964, 7, 168.
- Thomas, J. R. Time-out avoidance from a behavior-independent contingency. *Psychonomic Science*, 1965, 3, 217-218. (a)
- Thomas, J. R. Discriminated time-out avoidance in pigeons. *Journal of the Experimental Analysis of Behavior*, 1965, 8, 329-338. (b)
- Wagner, A. R. Frustrative nonreward: a variety of punishment. In B. A. Campbell and R. M. Church (Eds.), *Punishment and aversive behavior*. New York: Appleton-Century-Crofts, 1969. Pp. 157-181.

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