RESPONSE-DEPENDENT AND RESPONSE-INDEPENDENT TIMEOUT FROM AN AVOIDANCE SCHEDULE¹

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While rats were responding in a single-lever apparatus to avoid electric shock, a signal was presented and followed by a 5-min timeout period when all shocks were omitted. For the response-dependent member of each yoked pair, the first response 60 sec after onset of the pre-timeout signal terminated the signal and initiated timeout. The other, yoked animal was exposed to the same sequence except that signal termination and timeout onset were response independent. Under the response-dependent condition, response rates in the presence of the signal increased relative to baseline rates. Rate increases also occurred when timeout was response independent, but were of lesser magnitude and reliability. Subsequent reversal of the yoking arrangement produced stable and equivalent rate increases under both conditions. Other findings were that increased rates in the presence of the signal diminished when timeout was omitted but were maintained for a time on an avoidance-extinction baseline. In general, the results supported the conclusion of previous experiments that timeout from avoidance can serve as a positive reinforcer. The finding that response-independent presentation of timeout produced rate increases, particularly after a history with response-dependent timeout, was interpreted in terms of adventitious reinforcement of previously established behavior.

Recent interest in timeout has focused on influences of timeout from schedules of positive reinforcement [timeout (reinf)]. A number of experiments have suggested that timeout (reinf) has aversive properties insofar as postponement of timeout (reinf) maintains avoidance behavior (*e.g.*, Baer, 1960; Baron and Kaufman, 1966; Ferster, 1958) and response-contingent onset of timeout (reinf) suppresses behavior (*e.g.*, Baron and Kaufman, 1969; Kaufman and Baron, 1968; McMillan, 1967).

The behavioral effects of timeout from avoidance schedules [timeout (avoid)] are far less well known; only three investigations of timeout (avoid) could be found in the literature. In a series of experiments, Verhave (1962) trained rats on concurrent schedules in which responses on one lever avoided shock and responding on a second lever produced timeout, *i.e.*, an extended period when all shocks were omitted. Under these conditions, the timeout response was acquired and subsequently maintained by ratio and in-

terval schedules of onset of timeout. Similar evidence for the reinforcing properties of timeout was reported by Sidman (1962) in an investigation using monkeys as subjects, and subsequently by Findley and Ames (1965), whose single subject was a chimpanzee.

In the work cited above, shock avoidance and timeout (avoid) were contingent on different responses. Surprisingly, the reinforcing effects of timeout were not revealed when both events were contingent on the same response. In the only experiment using this procedure (Verhave, 1962, Exp. II), each response on a single lever postponed shock, and, in addition, the first response after 15 min produced a 15-min period of timeout when all shocks were omitted. The latter contingency was expected to produce positively accelerated rate changes during the avoidance component of the schedule. But such changes did not appear even after prolonged training and increases in the duration of timeout to 60 min.

The present experiment was designed to investigate further whether timeout (avoid) can strengthen behavior when avoidance and timeout (avoid) are contingent on the same response. In view of the negative results of Verhave's experiment with this procedure, as

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well as the limited number of investigations of timeout using other procedures, such evidence would provide needed support for the hypothesis that timeout can serve as a reinforcing event. In the present experiment, Verhave's procedure was modified in several ways designed to increase sensitivity to the timeout contingency. During each shock-avoidance session, a signal that preceded timeout was presented at irregular intervals; the first response 60 sec after onset of this signal then produced a 5-min period of timeout. Thus, by comparison with Verhave's procedure, the interval that ended with the timeout contingency was shorter, the interval was correlated with a signal, and there was a preceding baseline period when the contingency and signal were absent. The last two features of the procedure permitted evaluation of the reinforcing properties of timeout in terms of changes in response rates from the baseline period when the timeout contingency was absent to the signal period when the contingency was in effect.

A further question, not explored in previous work, concerned the role played by an explicit contingency between responding and timeout (avoid). The assumption that timeout can act as a reinforcer leads to the expectation that the response-dependent procedure, described above, would maximize the controlling effects of timeout. A different possibility, suggested by research concerned with shock-induced conditioned suppression, is that differential reactions to a signal preceding timeout are indicative of classical conditioning, *i.e.*, result from pairing of the signal (CS) with timeout (US). This second possibility leads to the expectation that response-independent presentation of timeout would produce much the same outcome as response-dependent presentation. To study this question, the present experiment used a yoking procedure in which responses by response-dependent subjects also controlled termination of the stimulus and onset of timeout for yoked, response-independent partners.

Additional comparisons of the effects of the response-dependent and response-independent training procedures were made by subsequently reversing the yoking conditions for pairs of subjects. Of interest in this connection is the finding that response-independent presentation of food reinforcers was more effective

in maintaining lever pressing with rats previously trained with response-dependent reinforcement (*i.e.*, conditioned to lever press) than for animals without such a history (Rescorla and Skucy, 1969). On this basis, it might be expected that any strengthening effects of response-independent timeout would be enhanced when this procedure was introduced following a history of response-dependent timeout.

METHOD

Subjects

Seven male rats from the Holtzman Co. (Madison, Wisconsin) were used. They were about three months old when the experiment began and were housed in individual cages with free access to food and water.

Apparatus

Training was conducted in two standard lever-pressing units (Grason-Stadler, E3125A). The subject chamber of each unit, 11.5 by 9.25 by 7.50 in. (29 by 23.5 by 19 cm), was of metal and plastic construction with metal front and rear walls and a grid floor. A single response lever was centered on the front wall. Charging of the grid and front wall with electric shock was from a source that delivered current to different pairs of grid bars and the front wall in rapid alternation (Grason-Stadler, E1064GS). This arrangement, together with the brief durations of the shocks, made unscheduled avoidance of the shocks unlikely. Adjacent to the chamber was a speaker used to present continuous white noise and a lamp that illuminated the chamber. Each chamber was enclosed in a sound-attenuating, ventilated chest.

Procedure

Baseline schedule. Except for the first few days of the experiment, subjects were trained on alternate days, 4 hr per session. The baseline schedule, employed throughout the experiment, was a free-operant avoidance schedule with a shock-shock interval of 5 sec and a response-shock interval of 20 sec, *i.e.*, brief shocks were delivered every 5 sec when the response (lever pressing) did not occur, and each lever press postponed the next shock for 20 sec. The shocks were of 1 mA intensity and 0.2 sec in duration. Lever pressing to avoid the shocks was established initially using shap-

ing procedures in which approximations of a lever press postponed the shocks. Once the avoidance response was established, training was continued for a minimum of 20 hr. The standard procedure for starting each session was first to place the subject in the dark, silent chamber with the avoidance schedule inoperative. With the start of the session, the chamber was illuminated, white noise was continuously presented, and the avoidance schedule was initiated. When the session was over, the avoidance schedule was terminated, and the chamber was made dark and silent until the subject could be returned to its home cage.

Design. For the remainder of the experiment, six of the seven subjects were trained on a yoked basis with the following pairings: S26 and S37; S35 and S28; S38 and S39. The seventh subject, S32, was trained without a yoked partner.

The experiment involved five consecutive phases: (a) Initially, subjects were adapted to the stimulus subsequently used as the pre-timeout signal (pulsation of the background white noise). In addition, in the absence of any signal preceding timeout, they were trained to discriminate periods of timeout (correlated with darkening of the test chamber) from the remainder of the session when the avoidance schedule was operative. (b) During the main phase of the experiment, the pre-timeout signal was scheduled to precede each period of timeout, and onset of timeout was either response-dependent or response-independent, depending upon the yoking assignment. Subsequent phases of the experiment studied responding in the presence of the pre-timeout signal: (c) when timeout was omitted, (d) when the yoking conditions were reversed, and (e) when the baseline avoidance schedule was suspended.

Adaptation to the pre-timeout signal and timeout discrimination training. The stimulus that served as the pre-timeout signal was pulsation of the background white noise at the rate of once per second (on time and off time = 0.5 sec). To eliminate any unconditioned reactions to this stimulus, it was presented at irregular intervals eight times during the last 3 hr of each of a series of 4-hr sessions according to the following procedure: for the response-dependent member of each yoked pair (S26, S35, S38), the first response

occurring 60 sec after onset of the pulsating noise stimulus terminated the stimulus for both subjects. Responses by the yoked, response-independent member of each pair (S37, S28, S39) had no influence on the duration of the stimulus. The seventh, solitary subject (S32) was trained with the response-dependent procedure. Throughout adaptation training, the baseline avoidance schedule was operative at all times; thus, the signal was never associated with timeout during this phase.

The three yoked pairs were given four sessions of adaptation to the pre-timeout signal before discrimination training and four to six additional sessions after discrimination training was completed. The post-discrimination adaptation sessions were omitted for the solitary subject (S32).

From five to 12 sessions were devoted to training the subjects to discriminate the timeout periods from the remainder of the session when the avoidance schedule was operative. Each timeout period lasted 5 min, during which no shocks were scheduled regardless of whether or not the subject responded. To aid in discrimination of the timeout periods, the periods were accompanied by complete darkening of the test chamber. At all other times during the session, when the baseline avoidance schedule was in effect, the chamber was illuminated. During sessions devoted to discrimination training, eight 5-min periods of timeout were presented at irregular intervals during the last 3 hr of each 4-hr session. To be noted is that during the sessions devoted to discrimination training, the pre-timeout signal was not presented.

By the end of signal-adaptation training, all subjects were making equivalent numbers of responses during the signal periods in comparison to the remainder of the sessions. With respect to discrimination of the timeout periods, four of the seven subjects (S28, S35, S38, and S39) formed the discrimination readily within five sessions and by this point, timeout rates averaged less than one-tenth of avoidance rates. The remaining three subjects (S26, S32, and S37) were slower in forming the discrimination and did not do so as effectively. When discrimination training was ended after 12 sessions for these subjects, timeout rates averaged between one-quarter and one-third of avoidance rates.

Signalled timeout. During this, the main phase of the experiment, the pulsating white noise signal preceded each period of timeout. Characteristics of the pre-timeout signal and the timeout periods were as described above, *i.e.*, the pulsating noise signal that preceded timeout had a minimum duration of 60 sec and each timeout period lasted for 5 min, during which all shocks were omitted and the chamber, which ordinarily was illuminated, was darkened. The first response by the response-dependent subjects (S26, S35, and S38) and the solitary subject (S32) 60 sec after onset of the pre-timeout signal terminated the signal and immediately instituted the period of timeout. Responses by the yoked, response-independent members of the pairs (S37, S28, and S39) had no effect on offset of the signal and onset of timeout these events were controlled by the response-dependent members of the pairs. Thus, durations of the pre-timeout signal and the timeout periods always were equivalent for both animals in each yoked pair. Aside from this correspondence, all other aspects of the avoidance schedule were independent of one another. The signal-timeout sequence was presented at irregular intervals, eight times during the last 3 hr of each 4-hr session. A total of at least 30 signalled timeout sessions were conducted on this basis.

Signal alone. Immediately after the signalled timeout phase, and without alteration in the yoking arrangements, subjects were observed for 16 additional sessions with timeout omitted. During these sessions, the pulsating noise stimulus that previously signalled timeout was presented eight times per session, but now was not followed by timeout. As before, responses by the dependent subjects terminated the stimulus and responses by the independent subjects had no influence on the duration of the stimulus.

Signalled timeout with reversal of the yoking conditions. At least 30 additional signalled timeout sessions then were conducted following the procedures of the prior signalled timeout phase. The only change was that the yoking conditions were reversed for the three pairs so that S37, S28, and S39 now were the response-dependent animals and S26, S35, and S38 the response-independent animals. The solitary subject, S32, previously trained with the response-

dependent procedure, was trained with a modified response-independent procedure in which the pre-timeout signal terminated automatically after 60 sec and was followed immediately by timeout.

Signalled timeout (avoid) superimposed on an avoidance extinction baseline. Finally, without further reversals of the yoking arrangements, training was continued for 30 additional sessions with the three pairs of subjects (S32 was not studied) using an avoidance-extinction baseline. The procedure was altered so that the shock-avoidance schedule was operative only for the first 30 min of each 4-hr training session; for the remainder of the session all shocks were omitted. This modified extinction procedure was designed to retard weakening of the baseline response. During the extinction phase, other aspects of the signalled timeout procedure and the yoking arrangement were maintained, *i.e.*, the pulsating noise signal was followed by darkening of the chamber (the stimulus previously correlated with timeout for 5 min contingent upon the response-dependent animal's first response 60 sec after onset of the signal. A minor procedural change was that the pre-timeout signal was automatically terminated and darkening of the chamber started 2 min after onset of the signal, if the response-dependent member of the pair had not responded by this time.

Worth nothing is that the correlation between darkening of the chamber and timeout was not completely eliminated during this phase; the standard procedure for starting each session involved placing the subject in the darkened chamber until the avoidance schedule (and illumination) could be initiated.

RESULTS

The results are summarized in Fig. 1 to 4 which show each subject's rates of response on each day of the experiment. Plotted points represent average daily rates during the 60-sec period immediately preceding the stimulus (baseline), during the 60-sec period following onset of the pre-timeout signal, and during the 5-min timeout period.

The first panel of each of the figures shows that by the end of the signal adaptation phase, rates of response during baseline and signal periods were approximately equal.

Fig. 1. Average response rates of S26 and S37 during the stimulus periods, the baseline periods (BL), and the periods of timeout from avoidance (TO) on each day.

Fig. 2. Average response rates of S35 and S28 during the stimulus periods, the baseline periods (BL) and the periods of timeout from avoidance (TO) on each day.

As may be seen in the second panels of the figures, introduction of the signalled timeout procedure had major influences on respond-

ing in the presence of the pre-timeout signal, depending on whether timeout was response dependent or response independent. The

Fig. 3. Average response rates of S38 and S39 during the stimulus periods, the baseline periods (BL) and the periods of timeout from avoidance (TO) on each day.

Fig. 4. Average response rates of S32 during the stimulus periods, the baseline periods (BL), and the periods of timeout from avoidance (TO) on each day.

four subjects trained with the response-dependent procedure (S26, S35, S38, and S32) responded at higher rates in the presence of the signal of timeout than during the baseline period. Although the extent of rate increases to the signal varied somewhat from subject to subject, all four response-dependent sub-

jects showed reliable increases above baseline levels and these increases were maintained to the end of the phase.

By comparison with the response-dependent subjects, the three subjects trained initially with the response-independent procedure (S37, S28, and S39) also showed increased respond-

ing in the presence of the signal, but differences between signal and baseline rates were not as substantial or reliable. Among the three response-independent subjects, S39 showed the clearest indication of rate increases, while S37 showed little or no differential responding except at the very end. The third subject, S28, showed differences between signal and baseline rates midway in training but these differences were not maintained.

When the procedure was changed so that timeout periods were omitted (third panel), previous differences between signal and baseline rates were progressively reduced. An exception may be seen in the case of S37, whose day-to-day rates became very variable during this phase.

The fourth panel of the figures summarizes performances when the signalled timeout procedure was reinstated in conjunction with reversal of the yoking arrangement in the paired subjects, and, in the case of S32, introduction of the response-independent condition. When the three subjects trained initially under the response-independent condition were exposed to the response-dependent condition (S37, S28, and S39), consistent and substantial rate increases developed in the presence of the pre-timeout signal. The magnitude of these increases during the response-dependent condition exceeded any increases previously manifested during prior training under the response-independent condition. The four subjects switched from the response-dependent condition in the earlier phase to the response-independent procedure (S26, S35, S38, and S32) also showed consistent and reliable increases in rate at magnitudes in the ranges previously manifested, except for S32, which showed some decrease as training was continued.

The final panels of Fig. 1 to 3 (extinction) show outcomes when the signal and the timeout stimulus were superimposed on the avoidance-extinction baseline. It is apparent that response rates in both the presence and absence of the signal decreased in the three pairs, but also that rates remained higher in the presence of the signal than in its absence. The last panel also suggests that responding in the presence of the signal was somewhat better maintained under the response-dependent condition than under the response-independent condition.

A final aspect of the data summarized in Fig. 1 to 4 concerns responding during the timeout periods. The figures show that such responding generally remained at low levels throughout the experiment. Further, it can be seen that there was no systematic relationship between the extent of rate increases in the presence of the signal of timeout and rates of response during the timeout periods themselves.

The results were examined also from the standpoint of numbers of shocks received during the various phases of the experiment. Throughout, avoidance responding during the baseline periods led to receipt of about 2% of the shock-shock scheduled shocks on the average (range = 0.1% to 6.7%). During the initial signal-adaptation phase, there was little or no difference between shock rates during the baseline and signal periods. Subsequent increases in responding when the signal preceded timeout had the effect of reducing the number of shocks received during the signal periods in comparison to the baseline periods. Such reductions, although small, were observed in all seven subjects, and were present under the response-independent condition as well as the response-dependent condition.

DISCUSSION

The results support the general conclusion reached by previous investigators of timeout (avoid) (Findley and Ames, 1965; Sidman, 1962; Verhave, 1962) that onset of a period of timeout (avoid) has reinforcing properties. The basis for this conclusion in the present study may be seen in performances under the response-dependent condition when onset of timeout was contingent on responding in the presence of the pre-timeout signal. Substantial increases in response rate developed during the signal periods and were maintained for an extended series of sessions. Additional evidence for the reinforcing properties of timeout was provided by the finding that heightened rates during the signal periods tended to diminish when the contingency between responding and timeout was removed by omitting timeout.

It is not clear why Verhave (1962, Exp. II) did not observe control by response-contingent timeout (avoid) with procedures generally similar to the present ones, *i.e.*, concurrent sched-

uling of avoidance and fixed-interval timeout (avoid) contingent on the same response. Procedural modifications in the present experiment, which may have contributed to differences in outcome, include use of a shorter fixed interval (1 min rather than 15 min) and a discriminative stimulus (the pre-timeout signal) accompanying the interval that ended with the timeout contingency.

In addition to the present finding of rate increases when timeout (avoid) was response dependent, the results also indicated increases when timeout (avoid) was presented independently of responding, particularly when the response-independent condition was preceded by response-dependent training. As suggested earlier, a possible account of such increases is that they reflected in some way classically conditioned reactions in anticipation of the period of timeout. Leitenberg (1966), for example, offered such an explanation of his finding that response rates increased in the presence of a signal of response-independent timeout (reinf) superimposed on a baseline of positive reinforcement.

A different and perhaps simpler account stresses the role of adventitious associations between responding and timeout (avoid) as well as the subject's history of such associations. Studies using positive reinforcers have shown that when response-independent positive reinforcement occurs periodically in the absence of a dominant response, the behavior that is strengthened varies idiosyncratically among subjects, presumably because a variety of responses may occur just before the reinforcing event is applied (Skinner, 1948). By comparison, when response-independent reinforcement occurs in conjunction with an already strengthened response, that response is maintained in preference to others, presumably because of its high probability at the time of reinforcement (Herrnstein, 1966).

The present results suggest similar outcomes when timeout (avoid) is related adventitiously to responding. Thus, when response-independent timeout was introduced as the initial condition, *i.e.*, at a point when increased responding in the presence of the stimulus was not well established, only irregular tendencies for increased responding developed. By comparison, when response-independent timeout was introduced following extended prior training with response-depen-

dent timeout, *i.e.*, at a point when increased responding had developed previously, increased rates were maintained at a high level. This finding bears similarity to the previously-cited study by Rescorla and Skucy (1969), as well as to one by Zeiler (1968), which showed that pigeons with a history of fixed-interval food reinforcement maintained the fixed interval pattern of responding when reinforcement was presented independently of responding at the same temporal intervals.

A question raised by the results concerns whether onset of timeout (avoid) was the sole source of reinforcement for increased responding. To be noted is that when both shock avoidance and timeout are scheduled concurrently on the same response, responding not only produces timeout, but also may have the consequence of reducing the local as well as long-term density of avoidable shocks. In this connection, the present results did indicate that rate increases during the signal periods reduced the number of shocks received in the presence of the signal. Thus, the possibility cannot be discounted that such local reductions in shock density may have contributed to the increased responding that was observed. The results made it clear, however, that local density reductions were not essential for increased responding because increased responding also occurred on an avoidance-extinction baseline during the final phase of the experiment.

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