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THE EFFECT OF TIMEOUT ON PERFORMANCE ON A VARIABLE-INTERVAL SCHEDULE OF ELECTRIC-SHOCK PRESENTATION[1]

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Responding was maintained in squirrel monkeys under variable-interval schedules of electric shock presentation when a period of timeout followed each response-dependent shock. Response rate decreased when timeout duration was decreased, and responding ceased when timeout was eliminated. These results indicate that under certain conditions, a shock-free period following each response-produced shock is necessary to maintain responding.

Recent studies have demonstrated that animals with specific types of behavioral histories will continue to respond when the only consequence of responding is the occasional presentation of a brief, intense electric shock (Byrd, 1969, 1972; Kelleher and Morse, 1968; McKearney, 1968, 1969, 1970, 1972; Morse, Mead, and Kelleher, 1967; Stretch, Orloff, and Dalrymple, 1968; Stretch, Orloff, and Gerber, 1970). The response patterns of monkeys and cats under such contingencies are remarkably similar to performances generated by schedules of food or water presentation.

Previous accounts of responding maintained by response-produced shock (*e.g.*, McKearney, 1969; Morse and Kelleher, 1970) have emphasized the invariant behavioral patterns that result when different environmental events are arranged according to identical scheduling conditions. Indeed, the concept of "schedules as fundamental determinants of behavior" (Morse and Kelleher, 1970) forces a reconsideration of the traditional distinction between "positive" and "negative" reinforcers, *i.e.*, between events such as food, whose onset normally acts as a reinforcer, and electric shock, whose offset normally acts as a reinforcer.

In some studies that have demonstrated maintained responding on schedules of response-produced shock, both shock and a period of time relatively free from shock were contingent on responding: the typical, periodic (fixed-interval) schedules generated discontinuous response rates, with the animals pausing for about half the fixed-interval before responding resumed. This pause may be taken as an indicator of a "functional timeout". Timeout (TO) from schedules of shock presentation has been shown to be reinforcing (*e.g.*, Sidman, 1962; Verhave, 1962). The maintenance of responding on response-dependent shock schedules could therefore be due to the response-contingent period of time free of shock, rather than to the shock that precedes it. In the present experiment, the effect of timeout duration on responding under a variable-interval schedule of shock presentation was studied.

METHOD

Subjects

Four experimentally naive adult squirrel monkeys (*Samiri sciureus*) were housed individually and treated according to the general specifications described by Kelleher, Gill, Riddle, and Cook (1963). Food and water were available at all times in the monkeys' home cages.

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Apparatus

Experimental sessions were conducted with individual monkeys seated in a restraining chair similar to that described by Hake and Azrin (1963). The restraining chair was located in an experimental chamber, where extraneous sounds were masked by white noise and an exhaust fan. Shock could be delivered through electrodes taped to a shaved portion of the tail. Electrode paste (Burdick Co.) was applied to the tail to ensure a low-resistance electrical contact with the electrodes. The response key was 9 cm above the waist plate of the chair and 9 cm below a red cuelight located on a panel facing the monkey. Each depression of the key with a force of at least 0.15N was recorded as a response and resulted in a "click" from a feedback relay in the chamber and a 50-msec offset of an otherwise continuously present cuelight and 25-W overhead houselight. All scheduling and recording functions were performed by electromechanical equipment located in an adjacent room.

Procedure

The monkeys were initially trained to respond by reinforcing a lever depression with the interruption, for a period of 15 sec, of a train of brief electric shocks that were otherwise scheduled to occur every 3 sec. Subsequently, the animals were trained on a continuous avoidance schedule (Sidman, 1953). Electric shock was scheduled to occur every 10 sec, but each response postponed the occurrence of the next shock for 30 sec. Sessions were 100 min long, and were conducted seven days a week.

After 10 sessions of the avoidance schedule, a constant-probability variable-interval 2-min (VI 2-min) schedule (Catania and Reynolds, 1968; 10 intervals) of response-dependent shock was arranged concurrently with the avoidance schedule. Under this arrangement, the avoidance schedule remained in effect, but the first response occurring after a variable period of time averaging 2 min produced a shock. The occurrence of a response-dependent shock was followed by a 60-sec blackout of cuelight and houselight (the timeout period), during which responding had no scheduled consequences. After 15 additional sessions, the avoidance schedule was eliminated, and the monkeys responded under the VI 2-min schedule with timeout for 15 sessions. Shock intensity was held constant at 6.0 mA and shock duration at 30 msec.

Table 1

Schedules of shock delivery and corresponding sessions for the first two phases of the experiment.

Schedule	*Monkeys* SF	NW	BB
Phase I			
avoidance	1-10	1-10	1-10
concurrent avoidance,			
VI 2-min, 60-sec TO	11-25	11-25	11-25
VI 2-min, 60-sec TO	26-40	26-40	26-40
VI 2-min, 20-sec TO	41-45	41-45	
VI 2-min, 60-sec TO	46-50	46-50	
VI 2-min, 10-sec TO	51-55	51-55	
VI 2-min, 60-sec TO	56-60	56-60	
VI 2-min, 150-sec TO	61-65		
VI 1-min, 60-sec TO		61-65	
VI 2-min, 0-sec TO	66-70	66-70	41-44
VI 2-min, 0-sec TO (limited-hold, 15-sec)			45-46
VI 2-min, 60-sec TO (limited-hold, 15-sec)			47-50
Phase II			
			Monkey HB
avoidance			1-10
concurrent avoidance,			
VI 2-min, 60-sec TO			11-25
VI 2-min, 60-sec TO			26-40
VI 2-min, 60-sec TO (timeout cue faded)			41-55
VI 2-min, 60-sec TO (timeout cue eliminated)			56-65
VI 2-min, 0-sec TO			66-75
VI 2-min, 0-sec TO (limited-hold, 15-sec)			76-80
VI 2-min, 60-sec TO (limited-hold, 15-sec)			81-90

Phase I. Table 1 summarizes the conditions, their order of occurrence, and the number of sessions devoted to each condition for the first two phases of the present experiment. In the first phase, the effects of varying the duration of timeout following each response-dependent shock were examined. Two monkeys, one male (Monkey SF) and one female (Monkey NW), were exposed to five-day alternations between the initial 60-sec TO and shorter timeout values. Immediately before the 0-sec condition (Session 61), Monkey SF was exposed to a 150-sec TO for five sessions, while Monkey NW was exposed to a VI 1-min schedule with a 60-sec TO, also for five sessions. After experimentation with SF and NW was complete, a third animal (Monkey BB) was introduced and exposed to the 60-sec and 0-sec TO conditions in Phase I. For Monkey BB, an attempt was made to recover responding by exposing the animal to the following response-independent shock contingency: if no response occurred by the fifteenth second after the shock had become available, the shock was delivered independently of any response by the animal. After two sessions, the 60-sec TO was re-introduced (Sessions 47 to 50).

Phase II. Following a training sequence identical to that employed in Phase I for Monkeys SF, NW, and BB (*i.e.,* 10 sessions of avoidance; 15 sessions of concurrent avoidance and VI 2-min response-dependent shock with a 60-sec TO; 15 sessions of VI 2-min response-dependent shock schedule with a 60-sec TO), the signal accompanying the 60-sec TO was gradually removed for Monkey HB by progressively brightening the chamber lights during the next 15 sessions. After the timeout signal was eliminated, behavior was maintained on the VI 2-min response-dependent shock schedule with an unsignalled 60-sec period of "timeout" for an additional 10 sessions. The unsignalled 60-sec "timeout" was then removed. After 10 sessions, the 15-sec response-independent shock contingency was instituted, and five sessions later, the unsignalled "timeout" was re-instated.

Phase III. After Phases I and II, Monkeys BB and HB were retrained under a continuous shock-avoidance schedule (Sidman, 1953) of S-S 10, R-S 30 for 10 sessions. Subsequently, the animals were exposed to a training sequence resembling McKearney's (1972): concurrent avoidance, fixed-time (FT) 10-min shock; FT 10-min shock alone; concurrent avoidance, VI 3-min response-produced shock; VI 3-min response-produced shock alone. Intervals comprising the VI schedule were identical to those used by McKearney (1972). Shock intensity (5.0 mA) and duration (30 msec) were held constant throughout this sequence.

RESULTS

Phase I. All three monkeys maintained patterns of constant responding characteristic of VI schedules of positive reinforcement, with little or no responding occurring during the timeout period. These data are summarized in Figure 1, where bars correspond to the

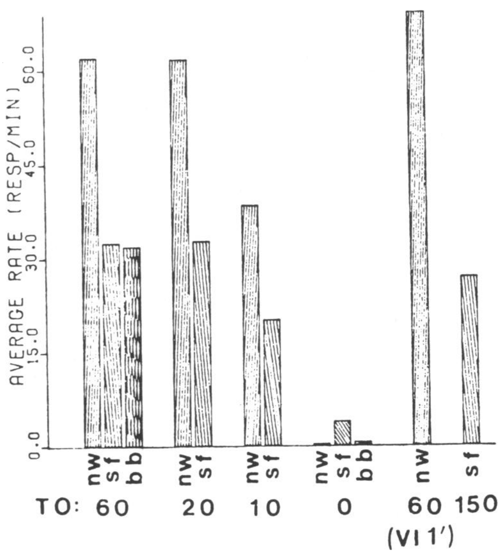

Fig. 1. Average response rate during the last three sessions of each condition. All three baseline conditions are averaged and presented over the "60-sec TO" label.

average rates during each of the three baseline (60-sec TO) conditions, and to the rates during the 20-, 10-, and 0-sec TO conditions. Since rates during the last baseline condition were slightly lower than during the previous two 60-sec TO conditions, the small (15%) decrease in rate between the first baseline and the 20-sec TO condition is not apparent in Figure 1. Figure 1 does, however, give a clear picture of the subsequent trend: a decrease in response rates to half the baseline rates when TO was shortened to 10 sec, and a final decrease to near-zero rate when the TO was eliminated. Of the few responses made during the 0-sec TO condition, many occurred immediately after a shock. Response rates during the 150-sec TO and the VI 1-min, 60-sec TO were near baseline levels.

Figure 2 shows the transition in Monkey BB's performance from the 60-sec TO (Session 40) to the 0-sec TO (Session 41) conditions. For this monkey, as for NW and SF, deletion of timeout had a clearly deleterious effect upon performance.

After timeout was eliminated for Monkey BB, responding was recovered by resetting the timeout to 60 sec and introducing the response-independent shock contingency described previously. Figure 3 shows the suppression and recovery of responding that resulted when the 60-sec TO was eliminated and re-instated. The low response rate in Sessions 45 and 46 indi-

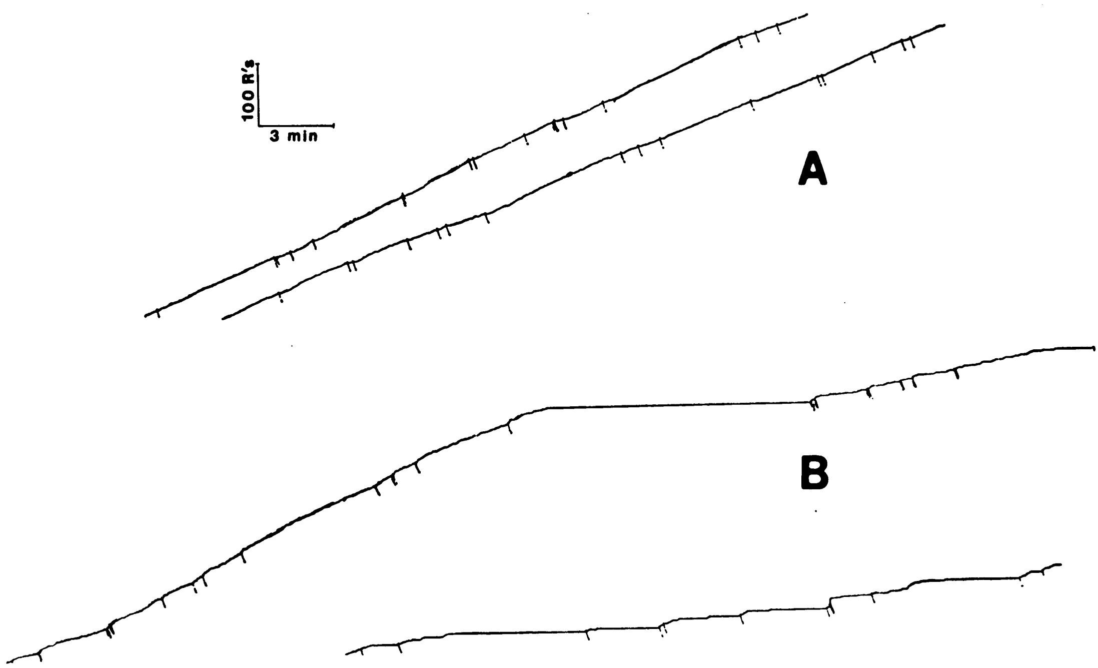

Fig. 2. Transition in Monkey BB's performance from 60-sec TO (A) to the 0-sec TO (B) conditions. A slash marks the occurrence of shock alone in (B). The cumulative recorder did not operate during timeout. Sessions 40 and 41 are represented in this figure.

cates that the response-independent shock contingency by itself was ineffective, and the elevated rates in Sessions 47 to 50 indicate the reinforcing effect of timeout.

Phase II. After the timeout signal was eliminated for Monkey HB, behavior was maintained at an average of 51 responses per minute for 10 days (Sessions 56 to 65). Pausing after each response-dependent shock began to appear by the third session (see Figure 4), indicating the development of a temporal discrimination not unlike that typically found under periodic schedules (*cf*. Byrd, 1972). The 60-sec "unsignalled timeout" was removed from the schedule after the tenth session, and within seven days response rate fell to zero (see Figure 5). Attempts to recover baseline responding through use of the response-independent shock contingency (Sessions 76 to 80), or the response-independent shock contingency plus

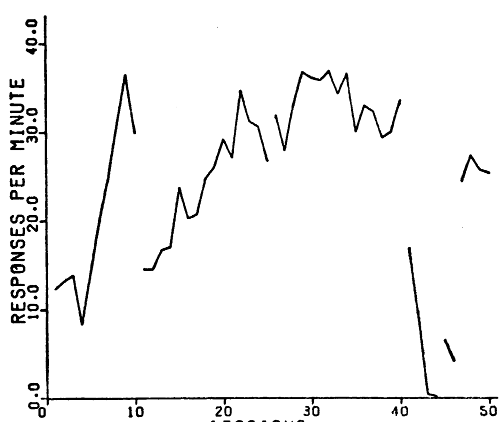

Fig. 3. Response rate throughout Phase I for Monkey BB. Consult Table 1 for contingencies.

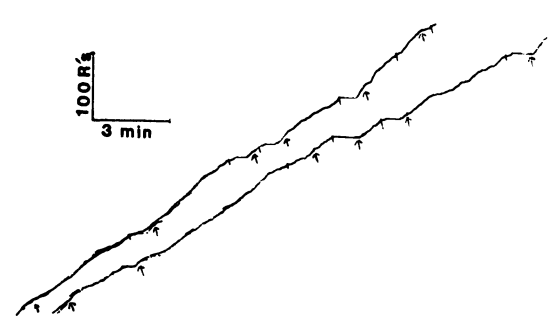

Fig. 4. Portion of a typical performance generated under a VI 2-min schedule of shock presentation with an unsignalled 60-sec timeout (Session 35, Monkey HB). A slash marks the occurrence of shock and the onset of timeout, an arrow the end of timeout. Note the presence of pausing in timeout, even though the timeout period was not explicitly signalled to the animal.

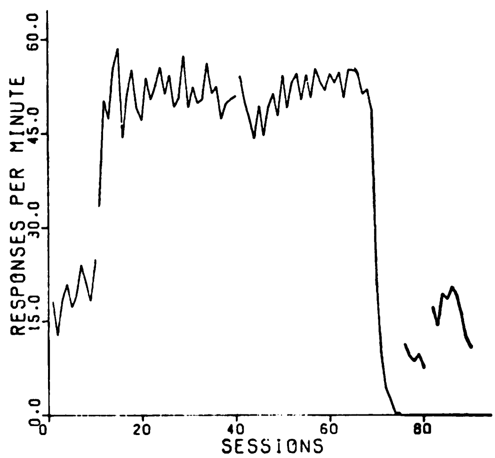

Fig. 5. Response rate throughout Phases I and II for Monkey HB. Consult Table 1 for contingencies.

Table 2

Schedules of shock delivery, sessions, and average responses per minute from the last two sessions of each condition under Phase III.

Schedule	Monkey BB Sessions	Monkey BB Rate	Monkey HB Sessions	Monkey HB Rate
avoidance	51-60	9	91-100	34
concurrent avoidance, fixed-time 10-min	61-70	26	101-110	65
avoidance	71-74	15	111-114	52
concurrent avoidance, fixed-time 10-min	75-77	26	115-117	75
fixed-time 10-min	78-80	20	118-120	55
avoidance	81-87	15	121-127	41
VI 3-min	88-96	4	128-136	8
concurrent avoidance, VI 3-min	97-101	38	137-141	79
VI 3-min	102-106	5	142-146	10

an unsignalled "timeout" (Sessions 81 to 90), were unsuccessful.

Phase III. Table 2 shows the average rate of responding for Monkeys BB and HB during the last two sessions at each step of the systematic replication of McKearney's (1972) experiment with VI response-dependent shock. As can be seen, responding decreased substantially when the concurrent avoidance schedule was eliminated.

DISCUSSION

The above experiments indicate that under certain conditions (1) responding can be maintained in the squirrel monkey under variable-interval schedules of response-dependent shock when a period of timeout follows the delivery of each shock, (2) response rates vary directly with the duration of the timeout period, and (3) responding is not maintained when the timeout is eliminated from the variable-interval schedule. In the various phases of the experiment, we attempted to examine a number of potential interpretations of the results. It might, for instance, be suggested that the decreases in response rate that accompany decreases in timeout duration are a manifestation of "generalization decrement" that occurs when testing conditions depart too widely from training conditions. To evaluate such an interpretation, Monkey SF was exposed to a 150-sec TO before the 0-sec TO condition. If the generalization-decrement interpretation is correct, we should expect a decrease in response rate under the 150-sec condition. Figure 1 shows, however, that there was no decrease in the response rate from that obtained on the prior 60-sec TO condition.

Another possible interpretation of the present data might attribute the response-rate decrements that accompany timeout omission to the increase in shock frequency that is concomitant with timeout omission, rather than to the omission of timeout *per se*. This possibility was examined by shifting Monkey NW to a VI 1-min schedule while timeout was held constant at 1 min. Under this arrangement, shocks occurred every 2 min on the average, the same frequency as that obtained under the VI 2-min schedule with no timeout. Figure 1 shows that, under these conditions, response rate increased rather than decreased.

It also appeared possible that the abrupt change in stimulus conditions that occurred concomitantly with timeout omission might have been responsible for the observed reduction in responding. In Phase II, this notion was tested by maintaining responding on a variable-interval schedule of response-dependent shock with an *unsignalled* period of timeout following each shock presentation. Figure 5 shows that responding was maintained under these conditions, and then, upon removal of the "unsignalled timeout", quickly decreased. The re-introduction of the unsignalled timeout, however, did not by itself bring about a sustained elevation of response rate.

Another potential interpretation of the present data is that, in order to maintain behavior on variable-interval response-dependent shock schedules, it is necessary to follow each shock with a period of time relatively free from shock. However, McKearney (1972) reported responding maintained in squirrel monkeys under a VI 3-min response-dependent shock schedule without an arranged period of time-out. Subtle differences in experimental procedure between the present study and that of McKearney are probably responsible for the contrasting results. Clearly, any conjecture on our part regarding procedural differences and their potential effects can only be speculative; more research will be needed to uncover the causes of this apparent discrepancy in experimental data. Nevertheless, it is worth examining some of the differences between the two experiments.

One salient difference lies in the experimental histories of the subjects in the two studies before the response-dependent shock schedules were introduced. McKearney's monkeys "... had both been used in various experiments involving schedules of food presentation . . ." (McKearney, 1972, page 426); the present animals entered the study experimentally naive. The crucial role of the individual organism's behavioral history in determining the effects that schedules of electric shock presentation will have in suppressing or maintaining responding (*cf.* Morse and Kelleher, 1970) lends credibility to this difference in accounting for the divergent outcomes of the two studies.

Another likely candidate is the difference in feedback stimuli provided after each response: a brief (50 msec) flicker of the cue and houselight in the present study, in contrast to a relay click in McKearney's study. Although it has been demonstrated that feedback stimuli of extended duration can come to exert considerable control over responding (*cf.* Hake and Azrin, 1969), the brevity of the stimuli used in McKearney's study and the present one makes it unlikely that feedback alone accounts for the differences obtained.

Other currently identified differences include the following: the shortest interval on McKearney's schedules was longer than that arranged on the constant-probability schedules (Catania and Reynolds, 1968) of the present study; differing shock intensities (6.0 mA in the present study; 5.0 mA in McKearney's) and durations (30 msec in the present; 200 msec in McKearney's study); and possible differences in the restraining chairs employed—although the devices in both experiments were constructed in accordance with the specifications described by Hake and Azrin (1963). But these differences appear to be small; certainly further research must determine those that are truly essential.

The facilitation of behavior by response-dependent electric shock is an anomalous phenomenon, in that suppression of behavior (*i.e.,* "punishment") is the rule under most similar conditions. The exact reinforcement history necessary to produce facilitation has not yet been specified, although simple training procedures appear sufficient (see, *e.g.,* Morse and Kelleher, 1970). Nor has there been any specification of the training that will best discourage or reverse facilitation. The contrasting results of the present experiment and those of McKearney (1972) are perhaps due to one or more of the procedural differences identified above, or to other aspects of the preliminary training procedure yet to be identified. One thing is clear at this point: the present procedure is one way to avoid getting monkeys into a situation where response-dependent shocks will maintain rather than suppress responding.

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