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A COMPARISON OF THE PUNISHING EFFECTS OF RESPONSE-PRODUCED SHOCK AND RESPONSE-PRODUCED TIME OUT[1]

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Electric shock and time out were compared as punishers in the squirrel monkey. At the parameters investigated, both suppressed responding to about the same degree. Scheduling punishment intermittently or administering pentobarbital reduced the effectiveness of both punishers. The effects of the punishers were different in that responding suppressed by shock recovered more within a session than responding suppressed by time out. Responding was suppressed after some shock-punishment components, but less often after time-out–punishment components. The similarities of the two punishers were more striking than the differences.

CONTENTS

Electric shock as a discriminative stimulus can either increase or decrease behavior (Holz and Azrin, 1962; McMillan and Morse, 1967). Electric shock also can decrease behavior by punishing the responses that produce it (Azrin, 1956) or maintain behavior that avoids it or terminates it (Sidman, 1953; Winograd, 1965; Morse and Kelleher, 1966).

Few studies have investigated the extent to which the properties of time out (an extinction period correlated with specific stimuli) are comparable to those of electric shock. Like electric shock, time out maintains the behavior which avoids or terminates it. Ferster (1958) showed that chimpanzees will press a lever to avoid time out. Wagner (1963) reported that rats will cross a hurdle to terminate stimuli associated with non-reward.

In contrast to the similar manner in which shock and time out maintain the behavior which avoids or terminates their occurrences, shock and time out have different properties when they are response-produced. Response-produced shock suppresses the rate of responding, but response-produced time out can increase or decrease the rate of responding (Herrnstein, 1955; Ferster, 1958). Leitenberg (1965), in a review of the literature, concluded that response rate increased in the presence of a stimulus correlated with response-produced time out and decreased in the presence of a stimulus correlated with response-produced shock.

Holz, Azrin, and Ayllon (1963) emphasized another difference between the punishing effects of shock and time out. When every 10th response of mental patients working for cigarettes was followed by time out, responding gradually was suppressed. The gradual suppression of behavior by response-produced

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time out is in contrast to the many reports of rapid suppression following response-produced shock.

Numerous properties of response-produced electric shock and response-produced time out have been compared. For example, if the intensity of a punishing electric shock is mild, the decrease in response rate lessens over time (Azrin, 1956; Rachlin, 1966). Ferster (1958) punished rapidly emitted responses with time out and found that time out initially depressed the rate of responding below the value necessary to avoid punishment. However, during subsequent sessions, rate increased (although there was no significant increase in the number of punished responses). Thus, the suppressive effects of both shock and time-out punishment may decrease over time.

Another interesting characteristic of time out and electric shock as punishers is their effectiveness after drugs have been given. Geller and Seifter (1960) and Kelleher and Morse (1964) reported that certain barbiturates will increase the number of responses punished by electric shock which an animal will emit. The drug-induced increases in punished responding in these studies should not be confused with the effects of barbiturates in the procedure established by Estes and Skinner (1941). In the Estes-Skinner procedure, electric shock occurred at the end of a preshock stimulus, but responses did not produce the shock. Kelleher and Morse (1964) have reviewed literature indicating that the effects of drugs on the Estes-Skinner procedure are quite variable, compared to the response-produced shock procedure.

The present experiments compared response-produced time out and response-produced electric shock as punishers in squirrel monkeys. In the presence of one stimulus, responses were punished by electric shock; in the presence of another stimulus, responses were punished by time out. A number of properties of the two punishers used were compared.

METHOD

Subjects

Two experimentally naive squirrel monkeys (S60 and S78), weighing between 800 and 900 g when given free access to food and water, were used. S60 was maintained at 80% of free feeding weight and S78 at 70% throughout the experiments.

Apparatus

A restraining chair (Hake and Azrin, 1963) held the monkey in a seated position by a waist lock; its tail was held motionless by a small stock. Electric current could be delivered through two hinged brass plates resting lightly on a shaved portion of the tail.

The response lever (Lehigh Valley Electronics rat lever, LVE, 1352) was mounted on the left side of the front panel facing the monkey; when the lever was pressed with a force of 30 g or more, a response was recorded and produced an audible click of a relay. Centered in the front panel was a circular recessed opening through which a solenoid-operated dipper provided access to 0.25 ml of liquid food (Ellison and Riddle, 1961) for 3 sec. During food delivery, the recessed opening was illuminated by two 6-w bulbs. The entire chair was enclosed in a ventilated, sound-attenuating chamber illuminated by a 25-w bulb. White noise was always present.

Mounted behind the transparent front panel of the restraining chair were six colored (2 red, 2 white, and 2 blue) 7.5-w bulbs which, when lighted, served as discriminative stimuli. During the variable-interval schedule of food presentation, the 25-w bulb was lighted, but the colored bulbs were not. During the schedule component when responses produced electric shock, the two red bulbs were lighted; when responses produced time out, the two blue bulbs were lighted. For a few sessions early in the training of S60, two white bulbs were used to indicate a period of extinction.

During time out (after a response in the presence of the blue stimulus lights) the experimental chamber was totally dark and reinforcement was not available. Occasionally, the response which produced a time out also produced reinforcement (concurrent with the first 3 sec of the time out).

The electric shock was 110 v ac, 60 cps, delivered to the brass plates through a series resistance. The range of shock was 1 to 3 ma delivered across the tail for 30 msec.

Conventional relay programming and recording equipment were used. Variable-interval food presentation was programmed from two independent sources, one during the punishment components and the other

during their absence. This prevented reinforcements from "carrying over" from one component, where responding had been suppressed, to the next component.

EXPERIMENT 1: INTRODUCTION OF BOTH PUNISHMENT COMPONENTS IN A SINGLE SESSION. MONKEY S78

Procedure

The lever pressing of S78 was first shaped with food as a reinforcer; the schedule was then changed so that responses were reinforced at irregular intervals on the average of once every minute (VI 1-min) for 21 sessions. In Session 22, after 10 min of VI 1-min, the red light was turned on. Each response in the presence of the red light produced a 1.0-ma electric shock of 30 msec to the monkey's tail. The shock-punishment component lasted 4 min. After an additional 10 min of VI 1-min, the blue light was turned on. Each response in the presence of the blue light resulted in 40 sec of time out (total darkness), after which the remaining portion of the 4-min time-out–punishment component continued.

Results

The VI 1-min schedule generated a steady rate of responding as a baseline for the evaluation of shock and time out as punishers. Figure 1 shows the cumulative response records of S78 on the first two days after the punishment components were introduced. In Session 22, both response-produced shock and response-produced time out suppressed the VI response rate almost immediately, and to about the same extent.

EXPERIMENT 2: INTRODUCTION OF PUNISHMENT COMPONENTS IN DIFFERENT SESSIONS AND A TEST OF THE SUPPRESSIVE EFFECTS OF THE RED LIGHT WITHOUT A SHOCK-PUNISHMENT CONTINGENCY. MONKEY S60

Procedure

The lever pressing of S60 was first shaped with food as a reinforcer; the schedule was then changed so that responses were reinforced at irregular intervals on the average of once every 1.5 min (VI 1.5-min). After stable performance developed on VI 1.5-min (Session 11), a new schedule alternated periods of VI 1.5-min with periods of extinction in the presence of a white light. The extinction condition was eliminated in Session 20 when it was decided to change the nature of the problem being investigated. The extinction condition should not be confused with the time out used later in the experiments. The time out was a period of total darkness, not a period in the presence of the extinction stimulus.

In Session 14, after 5 min of the VI schedule, a red light was introduced, during which the VI schedule was still in effect. After 2 min the red light was terminated and 5 more min of the VI 1.5-min schedule were presented. The second VI period was followed by 2 min in the presence of the white light correlated with the extinction schedule. The cycle was repeated five times. The red light was introduced in this manner to determine if it had any suppressive effect on VI response rate.

In the next session (Session 15) each response in the presence of the red light delivered 30 msec of 1.5-ma shock to the monkey's tail. The schedule of food presentation remained in effect except during the extinction stimulus. Reinforcement during the shock-punishment component was programmed independently of reinforcement during non-punishment components.

After Session 17, the VI component was increased to 10 min and the shock-punishment and extinction components were increased to 4 min.

After Session 20, the extinction condition in the presence of the white light was eliminated and replaced by a response-produced time-out component (time-out–punishment component). Any response in the presence of a blue light produced a 20-sec period of total darkness. During each cycle (VI 1.5-min, time-out–punishment component, VI 1.5-min, shock-punishment component) the blue light was on for 4 min. A response in the presence of the blue light produced a 20-sec time out in total darkness, after which the remaining portion of the time-out–punishment component continued. Thus, within each cycle, 4 min of the blue light occurred; the 4 min of blue light usually occurred over a much longer period of time, since it was often interrupted by responses which produced 20-sec time outs.

Results

Introduction of the red light. In Session 14, the red light was introduced, but responses in its presence did not produce shock. The VI schedule was still in effect during the red light. The rate of responding in the presence of the red light differed very little from the

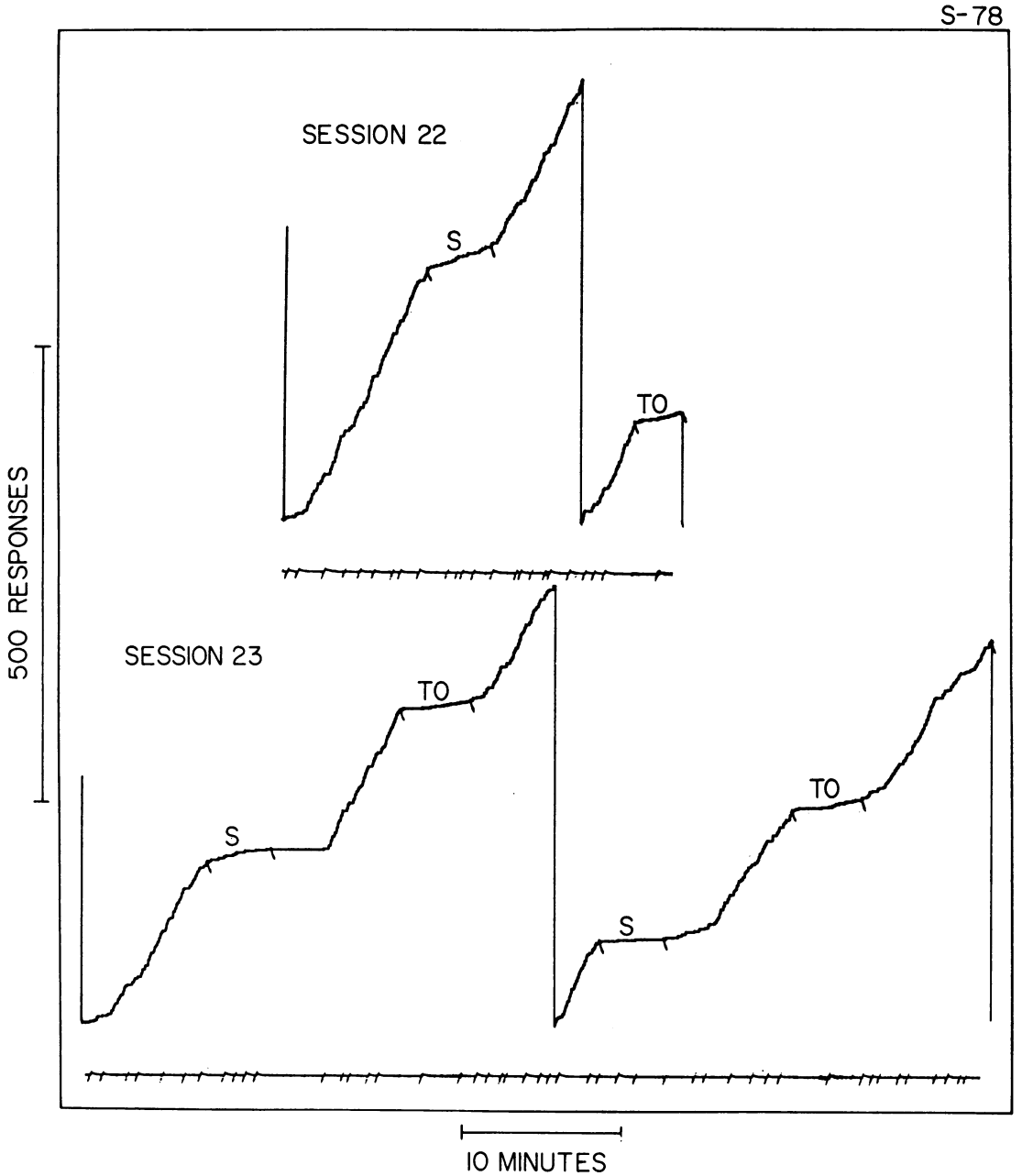

Fig. 1. Cumulative response records of performance of monkey S78 on the first two sessions after the shock-punishment component and the time-out–punishment component were introduced. Abscissa: time. Ordinate: cumulative number of responses. Diagonal offsets of the pen on the horizontal lines indicate delivery of food. Diagonal offsets of the pen on the cumulative response lines indicate the onset and termination of the time-out–punishment component (TO on figure) and the shock-punishment component (S on figure). Responses in the time-out–punishment component advanced the cumulative response pen, but responses during the time out did not advance the pen. The pen reset after 500 responses. The recorder motor did not operate during time out.

VI baseline rate (a decrease from 0.41 to 0.39 responses per sec over the entire session).

Introduction of the shock-punishment component. In Session 15, each response in the presence of the red light produced shock and occasionally food. When the red light was correlated with the shock-punishment component, responding in its presence immediately decreased well below the VI baseline rate (a decrease from 0.37 to 0.12 responses per sec).

Time-out–punishment component. Figure 2 shows the first session (Session 20) and the seventh session (Session 27) after time-out–punishment component was introduced. The shock-punishment component, introduced in Session

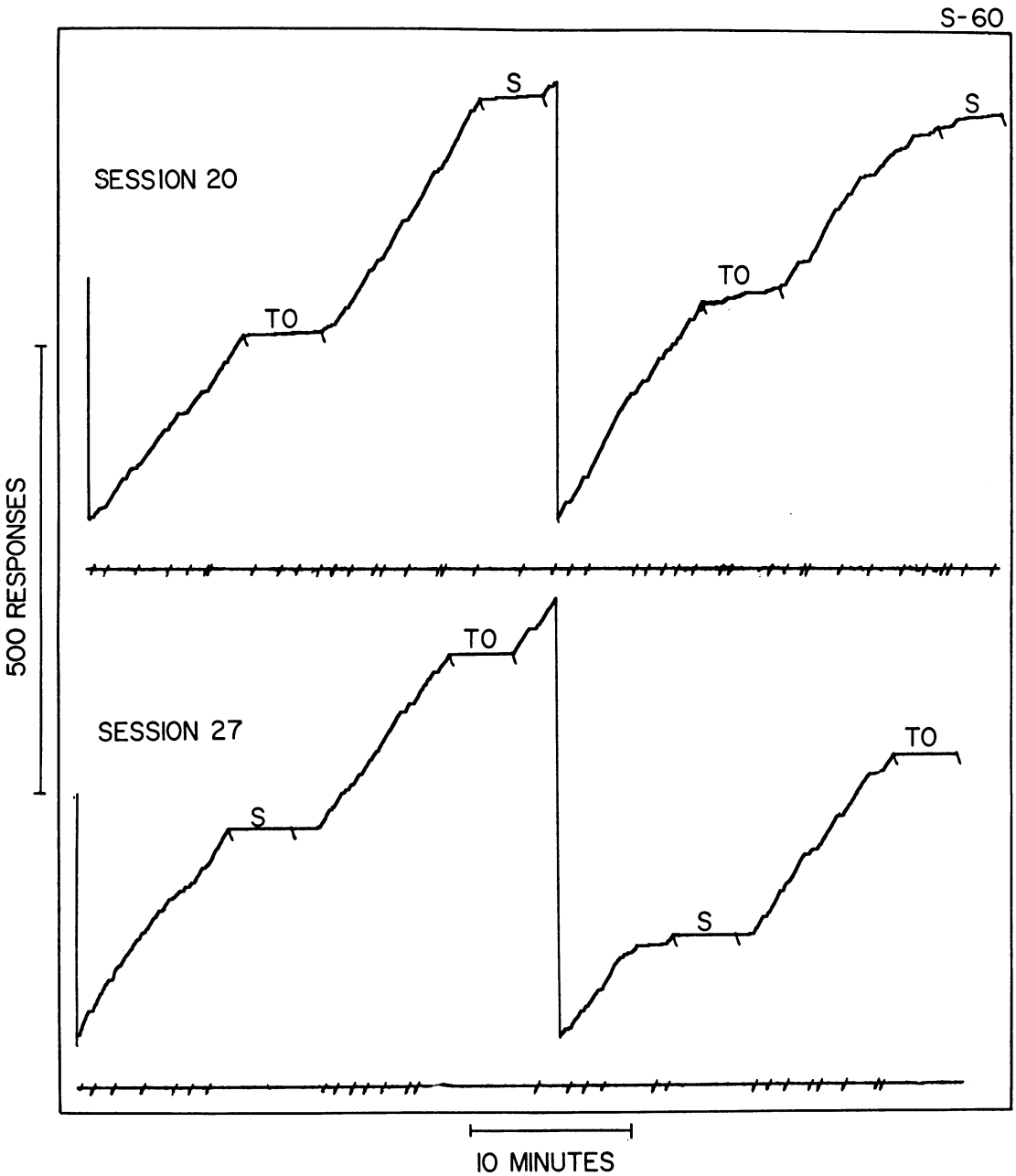

Fig. 2. Cumulative records of performance of monkey S60 on the first and seventh sessions after introduction of a stimulus in the presence of which responses produced a 20-sec time out. Recording as in Fig. 1.

15, had been in effect for five days before the time-out–punishment component was introduced. Responding in the presence of the time-out–punishment component was suppressed very quickly.

A red light alone did not suppress the VI response rate of a squirrel monkey, but when it was correlated with response-produced shock, responding in its presence was rapidly suppressed. Presentation of a blue light as a discriminative stimulus for response-produced time out also rapidly suppressed VI responding.

EXPERIMENT 3: A COMPARISON OF THE SHOCK-PUNISHMENT COMPONENT AND THE TIME-OUT–PUNISHMENT COMPONENT UNDER STABLE CONDITIONS. S60 AND S78

Procedure

In Session 29, the VI 1.5-min schedule was changed to VI 1-min for S60; *i.e.*, in the remaining experiments reinforcements were delivered on the average of 1 per min during both the VI schedule and the punishment components for both monkeys. While behavior was stabilizing, the shock level was increased to 3.0 ma for S60 and time-out duration was increased to 40 sec for S60 and 60 sec for S78.

Results

Table 1 shows the rate of responding during the first and second presentation of each 4-min punishment component for each of six consecutive sessions for each monkey. In Table 1 (and also in Fig. 4 and Table 2 of later experiments) responding during the time-out–punishment component is reported as a rate. Actually, the "rate" consists of a series of latencies following time outs. The number of latencies has been divided by the number of seconds in the time-out–punishment components to give a "rate" that may be compared with rates during the shock-punishment component and rates on the VI schedule. Table 1 shows that responding during the first shock-punishment component decreased more than during the second. This is seen very clearly in Sessions 35, 36, 39, and 40 for S78 and in Sessions 75, 76, and 78 for S60. Punished responding during sequential time-out–punishment components within a single session did not recover during this stage of these experiments. There were a few occasions earlier in training where time-out–punished responding did seem to recover slightly within a session (see Session 20, Fig. 1).

Table 1 also indicates that in certain ses-

Table 1

Rate during first and second presentations of punishment components within six different sessions for monkeys S78 and S60 (all presentations = 4 min).

	Responses/Sec			
	Shock-Punishment		*Time-out–Punishment*	
Session	*First Presentation*	*Second Presentation*	*First Presentation*	*Second Presentation*
MONKEY S78				
35	0.24	0.36	0.07	0.08
36	0.01	0.11	0.07	0.05
37	0.04	0.05	0.06	0.06
38	0.01	0.03	0.08	0.08
39	0.09*	0.23	0.06	0.07
40	0.02	0.36	0.08	0.06
MONKEY S60				
75	0.00	0.23	0.09	0.03
76	0.00*	0.07	0.07	0.08
77	0.00*	0.00	0.09	0.10
78	0.01*	0.33	0.10	0.14
79	0.01*	0.04	0.08	0.07*
80	0.01*	0.01	0.09	0.03

*No responses made for at least 30 sec after the end of the punishment component.

sions (Session 39 for S78 and 76, 77, 78, 79, and 80 for S60) no responses occurred for more than 30 sec after the shock-punishment component terminated. This suppression of the VI baseline outside the shock-punishment component occurred much less often after the time-out–punishment component, although it did occur occasionally (Session 79 for S60). Suppression of responding after the shock-punishment component was seen primarily in S60; it may have been related to the comparatively marked suppression of responding for S60 during the shock-punishment component, rather than to a difference between the effects of the punishers. However, in Session 36 and 38, S78's rate of responding was very low during presentation of the first shock-punishment component, but suppression did not continue after these shock-punishment components terminated. The rate of responding of S60 was equally low during Sessions 77 and 80 during the second presentation of the shock-punishment component, but once again the suppression did not continue after the shock-punishment component terminated. The failure of suppression to continue after the second presentations of the shock-punishment components may have been another reflection of the apparent tendency for shock-punished responding to recover within one session.

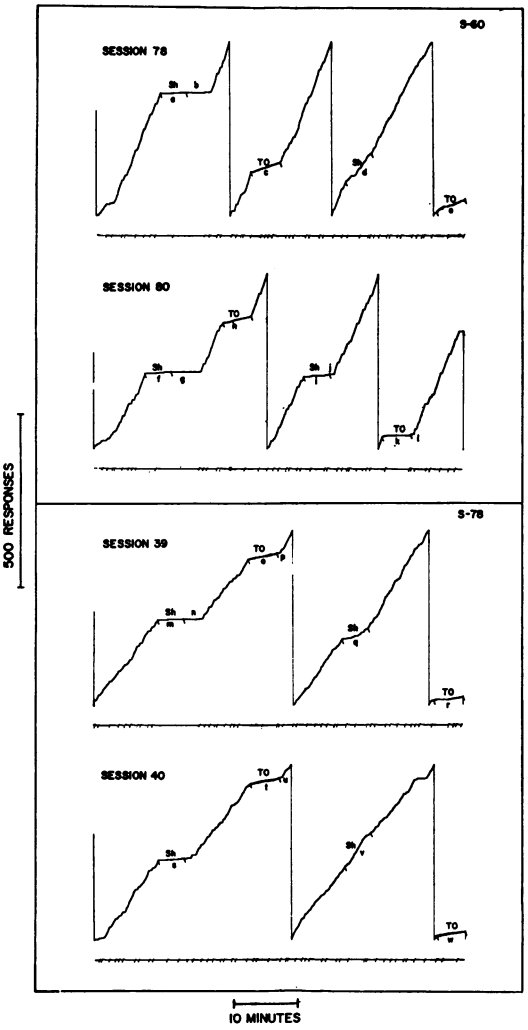

Fig. 3. Cumulative records of performance of monkeys S60 and S78 at steady state, illustrating characteristic patterns of responding during the shock-punishment component (Sh) and the time-out–punishment component. Recording as in Fig. 1.

Figure 3 shows the cumulative records for two of the sessions shown in Table 1 for each monkey, which illustrate recurring features of responding. In each, the shock-punishment component was the first punishment component to occur in the session. The recovery of shock-punished responses is strikingly illustrated when shock-punishment components a and d, m and q, and s and v are compared in Fig. 3. Points b, g, and n in Fig. 3 show the long pauses between termination of the shock punishment component and resumption of VI responding.

This experiment revealed differences between response-produced shock and response-produced time out even though they suppressed responding to about the same degree.

EXPERIMENT 4: EFFECTS OF PENTOBARBITAL ON PUNISHED RESPONDING

Geller and Seifter (1960) showed that pentobarbital and phenobarbital increase the response rate suppressed by electric shock punishment. Finding that a barbiturate increases the response rate suppressed by time out would indicate an important similarity between shock and time out as punishers; it would also extend the generality of the finding that barbiturates increase punished responding.

Procedure

Sodium pentobarbital was dissolved in 0.9% saline and injected intramuscularly not more often than twice weekly. Injections were given

10 min before the session began. Drug effects were determined once at each dose level for each monkey. S78 received saline first, then increasing doses of pentobarbital. S60 received 10 mg/kg pentobarbital first, then decreasing doses of pentobarbital and finally saline. All experimental parameters were as in Exp. 3, except that time out was increased to 90 sec for both monkeys.

Results

Figure 4 shows the effects of pentobarbital on responding during the two punishment components, and during time out.

Although graded dose-dependent effects were not always obtained, response rate increased during both punishment components at some doses of pentobarbital. The rate also increased during the time out (the 90 sec of darkness following a response in the time-out–punishment component). Pentobarbital increased responding suppressed by electric shock or time out.

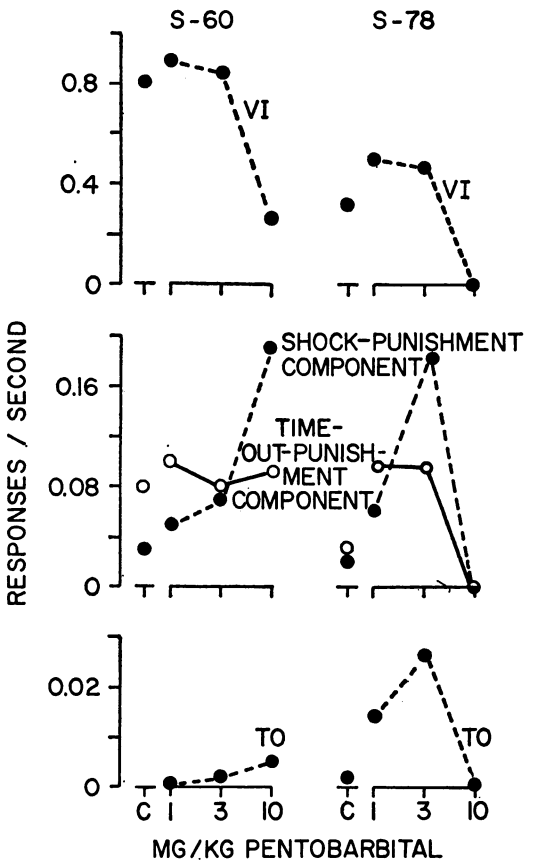

Fig. 4. Effects of pentobarbital on VI responding during the unpunished component, during the shock-punishment component (filled circles and broken lines of middle graph), during the time-out–punishment component (open circles and solid lines of middle graph) and during time out. Ordinate: dose, log scale. Abscissa: response/sec for the session. Points at C represent performance after a saline control injection. Each point is a single determination for one monkey.

EXPERIMENT 5: A FIXED-RATIO PUNISHMENT SCHEDULE

The shock duration was only 30 msec in the preceding experiments, but time out was as long as 90 sec. Therefore, behavior during the time-out–punishment component could have been suppressed by factors such as decreases in reinforcement frequency caused by repeated time out. By scheduling punishers intermittently during the punishment components, the decrease in reinforcement frequency caused by repeated time out can be minimized.

Procedure

After Session 215 (S60) and Session 158 (S78) the schedule was changed so that every third response in the presence of the punishment-component stimuli, rather than every response, was followed by electric shock or time out.

Results

The effect of the schedule change is shown in Table 2.

Table 2

Rate of responding during last three sessions of FR-1 punishment and first three sessions of FR-3 punishment for Monkeys S60 and S78. (Each value is the mean rate for three sessions.)

	Response/Sec		
Schedule	*Shock-Punishment*	*Time-Out–Punishment*	*Time Out*
MONKEY S60			
FR-1	0.04	0.05	0.01
FR-3	0.10	0.19	0.00
MONKEY S78			
FR-1	0.02	0.01	0.01
FR-3	0.03	0.06	0.00

For both subjects, responding increased during both punishment components when only every third response was punished; rate of responding during time out did not.

Rate of responding in the punishment components increased when shocks or time outs

were delivered intermittently rather than after every response during a punishment component. The increase in response rate during the punishment components was similar to the findings in Exp. 4 where pentobarbital increased the rate of responding during both punishment components. In time out, pentobarbital increased the response rate, but scheduling time out intermittently did not.

DISCUSSION

Punishment by response-produced time out can suppress lever pressing maintained by food in the squirrel monkey. When time outs of 60 to 90 sec were used, the degree of suppression was roughly equivalent to that produced by a 1- to 2-ma electric shock delivered for 30 msec.

Leitenberg (1965), in a review of the literature on time out from positive reinforcement, proposed that the effects of stimuli correlated with shock were different from those correlated with time out. He cited his own data, and those of Herrnstein (1955), in the pigeon, and Ferster's (1958) data in the chimpanzee, which seemed to indicate that under some conditions a pre-shock stimulus suppressed behavior, while a pre-time-out stimulus accelerated it. Herrnstein (1955) varied the frequency of reinforcement on a VI schedule and found that when frequency was low, responding accelerated. He did not find acceleration when reinforcement frequency was high. Herrnstein suggested that the increased responding before time out was evidence that the stimuli correlated with the low frequency of reinforcement were aversive. However, Ferster (1960) found that time out remained an aversive stimulus, even with a low rate of reinforcement, when low-rate responding was differentially reinforced (DRL) according to a variable-interval schedule. Ferster suggested that either species differences or differences in the inevitability of the time out might explain the disagreement between his findings and Herrnstein's. In Herrnstein's pigeon experiments the time out always occurred at the end of the pre-time-out stimulus; however, in Ferster's chimpanzee experiments, inhibition of responding during a short period near the end of the pre-time-out stimulus could avoid presentation of the time out.

In the present experiments, the occurrence of time out could be minimized by a low rate during the time-out–punishment component, or even eliminated if no responding occurred. Suppression may have occurred because of this contigency.

Reduction of response rates during the time-out–punishment component may have occurred in part because the stimulus changes associated with time out were aversive, and in part because a low rate of responding was differentially reinforced. If responding was completely suppressed during the time-out–punishment component, reinforcement rate would be zero during this period. However, if a few responses occurred, some of them would be reinforced because reinforcement was delivered according to a VI schedule during both punishment components. If the rate was low, reinforcements could be delivered without many time outs occurring to decrease the density of reinforcement during the duration represented by the time-out–punishment component plus the time spent in time out. However, a high rate of responding would have a negligible effect on reinforcement rate during the time-out–punishment component at the cost of a considerable increase in time spent in time out. It is possible that suppression in the time-out–punishment component occurred both because the time outs were aversive and because they reduced the frequency of reinforcement. However, if it is assumed that shock suppresses behavior when applied as a punisher because it is aversive, then the degree to which time out mimics the effect of shock under a variety of treatments may reflect the aversive aspects of time out. It may be impossible to separate completely the aversive properties of time out from the effects of a decrease in reinforcement rate, since the aversive properties may be a function of the reduction in reinforcement rate.

Another similarity between responding suppressed by electric shock and by time out is in the response to pentobarbital. Geller and Seifter (1960) and Kelleher and Morse (1964) indicated that barbiturates will increase responding suppressed by electric shock in several species under a variety of schedules of food and shock presentation. Pentobarbital was given to see if behavior suppressed by electric shock and by time out would be similarly increased by the drug. The increase in rate after pentobarbital during both punishment com-

ponents suggested a similarity between the two punishers.

The rate of responding during the time-out–punishment component after pentobarbital might have been even higher than Fig. 4 showed; the increase in responding after pentobarbital during time out (when the monkey was sitting in the dark) may have reflected a burst of time-out–punished responses. Although quantitative data are not available, observation indicated that the increased responding was not evenly distributed throughout the time out, but occurred immediately after the response that produced time out. The monkey responded, producing the time out, and then continued to respond during the first few seconds of time out. When the time out ended, the monkey repeated the process. Every response during the time-out–punishment component precluded the possibility of other punished responses until the time out had terminated. This was not the case with shock. A burst of responses during the shock-punishment component did not produce any delay. Thus, bursts of responses were recorded as punished responses during the shock-punishment component, but as one punished response and several time out responses in the time-out–punishment component.

Responding suppressed by electric shock usually was less suppressed later in the session, while responding suppressed by time out was maintained at about the same low level throughout the session. This finding in the squirrel monkey is in contrast to a previous report that responding suppressed by shock punishment does not recover in this species (Appel, 1961). The schedule parameters used by Appel differed from the present ones in a number of ways. Although the shock intensity was about the same in both experiments, Appel's shock duration was much longer (500 msec to 30 msec). Appel used a VI 6-min schedule to generate a baseline in unrestrained monkeys working in a box. The present experiment used VI 1.0-min and VI 1.5-min schedules for monkeys restrained in a chair. The longer shock duration and the lower density of reinforcement on the VI schedule may have made the shock more effective in suppressing the behavior of Appel's monkeys.

Both the transient suppression of shock-punished responding and its suppressive effect upon termination of the shock-punishment component could be interpreted in terms of a generalized effect of response-produced shock, *e.g.*, Rachlin (1966). Since similar effects were seen less often with response-produced time out, the generalized effects may be less important when time out is used as a punisher.

The approximately equal degree of suppression in both punishment components, the effects of scheduling the punishers intermittently, and the recovery of punished responding after pentobarbital would seem to emphasize that both shock and time out can be effective, and perhaps similar, punishers. However, the scheduling of time out necessarily involves contingencies (*e.g.*, reduced frequency of reinforcement) different from those of shock. The different contingencies may produce "side effects" of the punishers which give rise to dissimilar behavioral effects.

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