INTERMITTENT PUNISHMENT OF HUMAN RESPONDING MAINTAINED BY INTERMITTENT REINFORCEMENT¹

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To determine the effects of variable-interval shock punishment on behavior maintained by variable-interval and variable-ratio reinforcement, human subjects' key-pressing behavior was reinforced with money on a four-component multiple schedule. Components 1 and 2 were variable-interval 30-sec, and Components 3 and 4 were variable-ratio 210. After responding was stabilized, response-contingent electric shock was scheduled on a variable-interval 10-sec schedule during the second and fourth components of each cycle. Subjects instructed as to the reinforcement contingencies showed gradually increasing suppression of variable-interval responding at increasing shock intensities and either very high or very low rates of variable-ratio responding at higher intensities. Minimally instructed subjects showed suppression at higher shock intensities, but no clear differential suppression as a function of reinforcement schedule. Recovery from initial suppression was observed within sessions.

Until recently, there have been few investigations of intermittent punishment (*e.g.*, Estes, 1944; Azrin, 1956; Filby and Appel, 1966; Kaufman, 1966; Church, 1968). However, Azrin and Holz (1966, p. 401) noted: "In order to specify the nature of response reduction by punishment, it is necessary to specify the schedule of reinforcement that is maintaining the response." Clearly, schedules of punishment and their interactions with schedules of positive reinforcement deserve more attention than they have received.

For the most part, investigations of shock punishment as a function of reinforcement schedule have utilized a continuous-punishment schedule in which each response is followed by the brief presentation of electric shock. Azrin (1960) showed that when responding of pigeons maintained by variable-interval (VI) reinforcement is punished on each response, gradual reductions in rate are observed as a function of punishment shock intensity, and temporal patterning is unchanged. However, when responding maintained by fixed-ratio (FR) reinforcement is punished with relatively high intensity shocks on each response, the resulting rate is characterized by an all-or-none pattern, *i.e.*, re-

sponding occurs either at the unpunished rate or not at all (Azrin, 1959). Moreover, Kaufman (1966) found that human responding maintained by variable-ratio (VR) reinforcement, when punished with shock on an intermittent schedule, is also characterized by an all-or-none pattern, *i.e.*, suppression occurs only when shock punishment is relatively frequent, and when suppression occurs, it is usually complete. The results of these studies seem to indicate that punishment has substantially different effects depending upon whether positive reinforcement is arranged on a ratio or an interval schedule. The present investigation was undertaken to assess the effects of different intensities of VI shock punishment on responding maintained in the same human subjects by both VI and VR reinforcement.

In addition to other variables, human operant behavior is strongly influenced by verbal instructions (Kaufman, Baron, and Kopp, 1966). When, as in the present study, the effect of a variable like punishment may depend upon discrimination of the different reinforcement contingencies maintaining behavior, the method of establishing that discrimination may be important. Also, exposing subjects to different reinforcement contingencies in the absence of instructions may be an extremely uneconomical way to establish a discrimination which otherwise could be established quickly with instructions. The present study attempted to assess systematically the

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effects of instructions on punishment-produced suppression by providing information concerning the reinforcement contingencies to some subjects, but not to others.

METHOD

Subjects

Five female college students served. A job description was placed with the student employment service indicating that a 1-hr per day job on a psychology research project was available. The rate of pay was indicated as about \$1.50 per hr. Subjects contacted the experimenter who explained the nature of their participation, including the fact that they would be exposed to non-harmful electric shock. Subjects were told that if they decided to participate, they would be expected to serve for about 13 weeks (one semester).

Apparatus

A sound-attenuated audiometric room (Suttle Corp.) about 6-ft square contained a chair and a table mounted along one wall. A push-button response key (Grason-Stadler E8670A), five 0.62-in. diameter colored stimulus lights, and an impulse counter which was visible to the subject were mounted on a sloping panel 18-in. wide and 11-in. high attached to a table.

Each key press illuminated an orange light for 30 msec, which served as response feedback. Low intensity white noise was provided as a masking noise. Conventional electromechanical equipment, impulse counters, and a cumulative recorder located in an adjoining room were used to control and record the experiment.

Subjects were shocked through 0.25-in. by 1.25-in. stainless steel electrodes coated with electrode paste and taped to the index finger of the non-preferred hand. After the electrodes were applied, a mitten was placed over the subject's hand and taped at the wrist in order to discourage manipulation of the shock electrodes. Shock was generated by a 0 to 2400-v ac transformer. Thus, up to 2400 volts in series with 120,000 ohms could be applied to the subject's index finger. High voltage was used with high resistance to provide a relatively constant current with changes in subjects' resistance. Care was taken to fuse the circuit between the subject and the transformer and to eliminate any circuit between metal in the

experimental room and the output of the transformer. Shock intensities are expressed in this paper as the short-circuit current (0 to 14 ma) at the various voltage settings.

Procedure

Before the first experimental session, each subject agreed to participate after having been given the following information: (a) that no information could be given her about the nature of the research and, while the project was not secret, she should not discuss her participation with anyone; (b) that she could earn up to about \$1.80 per hr but that she would earn no money if she did nothing, for example, if she slept throughout the session; (c) that a daily record would be kept of her earnings and she would be paid one-half of the amount she earned every two weeks; the balance would be paid at the end of her participation. If she never missed a session throughout the semester, she would receive a \$5.00 bonus; if she missed more than two sessions without notification and excuse, she would be fined \$1.00 for the first session missed, \$2.00 for the second session missed, and so on (Kaufman, 1964); (d) that watches, pencils, paper, books, and purses were not allowed in the experimental room.

Instructions

At the start of the first session, three of the subjects were allowed to read the following schedule instructions:

You are here to earn money. The way you will know when you have earned money is that the counter on the sloping panel in front of you will register one count. Each time it registers, you will have earned 2 cents more. If the counter reads 10, it means 20 cents, if it reads 40, it means 80 cents. The counter will register only if the button in the center of the panel is pressed. You will know when you have pressed it by the brief flashing of the orange light.

When the red light is on, the counter can only register once each 30 seconds, *on the average*. This means that sometimes the counter will be ready to register only a few seconds after the last time it registered, while at other times the counter will be ready to register only after 30 seconds following the last time it regis-

tered. If you press the button before the counter is ready to register, nothing will happen. Of course, if you don't press the button when the counter is ready to register you will be losing time when you could be earning money.

When the green light is on, the counter can only register when you have made 180 button presses, *on the average*. This means that sometimes the counter will be ready to register only a few presses after the last time it registered, while at other times the counter will be ready to register only after 180 presses following the last time it registered. If you press the button before the counter is ready to register, nothing will happen. Of course, if you don't press the button when the counter is ready to register, you will be losing time when you could be earning money.

The blue light will be on during those periods when electric shock can occur. You will *never* receive a shock when the blue light is off. You will always feel the shock on your finger. The blue light will not come on during the first several days.

Two other subjects were allowed to read the following minimal instructions:

You are here to earn money. The way you will know when you have earned money is that the counter on the sloping panel in front of you will register one count. Each time it registers, you will have earned 2 cents more. If the counter reads 10, it means 20 cents, if it reads 40, it means 80 cents. You must do something to earn money.

The blue light will be on during those periods when electric shock can occur. You will *never* receive a shock when the blue light is off. You will always feel the shock on your finger. The blue light will not come on during the first several days.

Questions were responded to by referring the subjects back to the written instructions. The instructions remained in the experimental room during all subsequent sessions.

No-Punishment Baseline

Throughout the experiment, subjects were exposed daily to six cycles of a four-compo-

nent multiple schedule, each component lasting 2 min. During components one and two, a red stimulus light was illuminated, and reinforcement in the form of points on the subject's counter (1 point = 2 cents) was available on a VI 30-sec schedule for key pressing. During components three and four, a green stimulus light was illuminated, and reinforcement was arranged on a VR 210 schedule. Although the schedule instructions specified a VR 180 schedule, a value chosen to equate reinforcement rates on the VI and VR schedules, a procedural error led to the use of a VR 210 schedule, which produced a slightly lower rate of reinforcement during the VR components. All remuneration was based on the number of points accumulated during experimental sessions.

Schedule-instructed subjects were exposed to the VI 30-sec and VR 210 reinforcement schedules beginning with the first session. The two minimally instructed subjects were allowed to complete the first session with the VI 30-sec and VR 210 contingencies in effect in order to assess the effect of initial exposure to these contingencies. In subsequent sessions, when it was clear that responding during the VR components was extinguishing, the minimally instructed subjects' VR responding was shaped through exposure first to a FR 1 schedule and then to an increasing series of VR schedules terminating in the VR 210 schedule. The no-punishment baseline sessions were continued until responding was reasonably stable within and between sessions (10 to 14 sessions).

Punishment

Following the no-punishment baseline sessions, a blue stimulus light was always illuminated during the second VI and the second VR components of the multiple schedule. During punishment sessions, the blue light served as a stimulus which defined those components in which response-contingent electric shocks of 100-msec duration were arranged on a VI 10-sec schedule.

In order to assess the effect of the blue light in the absence of shock punishment, subjects were never shocked during the first 6 to 10 sessions after the blue stimulus was introduced (this represented the 0-ma condition). After the baseline sessions with the blue light and no-punishment were completed, punishment

was scheduled during the blue-light components in subsequent sessions. Starting with a series of sessions at 1 ma, a given shock intensity was scheduled until a stable rate developed at that intensity. A higher intensity was then scheduled for the next series of sessions, and intensities were increased in this fashion until either punished responding ceased, or the highest shock intensity used (14 ma) was reached. Subject 4 was observed for a number of sessions at 1.0-ma shock intensity on three separate occasions and was exposed to 0.5-ma shock after exposure to 3.0-ma shock. The minimum number of sessions in any series was four, the maximum 16, and the median seven.

RESULTS

No-Punishment Baseline

There were major differences between the schedule-instructed subjects and the minimally instructed subjects, both in the initial sessions and in the terminal stable baseline behavior. As Fig. 1 shows, during the first session the schedule-instructed subject began to respond immediately and showed good stimulus control of intermediate rates of responding during the red VI stimulus and high rates during the green VR stimulus. The minimally instructed subject, who was given no information about the key or the reinforcement contingencies, took some time to differentiate the key-press response, and then responded irregularly for the remainder of the first session.

Beginning with the second session for Subject 4 and the third session for Subject 5, responding during the VR stimulus was shaped, since it was not being maintained at a high rate in these minimally instructed subjects. Subjects were trained by exposing them to increasingly higher reinforcement ratios beginning with a reinforcement for every response. This took six sessions for Subject 4 and two sessions for Subject 5 and was successful in developing a high VR rate.

The right-hand panels of Fig. 1 present cumulative records of the sessions immediately before the blue punishment stimulus was introduced. During the terminal baseline phase, the schedule-instructed subjects continued to show a clear difference in response rate between the VI components and the VR components. The actual number of responses is

given in Table 1. The minimally instructed subjects, however, did not appear to discriminate between the VI and VR reinforcement contingencies. These subjects responded at an overall high rate that was slightly lower than the schedule-instructed subjects' VR rates.

Table 2 presents reinforcement frequencies during VI and VR components for the final three sessions of the baseline series and for each shock-intensity series. These data show that reinforcement rates were higher during the VI components for both schedule-instructed and minimally instructed subjects. The discrepancy between VI and VR reinforcement rates was greater, however, in the minimally instructed subjects. While all subjects received about two reinforcements per minute during the baseline VI components, the schedule-instructed subjects received about 1.6 reinforcements per minute during the baseline VR components as compared to approximately 1.1 VR reinforcements per minute for the minimally instructed subjects. It is apparent that one effect of providing information about the reinforcement schedules was to maintain reinforcement at about the same rate during both schedule components. Failing to provide schedule information resulted in more than a 30% reduction in the VR reinforcement rate when compared to the VR reinforcement rate of the schedule-instructed subjects.

Punishment

The major results of exposure to various intensities of VI punishment are presented in Fig. 2 and Table 1. Data are not shown in Fig. 2 for Subject 3, who did not suppress responding at any intensity of VI punishment used.

It is clear from Fig. 2 and Table 1 that higher shock intensities reduced responding more than low intensities in all subjects except Subject 3. Further, the two schedule-instructed subjects (Subjects 1 and 2) showed differential suppression of VI- and VR-maintained responding. For Subjects 1 and 2, suppression of VI-maintained responding occurred as a gradual slowing of responding with increasing shock intensity, and took place at lower intensities than suppression of VR-maintained responding. The partial suppression of VR-maintained responding at 10 and 14 ma for Subject 2 is the result of com-

Table 1
Mean Number of Responses per Session Based on the Last Three Sessions in Each Phase

Subject	Component	B	O	0.5	1.0	2.0	2.5	3.0	4.0	6.0	7.0	9.0	10.0	14.0
Schedule Instructions		Phase (Shock Intensity in ma)												
1	VI	1471	1641	—	1459	1558	—	1513	1514	1497	—	1459	—	1582
	VI/PUN	1548	1795	—	1384	392	—	445	844	322	—	230	—	13
	VR	3938	3917	—	4030	4053	—	4104	4359	4609	—	4585	—	4511
	VR/PUN	3925	3791	—	3884	3939	—	4065	4339	4534	—	4557	—	72
2	VI	308	324	—	502	—	532	—	450	—	365	—	312	393
	VI/PUN	259	253	—	452	—	427	—	475	—	232	—	123	168
	VR	4054	4553	—	4664	—	4419	—	4674	—	4244	—	4360	4807
	VR/PUN	4305	4349	—	4486	—	4444	—	4599	—	3964	—	3406	4197
3	VI	650	287	—	285	—	340	—	459	440	—	522 ^a	—	560 ^a
	VI/PUN	556	244	—	241	—	326	—	430	472	—	529	—	524
	VR	3587	3624	—	3757	—	3680	—	3548	3372	—	3633	—	3256
	VR/PUN	3664	4008	—	4195	—	3900	—	3843	3761	—	3758	—	3624
Minimal Instructions														
4	VI	1629	2190	347 ^b	379 ^c	—	—	1022	—	—	—	—	—	—
	VI/PUN	1772	2500	491	202	—	—	5	—	—	—	—	—	—
	VR	2252	2687	3247	2942	—	—	3651	—	—	—	—	—	—
	VR/PUN	2362	2555	3378	722	—	—	92	—	—	—	—	—	—
5	VI	2035	3344	—	3464	—	—	3642	—	3318	—	—	—	—
	VI/PUN	2005	3410	—	3147	—	—	3631	—	56	—	—	—	—
	VR	2038	3033	—	3451	—	—	3692	—	3781	—	—	—	—
	VR/PUN	2048	3097	—	3311	—	—	3681	—	78	—	—	—	—

^aVI 3-sec punishment.

^bSubject 4 was observed at 0.5 ma after exposure to 3.0-ma shock.

^cMean of three determinations.

Fig. 1. Representative cumulative records of the initial and terminal sessions of the no-punishment baseline phase for Subjects 1 and 5. The event pen on the bottom of the records was displaced during alternate 2-min components. The second VI components are indicated by shading and the second VR components by cross-hatching. The response pen was displaced downward during the VR components and reset at the end of each 8-min cycle. Reinforcements are indicated by small upward or downward marks on the response curve.

Table 2
Mean Number of Reinforcements per Session Based on the Last Three Sessions in Each Phase

Subject	Component	Phase (Shock Intensity in ma)													
		B	O	0.5	1.0	2.0	2.5	3.0	4.0	6.0	7.0	9.0	10.0	14.0	
Schedule Instructions															
1	VI	48	48	—	48	46	—	46	47	46	—	46	—	27	
	VR	36	36	—	37	38	—	37	41	43	—	43	—	21	
2	VI	42	47	—	45	—	42	—	42	—	41	—	38	41	
	VR	38	40	—	43	—	41	—	44	—	37	—	36	41	
3	VI	47	46	—	46	—	46	—	47	47	—	46 ^a			
	VR	34	34	—	37	—	35	—	35	34	—	34			
Minimal Instructions															
4	VI	48	48	39 ^b	30 ^c	—	—	26							
	VR	25	22	30	16	—	—	17							
5	VI	48	47	—	49	—	—	49	—	28					
	VR	29	20	—	30	—	—	34	—	18					

*VI 3-sec punishment.
^bSubject 4 was observed at 0.5 ma after exposure to 3.0-ma shock.
^cMean of three determinations.

Fig. 2. Mean punished rates of responding as a percentage of unpunished rates. Each data point is the mean of the last three sessions in each phase. Point B on the abscissa represents the baseline rate of responding in the second VI or VR component before the blue punishment stimulus was introduced.

plete response suppression in some early VR punishment components followed by within-session recovery. The minimally instructed subjects (Subjects 4 and 5) did not exhibit any clear differential suppression of responding and completely suppressed responding at somewhat lower shock intensities than the schedule-instructed subjects.

Table 2 shows that reinforcement rates at the various punishment shock intensities were maintained at approximately baseline levels until the higher intensities were reached, at which point complete suppression occurred. Two exceptions to this pattern were the VR reinforcement rate of Subject 1, which increased slightly at the intermediate shock intensities along with a slight increase in unpunished responding (*cf.* Table 1), and both reinforcement rates of Subject 4, where a gradual decrease was seen in the VI reinforcement rate as a function of punishment shock

intensity and an increase followed by a decrease was observed in the VR reinforcement rate.

The apparent suppression shown by Subject 2 in the baseline and 0-ma conditions was due to a carry-over effect early in the first VI component of the last five cycles in each session. As with Subject 1, shown in Fig. 1, points A and B, Subject 2 tended to maintain a high VR response rate into the first VI component. Thus, when the rates during the first and second VI components are compared, an apparent suppression effect is seen. This high rate carry-over dropped out over the course of the experiment.

Figure 3 illustrates the effect of punishment shock intensity on the rates of responding of the schedule-instructed subjects. When suppression of VR-maintained responding occurred for these subjects, it always occurred as complete cessation of responding. Suppres-

Fig. 3. Representative cumulative records obtained from the two schedule-instructed subjects at different shock-punishment intensities. Each segment is one complete cycle from one of the last three sessions at a given intensity. The VI punishment components are indicated by shading and the VR punishment components by cross-hatching. The event pen was displaced downward during unpunished components and marked punishments during punished components. Other recording as in Fig. 1.

sion of VI-maintained responding always occurred as a gradual reduction in rate except at shock intensities that extinguished responding.

Recovery from the suppressive effects of punishment illustrated in Fig. 4, occurred within sessions. The four subjects who showed suppression to punishment showed some degree of within-session recovery. Such recovery has been seen in responding suppressed by electric shock punishment in pigeons (Azrin,

Fig. 4. Sections of representative cumulative records from one subject showing responding during the first and last punishment components of a session. These records are from one of the last three sessions at a given intensity. Punishments are marked on the event line beneath the records. Other recording as in Fig. 1.

1959, 1960), rats (Appel and Peterson, 1965), and squirrel monkeys (Hake, Azrin, and Oxford, 1967).

In addition to the effect of shock intensity, three aspects of the response-rate data in Table 2 are noteworthy. First, except for Subject 4, the unpunished response rates were quite stable throughout the experiment. Although not shown in this table, unpunished response rates also were extremely regular from cycle to cycle within each session. This low variability provides an excellent baseline for evaluating the punishment effects. Second, Subjects 1 and 2 showed a gradual increase in their unpunished VR rates over the course of the experiment. Such an increase probably indicates the development of a slightly more efficient response topography. In addition, there was no evidence of any behavioral contrast in the unpunished VI components, such as Brethower and Reynolds (1962) reported. Third, Subject 4, who was given minimal instructions, developed a difference in rate between VI and VR components similar to that seen in the schedule-instructed subjects. However, Subject 4's behavior was not very stable, and it is not clear how she developed the discrimination or if the discrimination altered her reaction to punishment.

In order to examine the effect of schedule instructions after minimal instructions, Subject 5 was given the schedule instructions after 40 sessions with minimal instructions. This subject had maintained an overall high rate during both the VI and VR stimuli. Fig-

Fig. 5. Cumulative records showing the control of responding exerted by minimal instructions (Session 40) and schedule instructions (Sessions 41, 45, and 46) for Subject 5. Shock was scheduled at 6 ma during Session 40 but not during subsequent sessions. The second VI components are indicated by shading and the second VR components by cross-hatching. The symbol BL above the event marker line indicates that the blue-light punishment stimulus was present during that 2-min period. The symbol YEL indicates that a neutral yellow stimulus was present during that 2-min period. Recording as in Fig. 1.

ure 5 presents cumulative records from sessions before and after Subject 5 was given the schedule instructions. In addition to giving Subject 5 the schedule instructions, starting with Session 41, the blue-light punishment stimulus was not presented, and no responses were shocked. This condition represents a return to the no-punishment baseline phase. Presenting Subject 5 with schedule instructions immediately reduced rate during the VI stimulus and maintained a high rate during the VR stimulus. Behavior was very similar to that shown by Subjects 1, 2, and 3 from the start of the experiment (*cf.* Fig. 1). As a further test of stimulus control of responding, beginning with Session 43 the blue punishment stimulus was reintroduced into the second and fourth components of the multiple schedule without any shock arranged. Reintroduction of the blue stimulus immediately and completely suppressed responding. This complete suppression was maintained through Session 45, as shown in Fig. 4. During Session 46, the stimulus control of responding by the

blue punishment stimulus was tested. Omitting the blue stimulus during cycles one, two, and four did not suppress responding; when the blue stimulus was presented during cycles three and six, responding was completely suppressed. When a novel and presumably neutral yellow stimulus was presented during cycle five, responding was only momentarily interrupted.

DISCUSSION

The results of this experiment confirm and extend to human subjects the finding derived from previous punishment studies that reactions to punishment are dependent upon the schedule of positive reinforcement maintaining behavior (Azrin, 1959, 1960; Kaufman, 1966). These earlier studies found, as did the present investigation, that punishment of VI-maintained responding resulted in a gradual overall reduction in response rate, while punished FR- or VR-maintained responding momentarily occurred either at the unpunished rate or not at all.

A plausible explanation for local all-or-none suppression of intermittently punished VR-maintained responding has been advanced by Kaufman (1966). He proposed that under VI punishment, a substantial reduction in VR-maintained responding would result in a proportionate loss of reinforcement with little change in the number of shocks taken. Thus, given the appropriate schedule values, reinforcement could be reduced to the point where responding could not be maintained in the face of response-produced aversive stimulation. However, reduced responding for VI reinforcement under VI punishment would result in little change in both number of reinforcements and number of shocks, thus resulting in sufficient reinforcement to maintain responding.

The present data support such an explanation, since reduced VI responding at intermediate punishment intensities produced virtually no change in the rate of reinforcement, while VR-reinforced responding at the same shock intensities was maintained at the no-punishment level, resulting in maintenance of the reinforcement rate. This finding was particularly applicable to the schedule-instructed subjects, for whom the relationship between rate of responding and rate of reinforcement was made clear by the instructions; it may account for the additional finding that response rates were maintained at higher shock intensities for these subjects. For the subjects who received minimal instructions, the initial tendency to suppress responding at intermediate shock intensities could not be counteracted by the effect of the schedule instructions relating amount of reinforcement to rate of responding. Thus, the initial suppression could have weakened their behavior sufficiently through reinforcement loss to the point where suppression became complete. These results suggest that a major variable affecting response suppression is the rate of reinforcement resulting from variations in the rate of response.

An interpretation of the differential suppression of VI and VR responding found in the present experiment, based on the slightly lower frequency of reinforcement under VR, does not seem acceptable. The existing evidence, although not completely clear, suggests that the effect of reduced reinforcement is to weaken behavior or maintain it at a re-

duced rate relative to behavior that is more frequently reinforced (Church and Raymond, 1967; Tullis and Walters, 1968). Thus, the effect of reduced reinforcement frequency alone might be expected to result in more suppression during VR than VI, rather than the obtained result of more suppression during VI at intermediate shock intensities.

The results also tentatively indicate that differential suppression of VI- and VR-maintained responding is limited, at least for human subjects, to the case in which subjects have discriminated the VI and VR reinforcement contingencies. The two schedule-instructed subjects who discriminated between the VI and VR components with the aid of explicit written instructions showed all-or-none local suppression of VR-maintained responding and gradual suppression of VI-maintained responding. The minimally instructed subjects did not display any such clear differential suppression.

The powerful effect of instructions about the reinforcement contingencies, as demonstrated in response acquisition, development of a discrimination, and in reaction to punishment, is consistent with the results reported by Kaufman *et al.* (1966). The use of instructions with adult humans appears to be an extremely economical way of establishing a specific behavior when the pattern of acquisition of that behavior is not of particular interest, but when the stable behavior is used as a baseline to study the effect of some other variable. As in the present study, where the establishment of a discrimination was important for studying the effects of punishment on the discriminated schedules, the use of instructions can provide a rapid means to effect a stable baseline of discriminated human operant behavior.

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