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HUMAN, FREE-OPERANT AVOIDANCE OF "TIME OUT" FROM MONETARY REINFORCEMENT[1]

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To assess the aversive effects of withdrawing monetary reinforcement, human subjects were exposed to a free-operant avoidance procedure in which periods of no reinforcement occurred if the subject failed to respond, and each response postponed withdrawal of reinforcement. Avoidance behavior was developed either through specific instructions about the consequence of responding or through preliminary escape-avoidance training. In all cases, rates of response were found to be a positively accelerated function of decreases in the duration by which responding postponed reinforcement withdrawal. The findings with respect to the function relating avoidance behavior to the interval of postponement were viewed as similar to those obtained when shock is used as the aversive event in free-operant avoidance conditioning.

The major portion of knowledge of aversive control of behavior has come from experiments in which such stimuli as electric shock, extreme heat, intense noise, and tail pinches have served as the aversive events. Recent studies have demonstrated that a period of time when previously available positive reinforcement is made unavailable, *i.e.*, "time out" from positive reinforcement (TO), also can generate and maintain avoidance behavior (Leitenberg, 1965).

Using the free-operant avoidance procedure developed by Sidman (1953), Ferster (1958) reinforced the key-pressing behavior of chimpanzees with food, and then interrupted such reinforcement periodically unless a response to postpone TO was made on a second key. Stable rates on the avoidance key were observed, and there was some indication that such rates were inversely related to the scheduled duration by which TO was postponed. Baer (1960) also demonstrated that postponement of TO could maintain free-operant avoidance in a study in which pre-school children learned to press a key to avoid interruption of a cartoon movie they were watching.

Sidman's original study of free-operant avoidance of shock identified two temporal parameters which determined rates of response: the *shock-shock* (S-S) interval, or the rate of presentation of shock when responding does not occur, and the *response-shock* (R-S) interval, or the duration by which each response postpones presentation of the next scheduled shock. One purpose of the present study was to determine whether these same temporal parameters influence free-operant avoidance behavior under the control of TO. Thus, the procedures varied the durations of the *time out-time out* (TO-TO) interval and the *response-time out* (R-TO) interval. A second purpose was to investigate some of the conditions leading to acquisition of avoidance behavior by human subjects. In this regard, the procedures compared the relative effectiveness of two methods of establishing avoidance behavior: through escape-avoidance training and through instructions describing the avoidance contingency.

EXPERIMENT I

Subjects

Four female college students were paid for a series of five 50-min test sessions each week. Participation was represented as a work situation, payment to depend upon performance within the situation.

Apparatus

A sound-attenuated audiometric room, about 6 ft square, contained a chair, a table, a

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reading lamp, and a bookcase with reading materials (*e.g.*, magazines, paperbacks, *etc.*). Mounted on the table was a sloping panel, 18 in. wide and 11 in. high, on which were inset two groundglass screens, and a circular response key. The push-button key (Grason-Stadler E8670A) was 1½ in. in diameter and centered 5¼ in. from the bottom of the panel. The groundglass screens, onto which colored lights could be projected from the rear, were 3½ in. square. Their lower edges were 5½ in. from the bottom of the panel and the inside edges were 3½ in. to the right and left of the midline of the panel. Standard programming and recording equipment was located in an adjacent control room.

Procedure

Before the first experimental session, the following information was presented to each subject in accordance with a standard outline: (a) that no information could be given her about the nature or purpose of the research project; (b) that her earnings for each 50-min work session could range from $0.00 to $1.25; (c) that a record would be kept of the amount earned during each session, but that actual payment would only be given at the end of the experiment; (d) that payment would be signaled in the work room through the blinking of a green light on the left-hand panel, six blinks equalling one cent; (e) that a blue light on the right-hand panel indicated that the session was in progress; (f) that watches, pencils, books, and similar personal belongings were not permitted in the work room; (g) that she was free to do whatever she liked in the work room and that the books and magazines were provided for her benefit.

At the end of the first session, in line with the procedures developed by Kaufman (1964) for reducing the rate of experimental drop-outs, subjects were instructed that if they did not continue to the end of the experiment, all earnings would be forfeited, and that a fine of $1.00 would be imposed for each absence without prior notice and excuse. At the end of the first session, subjects were offered the chance to withdraw from the experiment; none did.

Operant level. From three to six sessions were conducted to determine the operant level of key pressing and to adapt subjects to the experimental environment. During these sessions, brief blinks of the green light were presented on the left-hand panel. Each blink of the green light had a duration of 1.3 sec and the rate of blink was programmed according to a 4-sec variable interval (VI) schedule (range = 2-6 sec). The green light was presented independent of any response. During the operant level sessions, key presses had no consequence.

Escape-avoidance. After the operant level sessions, a free-operant escape-avoidance procedure was introduced in which the aversive event was a 15-sec time out from the VI 4 sec blinks of the green light. To increase its discriminability, the TO period was accompanied by a low intensity white noise signal (approximately 1 db above the background level of 51 db). The free-operant escape-avoidance procedure involved the following elements: when the response key was not pressed, TO occurred at designated intervals timed from the previous TO, *i.e.*, the TO-TO interval. Each depression of the response key when time was in served to postpone (avoid) the next TO period by a designated interval, *i.e.*, the R-TO interval. Finally, key presses made after the TO period had begun terminated the TO period (escape) and initiated the R-TO interval.

Before the first escape-avoidance training session, the following instructions were read to the subject:

> There may be times during the session when the green light will stop blinking. I don't mean that it will speed up or slow down. You have probably learned by now that the green light always blinks at about the same rate. I mean that there may be times when the green light stops completely. Of course, when the green light stops, this means that you are losing money as long as it is off.

Before the second session of escape-avoidance training, the following additional instructions were read:

> I don't know whether you noticed that you didn't make as much money during the last session as you did before. That's because the light sometimes stopped blinking while you were in the booth. Now we want you to understand that you

can make as much money as you did before if you want to. That's right. We are prepared to pay you as much as before. But it is up to you to do something about it.

No further information was provided; questions were responded to by rereading the instructions to the subject.

Subjects were exposed to a series of escape-avoidance training sessions in which the TO-TO and R-TO intervals were both 10 sec in duration. Training was continued for at least 10 50-min sessions.

Avoidance only. After exposure to the escape-avoidance contingencies, the procedure was changed to a free-operant avoidance procedure. This was identical in all respects to the escape-avoidance procedure described above except that the escape contingency was removed. Thus, responses made when time was in postponed TO by 10 sec but responses made after TO had begun had no consequence during the 15-sec TO period. Avoidance training was continued for a minimum of five 50-min sessions.

Replacement of blinking light with continuous light. After avoidance behavior was established in three of the subjects (subjects 1, 2, and 6), the procedure was altered to assess the role of the VI 4 sec payment signal as a potential temporal cue. Since avoidance behavior had not been displayed by subject 4, she was not exposed to the change in procedure. In the altered procedure, the green panel was continuously illuminated when time was in, and went off when time was out accompanied by the white noise signal. The subject was informed through reading of the following instructions that payment would continue as long as the green light remained on:

Starting with this session, we are introducing a change in the procedure. The points you have been receiving will be given as before, that is, six points will continue to equal one cent. But in the booth the green light will not flash any more. Instead, when you are earning money the green panel will be continuously illuminated. When it is lit up green, it means that you are earning money at the same rate as you always have. But if the green panel goes off it means that you are no longer earning money.

Avoidance training was continued for at least seven additional 50-min sessions with payment signaled by continuous panel illumination but with other aspects of the procedure unchanged.

Table 1 summarizes for each subject the number of training sessions in each of the phases of Exp I.

Table I

Number of sessions in each phase of Experiment I

Phase	*Subject* 1	2	4	6
Operant level	3	3	3	6
Escape-avoidance	10	10	10	11
Avoidance-only: Blinking	6	6	5	7
Avoidance-only: Continuous	7	10	—	8

Results

Operant level. Response rates during the operant level phase were generally low or absent. Two subjects did not respond at all and one responded once. Subject 6 developed the pattern of sometimes responding when the payment signal went on but her rate decreased to zero by the fifth and sixth operant level sessions.

Escape-avoidance training. None of the subjects responded on the first day of exposure to the escape-avoidance contingencies. Following the additional instructions that they could

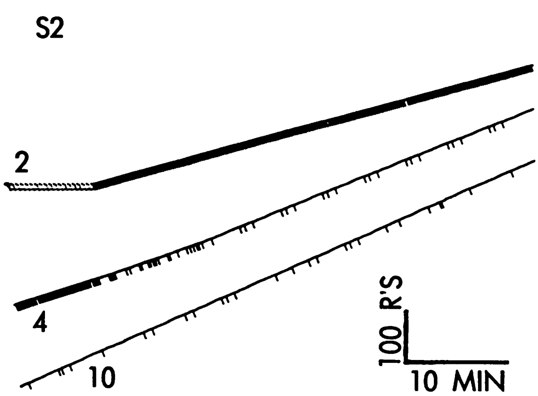

Fig. 1. Cumulative records of subject 2 during escape-avoidance sessions 2, 4, and 10. Each response postponed TO by 10 sec; responses when time was out terminated the TO period. The pen deflected downward during TO.

"do something about it", all four subjects quickly came to respond during the second escape-avoidance session. Although initial responding was generally the same for all subjects, in that behavior mainly involved short-latency escape responses, two characteristically different patterns emerged with further exposure to the escape-avoidance contingencies. For subjects 1 and 2 the majority of responses changed from escape to avoidance responses. This transition may be seen in Fig. 1 which presents the cumulative records of subject 2 during escape-avoidance training. The records of subjects 4 and 6 showed no avoidance behavior, and short-latency escape reponses predominated throughout all sessions. The cumulative records presented in Fig. 2 (subject 6) indicate that occasional avoidance responses manifested during the initial escape-avoidance sessions virtually disappeared by the end of training.

Avoidance-only training. Adjustment to removal of the escape contingency was a distinct function of the pattern of behavior previously developed during escape-avoidance training. For the two subjects who had previously avoided (subjects 1 and 2), removal of the escape contingency immediately increased response rates and reduced the frequency of TOs. The development of this pattern on the initial avoidance day and its maintenance after six days of training is illustrated in Fig. 3 (subject 2). For the remaining two subjects, who had displayed escape behavior almost exclusively during escape-avoidance training, removing the escape contingency initially disrupted behavior markedly. Figure 4 presents the records of one of these (subject 6). It may be seen that removal of the escape contingency produced irregular increases in response rates both between and within the TO periods but that continued exposure resulted eventually in a smooth pattern of avoidance behavior with only occasional lapses. Behavior of the remaining subject (subject 4) broke down when the escape contingency was removed. Figure 5 indicates that virtually all of her responses during avoidance-only training occurred within the TO periods and that by the fifth avoidance-only session, key pressing had virtually extinguished.

Continuous payment signal. Observation of the avoidance responses of the three subjects acquiring such behavior indicated that they sometimes timed this behavior by pacing with the VI 4 sec payment signal; since the signal rate was never less than one blink every 10 sec, pacing resulted in efficient avoidance of the TO.

When the continuous rather than the VI payment signal was employed, avoidance behavior was maintained without disruption. Subjects 1 and 2 showed relatively minor changes in their rates of avoidance behavior; one increased by about 10% and the other decreased by about 15%. Subject 6 showed a

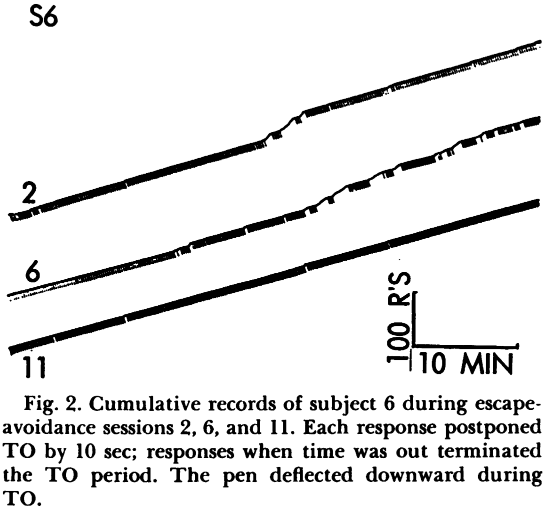

Fig. 2. Cumulative records of subject 6 during escape-avoidance sessions 2, 6, and 11. Each response postponed TO by 10 sec; responses when time was out terminated the TO period. The pen deflected downward during TO.

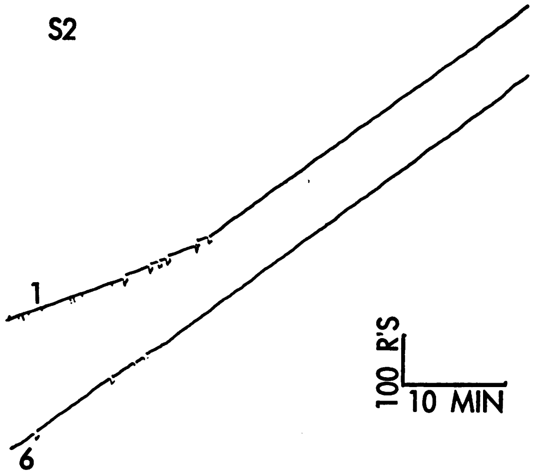

Fig. 3. Cumulative records of subject 2 during avoidance-only sessions 1 and 6. Session 1 followed the tenth session of escape-avoidance training shown in Fig. 1. The escape-avoidance contingency was programmed during the first 10 min of session 1; thereafter, TO's were inescapable with TO-TO = R-TO at 10 sec. The pen deflected downward during TO.

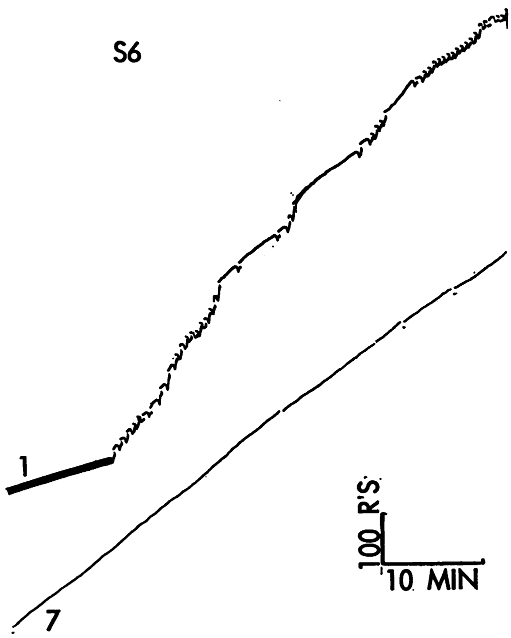

Fig. 4. Cumulative records of subject 6 during avoidance-only sessions 1 and 7. Session 1 followed the eleventh session of escape-avoidance training shown in Fig. 2. The escape-avoidance contingency was programmed during the first 10 min of session 1; thereafter, TO's were inescapable with TO-TO = R-TO at 10 sec. The pen deflected downward during TO.

threefold increase in response rate, and maintained it until she left the experiment eight sessions later.

EXPERIMENT II

Subjects

Five were used. Subjects 1, 2, and 4 had served in Exp I. Subjects 3 and 5 had no prior exposure to the experimental procedures.

Apparatus

The same as used in Exp I.

Procedure

Experiment II was designed to investigate the consequences upon avoidance behavior of varying the R-TO and TO-TO intervals. The avoidance procedure was the same as described for Exp I and for all subjects payment was signaled through continuous illumination of the left-hand panel with a green light. In all phases of Exp II, the TO-TO interval was equal to the R-TO interval.

For subjects 1 and 2, who had acquired the avoidance response in Exp I, Exp II followed without interruption in the procedure. These two subjects were exposed to a descending series of TO-TO = R-TO intervals in the order 10, 5, and 2.5 sec with a sufficient number of sessions at each interval to stabilize response rate.

Before and just after the first experimental session, the two new subjects (subjects 3 and 5) were given the same preliminary instructions described for Exp I except that the instructions indicated that payment would be signaled through continuous illumination of the green light panel. The new instructions stated that when the green light was present payment was at the rate of $1.50 per hour (or $1.25 per 50-min session) and that in the absence of the green light there would be no payment. Subjects 3 and 5 were then given three operant level sessions. Before the fourth session, these subjects were read instructions which indicated the contingencies to which they would be exposed on the avoidance schedule. The instructions read to subject 3 are given below; the instructions read to subject 5 were identical except that wherever reference was made to temporal intervals, the instructions stated "60 sec".

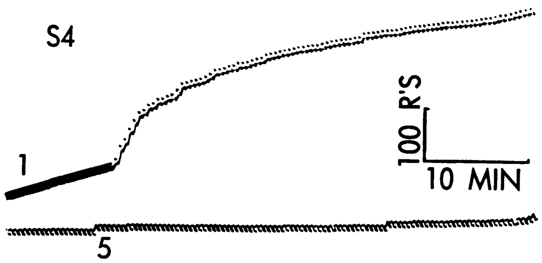

Fig. 5. Cumulative records of subject 4 during avoidance-only sessions 1 and 5. Subject 4 showed only escape behavior during previous escape-avoidance training. The escape-avoidance contingency was programmed during the first 10 min of session 1; thereafter, TO's were inescapable with TO-TO = R-TO at 10 sec. The pen deflected downward during TO.

> From time to time during the session, the green light may go off for a short period of time. Each time that happens you will be losing money because we only pay you when the green light is on. Once the green light goes off, you can't do anything about it. But you can keep the green light on all of the time by pressing the button. Here is how it works. Each time you press the button you keep the green light on for 30

sec. But if you make another press before 30 sec are up, you can keep the green light on for another 30 sec and so on. All you really have to do then to keep the green light on is to press once every 30 sec or so. That way you will keep on postponing the stopping of the green light. But if you wait too long, that is, if you should wait more than 30 sec between presses, the green light will go off and then you won't be able to do anything about it until it goes on again. Of course what you do within the booth is up to you and you can do whatever you like. We will pay you on the basis of how long the green light has been on while you are in the booth. One other thing. For the time being, you can postpone the light going off for 30 sec. Later on, the time will be different.

If there were questions, the instructions were reread to the subject but no further information was provided.

Subjects 3 and 5 were then exposed to a descending series of TO-TO = R-TO intervals. The sequence for subject 3 was 30, 20, 10, 5, and 2.5 sec. The sequence for subject 5 was 60, 40, 20, 10, 5, and 2.5 sec.

The final subject (subject 4) had participated in Exp I but had not acquired the avoidance response during escape-avoidance training. Before Exp II started, she was given the specific instructions about the experimental contingencies described above, and then exposed to a descending series of intervals, 30, 20, 10, 5, and 2.5 sec.

Exposure to each of the TO-TO = R-TO intervals investigated in Exp II was continued for at least five consecutive sessions and longer when day-to-day variability was high or when sequential changes in rate still were apparent. Table 2 summarizes for each subject the number of training sessions with each TO-TO = R-TO interval.

Table 2

Number of sessions at each TO-TO = R-TO interval with avoidance-only procedure and continuous payment signal

			Subject		
Interval	*1**	*2**	*3†*	*4*†*	*5†*
60	—	—	—	—	7
40	—	—	—	—	8
30	—	—	5	10	—
20	—	—	7	9	9
10	7	10	14	20	9
5	8	34	7	11	15
2.5	17	37	19	10	24
10	—	10	—	—	26

*Prior escape-avoidance training
†Instructions about avoidance contingency

After the above procedures were completed, subjects 2 and 5 were studied further to determine whether the changes in rate which accompanied changes in the TO-TO = R-TO intervals were reversible. After the last session at 2.5 sec, the intervals were increased to 10 sec for both subjects and additional sessions were conducted until stable performance levels were observed (10 and 26 sessions respectively).

Results

Neither of the two new subjects responded during the operant level sessions. They, as well as subject 4, who had not developed avoidance behavior in Exp I, immediately developed avoidance behavior following instructions about the experimental contingencies.

The performance of all five subjects indicated that the different temporal intervals generated markedly different rates of response. Figure 6 shows their performance as a function

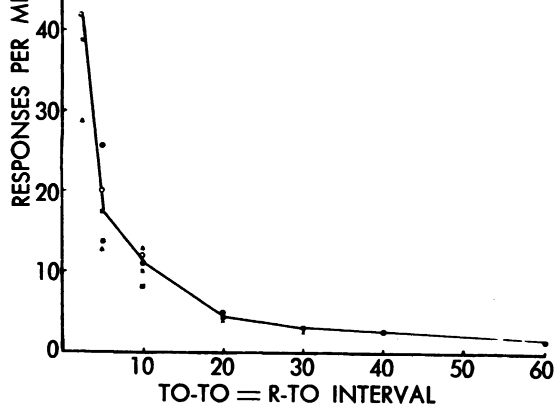

Fig. 6. Response rates for each subject at different TO-TO = R-TO intervals. Points represent mean rates during the last five days of exposure to each interval. The solid line shows median performance at each interval.

of the descending series of TO-TO = R-TO intervals. The values represent mean rates of response (per minute) during the last five days of training at each of the temporal intervals. Variations in response rate were a negatively accelerated decreasing function of the TO-TO = R-TO intervals, with the largest decrements in rate occurring in the range from 2.5 to 10 sec.

In general, the relationship between temporal intervals and response rates was consistent from subject to subject and within the performances of individual subjects. Figure 6 shows that increases in rate with decreases in the intervals were orderly and without reversal for four of the five subjects. The single exception (subject 2) showed no change in rate from 10 to 5 sec but did markedly increase in rate when the intervals were reduced further to 2.5 sec.

At all temporal intervals, response rates were always sufficiently high so that virtually all TOs were avoided. Thus, the median number of TOs actually received per session for the sessions upon which Fig. 6 was based was about 1 (range = 0-33) and even in the most extreme cases, monetary loss never amounted to more than about 20¢ of the $1.25 potentially available per session. Further, there was no indication of systematic differences in numbers of TOs encountered as a function of the TO-TO = R-TO intervals. However, as Fig. 6 shows, the number of responses in excess of the average minimum required to avoid all TOs did increase markedly as the temporal intervals were reduced to the shorter values.

Figure 6 gives no indication of systematic differences in performance as a function of the nature or extent of preliminary training. The performance of the three subjects given instructions about the experimental contingencies fell within the range of performances of the two subjects not given this information.

Inspection of the cumulative records obtained during each test session indicated that short-term rates of response were generally quite regular. The cumulative records shown in Fig. 7 (subjects 3 and 5) are typical and illustrate the details of intrasession responding with different TO-TO = R-TO intervals, *i.e.*, after training with 20 sec, at the beginning and end of training with 10 sec and at the beginning of training with 5 sec. Adjustment to the new intervals occurred rapidly and any irregularities in short-term rates usually occurred during the early part of the first session in which the TO-TO = R-TO intervals were shortened.

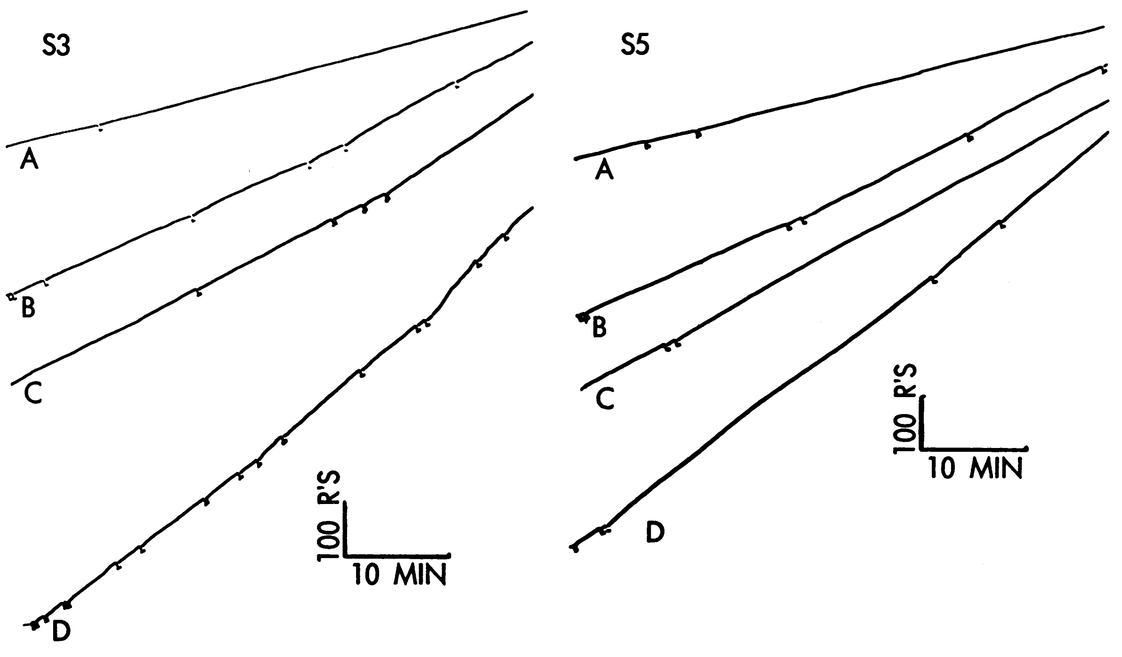

Fig. 7. Cumulative records of subjects 3 and 5 during avoidance-only training at different TO-TO = R-TO intervals: (a) last day of training at 20 sec; (b) first day of training at 10 sec; (c) last day of training at 10 sec; (d) first day of training at 5 sec. The pen deflected downward during TO.

With respect to reversibility of behavior, increasing the interval from 2.5 sec back to 10 sec markedly reduced rates in both of the subjects observed under this condition. Subject 2 decreased from 28.8 responses per minute at 2.5 sec, to 7.1 responses per minute when returned to 10 sec. This reduction occurred rather suddenly during the fourth session after the shift. Subject 5 showed a similar change from 54.6 responses per minute at 2.5 sec to 18.9 responses per minute at 10 sec. In her case, the decline was more gradual and extended over more than 20 sessions.

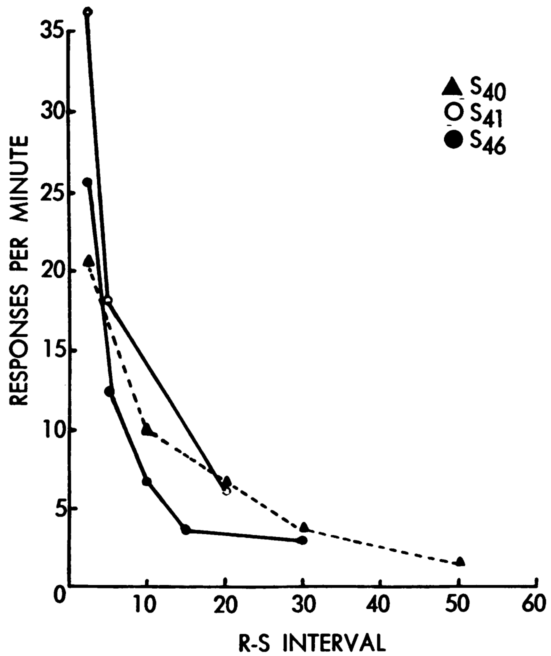

Fig. 8. Data plotted from Sidman (1953) showing response rates for individual rats exposed to free-operant shock-avoidance schedules with S-S = R-S intervals in the same temporal range as the TO-TO = R-TO intervals investigated in the present study.

DISCUSSION

By showing that young-adult human subjects will respond in order to avoid cessation of a signal of monetary payment, the present results extend the findings of Ferster (1958) and Baer (1960) concerning the generation and maintenance of avoidance behavior when TO from positive reinforcement serves as the aversive event. The present study also demonstrated that rates of response generated by TO avoidance varied as a function of the temporal requirements of the schedule. In this regard, it is of interest to compare the present findings with those of Sidman (1953) in his classic study of free-operant shock avoidance by rats. Figure 8 was derived from data presented by Sidman for three rats under conditions when the S-S and R-S intervals were equal. The similarity between the shapes of the functions obtained in Sidman's study and the present study is apparent. Similar results were also reported by Verhave (1959) who followed the present procedure of always programming shock avoidance with equal R-S and S-S intervals.

Although the present results agree with those of studies of animal shock avoidance in terms of the functional relationship between temporal intervals and gross response rates, a number of differences were present in short-term aspects of performance. In general these differences are due to the remarkable regularity of the human subjects' avoidance behavior. Thus, even though response rates rose almost immediately in those sessions when the TO-TO = R-TO intervals were shortened, there was none of the bursting and irregularity characteristic of animals' behavior in shock-avoidance situations. The human subjects, after receiving a few TOs, simply increased their very regular rates. Several other characteristic aspects of animal shock avoidance were absent in TO avoidance by the human subjects of the present study, *e.g.*, warm-up during the early part of the session, bursts of responses after TO occurred, and declining rates during the session.

Comparisons of the present results with those of shock-avoidance procedures should take into account the small extent of loss associated with each 15-sec TO (⅝ths of a cent). Ader and Tatum (1961) in their study of shock avoidance with human subjects point out that the shock employed was sufficiently noxious that about one-third of their subjects "walked out," and that few subjects ". . . purposely delayed a response in order to '. . . see if the shock was still there.' " By contrast, in the present study TO was not aversive enough to lead to "walking-out" behavior in any subject, and subjects occasionally waited until the first TO had occurred before beginning to respond. Nevertheless, response rates in the present study were quite persistent and sustained during each session, and three of the five subjects had runs as long as 10 sessions without encountering a single TO. In comparison with electric shock stimulation, whose aversive aspects can be accounted for in large part by unlearned factors, the aversive aspects of TO from positive reinforcement appear to generate far less irregularity in short-term rates of responding. The difference may be attributable to the competing responses generated by electric shock stimulation, to species differences, or to the extensive reinforcement histories of human subjects.

The role of pre-avoidance procedures in determining acquisition of avoidance behavior deserves comment. Previous studies have shown that exposing the uninstructed, unshaped human directly to an avoidance schedule leads to acquisition failures in as many as half of the subjects (cf. Ader and Tatum, 1961; Ader and Sibetta, 1964). The same procedure used with animals also results in substantial numbers of failures to produce avoidance behavior, particularly when the R-S interval does not exceed the S-S interval (Black and Morse, 1961; Leaf, 1965) or when the response does not have immediate stimulus consequences (Bolles and Popp, 1964).

An alternate procedure for the development of avoidance behavior is that of preceding avoidance training with escape-avoidance training, as was the case in the present Exp I. Other studies have shown that this procedure leads to the gradual emergence of avoidance behavior on the escape-avoidance schedule (Baer, 1960; Hefferline, Keenan, and Harford, 1959). Similar findings were obtained in two of four subjects exposed to this procedure in the present study. That the escape-avoidance procedure may be detrimental for the eventual establishment of avoidance behavior was indicated, however, by the performances of the two subjects whose pattern of escape responding was apparently of sufficient strength to interfere with, and in one case to preclude, adjustment to the avoidance schedule. This observation is consistent with the report of Bixenstine and Barker (1964) who found that when responses on different response apparatus are required for either escape or avoidance, early conditioning of escape behavior may be detrimental for the development of subsequent avoidance.

A last procedure, available only with human subjects, is to provide specific instructions about the appropriate response and its consequences before avoidance training begins. In the present study this procedure immediately produced stable avoidance behavior in all three subjects with whom it was employed. One of these subjects had not acquired the avoidance response during previous escape-avoidance training.

Finally, it is important to emphasize that the different pre-avoidance procedures employed in the present study were not systematically related to eventual rates of avoidance responding on the different temporal schedules. Thus, the findings suggest that within a broad range of acquisition conditions, TO avoidance is sensitive to the temporal contingencies defined by the TO-TO and R-TO intervals.

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