SIGNALLED REINFORCEMENT IN DIFFERENTIAL-REINFORCEMENT-OF-LOW-RATE SCHEDULES¹

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At several fixed and variable minimum reinforced interresponse times, a stimulus was added to differential-reinforcement-of-low-rate schedules to signal the availability or non-availability of reinforcement. As the minimum reinforced interresponse time increased, the rate of unreinforced responding decreased. Changing from fixed to variable minimum interresponse time in the basic differential-reinforcement-of-low-rate schedule further decreased the rate of unreinforced responding. Both effects were to some degree reversible. For fixed minimum reinforced interresponse times of 30 sec or shorter, most unreinforced responses terminated interresponse times just short of that required for reinforcement. The minimum reinforced interresponse time and the number of short response latencies (≤ 0.5 sec) to the onset of the signal were negatively correlated. Both of these analyses suggested that at values of 30 sec or shorter, the subjects discriminated the availability of the reinforcer more on the basis of time than on the basis of presence or absence of the signal.

The stimulus control that a discriminative stimulus has over responding can be assessed by signalling the availability of the reinforcer and by observing the resultant changes in performance. Such schedules have been used to study behavioral contrast (Brownstein and Hughes, 1970; Brownstein and Newson, 1970; Reynolds and Limpo, 1968; Wilkie, 1973), concurrent schedules (Catania, 1963; Pliskoff and Green, 1972; Shimp, 1968, 1971), and fixed-interval schedules (Ferster and Skinner, 1957). Yet little is known about how adding a stimulus to signal reinforcer availability affects both the rate and pattern of responding maintained by differential-reinforcement-of-low-rate (DRL) schedules of reinforcement. Technically speaking, adding a stimulus that signals reinforcer availability affects different classes of reinforcement schedules in different ways. Adding a signal to fixed- or variable-interval schedules creates a multiple schedule with both a continuous reinforcement (CRF) and an extinction component (*mult* EXT-CRF), while the same addition changes a DRL schedule to a chain schedule with both a differential-rein-

forcement-of-other-behavior and a CRF component (chain DRO-CRF). In chain DRO schedules, not responding for a specified period of time (DRO value) in the presence of the stimulus correlated with nonreinforcement (S2) is followed by the onset of the stimulus correlated with reinforcement (S1).

Although stimulus control in multiple schedules that include extinction components has been compared with control in analogous chain DRO schedules (Mello, 1966; Terrace, 1963a, 1963b), little is known about how variations in the DRO component affect responding in the presence of the S2 and S1 stimuli. An analysis of the existing literature (Catania, 1970; Shimp, 1968; Stevenson and Clayton, 1970) suggests that adding stimuli to DRL schedules to signal reinforcer availability has differential effects on responding. The relative degree of stimulus control exerted either by the added stimulus dimension or the basic temporal dimension of the DRL schedule appears to be a function of the DRL value. Catania (1970) and Shimp (1968) reported that at short DRL values, adding a signal does not eliminate unreinforced responding. Shimp's data suggest the involvement of a temporal discrimination, because a significant number of unreinforced responses terminate interresponse times (IRT) just short of those necessary to produce the reinforcer. Stevenson and Clayton (1970), however, in a related study in

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which lever-holding durations of 40 sec (minimum reinforced duration) were signalled, reported no evidence that animals discriminated the 40-sec duration on the basis of the temporal dimension. Instead, they provided evidence that the holding response was under almost complete control of the signal.

The present study investigated the effect of signalling reinforcer availability in DRL schedules on both the rate and pattern of responding in the S1 and S2 intervals as a function of the DRL value. The present study also examined whether the control exerted by the signal could be increased by changing the minimum reinforced IRT from a fixed to a variable duration of equal mean value.

METHOD

Subjects

Thirty Sprague Dawley male albino rats, approximately 90 to 100 days old, were maintained at 85% of their free-feeding weight throughout the experiment. Water was available in the home cage but not during the experimental session.

Apparatus

The experimental chamber was a wire-mesh enclosure 22 by 27 by 22 cm. A Gerbrands rat lever, requiring a force of 0.065 N to operate, was mounted on one wall 5.2 cm on center from the left wall and 6.6 cm on center from the floor. A Gerbrands food cup was located on the same wall 7.6 cm on center to the right of the rat lever and 6.4 cm from the floor. The pellet dispenser was mounted on top of the chamber and the reinforcer consisted of a 45-mg Noyes food pellet.

Two 28-V heavy duty relays, each located 57 cm from the lever, on either side of the animal enclosure, separated by a distance of 132 cm and an angle of 120°, were operated 10 times per second. The loci of the clicking noise generated by the rapid operation of the relays were used as the discriminative stimuli.

Procedure

Discrimination training for all subjects began during the first experimental session. After 30 responses were reinforced, the schedule was changed from CRF to the appropriate signalled DRL schedule.

Eighteen subjects were assigned to one of

six conditions (three subjects per condition) that differed with respect to the duration of the minimum reinforced IRT (the DRL value): 5, 10, 30, 60, 120, and 240 sec. All animals were trained to discriminate a clicking stimulus located to the left of the chamber (S2) from a clicking stimulus located to the right (S1). The actual duration of the S2 interval depended on both the DRL value and the animal's behavior in the presence of S2. Termination of S2 and the onset of S1 was contingent upon a fixed minimum interval of no lever pressing in the presence of S2. A response in S2 simply delayed the onset of S1 by a fixed time interval equal to the DRL value. The first response after the onset of S1 resulted in the presentation of a 45-mg food pellet, the termination of S1, and the onset of S2. During each session, the S1 and S2 intervals were alternated in simple fashion until 150 reinforcements were obtained.

In Session 12, except for the 240-sec animals, the schedule was changed from signalled fixed DRL to variable DRL of equal mean DRL value. The termination of S2 and the onset of S1 was contingent upon a variable minimum interval of no lever pressing in the presence of S2 (variable DRL value). The sequence of variable DRL values for all animals was a multiple of the following 5-sec variable DRL sequence: 6, 5, 8, 1, 10, 2, 2, 1, 5, 13, 3, 5, 1, 5, 8. The numbers refer to the interval durations in seconds. The first response that occurred during each S2 interval delayed the scheduled onset of S1 by the duration of the next scheduled DRL value. Additional responses during the same scheduled interval as the first response had no effect. However, the first response occurring after the next scheduled DRL value had set up (the delay interval) would again delay the newly scheduled onset of S1 by the next scheduled DRL value. For example, consider the first three intervals of the 5-sec variable DRL sequence; 6, 5, and 8 sec. The first response within the 6-sec interval would delay the scheduled onset of S1 by the duration of the next tape interval, *i.e.*, 5 sec. Additional responses during the 6-sec interval had no effect. If a response occurred at any time during the 5-sec delay interval (*e.g.*, after 4 sec) the onset of S1 would now be delayed by the next scheduled tape interval, *i.e.*, 8 sec. This procedure remained in effect until one of the scheduled tape intervals had elapsed without

a response. Thus, the minimum delay between an unreinforced response and S1 onset was at least equal to the shortest tape value. Also, in Session 12, the DRL value for two of the 240-sec animals was changed to 10 sec and in Session 19 it was returned to 240 sec. The responses of two additional animals were reinforced on a DRL 240-sec schedule for 11 sessions of 150 reinforcements per session.

To check the effect of the sequence of schedules, 10 other animals, two at each of the following scheduled durations, 5, 10, 30, 60, and 120 sec, were given the reverse sequence. That is, the minimum reinforced IRT of the basic DRL schedule was variable during Sessions 1 to 11 and fixed during Sessions 12 to 22.

RESULTS

All available IRT distributions are presented in Figure 1. Due to a shortage of equipment, IRT data were not available for all animals. With the exception of Animal #22 (distribution calculated from data of seven sessions), each point is the arithmetic mean of the last five sessions under each condition. Class-interval size is equal to one fifth of the DRL value. All IRTs falling in the sixth class interval or above were reinforced and all IRTs greater than twice the DRL value are included in the eleventh class interval. The IRT distributions to the left of the vertical line are those of animals for which the DRL value was fixed during Sessions 1 to 11. The IRT distributions for Animal #22 were obtained from the subject's performance during Sessions 12 to 18 after the animal was switched from a 240-sec to a 10-sec fixed DRL value. The IRT distributions in the right panel are those of the animals for which the DRL value was fixed during Sessions 12 to 22. The IRT distributions of the unsignalled 240-sec DRL animals are also included in the right panel of Figure 1. Several properties of the distributions are apparent. First, the number of unreinforced IRTs decreases as the DRL value increases. Second, the IRT distributions at each DRL value are similar, even though the subjects whose distributions are presented in the right panel were first exposed to schedules in which the DRL value was variable. The IRT distribution for Animal #22 is very similar to the IRT distributions for the two other 10-sec animals (#30 and #4), even though they had

been subjected to vastly different training histories. Third, the largest number of unreinforced IRTs for the 5- and 10-sec animals of both conditions and the 30-sec animal of the left panel occur in the fifth class interval, even though the occurrence of these responses nearly doubled the actual duration of the S2 interval. Fourth, the IRT distributions for the 5-sec animals are similar in form to the distributions of unsignalled DRL 240-sec animals. Both the majority of the unreinforced IRTs occurred in the fifth class interval and a large number of the reinforced IRTs occurred in the intervals above the sixth. This similarity exists despite the fact that the availability of the reinforcer was signalled for the 5-sec animals. A comparison of the 5- and 10-sec *versus* the 240-sec animals for which the reinforcer availability is signalled shows that at the long DRL values, almost no unreinforced IRTs occur and that 100% of the reinforced IRTs fall in the sixth class interval. The data of the 5- and 10-sec animals show both a significant number of unreinforced IRTs and substantial number of reinforced IRTs in the seventh and eighth class intervals. The data of the 60- and 120-sec animals appear similar to those of the 240-sec animals.

Table 1 shows the data for each rat for the last five sessions at each fixed (F) and variable (V) DRL value. The data of the 240-sec unsignalled DRL animals (F-NS) are presented in the bottom two rows of Table 1. Column 3 lists the order of presentation (fixed or variable minimum reinforced IRT); column 4, the mean IRT; column 5, the actual time in the presence of S2 (in minutes); column 6, the actual time in S1 (in minutes); and column 7, the total number of S2 responses. The total number of S1 responses for the last five sessions at each condition was constant at 750. The average response rate in the presence of S2 (column 8) was obtained by dividing the number of S2 responses (column 7) by the actual duration of the S2 interval (column 5). For example, consider a 20-sec DRL schedule in which a reinforced response begins a sequence in which a 10-sec IRT is followed by a 30-sec IRT. The number of S2 responses (unreinforced responses in the unsignalled schedule) would be one. The actual time in S2 (the time that reinforcement was not available in the unsignalled schedule) is equal to 10 sec plus 20 sec of the 30-sec IRT for a total of 30

Fig. 1. IRT distributions in cases where IRT data were available. Class interval size is equal to one-fifth of the DRL value. All IRTs falling in the sixth class interval or above were reinforced. IRTs greater than twice the DRL value are included in the eleventh class interval. The IRT distributions in the right panel are those of the animals for which the DRL value was fixed during Sessions 12 to 22. The IRT distributions of the 240-sec un-signalled DRL animals are also included in the right panel. The IRT distributions in the left panel are those of animals for which the DRL value was fixed during Sessions 1 to 11. The IRT distribution for Animal #22 (left panel) was obtained from Sessions 12 to 18 after the DRL value was reduced from 240 to 10 sec.

Table 1

DRL value, order of procedures: mean IRT, total time in S2 (in minutes), total time in S1 (in minutes), S2 responses, rates of responding in the presence of S2, mean number of S1 latencies ≤ 0.5 sec and the average standard deviations for the last five sessions at each fixed (F) and variable (V) DRL value. S1 was the stimulus correlated with reinforcement; S2, the stimulus correlated with nonreinforcement.

Subject	DRL	3 SEQ	4		5		6		7		8		9		10	
			Mean IRT		Time S2		Time S1		S2 Responses		S2 Rate		Mean No. S1 Latencies		Mean SD	
			F	V	F	V	F	V	F	V	F	V	F	V	F	V
2	5	F-V	6.4	6.0	89.3	84.4	26.0	14.7	335	232	3.750	2.750	32.4	15.0	1.54	1.03
30	5	F-V	6.1	6.6	97.5	79.1	24.6	17.0	451	125	4.620	1.580	24.0	13.2	1.38	0.85
11	5	F-V	7.0	6.1	93.8	97.5	22.8	19.3	253	393	2.700	4.030	21.2	3.0	1.91	1.21
20	5	V-F	6.3	5.9	91.2	104.1	13.0	16.2	489	468	5.360	4.490	34.6	11.0	1.21	1.00
2RS	5	V-F	6.0	6.2	80.6	115.5	19.4	28.7	248	619	3.080	5.550	20.0	12.2	1.35	1.37
RS	10	F-V	11.1	11.6	164.4	141.0	25.1	17.8	278	69	1.690	0.490	16.8	5.2	2.00	2.47
20	10	F-V	11.6	13.2	171.8	149.2	36.0	39.5	326	108	1.900	0.720	15.6	8.0	1.22	0.90
RS10	10	F-V	11.2	Died	173.1	—	26.7	—	318	—	1.840	—	13.0	—	0.98	—
30	10	V-F	10.4	11.6	174.3	134.8	10.2	16.0	312	29	1.800	0.220	55.2	6.4	1.26	1.07
4	10	V-F	10.7	12.2	172.5	156.3	14.7	20.7	299	119	1.730	0.760	16.2	3.0	0.58	0.49
2RS	30	F-V	31.7	30.6	404.4	385.5	34.7	18.6	83	42	0.200	0.110	6.2	3.0	1.24	0.88
LS2	30	F-V	30.2	30.9	410.0	405.9	24.6	13.6	113	64	0.280	0.160	5.4	0.8	0.74	0.47
20	30	F-V	30.3	32.7	401.6	383.1	20.1	33.6	87	15	0.220	0.040	12.0	1.0	0.82	2.22
B	30	V-F	28.9	31.3	403.4	399.8	13.8	21.7	116	58	0.290	0.140	4.0	0.0	0.72	0.59
LS	30	V-F	30.2	31.9	383.5	396.2	37.3	25.5	87	43	0.230	0.110	53.2	0.0	0.32	0.90
LS	60	F-V	59.8	60.7	772.2	742.7	27.9	27.6	53	11	0.070	0.010	0.0	0.0	0.29	0.41
10	60	F-V	59.7	60.7	774.9	756.6	19.5	14.2	48	24	0.060	0.030	0.0	0.0	0.42	0.83
A	60	F-V	59.7	61.1	762.8	764.1	19.4	13.9	36	15	0.050	0.020	4.0	0.0	0.050	0.21
C	60	V-F	60.9	61.9	755.1	755.3	18.2	25.4	12	7	0.020	0.009	1.0	0.0	0.63	0.69
D	60	V-F	61.7	60.7	756.4	767.2	21.5	15.8	6	24	0.010	0.030	0.0	0.0	0.33	0.42
2	120	F-V	120.2	120.8	1517.0	1507.9	17.7	18.3	16	8	0.015	0.005	0.0	0.0	0.62	0.38
14	120	F-V	117.2	120.8	1542.7	1513.8	34.0	16.2	57	10	0.037	0.007	0.0	0.0	0.53	0.40
4	120	F-V	120.8	121.4	1517.1	1509.4	22.4	15.7	15	4	0.010	0.003	1.2	0.0	0.48	0.50
2RS	120	V-F	120.9	121.3	1498.7	1509.4	20.6	20.5	4	7	0.003	0.005	0.0	0.0	0.49	0.58
RS	120	V-F	119.5	122.5	1496.9	1514.0	24.5	27.3	14	5	0.009	0.003	0.0	0.0	0.87	0.99
LSRS	240	F	237.2		3001.5		18.4		14		0.005		0		0.68	
22	240	F	236.4		3019.8		25.6		23		0.007		0		0.44	
10	240	F	239.6		3009.0		34.5		12		0.004		0		0.52	
3	240	F-NS	231.1		6168.8		1232.9		1172		0.190					
4	240	F-NS	227.7		6487.7		902.6		1197		0.185					

sec. The S2 response rate would be equal to two responses per minute. Column 9 lists the average number of latencies to S1 onset ≤ 0.5 sec and column 10 presents the average standard deviations of the individual latency distributions.

The data of Table 1 show that as the DRL value increased, the average response rate in the presence of S2 decreased (column 8). For DRL values from 5 to 120 sec, the total number of S2 responses also decreased as the DRL value increased. Increasing the DRL value to 240 sec did not appreciably affect the number of S2 responses. This suggests that at the very long DRL values (120 and 240 sec), the frequency of S2 responding is constant, rather than a function of the absolute amount of time in S2.

With four exceptions, both the S2 rate and the number of S2 responses at each DRL value were lower for sessions in which the minimum reinforced IRT was variable, regardless of the order of presentation. A comparison of performance on signalled and unsignalled 240-sec DRL schedules indicates that while the unreinforced response rates were low in both cases, the unreinforced response rate for the unsignalled DRL 240-sec animals was approximately 36 times that of the signalled DRL 240-sec animals. The number of unreinforced responses emitted by the unsignalled 240-sec animals was approximately 72 times greater.

While the average latencies to S1 onset (column 6 divided by 750) did not vary systematically, both the standard deviations of the individual latency distributions (column 10) and the mean number of S1 latencies ≤ 0.5 sec (column 9) were a function of the DRL value. A significant number of short latencies to S1 onset (≤ 0.5 sec) occurred at short fixed DRL values regardless of the order of presentation of the fixed and variable conditions. Changing the DRL value from fixed to variable eliminated most of these short latencies. For both fixed and variable DRL values, the standard deviations of the latency distribution decreased as the DRL value increased (correlations significant at beyond the 0.025 level).

Figure 2 shows the proportion of unreinforced responses as a function of the DRL value (log scale). The proportion of unreinforced responses was calculated by dividing the total number of unreinforced responses emitted during the last five sessions of each

Fig. 2. The mean proportion of unreinforced responses as a function of the log DRL value for both fixed (closed circles) and variable (open circles) DRL values.

condition by the total number of responses emitted. Since the different orders of fixed or variable DRL values had little effect on the behavior of the subjects, the data were combined and the mean proportion for each DRL value for both the fixed (closed circles) and the variable (open circles) DRL values are presented in Figure 2. For both fixed and variable DRL values from 5 to 60 sec, the mean proportion of unreinforced responses decreased as the DRL value increased. Also, with the exception of the 5-sec animals, the proportion of the unreinforced responses, at DRL values of 60 sec or less, was lower for animals exposed to schedules in which the DRL value was variable.

The negligible difference in the mean proportions at the 5-sec variable and fixed DRL value was a result of the tape interval values selected for the variable DRL value condition. The selection of short intervals affected the response rate for all 5-sec animals exposed to the variable DRL schedules for both sequences of schedules. Changing from a fixed to a variable DRL value in which there were scheduled intervals shorter than 5 sec (minimum interval 1 sec) increased the probability (from zero to some positive value) that an IRT shorter than 5 sec would be reinforced. Since many IRTs longer than 1 sec but shorter than 5 sec were occurring (Figure 1) at the time of the sched-

ule change, the result was that many of these IRTs were reinforced and an actual increase in the S2 rate was observed in several cases. The S2 rates of animals exposed to schedules in which the 5-sec DRL value was variable during Sessions 1 to 11 were also affected by the selection of these short intervals. Since S2 responses delayed the onset of S1 by a duration equal to the next DRL interval scheduled by the tape, it is quite probable that in many cases S2 responding delayed the onset of S1 for only slightly more than 1 sec. Such occurrences would serve to maintain S2 responding at a level higher than that expected if the shortest tape interval were longer than 1 sec.

Figure 3 shows the response rate in S2 per session for Animals #LSRS and #22. For both animals, the fixed DRL value of 240 sec was changed to 10 sec in Session 12 and then returned to 240 sec in Session 19. By Session 11, the S2 response rate for both animals had decreased to virtually zero. Reducing the DRL value to 10 sec increased the rate of S2 responding of both animals. Also included in Figure 3 is the unreinforced IRT distribution of Animal #22 (in 2-sec class intervals) for the seven sessions at the 10-sec duration. The majority of the unreinforced IRTs fell into the fifth class interval (8 to 9.9 sec). When the animals were returned to the 240-sec value in Ses-

sion 19, the S2 response rates quickly returned to zero.

The data of Figures 1 and 3 and Table 1 provide some evidence of the degree of stimulus control obtained at long DRL values. For example, the data of Rat #LSRS in Session 11 indicate that the S2 response rate was zero and 95 of 150 S1 latencies occurred between 1.0 and 1.5 sec after S1 onset. In terms of interresponse times, 63% of the IRTs emitted by Rat #LSRS in Session 11 fell between 241.0 and 241.5 sec. In fact, all of the IRTs emitted in Session 11 fell between 240.5 and 243.0 sec.

The effect of reducing the DRL value from 240 to 10 sec on the shape of the latency distribution was to (1) increase the standard deviation of the distribution, and (2) increase the number of response latencies to S1 onset ≤ 0.5 sec. In general, the distribution became very similar in shape to the other 10-sec latency distributions.

To provide information as to how the addition of discriminative stimuli affects performance under control of schedule variables, the performance of the signalled DRL animals was compared to that of unsignalled DRL animals. Figure 4 shows the percentage of the maximum reinforcement rate attained as a function of the DRL value. Maximum reinforcement

Fig. 3. The S2 (stimulus correlated with nonreinforcement) response rates per session for Rats #LSRS and #22 at DRL values of 240 and 10 sec. The unreinforced IRT distribution of Rat #22 (in 2-sec class intervals) for the seven sessions at the 10-sec duration is included in the insert.

Fig. 4. Percentage of the maximum reinforcement rate attained as a function of DRL value for both signalled, fixed and variable (filled and open circles respectively), and unsignalled DRL schedules (crossed half-filled circles).

rate was calculated by dividing the number of reinforcements possible per session by the DRL value. The percentage of maximum reinforcement rate attained is equal to the obtained reinforcement rate divided by the maximum reinforcement rate. Each point represents the data of one subject. The filled and open circles of Figure 4 represent the average percentage of maximum reinforcement attained during Sessions 7 to 11 by each subject for fixed and variable DRL schedules respectively, as a function of the DRL value. The solid and dashed lines represent the mean percentage attained at each DRL value. As the DRL value increased, the percentage of the maximum reinforcement rate for both fixed and variable DRL values approached 100%. Also, the percentage of the maximum reinforcement rate attained at 10, 30, and 60 sec was greater at the variable DRL values.

Figure 4 also shows the percentage of maximum reinforcement rate attained by unsignalled DRL animals (crossed half-filled circles). Data reported in the literature were included only if the actual reinforcement rate for the entire session of stable responding could be obtained. The points for the 30-sec animals were calculated from the data of Barofsky (1969) Figure 1. The 40-sec animals from the data of Farmer and Schoenfeld (1964) Figure 3, Figure 1; the 10-sec values from unpublished data of the present author. The data points for the 240-sec animals were calculated from the performance of Subjects #3 and 4 (DRL 240-sec) of the present experiment. For the DRL animals, there does not appear to be a systematic increase in the percentage of maximum reinforcement attained as the DRL value increases.

DISCUSSION

The present data are in agreement with those of Catania (1970), Clayton and Stevenson (1970), and Shimp (1968), in that they demonstrate that within a range of 5 to 120 sec, stimulus control of S2 responding increases as the DRL value increases. At DRL values of 30 sec or shorter, S2 responding is maintained, even though the availability of the reinforcer is signalled and the occurrence of these responses decreases the rate of reinforcement. Catania (1970) attempted to account for this increase in S2 rate at short DRL

values by assuming that the increase is a dynamic property of the schedule and constitutes an increase in the number of short IRTs. Although a dynamic interpretation may be reasonable, neither the present results nor those of Shimp (1968) demonstrate an increase in the number of short IRTs. Instead, as the present study demonstrates, the increase in S2 rate that accompanies a decrease in DRL value is associated with an increase in the number of IRTs just short of the minimum reinforced IRT.

At DRL values longer than 30 sec, very little S2 responding occurs, and the majority of the S1 response latencies fall within a very narrow range. These data are essentially in agreement with those of Stevenson and Clayton (1970), who reported a much higher degree of stimulus control at the 40-sec DRL value than Catania and Shimp found at shorter DRL values. Stevenson and Clayton demonstrated, in extinction, that omitting the stimulus (white noise) that signalled response durations long enough for reinforcement produced an increase in the maximum response durations of all animals over that obtained in extinction when the signal was presented. A similar finding was observed in the present experiment at long DRL values. In those instances of equipment failure where S1 was not presented, no S2 responses occurred for periods of as long as 4 hr.

If the above relationship applies to simple DRO schedules, in which reinforcement is contingent upon nonresponding for a specified period of time, then the present data are in agreement with Davis and Bitterman (1971). They suggest that an important variable in studies concerned with the efficacy of DRO *versus* extinction procedures (Nevin, 1968; Rescorla and Skucy, 1969; Uhl and Garcia, 1969) may be the scheduled duration of the DRO component. They also suggest that the failure of Rescorla and Skucy (1969) to demonstrate the superiority of DRO procedures may be due to the use of too short a scheduled DRO duration.

The present results suggest that at DRL values of 30 sec or shorter, some type of temporal discrimination is involved. Table 1 shows that at short fixed DRL values, the number of response latencies to S1 onset ≤ 0.5 sec is greater than at either any longer or at any variable DRL value. The present data suggest that

these extremely short response latencies are not indicative of the control of the auditory stimuli, but rather of the control of some temporal dimension. In these instances, the onset of S1 did not set the occasion for a response, but rather appeared while the response was being emitted. Support for this interpretation is considerable. First, a response latency ≤ 0.5 sec represents an extremely fast reaction time. Second, if the majority of S2 responses, at short DRL values, terminate IRTs just short of the minimum required IRT, then it is reasonable to expect that the distribution of these IRTs vary about some average IRT. Thus, it is likely that a number of these responses would occur just after the onset of S1. Third, the number of IRTs occurring in the IRT class just before the reinforced IRT class is directly related to the number of these short response latencies. Further evidence as to the involvement of a temporal discrimination is obtained from the results of changing the DRL value from fixed to variable and *vice versa*. Table 1 shows that regardless of the sequence of schedules, both the S2 response rate and the number of short response latencies occurring are to a certain degree dependent on the pattern of S1 presentations. Thus, at DRL values of 30 sec or shorter, few S2 responses and S1 latencies ≤ 0.5 sec occur with variable DRL values.

In general, the results suggest that the effect of signalling reinforcer availability in DRL schedules is a function of both the DRL value and of whether the minimum reinforced IRT is fixed or variable. It appears that time is a highly salient stimulus for rats. At short DRL values, time governed responding, *i.e.*, the performance of rats on signalled DRL resembled that of rats on unsignalled DRL schedules (Figure 1), even though the use of the discriminative stimuli would have increased the rate of reinforcement (Figure 4). At long DRL values, where temporal discrimination is difficult and the potential drop in reinforcement rate is great, the rats shifted to the auditory localization dimension. Further research is needed to see whether this shift to the added exteroceptive dimension is a function of the discriminability of the stimuli employed. For example, the less discriminable the added stimuli the more the signalled DRL performance should resemble that generated by unsignalled DRL schedules.

These findings have widespread implications in the area of discrimination learning. Many studies now employ a discrete-trial procedure (Logan, 1971; Terrace, 1963) in which either a positive or negative stimulus is presented after a specified period of nonresponding in the presence of a third stimulus. According to the present results, an occurrence or nonoccurrence of a response in the presence of the positive and negative stimuli is not only a function of the reinforcement contingencies associated with each stimulus but also a function of the frequency and manner of scheduling these stimuli.

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