

INTERCURRENT AND REINFORCED BEHAVIOR UNDER MULTIPLE SPACED-RESPONDING SCHEDULES¹

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Lever pressing in rats was reinforced with food under a multiple spaced-responding schedule. A lever, food cup, and drinking tube were mounted in a running wheel so that lever pressing, running, and licking could be recorded. Running and licking had no scheduled consequences. Lever pressing was reinforced under a multiple schedule with three spaced-responding components and an extinction component. Each component was associated with a different auditory stimulus. Spaced-responding components reinforced only lever presses terminating interresponse times equal to or greater than 10, 20, or 60 sec, respectively. Rates of lever pressing, reinforcement, and licking all decreased as schedule parameter increased. Efficiency of spaced responding, as measured by reinforcements per response, also decreased. Rate of wheel running either increased or increased and then decreased with increasing schedule parameter. Individual running rates differed substantially. Neither licking nor running rate correlated with individual differences in efficiency. Analysis of conditional probabilities among the several response classes showed that, as the schedule requirement increased, the probability of running after a lever press increased and the probability of licking after a lever press decreased. After reinforcement, one subject always pressed the lever next. In the other subjects, the conditional probability of lever pressing, given reinforcement, increased while the probability of licking, given reinforcement, decreased with increasing schedule requirement. Results are discussed in relation to the concepts of schedule-induced and mediating behavior.

Reinforcement schedules not only produce characteristic temporal patterns of the experimentally defined response, but they also lead to specific distributions of "other behavior", which is often unrecorded. For example, specific patterns of behavior are associated with the initial pause in responding under fixed-interval schedules (Falk, 1966*b*; Skinner and Morse, 1957; Stein, 1964). Orderly sequences of behavior have also been observed under spaced responding or differential-reinforcement-of-low-rate (DRL) schedules (Laties, Weiss, Clark, and Reynolds, 1965; Laties, Weiss, and Weiss, 1969; Segal and Holloway, 1963; Wilson and Keller, 1953). Spaced-re-

sponding schedules reinforce only responses that terminate an interresponse time exceeding some criterion value. Behavior during interresponse times under spaced-responding schedules may be called intercurrent behavior, a term that is neutral with respect to the origin and function of such responding.

Intercurrent behavior may take different forms, according to the arrangement of the experimental environment. Examples that have been studied in relation to explicitly reinforced lever pressing or key pecking are wheel running (Skinner and Morse, 1957), drinking (Clark, 1962; Falk, 1961, 1966*a*, 1966*b*, 1967; Keehn, 1970; Kissileff, 1969; Segal, 1965; Segal and Holloway, 1963; Stein, 1964), nibbling (Laties *et al.*, 1965; Laties *et al.*, 1969; Weiss and Laties, 1964), and pressing another lever or pecking another key (McMillan, 1969; Mechner, 1958; Millenson, 1966; Segal, 1963; Zuriff, 1969).

Although the occurrence of characteristic patterns of intercurrent behavior is well established, the role of this behavior in relation to the reinforced response class and the variables responsible for its occurrence and dis-

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tribution are not well understood. One of the earliest views (*e.g.*, Weiss and Laties, 1964; Wilson and Keller, 1953) was that intercurrent behavior under spaced-responding schedules has a mediating role with respect to the reinforced response. According to this interpretation, intercurrent response chains of sufficient duration are followed by reinforcement of the experimentally defined response, and hence, being strengthened by adventitious reinforcement, come to provide time-correlated discriminative stimuli for the reinforced response. Others (*e.g.*, Falk, 1961; Levitsky and Collier, 1968; Segal, 1965; Skinner and Morse, 1957; Staddon, 1972) have suggested that intercurrent behaviors are induced by reinforcement schedules without entering into the temporal control of directly reinforced responding. According to this view, intercurrent responding is a byproduct of the schedule-controlled pattern of reinforced behavior. The occurrence of an intercurrent response such as licking may even reduce the frequency of reinforcement of another response (Segal and Oden, 1969).

The present experiment sought to examine relations between reinforced and intercurrent behaviors under different parameters of spaced-responding schedules. Although several manipulations of the relations between reinforced and "other" behaviors have been studied, only an occasional change in schedule parameters has been reported (*e.g.*, Segal, 1963). In the present experiment, lever pressing by rats was reinforced with food and both wheel running and licking a water tube were recorded as intercurrent responses. Behavior under different parameters of spaced-responding schedules was studied via a multiple schedule. Changes in the rate of each response and changes in sequential relations between different responses were examined as functions of the schedule parameter.

METHOD

Subjects

Three male Wistar rats (R1, R2, and R3) were maintained at 80% of their free-feeding weights. Animals were about four months old at the start of the experiment and had a history of lever pressing under spaced-responding schedules. Water was continuously available in individual home cages.

Apparatus

Experiments were conducted in cages mounted in ventilated, sound-isolated chambers. Each experimental cage consisted of a bidirectional running wheel with a Lehigh Valley rat lever, a food cup, and a water tube mounted on an adjacent wall. Thus, animals did not have to leave the running wheel for lever pressing, eating, or drinking. The diameter of the running wheel was 35 cm, and the width of the running wheel floor was 11 cm. The response lever was mounted about 5 cm above the floor and was centered between the food cup 8 cm to the right and the water tube 8 cm to the left. The water tube was connected to a Grason-Stadler Drinkometer, Type E4690A. A running response was defined by the closure of a precision switch by either of two cams arranged 180° apart on the running-wheel shaft. Movement of the running wheel required a tangential force of approximately 0.15 N. Reinforcers were 0.045-g Noyes food pellets delivered by a Foringer feeder. A click from a relay mounted behind the lever accompanied each effective lever press (0.15 N). Two 3-W incandescent lamps indirectly illuminated each cage. Scheduling and recording equipment were located in an adjoining room.

Procedure

A schedule that specifies a minimum reinforced interresponse time is called a spaced-responding or differential-reinforcement-of-low-rate (DRL) schedule. In this experiment, lever pressing was reinforced according to a multiple schedule containing three different DRL components and an extinction (S^A) component. These components and their associated auditory stimuli were DRL 10-sec (tone), DRL 20-sec (train of clicks), DRL 60-sec (white noise) and S^A (no scheduled auditory stimulus). Daily 3-hr sessions consisted of three 15-min exposures to each DRL component in a mixed order, with each component occurring once in each hour. Each DRL component was followed by a 5-min S^A period. Running or licking could occur at any time during the multiple schedule but had no arranged consequences. Before being placed on the final multiple schedule, all animals had received 61 sessions of training under multiple DRL schedules with smaller values of one

or more parameters. Subjects were exposed to the final schedule for 26 sessions, and data from the last three sessions were analyzed.

Lever presses, running-wheel switch closures, licks, and food presentations within each schedule component were recorded on digital counters and on separate channels of a strip-chart recorder. In addition, lever presses and closures of the running-wheel switch were recorded on separate cumulative recorders. Lever-press interresponse times and first-order conditional probabilities among all the recorded response classes were determined from the strip-chart recordings. Conditional probabilities were calculated among four events: lever pressing, licking, running, and food delivery. The first-order conditional probability of one event given another is the frequency of that sequence divided by the frequency of all possible sequences initiated by the same event. For example, the conditional probability of a lever press given a lever press (lever/lever) is the frequency of that sequence divided by the sum of the frequencies for (lever/lever), (lick/lever), (run/lever), and (food/lever).

RESULTS

Figure 1 shows five dependent variables (rows) as functions of the DRL parameter for each animal (columns). Each point represents the mean value of the dependent variable for one session. In each case, the last three sessions for each subject are plotted. Straight lines join the means of the last three sessions.

The top row of Figure 1 shows that rate of lever pressing (the reinforced response) was a decreasing function of the DRL requirement for each subject. Similar functions have been previously reported both where DRL parameters were varied sequentially (Wilson and Keller, 1953) and where the parameter differed among the components of a multiple schedule (Zimmerman and Schuster, 1962).

The second row shows the rate of intercurrent running as a function of the DRL parameter. Both the level of running and the shape of functions varied among the subjects. For Rat R1 (left column), running was an increasing function of the DRL parameter, with very low rates at the two shorter values and high rates under DRL 60-sec. (This animal also displayed high running rates in S^A.) In the case of Rats R2 and R3, running rates

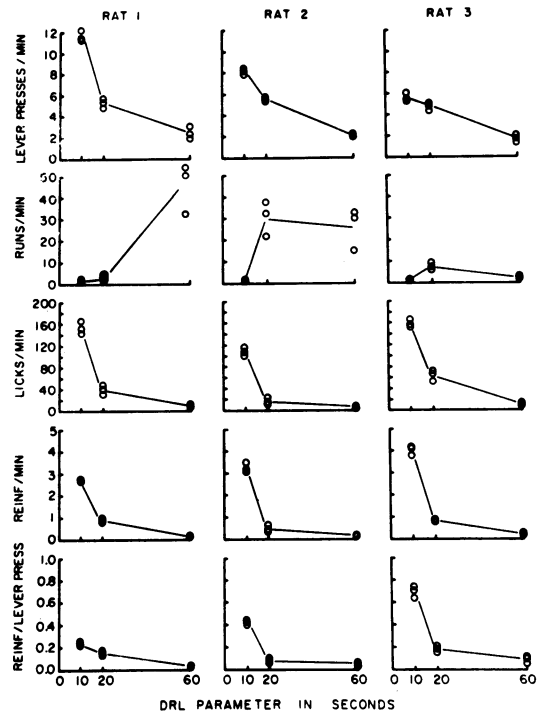


Fig. 1. Five dependent variables (rows) as functions of schedule parameter for each animal (columns). Mean values for the last three sessions are plotted for each animal. By rows, the dependent variables are lever presses per minute, runs per minute, licks per minute, reinforcements per minute, and reinforcements per lever press.

were low at DRL 10-sec, increased at 20-sec and decreased again at 60-sec. Large differences in the level of running can also be seen in the data from these two subjects. Rat R2 ran at substantial rates under both DRL 20-sec and 60-sec, while rates were low under all schedules for Rat R3, with appreciable running only under DRL 20-sec. Thus, although lever-pressing rates in all three animals were comparable at DRL 20-sec and 60-sec, these were associated with quite different rates of intercurrent running in the different subjects.

Rows 3 and 4 of Figure 1 show, respectively, licking rate and reinforcement rate as functions of the DRL parameter. Both licking and reinforcement rates were decreasing, negatively accelerated functions of DRL parameter. Both functions were similar in shape for all subjects. In general, decreases in reinforcements and licks as a function of the schedule parameter were also similar to the changes in lever pressing seen in the top row of Figure 1. Thus, while the running rates associated with

similar rates of lever pressing at the longer DRLs differed among the subjects, rates of intercurrent licking were quite similar. Further, the similarity of functions for reinforcement rate and licking rate suggests that licking may have been controlled by the frequency of food presentation.

The bottom row of Figure 1 shows reinforcements per lever press as a function of DRL parameter. This variable has been used as a measure of the "efficiency" of spaced responding (*e.g.*, Brady and Conrad, 1960; Kelleher, Fry, and Cook, 1959; Laties *et al.*, 1969). A value of 1.00 in reinforcements per lever press would indicate reinforcement of all DRL responses. Smaller values indicate corresponding proportions of responses reinforced. If responses and reinforcement rates decreased according to the same function of the DRL parameter, then this measure of efficiency would be constant over the different schedules. It is apparent from Figure 1 that this was not the case. The proportion of reinforced interresponse times decreased with increasing schedule requirement in all subjects. Differences in the absolute value of reinforcements per response between subjects were necessarily related to differences in the rate of lever pressing and rate of reinforcement. Thus, the largest differences in efficiency occurred at DRL 10-sec, where differences in lever-pressing rates were also greatest. It should also be noted that efficiency, as measured by reinforcements per lever press, bore no simple relation to intercurrent running and licking rates. Thus, between-animal differences in running and licking were smallest at DRL 10-sec, where differences in efficiency were greatest. Rat 3 had the highest efficiency at DRL 10-sec, but displayed about the same running and licking rates under this schedule as Rat 1, whose efficiency was lowest. At DRL 20-sec and 60-sec, on the other hand, reinforcements per response were about 0.2 or less in all subjects, although there were large differences in intercurrent running rates under these schedules.

Response rates during S^A are not plotted in Figure 1. Lever-pressing rates in S^A were the same or lower than those maintained under DRL 60-sec in all subjects. Licking rates during S^A were near zero for all animals. Running rates in S^A , however, differed among the subjects. Mean running rates during S^A for the three animals, respectively, were approxi-

mately 20 (R1), 10 (R2), and two (R3) responses per minute. Thus, running rates of R1 and R2 during extinction periods were comparable to the high rates of running seen in these subjects at the longer DRLs. On the other hand, the low running rate of Rat R3 during S^A was comparable to the lowest rates displayed by this animal under DRL.

Figure 2 shows the distribution of lever interresponse times and interresponse times per opportunity for each subject under each DRL schedule component. The data are means of the last three sessions, using 2-sec class intervals. The ordinate gives the proportion of interresponse times and the conditional probability (IRT/OP) of a response in each class interval, given that no response occurred at a shorter interval (Anger 1956, 1963). Rows in Figure 2 show distributions for individual animals at each schedule parameter (columns). Vertical lines indicate the minimum reinforced interresponse time under each schedule. The data in Figure 2 are typical of DRL schedules. Interresponse-time distributions were bimodal at DRL 10-sec and 20-sec, with the second mode just short of the schedule requirement. At DRL 60-sec, IRT distributions were relatively flat, with nearly all responses falling short of the schedule requirement. Interresponse times per opportunity

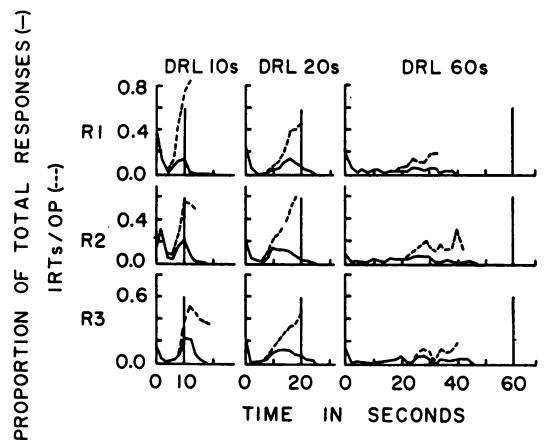


Fig. 2. Proportion of lever-press interresponse times (solid lines) and interresponse times per opportunity (broken lines) in successive 2-sec intervals. Rows show distributions for each animal; columns show distributions for each schedule parameter. Solid vertical lines indicate the lower boundary of time intervals in which reinforcement could occur. No values of interresponse times per opportunity were computed when opportunities were fewer than 20. Points represent mean values for the last three sessions.

increased as a function of time under all three schedules. The distributions in Figure 2 confirm that typical patterns of lever pressing were generated in all subjects under each schedule, although intercurrent running differed among the subjects and schedules.

Figure 3 shows individual conditional probabilities for selected response sequences as a function of the schedule parameter. Probabilities associated with sequences initiated by a lick are omitted because they were not affected by the schedule requirement. The probabilities of a lever press given a lick, and of a run given a lick, were below $p = 0.05$ for all animals in all schedules. Probabilities for lick following lick were all above $p = 0.95$. Rows in Figure 3 show conditional probabilities associated with sequences initiated by a given event (lever press, run, and reinforcement, respectively). Columns show probabilities for different sequences terminating in the same event. The first row of Figure 3 shows that, as the DRL requirement increased, the probability of a run following a lever press in-

creased in all subjects (center frame), while the probability of licking after a lever press decreased (right frame). The schedule parameter did not have large effects on the probability of a lever press following a lever press (left frame, top row), and these effects differed among the subjects. Thus, this probability decreased with increasing schedule parameter in Rat R1, was essentially unchanged in R2, and increased in R3. Differences between animals in the conditional probability of a lever press given a lever press correlate positively with lever-pressing rates and negatively with reinforcement rates and reinforcements per lever press in Figure 1 above. These correlations are most obvious at DRL 10-sec. In summary, the top row of Figure 3 shows that, as the DRL parameter increased, animals were more likely to run after a lever press and less likely to lick. Licking after unreinforced lever presses was confined largely to the DRL 10-sec schedule. It is noteworthy that the functions relating the probability of running after a lever press to the schedule parameter are all

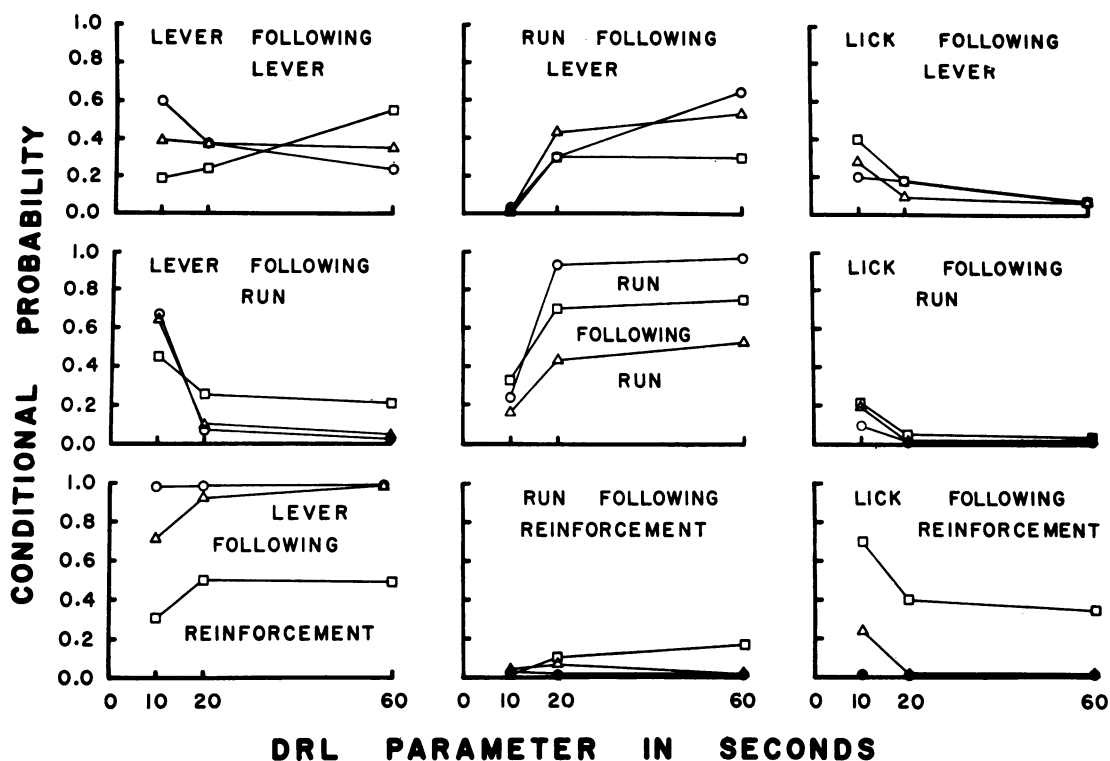


Fig. 3. First-order conditional probabilities for response sequences involving lever presses, runs, licks, and reinforcements as a function of schedule parameter for R1 (circles), R2 (triangles), and R3 (squares). Points represent mean values for the last three sessions.

similar in shape in spite of the large individual differences in running rates seen at the longer DRLs in Figure 1.

The second row of Figure 3 shows that, as the DRL requirement increased, the probability of lever pressing after a run decreased, the probability of running increased, and the probability of licking decreased. The probability of licking after running was appreciable only at DRL 10-sec, where running rates were very low and licking rates were high in all three subjects. Again, individual functions relating the probability of sequences initiated by a run to the schedule parameter were of the same shape for all subjects in each case in spite of individual differences in response rates, as seen in Figure 1.

The bottom row of Figure 3 shows the conditional probability of different responses after reinforcement as a function of the schedule. The left frame shows that Rat R1 always pressed the lever immediately after reinforcement, regardless of the schedule. In the other two subjects, the probability of a lever press after reinforcement increased at the longer DRLs, approaching 1.0 in Rat R2. Concomitantly, licking after reinforcement (right frame) decreased at the longer DRLs in the two subjects that emitted this sequence under DRL 10-sec. The center frame, bottom row of Figure 3 shows that there was little effect of the schedule on the probability of running after reinforcement. This sequence rarely occurred except in Rat R3 at the longer DRLs. Comparison of the three lower frames in Figure 3 shows that the most likely event after reinforcement was a lever press. This was the case for all subjects under all schedules, with the single exception of Rat R3 at DRL 10-sec, where licking after reinforcement was more likely than lever pressing. In view of the theory that food presentation is primarily responsible for initiating bursts of schedule-induced drinking (*e.g.*, Falk, 1967, 1972; Stein, 1964), these findings are interesting. In spite of the fact that bursts of licking usually occurred in reinforced interresponse times at DRL 10-sec and occasionally occurred at the longer DRLs, licking after reinforcement was more likely than some other sequence only in Rat R3 at DRL 10-sec. With this exception, the more likely event after reinforcement was a lever press. And in Rat R1, the probability of lever pressing after reinforcement

was 1.0 under all schedules. The right column of Figure 3 shows that, again with the exception of Rat R3, licking was more likely to be initiated after a lever press than after other events. Since bursts of licking occurred in most reinforced interresponse times under DRL 10-sec, and since licking rates correlated with reinforcement rates (Figure 1), food delivery seems a good predictor of licking temporally, though not sequentially. Inspection of individual strip-chart recordings confirms this. The data show that one or more lever presses usually intervened between reinforcement and bouts of licking.

Figure 4 shows cumulative records of final performance of Rats R1 and R3. Records show the second hour of a 3-hr session. The upper record of each pair cumulates lever presses and the lower record cumulates half turns of the running wheel. Licking is recorded on event pens of both records. Reinforcements are marked by displacement of response pens on both lever-pressing and running records. Response pens reset at the end of each schedule component. The order of schedule components is marked above the upper record (lever pressing) of each pair. Records are aligned for comparison of different responses under the same schedule. Figure 4 illustrates differences in intercurrent responding that were plotted in Figure 1. Rat R1 (top frame) ran very little during DRL 10-sec or 20-sec but showed high running rates in DRL 60-sec and in S^A. Rat R3 had low running rates in all components, but ran more in DRL 20-sec than during other components. Lever-pressing patterns of both animals (upper records in each frame) were typical of DRL schedules. Thus, different patterns of intercurrent responding were associated with similar patterns of schedule-controlled lever pressing.

DISCUSSION

In this experiment, rate of lever pressing, rate of reinforcement, rate of licking, and the efficiency of spaced responding, as measured by reinforcements per response, were all similar decreasing functions of the DRL parameter. Rates of wheel running, on the other hand, were different functions of the DRL parameter in different subjects. Rat R1 ran at high rates in DRL 60-sec and S^A and displayed almost no running under the other schedules. Rat R2 ran at moderately high

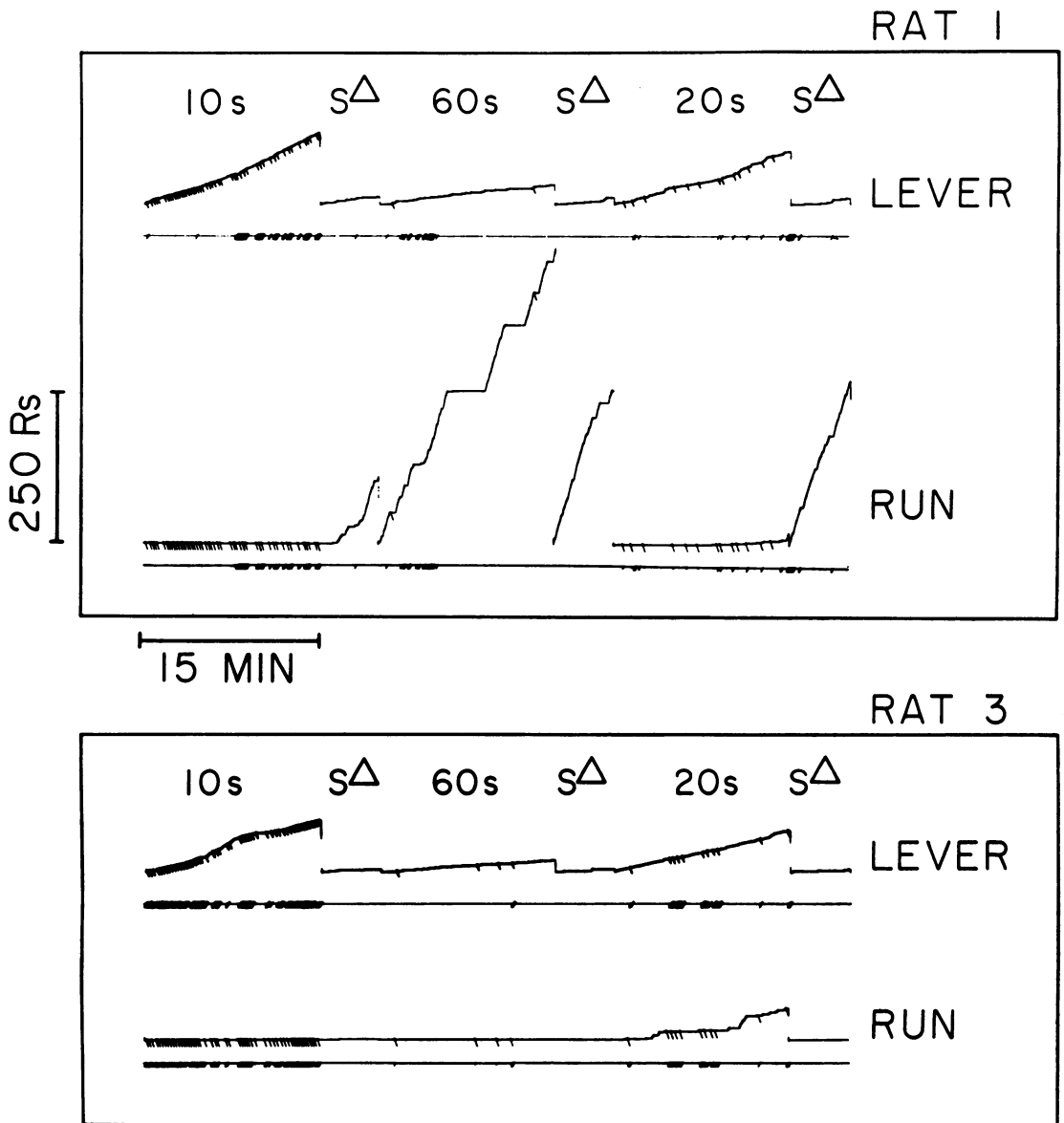


Fig. 4. Cumulative records of final performance for R1 and R3. For each rat, the top record shows cumulative lever presses and the bottom record shows cumulative wheel runs. Displacement of response pens indicates the occurrence of reinforcement. The event pen of both records was displaced by licks. The recording pen reset after each multiple-schedule component.

rates under DRL 20-sec and 60-sec; R3 ran appreciably only under DRL 20-sec. Thus, similar patterns of schedule-controlled lever pressing were associated with different patterns of intercurrent running. Analysis of first-order conditional probabilities among the several response classes revealed a number of orderly relations between the schedule requirement and transition probabilities. As the DRL parameter increased, animals were more

likely to run and less likely to drink after an unreinforced lever press. Similarly, as the DRL increased, running was more likely and both lever pressing and licking were less likely following a run. After reinforcement, the probability of lever pressing increased and the probability of licking decreased with increasing DRL requirement. In general, the most likely event after reinforcement was a lever press, and one subject invariably pressed

after reinforcement under all schedule components. In spite of the rather large individual differences in running rates as a function of the DRL parameter, conditional probabilities involving running, either as an antecedent or consequent event, were similar functions of the DRL for all subjects in each case.

The distributions of lever-pressing interresponse times under the several schedules in this experiment, as well as changes in rate of the reinforced response as a function of the schedule requirement, were similar to those reported previously with DRL schedules (*e.g.*, Wilson and Keller, 1953; Zimmerman and Schuster, 1962). Changes in reinforcement rate and efficiency as a function of the schedule were also as expected, although similar data are often not reported.

Properties of spaced responding under direct schedule control varied but little between the subjects. Hence, the availability of explicit intercurrent behaviors such as running and drinking did not alter the general characteristics of schedule-controlled responding. On the other hand, rates of intercurrent running, not under direct schedule control, were not uniformly related to the schedule requirement, differed among the subjects, and bore no simple relation to schedule-controlled lever pressing. For example, similar rates of lever pressing and of reinforcement were maintained at DRL 20-sec and 60-sec in association with very different rates of intercurrent running. Conversely, running rates were near zero in all subjects at DRL 10-sec, where lever pressing and reinforcement rates differed most. Under other schedules of reinforcement, specifically fixed interval, similar rates and patterns of running *are* associated with similar patterns of reinforced lever pressing (Skinner and Morse, 1957). The lack of a uniform relation between induced running rates and reinforced lever pressing in the present data suggests that the spacing of DRL responses was not dependent upon the level of running during interresponse times.

Although relations between the rate of running and lever pressing at different DRLs were not uniform, all the conditional probabilities for response sequences involving running were uniformly related to the schedule requirement. For all animals, the probability of running after a run and of running after a lever press increased as a function of the

DRL requirement. And the probability of pressing the lever and of drinking after a running response decreased in all subjects at the longer DRL requirements. Thus, the structure of response sequences involving running varied as an orderly function of the schedule parameter even when absolute running rates differed substantially.

The development of drinking after food presentation has been reported frequently (*e.g.*, Falk, 1961, 1966*a*, 1966*b*; Segal, 1965). It has also been observed that when bursts of licking reliability follow food presentation, decreases in food frequency reduce overall licking without appreciably changing rates within bursts (Segal and Deadwyler, 1964). It has already been noted that the simple hypothesis of immediate sequential control over licking by the presentation of food is not supported by the present data. In the case of one animal, licking was never the next response after reinforcement. In the other two subjects, the conditional probability of licking after reinforcement decreased as the DRL parameter increased. And except for one subject at DRL 10-sec, a lever press was more likely after reinforcement than a lick. Thus, it cannot be said that reinforcement initiated drinking, in the sense that licking was likely to be the next response after reinforcement. But there was a temporal relation; bouts of licking typically occurred soon after food delivery (with one or more lever presses intervening).

Neither does drinking appear to account for differences in reinforcement rate or in efficiency. Although functions relating licking rate and reinforcement rate to the DRL requirement were similar in shape, the highest licking rates under DRL 10-sec were displayed by the two rats whose reinforcement rates and efficiencies differed most under that schedule. This can be seen concretely in the cumulative records of Figure 4. In the data of Rat R1, bursts of licking under DRL 10-sec and 20-sec accompany local decreases in reinforcement rate. In the records of R3, on the other hand, bursts of licking under these schedules correlate with local increases in reinforcement rate. Thus, it appears that the occurrence of drinking was not necessarily responsible for the spacing of reinforced lever presses, even under DRL 10-sec, where most reinforcements were obtained and most licking occurred.

Intercurrent behavior has been considered

both as mediating and as schedule induced (*cf.* Segal, 1972). The criteria for assigning a mediating function to some interim behavior are not well articulated, however. The two most important assumptions appear to be that intercurrent responses provide discriminative stimuli for a subsequent response and that they are strengthened by reinforcement of the latter, albeit adventitiously. Both assumptions appear to permit only indirect tests. For example, the intercurrent behavior may be prevented and changes in the reinforced response observed (*e.g.*, Laties *et al.*, 1965); or, explicit discriminative stimuli may be made contingent on intercurrent behavior (*e.g.*, Segal, 1963). A decision in the case of the present data would be premature. The experiment was designed only to examine the amount and distribution of running and licking in relation to reinforced responding as a function of the schedule. It might be considered, however, that differences between subjects in running at longer DRLs are just what would be expected if the form of mediating behavior were the result of adventitious reinforcement. But such *post hoc* invocations of adventitious reinforcement are becoming notoriously overworked. In this case, a study of the effects of schedule parameters when a specific intercurrent response is required to precede the reinforced response appears promising.

The view that intercurrent behavior may be schedule induced is somewhat simpler. According to this view, a schedule generates a particular distribution of interresponse times, and some behavior must fill these. In the present experiment, the DRL schedule may be said to restrict opportunities of the reinforced response and produce a loose hierarchy including all responses. Thus, a particular distribution of intercurrent activity may be entirely a byproduct of the schedule: available intercurrent behaviors occur at times when schedule control renders the probability of the reinforced class low.

Although occurrences of some intercurrent behavior may be schedule induced, and the frequency of its occurrence may be a function of both schedule and schedule parameter, induction of a particular response because of a special relation to specific antecedent or subsequent events represents a stronger claim. Examples include induced post-food drinking (Falk, 1972) and induced pre-food pecking

(Brown and Jenkins, 1968; Staddon and Simmelhag, 1971). Again, the conditions for attributing the form of induced behavior to a special relation to preceding or succeeding events are not fully articulated (Falk, 1972), although Staddon (1972) explored a methodology for distinguishing sequential from temporal control. The occurrence of drinking, where it follows food delivery and varies as a function of intermittent food presentation, has been widely attributed to a special relation to ingestive behavior. Surprises, however, continue to present themselves. Thus, in this experiment, a decision to analyze response sequences and calculate conditional probabilities uncovered the fact that, although the amount of licking and its temporal distribution were related to food delivery, other behavior (lever pressing) almost always intervened between food presentation and drinking. If food presentation (or ingestive behavior) controls drinking, this control must be temporal, not sequential (Staddon, 1972).

If a particular intercurrent behavior such as drinking occurs because of a dependency on preceding food presentations, it may be favored as a mediating response under spaced-responding schedules. Thus, licking, induced by an antecedent food presentation, could, in turn, make reinforcement of a subsequent lever response more likely, further strengthening drinking, and so forth. The present data suggest that the conditions for such a cycle are, at most, marginal. Significant amounts of licking occurred only at the shorter DRLs, and differences in licking rate did not account for differences in efficiency of spaced responding. As noted above, bursts of licking were also negatively correlated with local reinforcement rates in one subject.

It must be concluded that the present data pose difficulties at one point or another for each of the simpler hypotheses that have been put forth to account for the relations between reinforced and intercurrent behaviors. At the same time, both reinforced and intercurrent behaviors were shown to be orderly functions of the schedule requirement, although indirect control apparently permits a considerable latitude for differences in the rate of intercurrent responses. In this connection, the analysis of conditional probabilities appears to have much to recommend it. This analysis revealed a sequential structure in response se-

quences involving intercurrent behavior that was not apparent from an examination of response rates only (cf. Frick and Miller, 1951). It showed important conditional probabilities to be simple functions of the schedule parameter, and it uncovered the intrusion of lever pressing into the sequence from food to drinking.

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