INTERACTION AMONG COMPONENTS OF A MULTIPLE SCHEDULE[1]

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In a multiple schedule (1), an animal is trained to engage in several different kinds of behavior. Each behavior is occasioned by a particular exteroceptive stimulus which the multiple schedule presents, one at a time, in a regularly or randomly repeating series. The behaviors may differ along several dimensions. The form of the reinforcer, as well as the conditions of its delivery, may be identical in the presence of all the stimuli, but the appropriate topography of response may be varied; e.g., only lever-pressing is reinforced in the presence of one stimulus, and only chain-pulling in another. Topographies may be held constant, but the form of the reinforcer is varied; e.g., food in the presence of one stimulus, water in another, and escape from electric shock in a third. Both topography of response and form of reinforcer may be held constant, while the schedule of reinforcement is varied from stimulus to stimulus. Finally, the multiple schedule may arrange only quantitative variations within a dimension from stimulus to stimulus; e.g., magnitude of reinforcement or minimal amplitude of response is varied while everything else is held constant.

Multiple schedules permit sampling a variety of behaviors in a single organism within short periods of time. The reduction in variability (both inter-organismic variability and variability resulting from measurements separated by long periods of time) and the gain in information gathered per experimental period make these schedules particularly advantageous for the investigation of certain kinds of experimental questions. The advantages have been clearly exemplified in studies of the effects of drugs on behavior (e.g., 2). To some extent, these advantages of multiple schedules depend upon the mutual independence of the components of the schedule. Ideally, if the multiple schedule is to be used in the manner described above, then each component should behave as if it were being studied in isolation. The degree to which this condition is not met determines the extent to which generalizations about a particular type of behavior must be qualified when the behavior is studied within the context of a multiple schedule.

Ferster and Skinner (1, p. 520) have already demonstrated that the components of at least one type of schedule are, in fact, not entirely independent of each other. The general form of their technique is to vary a parameter of one of the components and observe the changes that occur in the other. This technique is used in the present experiment to investigate some of the possible interactions among the components of an appetitive-aversive multiple schedule.

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METHOD

Subjects

Two adult, male, albino rats maintained at 60% of their 200-day weights. In preliminary studies, these rats were exposed to a variety of values of the multiple schedule under study.

Apparatus

The experimental chamber was a box consisting of aluminum walls, glass ceiling, and a stainless steel grid floor. The interior dimensions were 10 inches wide, 10 1/2 inches long, and 12 inches deep. The rods constituting the floor were of 1/4-inch diameter and were spaced 13/16 inch, center-to-center. This chamber was enclosed in a light-insulated, ventilated box. The experimental unit was kept in a cubicle in which temperature was 75 ± 3 degrees and in which white noise of a sufficient level to mask extraneous sounds was continuously present.

The response-lever, which was a modified telegraph key, projected through one of the walls at 3 inches from the floor. A force of about 10 grams through a distance of about 1/16 inch was required to operate the lever. A relay in the experimental unit operated and made an audible click every time the lever was effectively depressed, thereby providing auditory feed-back of effective responses to the rat.

The reinforcer was sweetened condensed milk[3] and was presented to the rat by means of a cam-operated dipper that was raised to the level of the floor of the box between the front wall and the first grid. A buzzer was sounded continuously during reinforcements. The dipper held approximately 0.1 cubic centimeter of the milk, but each reinforcement presented the dipper three times, for a total of 0.3 cubic centimeter. The total duration of the reinforcement was 18 seconds.

The electric shock was approximately 2 milliamperes and had a fixed duration of 0.4 second. It was presented, via a "grid scrambler," to the floor, walls, and lever.

Procedure

Rats were used daily for 5-hour experimental sessions. During each session, a rat was exposed to 15 cycles of a 4-ply multiple schedule. The components of the schedule were as follows: a 5-minute fixed interval for food reinforcement[4]; a 5-minute period during which responses had no explicitly programmed consequence (S_1^{Δ}); 5 minutes of shock avoidance; a second 5-minute S^{Δ} period (S_2^{Δ}). These components always followed each other in the order just mentioned. Each component was associated with a particular stimulus condition, as follows: the fixed interval, illumination of two small (about 2 watts each) lamps; S_1^{Δ}, none; avoidance, a continuous tone; and S_2^{Δ}, a clicking noise. Two 7-watt lamps remained illuminated throughout the experimental session.

In the initial phase of this experiment, shocks were presented every 20 seconds (the S-S interval) in the absence of lever-pressing during the avoidance component. Each lever response postponed the shock for 20 seconds (the R-S interval) (3). In the second phase, the value was changed to 5 seconds (for both the S-S and R-S

[3]Borden's Eagle Brand sweetened condensed milk diluted with equal quantities of water.

[4]Actually a fixed interval with a "limited hold" of 2 minutes (1). The reinforcement is available for 2 minutes following the end of the 5-minute interval.If no response occurs during this 2-minute period, the schedule automatically advances to the next component and the reinforcement is lost.

intervals). In the third phase, no shocks at all were given during the avoidance component (avoidance extinction). In the last phase, the interval was made 10 seconds. Each phase lasted for at least 15 sessions (75 experimental hours). None of the other components was explicitly manipulated.

RESULTS

Figure 1 summarizes the effects of variations in the avoidance interval on each component of the multiple schedule. Each curve shows median values for one rat. The medians were obtained from the last seven sessions of each phase of the experiment. It should be noted that the abscissa is logarithmic and that there is a break

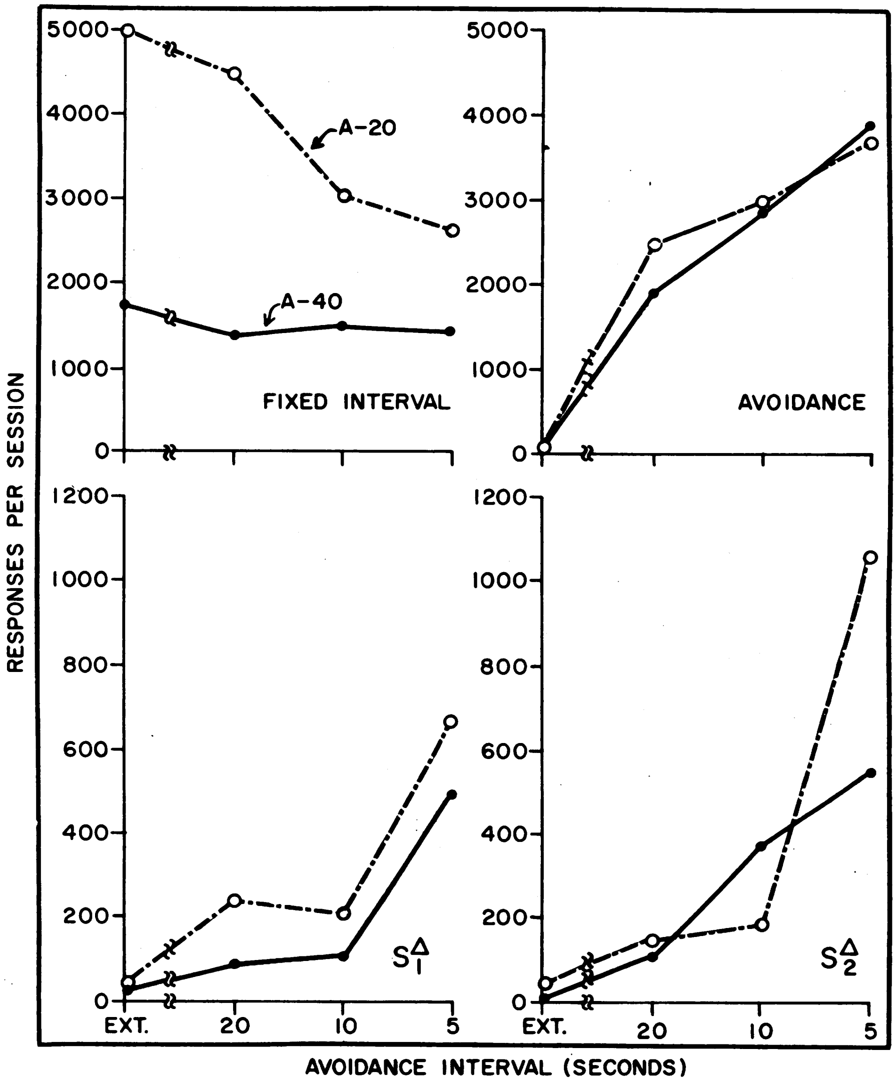

Figure 1. Response rate in each component of the multiple schedule as a function of R-S interval in the avoidance component.

between avoidance extinction and the 20-second avoidance interval. The ordinate is a measure of rate of responding, since each component was present for a total of 75 minutes per experimental session. The ordinates are equal for the fixed-interval and the avoidance components, and have been expanded for the two S^{Δ} components.

Rate of responding during the avoidance component is an inverse function of the size of the avoidance interval. A similar relationship is found when this type of avoidance behavior is studied in isolation (4). The three values used in the present experiment suggest that the relationship may be logarithmic.

The rate of responding during the two S^{Δ} components also increases as the avoidance interval is decreased. In three out of the four curves in Fig. 1, this relationship is monotonic. The single reversal and the apparent flatness of two of the curves between avoidance intervals of 20 and 10 seconds may be a result of the order in which the avoidance interval was varied.

The two rats do not show similar changes in the rate of responding during the fixed-interval component. Whereas one shows a decrease in rate as the avoidance interval was reduced, the other does not. The large difference between these two rats in the over-all rate during the fixed-interval component may be related to the disparity in the effects of varying the duration of the avoidance interval.

Figures 2 and 3 show for A-20 and A-40, respectively, the immediate changes in responding that resulted when the avoidance interval was shortened from 20 to

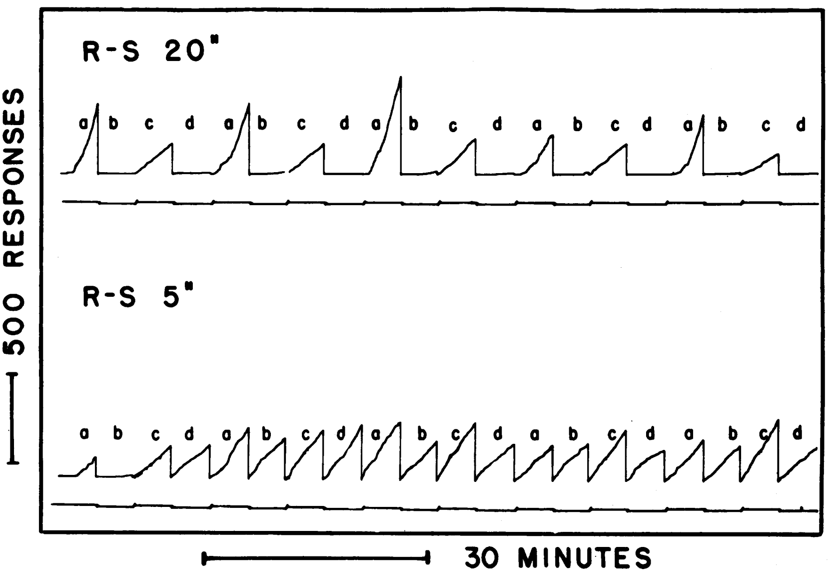

Figure 2. Sample cumulative record from Rat A-20 showing multiple-schedule performance during the final 100 minutes with R-S interval of 20 seconds in the avoidance component (upper portion of figure) and during the initial 100 minutes with R-S interval of 5 seconds in the avoidance component (lower portion of figure).

5 seconds. The upper portion of each figure presents the cumulative records of the final 100 minutes on the multiple schedule when the avoidance interval was 20 seconds. The record resets to the base line at the end of each component. Fixed-

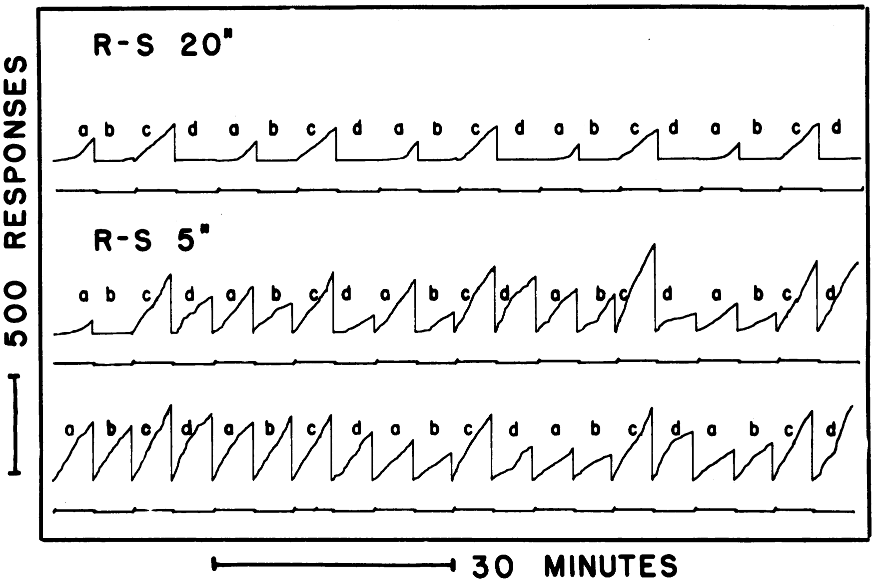

Figure 3. Sample cumulative record from Rat A-40 showing multiple-schedule performance during the final 100 minutes with R-S interval of 20 seconds in the avoidance component (upper portion of figure) and during the initial 200 minutes with R-S interval of 5 seconds in the avoidance component (lower portion of figure).

interval components are labelled *a*; S_1^Δ, *b*; avoidance, *c*; and S_2^Δ, *d*. The line directly below the cumulative record is in the "up" position during the fixed-interval and the avoidance components, and down during S^Δ periods.

The upper portions of both figures show appropriate performances. The fixed-interval components have the positive curvature that is typical of this schedule when studied in isolation, the rate of S^Δ responding is low, and avoidance behavior is maintained at a high enough rate to prevent shocks. In the segments reproduced here, neither rat received any shocks. (If shocks had occurred, they would have been indicated by short, diagonal marks on the cumulative record.)

At the beginning of the next session, the avoidance interval was changed to 5 seconds. The bottom portion of Fig. 2 shows the first 100 minutes of the new condition, and that of Fig. 3, the first 200. The changes that were summarized in Fig. 1 are immediately apparent and in greatly exaggerated form. A single 5-minute period of avoidance with the 5-second avoidance interval is sufficient to increase the rate of both avoidance responding and responding during the two S^Δ periods, and to disrupt the typical pattern of fixed-interval responding. For some period of time during this initial exposure to the 5-second avoidance interval, each rat is responding at virtually equal rates during all components of the schedule. This "levelling" occurs more rapidly for A-20 (Fig. 2) than for A-40 (Fig. 3). However, A-20 received a larger number of shocks in the first two avoidance periods.

The loss of stimulus control just mentioned is a transitory effect of the shortened avoidance interval. The upper portions of Fig. 4 and 5 are (for A-20 and A-40, respectively) cumulative records of the final 100 minutes during which the avoidance interval was 5 seconds. The rate of avoidance responding is now sufficiently high to keep shock frequency at a low level; S^{Δ} responding has fallen, but is not so low as it was when the avoidance interval was 20 seconds, and the pattern of responding within fixed-interval periods is again typical of this schedule. The pattern of responding within S^{Δ} periods now shows an interesting consistency, particularly for A-40 (Fig. 5), and, also for A-20 (Fig. 4), but to a less marked degree. The *b* periods, which precede the avoidance periods, contain responding that is largely confined to its closing minutes. For *d* periods this pattern is reversed: responding tends to occur at the beginning of these periods and then falls off.

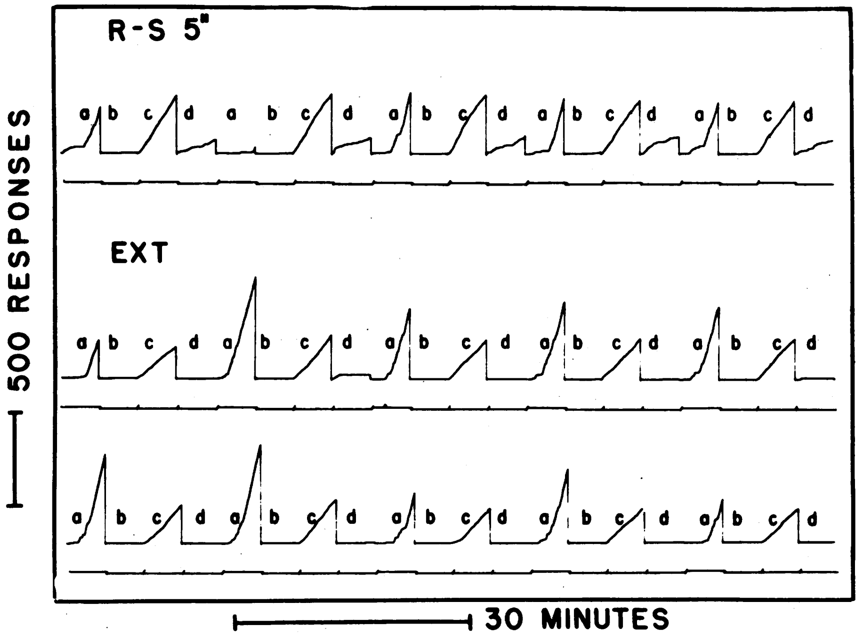

Figure 4. Sample cumulative record from Rat A-20 showing multiple-schedule performance during the final 100 minutes with R-S interval of 5 seconds in the avoidance component (upper portion of figure) and during the initial 200 minutes of avoidance extinction (lower portion of figure).

The lower portions of Fig. 4 and 5 are the initial 200 minutes of the avoidance extinction phase. The initial effect of this change is most pronounced in the rate of responding during S^{Δ} periods. This rate is close to zero by the second 100 minutes (the bottom record) even though the responding during avoidance periods continues to occur at a high rate.

DISCUSSION

The present experiment shows clearly that some degree of interaction exists among the components of the multiple schedule under study. Several questions are, however, left unanswered. Whether variations in a component other than avoidance would also show interactions is not known. Nor is it known to what extent the relationships summarized in Fig. 1 are transitory. Figures 2 and 3 show that the immediate effects of shortening the avoidance interval are very pronounced and de-

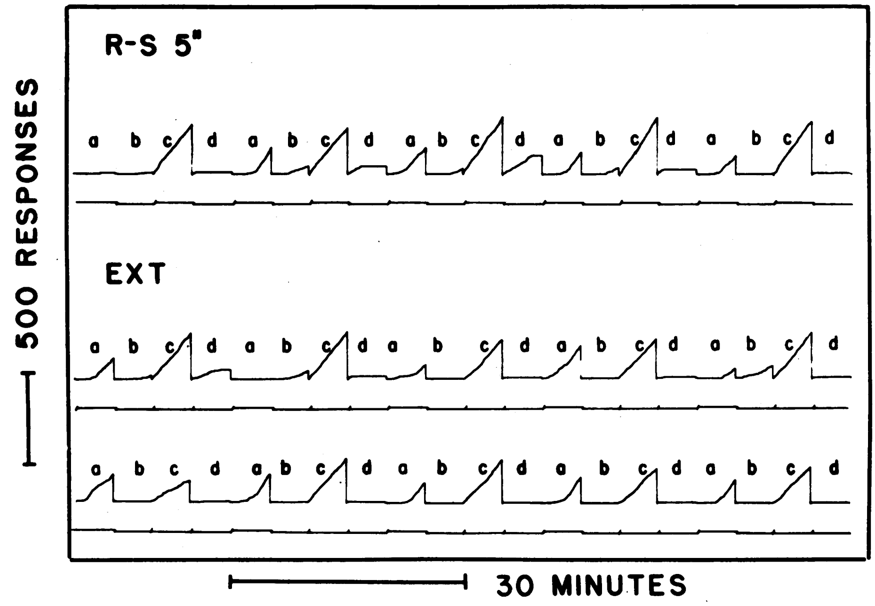

Figure 5. Sample cumulative record from Rat A-40 showing multiple-schedule performance during the final 100 minutes with R-S interval of 5 seconds in the avoidance components (upper portion of figure) and during the initial 200 minutes of avoidance extinction (lower portion of figure).

tectable in all components of the schedule. After continued exposure to an avoidance interval of 5 seconds, the effects outside of the avoidance component are considerably attenuated. With even longer exposure than was used here, or with repeated shifts in the avoidance interval, these effects possibly would disappear entirely.

The interest of the present findings, however, is not completely dependent upon the stability of the interactions shown among the various components. From a practical point of view, transitory interactions are highly significant. A drug may, for example, have transitory effects in much the same way as does a change in the avoidance interval from 20 to 5 seconds. (See Fig. 2 and 3.) This would be the case if the drug directly affected only the avoidance component, and in a manner analogous to the shortening of the avoidance interval. One might then observe changes in all the components as a result of the drug even though these other components might be unaffected when studied in isolation.

Once known, such interactions as the ones demonstrated in the present experiment can be taken into account when the multiple schedule is used as a base line for the operation of other independent variables. In addition, the preliminary investigations that must be conducted in order to discover these interactions are a potential source of understanding of the multiple schedule itself.

SUMMARY

A multiple schedule consisting of a fixed interval for food reinforcement, a period of S^{Δ}, a period of shock avoidance, and another period of S^{Δ} was investigated for

possible interactions among the components. It was shown that variations in the interval for which responses postponed the shock in avoidance periods produced changes in the rate of avoidance responding and in the rate of responding during both S^{Δ} periods. As this interval was shortened, these rates rose. The rate of responding during the fixed-interval component decreased for one *S* and remained unchanged for the other.

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