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CONTROLLING HUMAN FIXED-INTERVAL PERFORMANCE[1]

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Both high and relatively constant rates of responding without post-reinforcement pauses and lower rates with pauses after reinforcement are produced by human subjects under fixed-interval (FI) schedules. Such FI rates and patterns may be controlled when subjects are provided with different histories of conditioning and different conditions of response cost (reinforcement penalties per response). Subjects with a conditioning history under ratio schedules typically produce high and relatively constant rates of responding under FI schedules; this responding does not change systematically with changes in FI value. In contrast, subjects with a history under schedules which produce little or no responding between reforcements [such as differential-reinforcement-of-low-rate (DRL) schedules] tend to pause after reinforcement and respond at low rates under FI schedules, whether or not they also have ratio conditioning histories; cost increases the likelihood of this type of performance. For DRL-history subjects, post-reinforcement pauses increase and response rates decrease as FI values increase.

CONTENTS

Under a fixed-interval (FI) schedule, reinforcement depends on a single response after a fixed interval of time has passed since a previous reinforcement. Responses before that time has passed have no effect upon the occurrence of reinforcement. Infra-human organisms tend to pause after reinforcement under FI schedules. After a post-reinforcement pause of variable duration, rate of responding is typically positively accelerated, producing what is commonly referred to as a scalloped pattern (Ferster and Skinner, 1957). Extended training under an FI schedule with a long interreinforcement interval occasionally produces a fairly constant rate of responding after a post-reinforcement pause (Cumming and Schoenfeld, 1958).

A variety of response rates and patterns have been obtained from humans under FI schedules. Some humans respond at fairly constant rates throughout each interval; they do not pause after reinforcement (*e.g.*, Blair, 1958; Lippman and Meyer, 1967; Weiner, 1962). Other humans pause after reinforcement either for the entire time between reinforcements or for a shorter period, after which some terminal responding precedes reinforcement. The rate of such terminal responding may be positively accelerated (Holland, 1957, 1958) but more frequently it is relatively constant (*e.g.*, Azrin, 1958; Laties and Weiss, 1963).

Although response rates can vary independently of the post-reinforcement pause under FI schedules, the overall rates of responding obtained from humans who fail to pause after

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reinforcement are invariably higher than those obtained from humans who do pause after reinforcement (*e.g.*, Lippman and Meyer, 1967). Thus, two general types of human FI performance can be distinguished: high and relatively constant response rates without post-reinforcement pauses (hereafter referred to as the high-rate performance); and lower response rates with post-reinforcement pauses (hereafter referred to as the low-rate performance).

High-rate and low-rate FI performances have been obtained from humans under FI schedules arranged alone (*e.g.*, Weiner, 1964*a*) or as components of multiple, chained, or tandem schedules (*e.g.*, Long, 1962, 1963); (2) under FI schedules with normal children (*e.g.*, Long, Hammack, May, and Campbell, 1958) retarded children (*e.g.*, Orlando, 1961), normal adult humans (*e.g.*, Leander, Lippman, and Meyer, 1968) and adult psychiatric patients (Weiner, 1964*a*); and, (3) under FI schedules employing a variety of reinforcers, such as pennies, tokens, trinkets (*e.g.*, Long *et al.* 1958), candy (*e.g.*, Orlando and Bijou, 1960), signal detections only (Blair, 1958), and signal detections and point scores on a counter (Weiner, 1964*a*) and just scores on a counter (*e.g.*, Lippman and Meyer, 1967).

Few studies have attempted systematically to isolate and control factors which produce the two common types of human FI performance. Lippman and Meyer (1967) showed that instructions to subjects may be a factor. High-rate performances occurred under an FI 20-sec schedule when human subjects were told that reinforcements (points) depended upon a certain number of responses. Low-rate performances occurred when subjects were told that they could obtain points by responding after a certain time had elapsed since a previous reinforcement. In the absence of instructions, some subjects gave high-rate performances and stated that a number of responses was required for reinforcement; others gave low-rate performances and correctly described the interval aspects of the FI 20-sec schedule.

Long *et al.* (1958) obtained data with children working for pennies and trinkets which suggested that different histories of conditioning may produce the two common types of FI performance. Children shifted from a fixed-ratio 25 (FR 25) schedule to an FI 60-sec schedule were more likely to give the high-rate performance than children who were either moved from a variable-interval 30-sec schedule to the FI 60-sec schedule or who began on the FI 60-sec schedule without prior training. Weiner (1964*b*), using normal human subjects, found that high-rate performances were produced consistently under an FI 10-sec schedule of point reinforcements when subjects responded previously under an FR 40 schedule. Subjects with a history under a differential-reinforcement-of-low-rate 20-sec (DRL 20-sec) schedule gave low-rate performances consistently under the FI 10-sec schedule. Weiner (1956*b*) obtained similar effects of FR 40 and DRL 20-sec histories under an FI 10-sec schedule with an added response cost (point reinforcement penalties per response) contingency.

The two types of human FI performance may also depend on the "cost" of responding. Azrin (1958) reported that increasing the physical cost (effort) of responding increased the incidence of low-rate performances under an FI 180-sec schedule with adult humans. Weiner (1962, 1964*a*, 1965*a*) found that the addition of response cost (point reinforcement penalties per response) changed high-rate performances to low-rate performances under FI 10-sec, FI 25-sec, and FI 60-sec schedules with adult humans.

Other procedures that were effective in producing low-rate performances under FI schedules with humans include (1) adding a DRL contingency to an FI schedule (Long, 1962); (2) providing subjects with an external clock or some cue concerning the temporal aspects of and FI contingency (Azrin, 1958; Long, 1962, 1963); and (3) having subjects perform a concurrent task (Laties and Weiss, 1963).

The present paper extends previous work (Weiner, 1962, 1964*a*, 1964*b*, 1965*a*, 1965*b*) on conditioning history and response cost as factors which control performances under FI schedules with humans. Human FI performances in the absence of a conditioning history were examined and systematic experimental analyses provided detailed information about how variations in the type, sequence, and parameters of different history schedules interact with both response-cost conditions and changes in the parameters of FI schedules to control responding.

METHOD

Subjects

Male and female psychiatric nursing assistants, ages 18 to 50, were paid by the hour only, at rates of from $2.50 to $4.00 depending upon their salary level as nursing assistants.

Procedure

Each subject was seated alone in an experimental room facing a microswitch button and a display mounted in a Bud inclined cabinet rack with desk top (Series 60-2309). The display consisted of a five-digit add-subtract electronic counter and some distinctive lettered and numbered lights.

The subjects began each experimental session with five zeros showing on the add-subtract counter and were instructed to use the microswitch button to score as many points and lose as few points as possible on the counter. Addition and/or subtraction of points depended on button-pressing. An effective button-press required a force of approximately 20 g through a distance of 1 cm to close a microswitch mounted underneath it. Transistorized digital equipment (Weiner, 1963) was used to schedule contingencies.

The only instructions the subjects received were given at the beginning of the first hour of conditioning, when the following was read to each subject:

> "Your task is to gain as many points and lose as few points as possible. You can score points by pressing or not pressing this button in some fashion. You will start each session with a zero score, that is with five zeros showing on the counter. The counter may either add points, subtract points, or both add and subtract points. Your job is to make it add as much as possible and subtract as little as possible.
>
> "If you score points above zero, this score card (Experimenter indicates) which will be given to you at the end of each session, will read '+ some number', depending upon the amount of points you have scored. If you have scored no points, your score card will read '0'. If you get a minus (−) score, it means that you have gone below zero in score, that is, gotten a lower score than you started with. A zero score is better than a minus score, but a plus score is, of course, better than zero.
>
> "From time to time there may be different conditions; do not think that the machine is broken or not functioning properly. If the machine does break, I will know about it and will tell you that such is the case. Just try to get the best score you can under all conditions."

After the instructions, the subjects were left alone to respond under different schedules of point reinforcements as described later in this paper. For all schedules, reinforcements consisted of 100-point additions to a subject's score on the counter. Under all time-based schedules, reinforcements remained available indefinitely (no limited hold). The cost contingency added to schedules consisted of the subtraction of one point per response from the counter. Under cost, therefore, reinforcements consisted of 99-point additions to a subject's score on the counter.

Unless indicated otherwise, each subject received ten 1-hr conditioning sessions per schedule. Different lettered and numbered lights on the display in front of the subjects were associated with the different reinforcement schedules. After each session, the subjects received a score card which contained the net gain or net loss of points achieved during that session.

EXPERIMENT 1: HUMAN FI PERFORMANCES IN THE ABSENCE OF A CONDITIONING HISTORY: EFFECTS OF FI VALUE AND COST

Little data are available on how human FI performances vary with FI values (interreinforcement intervals) when subjects have no conditioning history. Using different groups of subjects for each schedule, Leander *et al.* (1968) found no significant differences in the relative frequency of high and low-rate performances with adult humans under FI 20-sec, FI 40-sec, FI 60-sec, and FI 80-sec schedules. Under all of these schedules, about 30% of the subjects gave high-rate performances while about 70% gave low-rate performances. This preponderance of low-rate performances was probably related to the fact that 1200 g of force was necessary for an effective response. Azrin (1958) showed that the incidence

of high- and low-rate FI performances with humans varies as a function of the force required to emit a response. Whereas the majority of subjects gave high-rate performances under an FI 180-sec schedule when a 15-g force requirement was in effect, Azrin found that most subjects gave low-rate performances when this force requirement was increased to several hundred grams. Likewise, Weiner (1962, 1964*a*, 1965*a*, 1965*b*) obtained high-rate performances from most subjects under FI 10-sec, FI 25-sec, and FI 60-sec schedules when a low force (20 g) was required for each effective response. Subjects who gave high-rate performances all gave low-rate performances when cost was introduced.

Unfortunately, different experimental tasks, instructions, reinforcers, small numbers of subjects (varying from two to four per FI schedule), and only short FI values were used in these studies by Weiner. Also, FI and FI cost performances were not obtained under identical conditions because FI cost performances were always assessed after subjects had a history of responding under FI schedules. The present experiment attempted to provide more systematic and extensive data on how human FI performances vary with FI values and cost conditions when a small force (20 g) is required to emit a response and when subjects have no conditioning history.

Procedure

Three different groups (nine subjects per group) were conditioned under either an FI 10-sec, FI 600-sec, or FI 10-sec cost schedule.

Results

Figure 1 shows the final performances of each subject under the three FI schedules. High- and low-rate performances occurred under all three FI schedules. Most subjects gave high-rate performances under the FI 10-sec and FI 600-sec schedules. In contrast, low-rate performances were obtained from the majority of subjects under the FI 10-sec cost schedule. More subjects gave low-rate performances under the FI 10-sec cost schedule than under the FI 600-sec schedule despite the fact that net gain in points was higher under the FI 10-sec cost schedule.

Figure 2 presents average response rates per session for each subject under the three FI

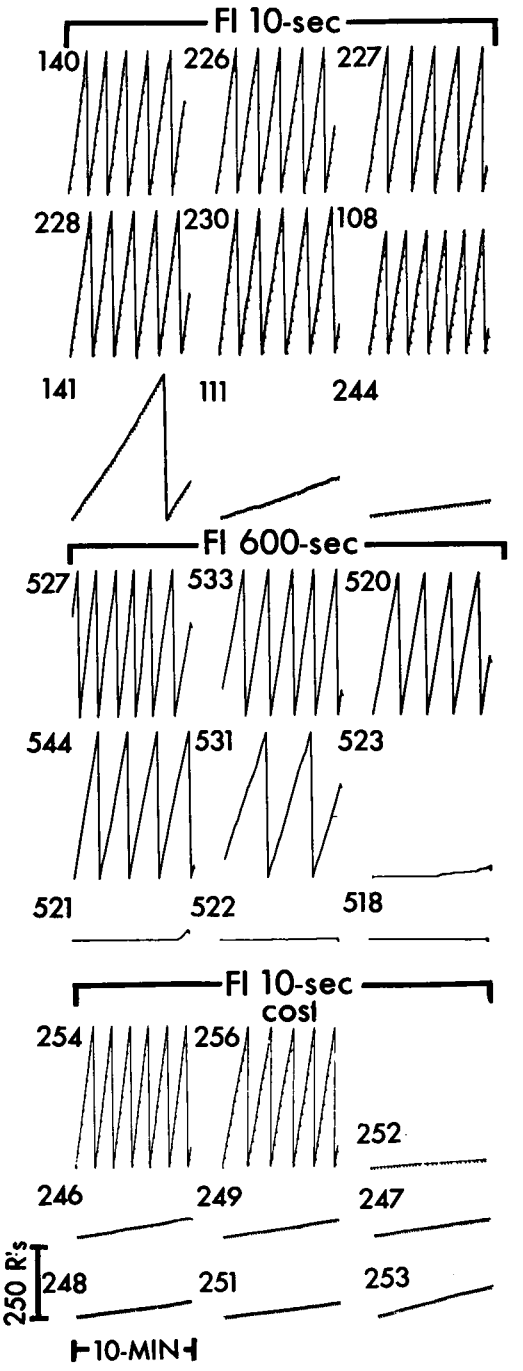

Fig. 1. Final FI 10-sec, FI 600-sec, and FI 10-sec cost performances. Each cumulative record presents the typical response pattern and a close approximation of the average response rate (±5 responses per minute) during the last four of ten 1-hr sessions under each schedule. Vertical marks on the records indicate the occurrence of 100-point reinforcements.

schedules. Inter-subject differences in response rates did not decrease over sessions and final response rates (last four sessions) did not appear simply related to initial (first session) rates. For example, under the FI 600-sec schedule, Subjects 520 and 518 had comparable initial response rates and markedly different final rates, but Subjects 520 and 544 had markedly different initial rates and fairly comparable final rates. Some subjects (*e.g.*, 522) showed virtually no change in response rate over the 10 sessions. Similar initial-final rate relationships can be noted under the FI 10-sec and FI 10-sec cost schedules in Fig. 2.

Discussion

With animals, low-rate performances are common under FI schedules, particularly when the FI value is as long as 600 sec. Such low-rate performances are generally attributed to the fact that all responses before a primed reinforcement are unreinforced under an FI schedule.

Obviously, the lack of reinforcement for responding between FI reinforcements had little effect upon the present human subjects. In the absence of any scheduled conditioning history, the majority of subjects gave stable high-rate performances under both FI 10-sec and FI 600-sec schedules. Only when cost was added to an FI 10-sec schedule did most subjects give low-rate performances. Even under cost, however, some subjects gave high-rate performances.

EXPERIMENT 2: BETWEEN-SUBJECT EFFECTS OF FR AND DRL HISTORIES UPON HUMAN FI PERFORMANCE

One alternative to account for high and low-rate performances under FI schedules is to assume that they are due to pre-experiment histories in environments sharing common stimulus properties with the laboratory. If this is true, it should be possible to generate and hence control such performances by deliberately scheduling different histories in the laboratory. Two previous studies have shown that this is possible. Weiner (1964*b*) demonstrated that subjects given an FR 40 history produced high-rate performances while DRL 20-sec-history subjects produced low-rate per-

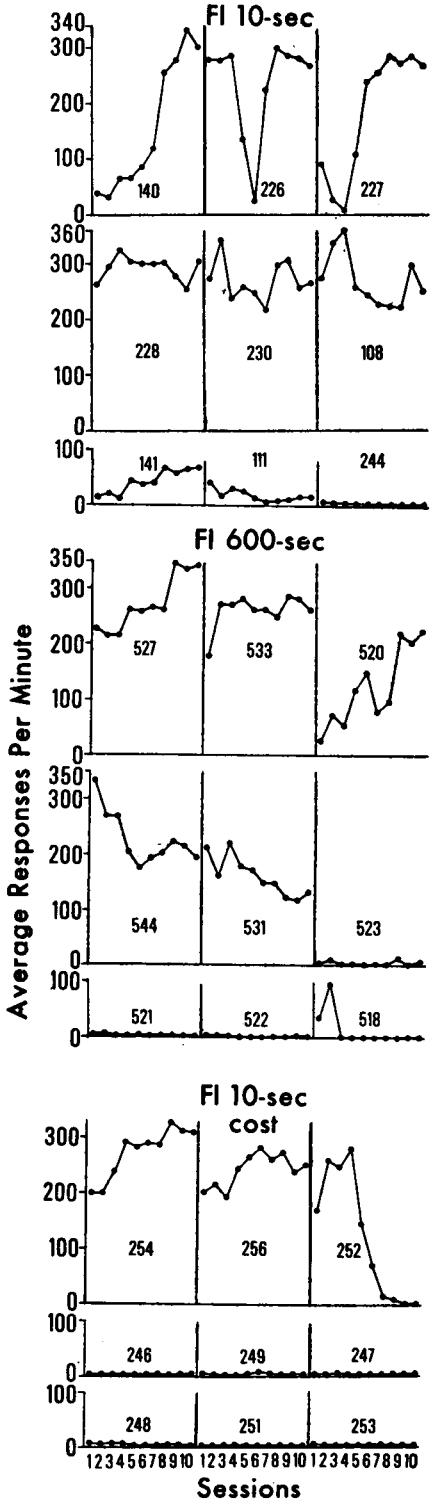

Fig. 2. Session-to-session response rates under the FI 10-sec, FI 600-sec, and FI 10-sec cost schedules.

formances under an FI 10-sec schedule. Weiner (1965*b*) also showed that FR 40 and DRL 20-sec-histories produced similar effects under an FI 10-sec cost schedule.

The present experiment examined the effects of an FR 40 or DRL 20-sec history under FI schedules with a variety of other FI values. In addition, this experiment compared the FI cost performances of subjects with a DRL 20-sec followed by an FR 40 history with those produced by subjects who only had FR 40 or DRL 20-sec histories.

Procedure

Subjects were given either an FR 40 history, a DRL 20-sec history, or a DRL 20-sec followed by an FR 40 history. Under FR 40, every fortieth response produced a reinforcement. Under the DRL 20-sec history schedule, reinforcements were contingent upon the spacing of two successive responses by at least 20 sec. Interresponse times of less than 20 sec postponed reinforcement for at least 20 sec.

After their respective history schedules, subjects were conditioned under different FI schedules. In Phase 1, four FR 40 and four DRL 20-sec-history subjects were conditioned under the following progression of FI schedules: FI 10-sec, FI 30-sec, FI 60-sec, and FI 300-sec. In Phase 2, three FR 40 and three DRL 20-sec-history subjects were conditioned under either an FI 600-sec or an FI 10-sec cost schedule. In addition, three subjects with a DRL 20-sec followed by an FR 40 history were also conditioned under the FI 10-sec cost schedule.

Results

Phase 1. Figure 3 presents final performances under the FR 40 or DRL 20-sec schedules and under the subsequent FI 10-sec, FI 30-sec, FI 60-sec, and FI 300-sec schedules. Figure 4 presents average FI rates (last four sessions) as a function of FI value obtained after FR 40 or DRL 20-sec histories. Figure 5 shows average response rates per session for each subject under the FR 40 or DRL 20-sec histories and under the different FI schedules.

As shown in Fig. 3, three of the four FR 40-history subjects (159, 160, and 236) gave high-rate performances under all FI schedules. The fourth FR 40-history subject (161) gave high-rate performances under FI 10-sec and FI 30-sec and low-rate performances under the FI 60-sec and FI 300-sec schedules. Figure 4 shows that the FI response rates of the FR 40-history subjects were not related systematically to FI values.

Figure 3 also shows that, unlike the FR 40-history subjects, all of the DRL 20-sec-history subjects gave low-rate performances under the FI 10-sec, FI 30-sec, FI 60-sec, and FI 300-sec schedules. More responses tended to occur just before reinforcement under the FI schedules compared to the DRL 20-sec schedule.

The data in Fig. 3, taken together with those in Fig. 4, reveal that the FI responding of each DRL 20-sec-history subject was related to FI values. The duration of post-reinforcement pauses increased and overall response rates decreased as FI values increased.

Although there was some variability in response rates from session-to-session, Fig. 5 shows that there was reasonable stability in responding during the last four sessions under each history schedule and under each of the four FI schedules. There was no clear evidence that the marked differences in FI performances after different histories were transitory: response rates did not appear to be changing in a systematic direction during the final four sessions under each of the FI schedules.

Phase 2. Effects of FR 40 and/or DRL 20-sec histories upon FI 600-sec and FI 10-sec cost performances are shown in Fig. 6. High-rate performances were obtained from all FR 40-history subjects while the DRL 20-sec-history subjects all produced low-rate performances under FI 600-sec (Fig. 6A) and FI 10-sec cost (Fig. 6B). All subjects with the DRL 20-sec to FR 40 history sequence gave low-rate performances under FI 10-sec cost which were comparable to those obtained from the DRL 20-sec-history subjects (Fig. 6B). It may be concluded, therefore, that DRL 20-sec history responding, rather than some combination of DRL 20-sec and FR 40 history responding, was responsible for the FI 10-sec cost performances of the DRL 20-sec to FR 40-history subjects.

Figure 7 presents average response rates per session for each subject under the different history schedules and under the FI 600-sec and FI 10-sec cost schedules. As in Phase 1 of this experiment, history-produced inter-subject differences in response rates were stable and not decreasing during the final four ses-

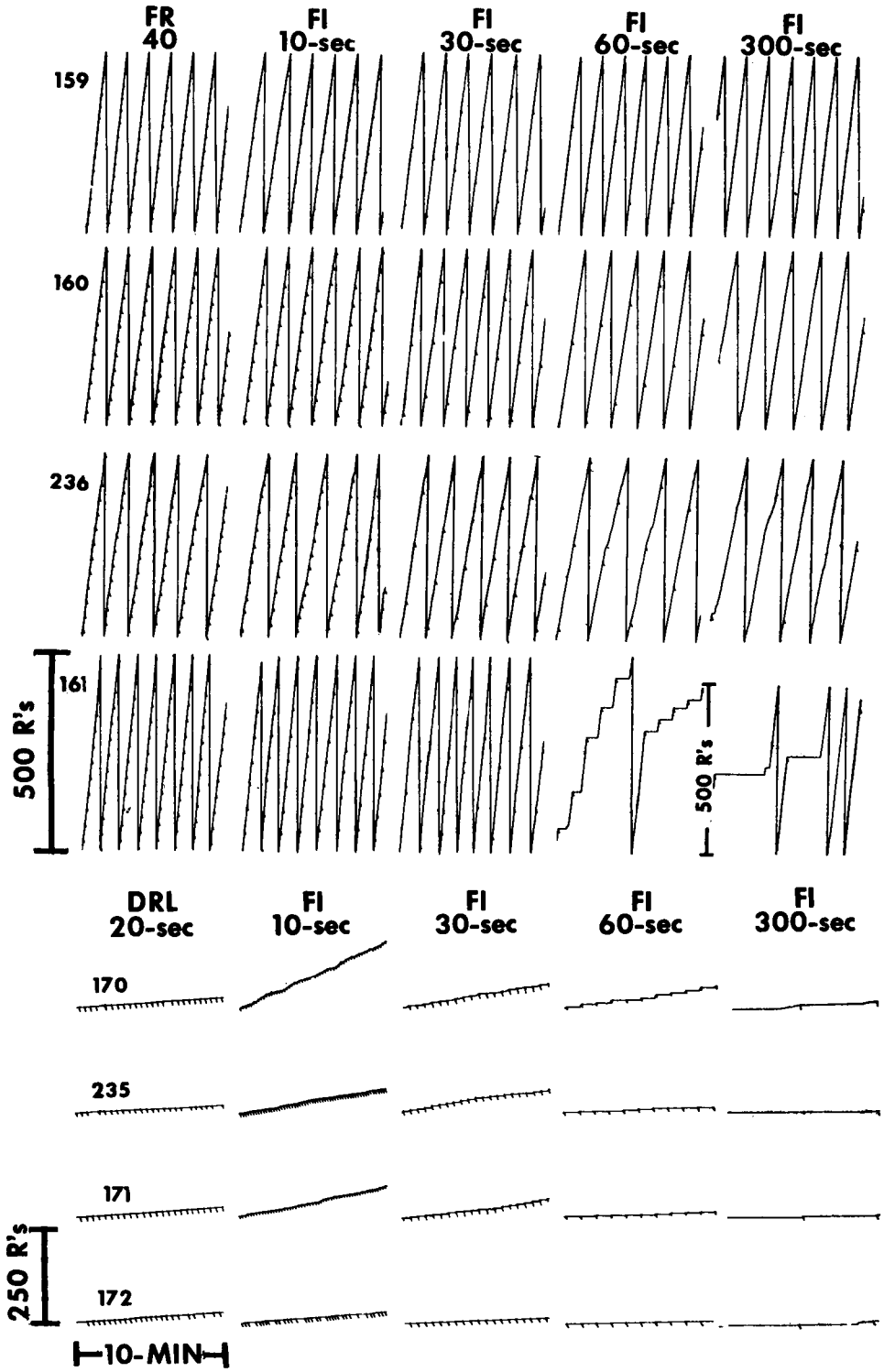

Fig. 3. Final performances under the FR 40 or DRL 20-sec history schedules and under the FI 10-sec, FI 30-sec, FI 60-sec, and FI 300-sec schedules. Other details as in Fig. 1.

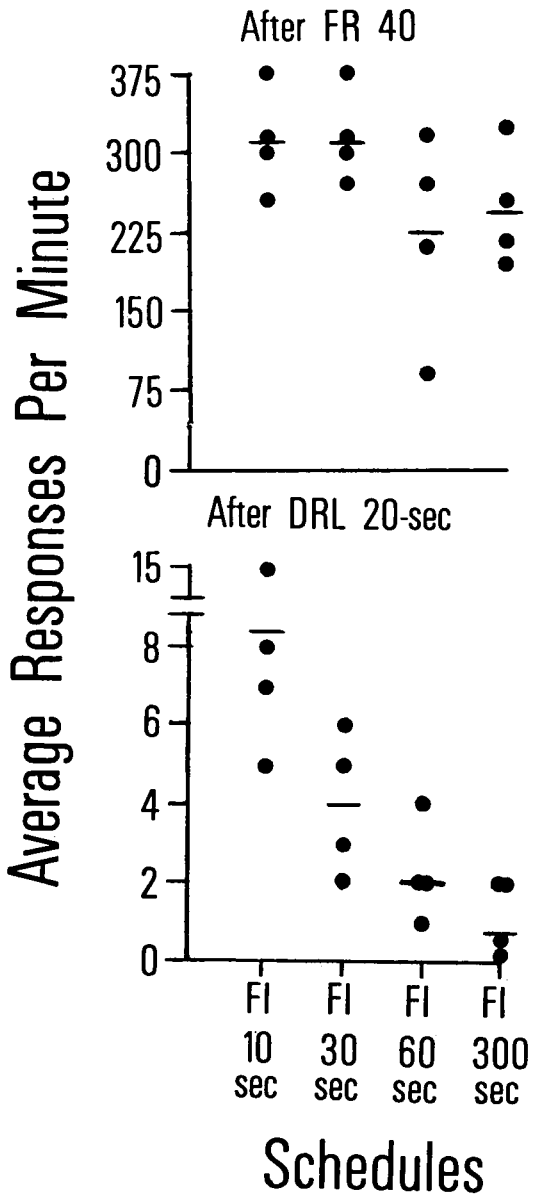

Fig. 4. Response rates as a function of FI value following FR 40 or DRL 20-sec histories. Data points represent mean rates for individual subjects and horizontal dashes indicate mean rates for all subjects under the different FI schedules during the last four of ten 1-hr sessions. The same subjects were conditioned under each FI schedule.

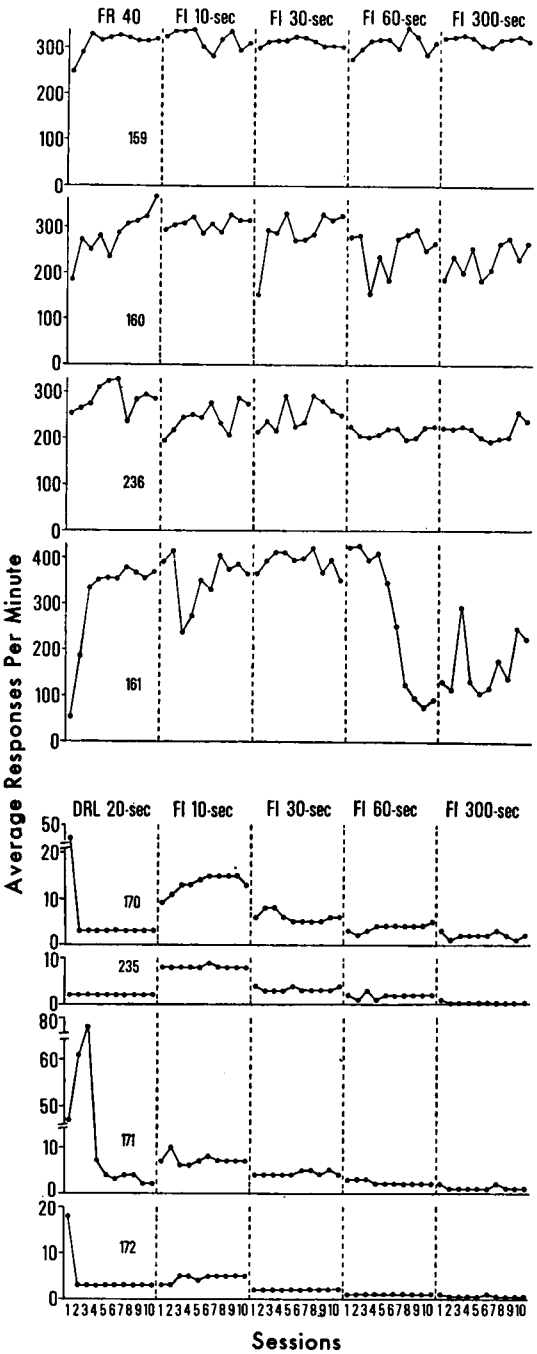

Fig. 5. Session-to-session response rates under the FR 40 or DRL 20-sec history schedules and under the FI 10-sec, FI 30-sec, FI 60-sec, and FI 300-sec schedules. Note that the graphs for the FR 40 and the DRL 20-sec-history subjects have different ordinate values.

sions under the FI 600-sec and FI 10-sec cost schedules.

The data in Fig. 7 suggest that final (last four sessions) low-rate performances under DRL 20-sec for both the DRL 20-sec and DRL 20-sec to FR 40-history subjects was the best predictor of final low-rate performances under FI 10-sec cost. Initial (first session) performances under DRL 20-sec, initial and final

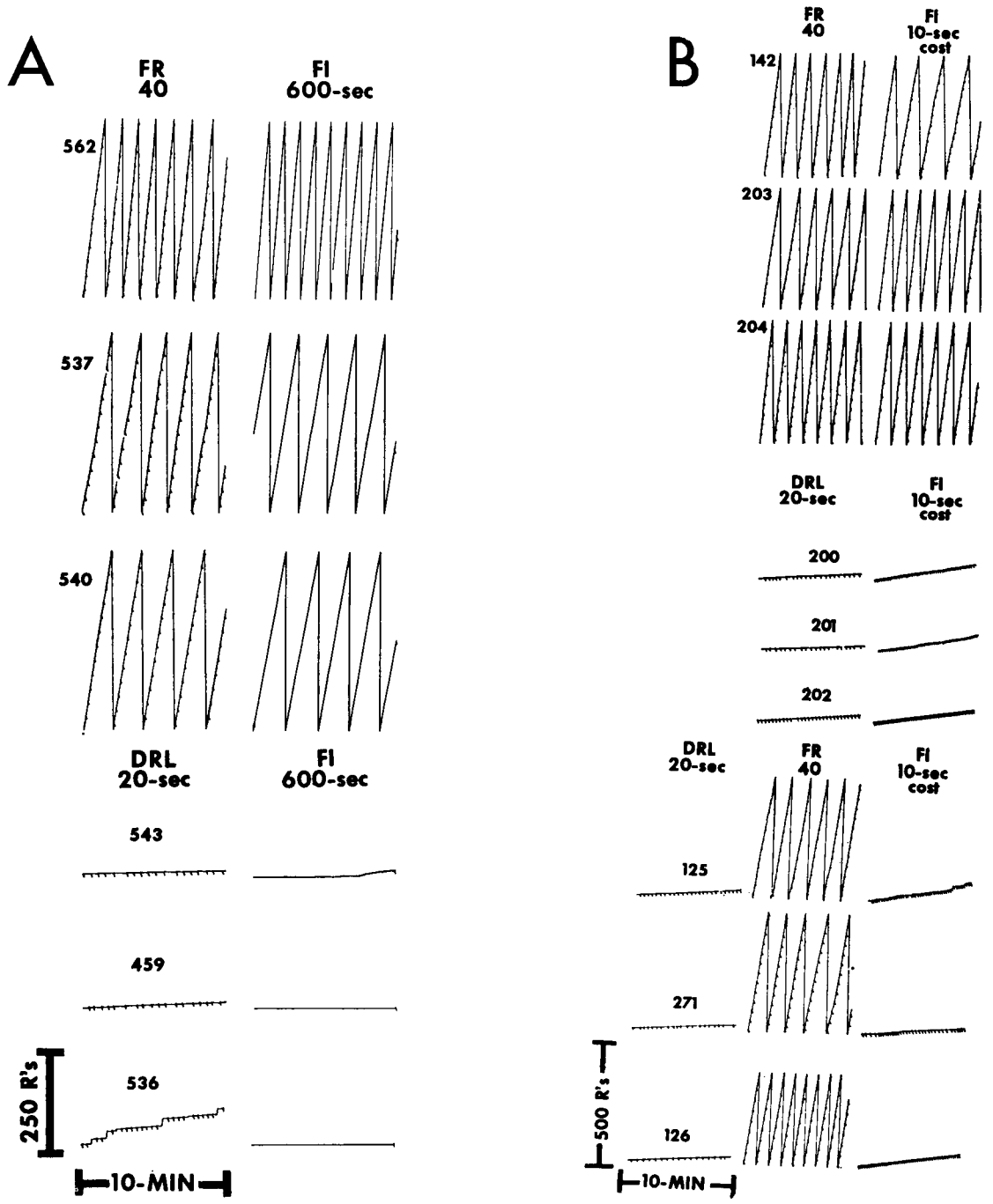

Fig. 6. Final performances under (A) FR 40 or DRL 20-sec histories and under FI 600-sec and (B) FR 40, DRL 20-sec, or DRL 20-sec to FR 40 histories and under FI 10-sec cost. Other details as in Fig. 1.

performances under FR 40 (*cf*, the data of the FR 40 and DRL 20-sec to FR 40-history subjects), and initial performances under FI 10-sec cost did not appear to be related to final low-rate performances under FI 10-sec cost.

The different final FI 10-sec cost performances obtained from the FR 40 *versus* the DRL 20-sec and the DRL 20-sec to FR 40-history subjects did not appear to be a simple function of interresponse times (IRTs) dur-

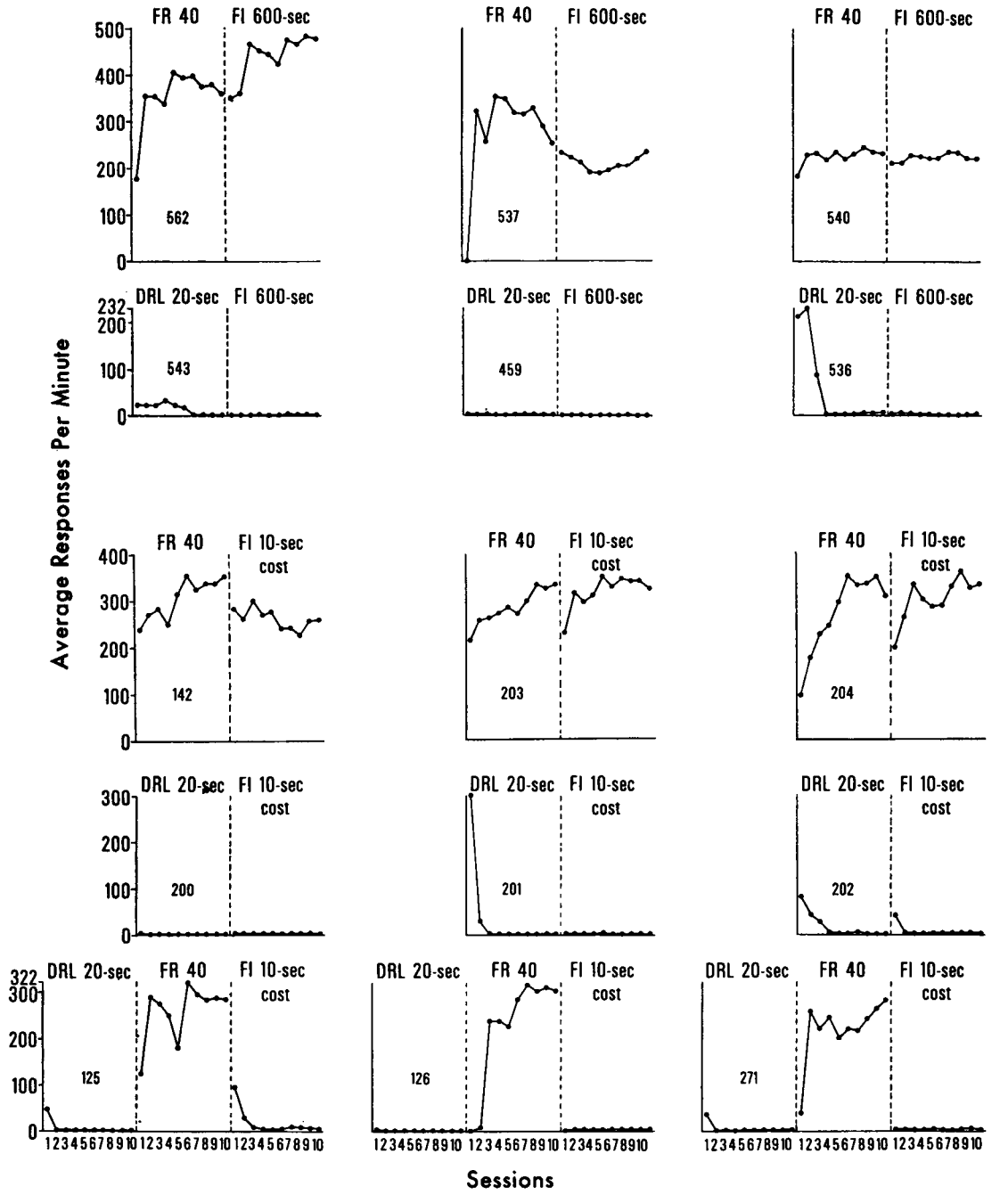

Fig. 7. Session-to-session response rates during the FR 40, DRL 20-sec, or DRL 20-sec to FR 40 histories and under the FI 600-sec and FI 10-sec cost schedules.

ing the first moments of conditioning under FI 10-sec cost. This may be seen in Fig. 8 which presents first and tenth-hour FI 10-sec cost performances of an FR 40, a DRL 20-sec, and a DRL 20-sec to FR 40-history subject. Looking at the first 500 responses emitted during the first session of FI 10-sec cost, one may see that the longer IRTs of Subject 204 (the FR 40-history subject) were reinforced more frequently than those of either Subject 202 (the DRL 20-sec-history subject) or Subject 125 (the DRL 20-sec to FR 40-history sub-

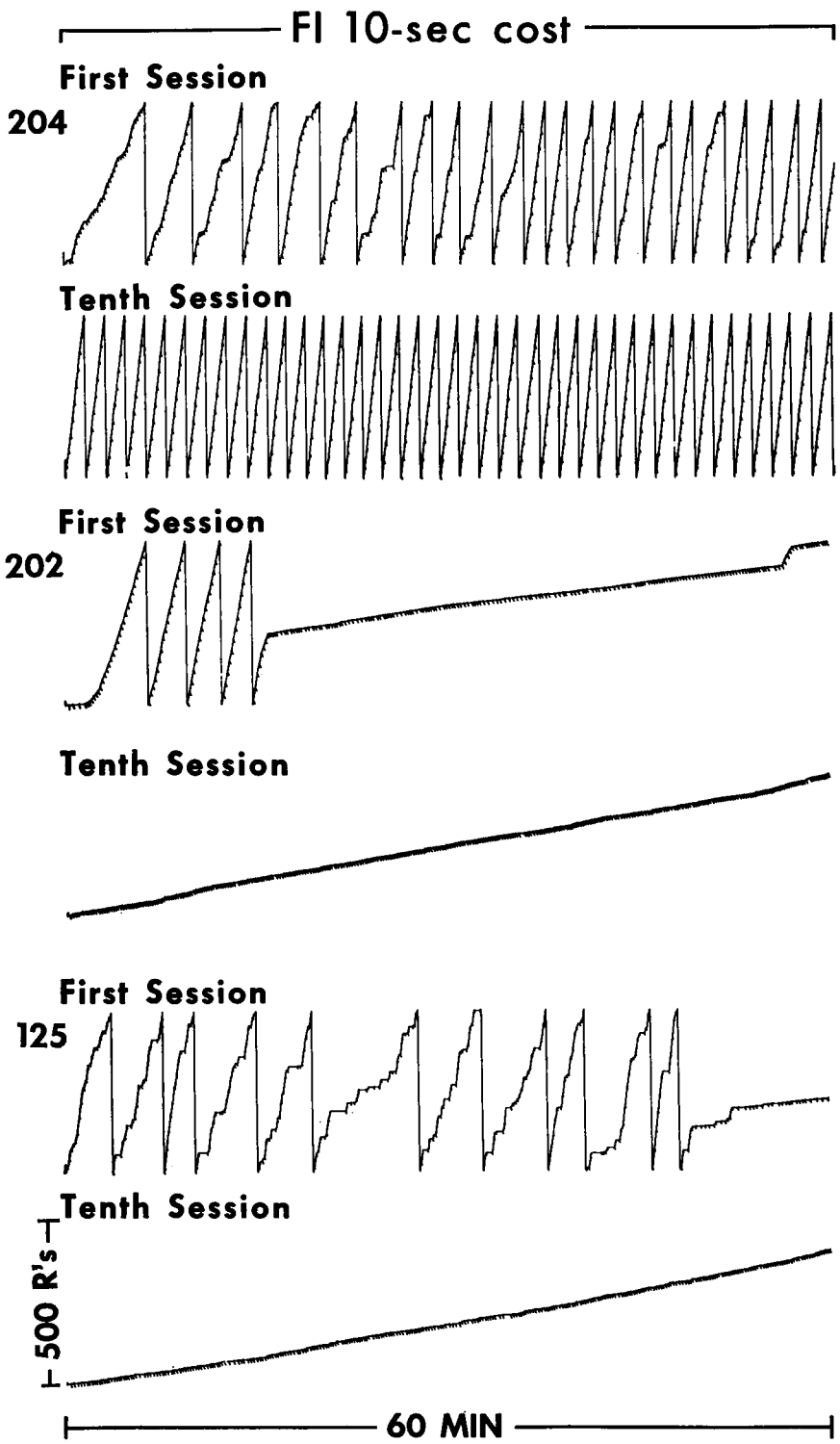

Fig. 8. The FI 10-sec cost performances of an FR 40-history subject (204); a DRL 20-sec-history subject (202); and a DRL 20-sec to FR 40-sec history subject (125). Vertical marks on the records indicate the occurrence of 100-point reinforcements.

ject). In spite of this, Subject 204 *decreased* his IRTs as conditioning progressed and produced a high-rate performance throughout the tenth session of FI 10-sec cost; Subjects 202 and 125 progressively *increased* their IRTs and gave low-rate performances consistently during the tenth session of FI 10-sec cost. It appears that the differential reinforcement of long IRTs only increased the likelihood of long IRTs for Subjects 202 and 125 who had the DRL 20-sec history.

Discussion

In Exp. 1, subjects gave both high-rate and low-rate performances under FI 10-sec, FI 600-sec, and FI 10-sec cost schedules in the absence of a conditioning history. The present experiment showed that high and low-rate performances under these schedules may be produced experimentally and hence controlled by providing subjects with different histories of positive reinforcement. Subjects given an FR 40 history, but not a DRL 20-sec history, gave high-rate performances consistently under FI 10-sec, FI 600-sec, and FI 10-sec cost schedules. Subjects who were provided with a history of DRL 20-sec responding gave low-rate performances consistently under these schedules, whether or not they also had a history of FR 40 responding.

The differential effects of FR 40 and DRL 20-sec histories upon FI 10-sec cost performances obtained in this experiment replicate previous results (Weiner, 1965*b*). The data concerning the effects of a DRL 20-sec to FR 40 history sequence upon FI 10-sec cost performances have not been obtained in previous studies. These data permit two conclusions: (1) An FR 40 history *per se* does not necessarily lead to high-rate performances under FI 10-sec cost. Rather, as shown in Fig. 6, it is the presence or absence of a DRL 20-sec history that determines whether such high-rate performances will occur. (2) The different FI 10-sec cost performances obtained from subjects who had only the FR 40 history or had only the DRL 20-sec history, cannot be ascribed simply to the fact that these subjects were responding with different rates and patterns just before FI 10-sec cost. As shown in Fig. 6, the FR 40 and DRL 20-sec to FR 40-history subjects had fairly comparable final response rates and patterns under FR 40 just before FI 10-sec cost; yet, all FR 40-history subjects gave high-rate performances under FI 10-sec cost while all DRL 20-sec to FR 40-history subjects gave low-rate performances under FI 10-sec cost. Likewise, the DRL 20-sec and the DRL 20-sec to FR 40-history subjects had different final response rates and patterns just before FI 10-sec cost, and yet all of the DRL 20-sec and DRL 20-sec to FR 40-history subjects gave low-rate performances under FI 10-sec cost. Apparently, even a remote (in time) history of DRL 20-sec responding, which is not reflected in ongoing behavior just before FI 10-sec cost, may, nevertheless, lead to low-rate performances under FI 10-sec cost.

EXPERIMENT 3: INTRA-SUBJECT EFFECTS OF FR AND DRL HISTORIES UPON HUMAN FI PERFORMANCE

This experiment attempted intra-subject replications of some of the effects obtained in Exp. 2. First, an attempt was made to generate low-rate performances under FI 10-sec, FI 30-sec, FI 60-sec, and FI 300-sec schedules via DRL 20-sec conditioning after high-rate performances had been produced by an FR 40 history. Second, this experiment tried to produce high-rate performances via FR 40 conditioning in a subject who was giving low-rate performances under FI 10-sec, FI 30-sec, FI 60-sec, and FI 300-sec schedules after a DRL 20-sec history. Finally, this experiment investigated whether conditioning under DRL 10-sec cost would result in low-rate performances under FI 10-sec cost after high-rate performances had been generated by an FR 40 history. A DRL 10-sec cost schedule was used to keep interreinforcement intervals constant in comparing the relative power of FI 10-sec cost and DRL 10-sec cost contingencies in generating low-rate FI performances following an FR 40 history.

Procedure

Phase 1. One of the FR 40-history subjects (236) in Phase 1 of Exp. 2 was given additional training under the following schedules in the following order: *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec (four, 1-hr sessions), DRL 20-sec (ten, 1-hr sessions), and *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec (five, 1-hr sessions). One of the DRL 20-sec-history subjects (170) in Phase 1 of Exp. 2 was also given

additional training under *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec (four, 1-hr sessions). Unlike 236, however, 170 was then conditioned under FR 40 (ten, 1-hr sessions) instead of DRL 20-sec. After conditioning under FR 40, Subject 170, like 236, was re-exposed to the *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec schedule (five, 1-hr sessions). Each component of the *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec schedule was presented for 15-min, in fixed order, during each 1-hr session.

Phase 2. Two subjects were conditioned under the following schedules in the following order: FR 40, FI 10-sec cost, DRL 10-sec cost, FI 10-sec cost, FR 40, and FI 10-sec cost. One of these subjects (142) had been conditioned previously on the first two of these schedules in Phase 2 of Exp. 2 and therefore was conditioned only under the last four of these schedules in this experiment.

Results

Phase 1. Figure 9 shows that Subject 236 with the FR 40 history maintained high-rate performances during the first and fourth sessions of the initial series of conditioning under the *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec schedule. Comparable responding was obtained during the second and third sessions under this schedule (not shown). During the first session under the DRL 20-sec schedule, Subject 236 failed to obtain any reinforcements because he responded at high rates of constant responding. During the second session of DRL 20-sec, however, the number of DRL reinforcements obtained progressively increased. During Sessions 3 to 9 under DRL 20-sec (not shown), 236 increased the number of DRL 20-sec reinforcements obtained. His response rates and patterns during the last four sessions under DRL 20-sec were similar to his tenth-session performance shown in Fig. 9.

When re-exposed to the *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec schedule, Subject 236 moved from low-rate to high-rate performances during the first and second sessions. However, during the final three sessions of *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec, he produced low-rate performances which were related to the FI value. As the FI value increased, the duration of post-reinforcement pauses increased and overall response rates decreased.

Figure 10 shows that Subject 170 with the DRL 20-sec history maintained low-rate performances, which were related to FI value, during the first and fourth sessions of the initial series of conditioning under the *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec schedule. Comparable responding was obtained during the second and third sessions under this schedule (not shown).

During the first session under the FR 40 schedule, Subject 170 produced a very low rate of responding and obtained only two reinforcements. Such a low response rate continued during the second session under FR 40. Subject 170's first reinforcement during the second session of FR 40 came after three quarters of the session had elapsed. After this reinforcement, 170 increased his response rate, thereby obtaining several reinforcements toward the end of the second session of FR 40. During Sessions 3 to 10 (Sessions 4 to 9 not shown), 170 gradually increased his response rate. High rates of constant responding characterized this subject's last four sessions under FR 40.

When re-exposed to the *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec schedule, Fig. 10 shows that 170 again gave low-rate performances related to the FI value. Such responding was maintained during all five sessions (Sessions 2 to 4 not shown) of *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec. Although 170's overall response rate was somewhat higher, his general pattern of responding during this second conditioning series under *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec was quite similar to that established during his first series under *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec.

Phase 2. Intra-subject effects of FR 40 or DRL 10-sec cost histories upon FI 10-sec cost performances are presented in Fig. 11. After FR 40, both subjects gave high-rate performances under FI 10-sec cost but produced low rates with virtually no responding between reinforcements under DRL 10-sec cost. After DRL 10-sec cost, both subjects gave low-rate performances under FI 10-sec cost even after reconditioning under FR 40.

Discussion

The present experiment showed that DRL conditioning can generate low-rate perform-

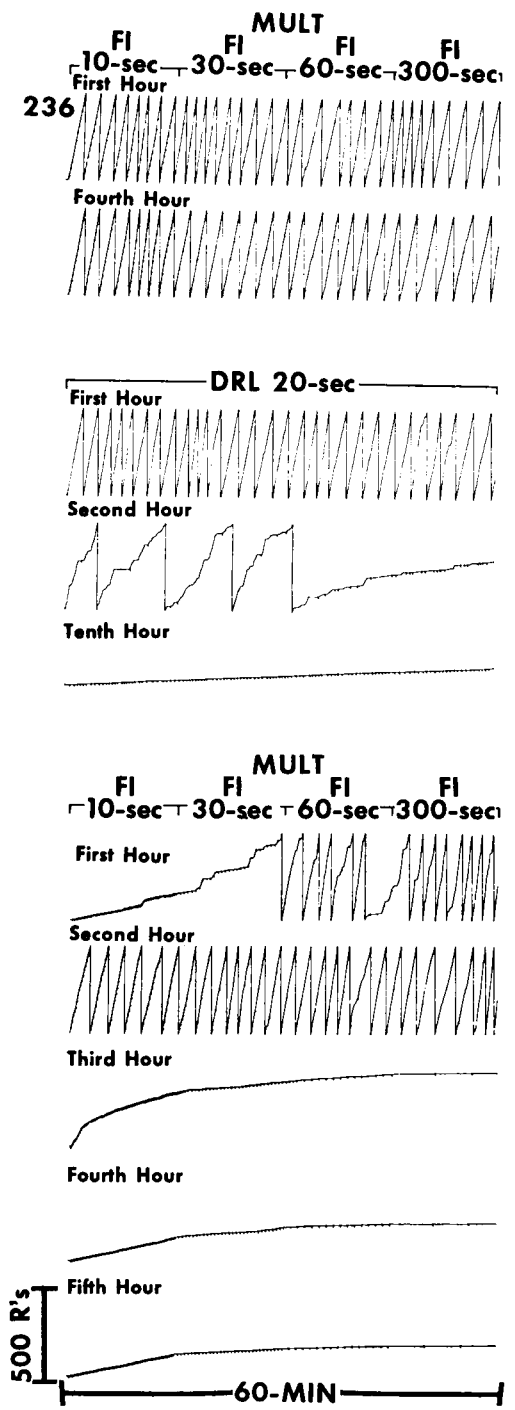

Fig. 9. Performances obtained from Subject 236 under the following sequence of schedules: *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec, DRL 20-sec, and *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec. Vertical marks on the records indicate the occurrence of 100-point reinforcements.

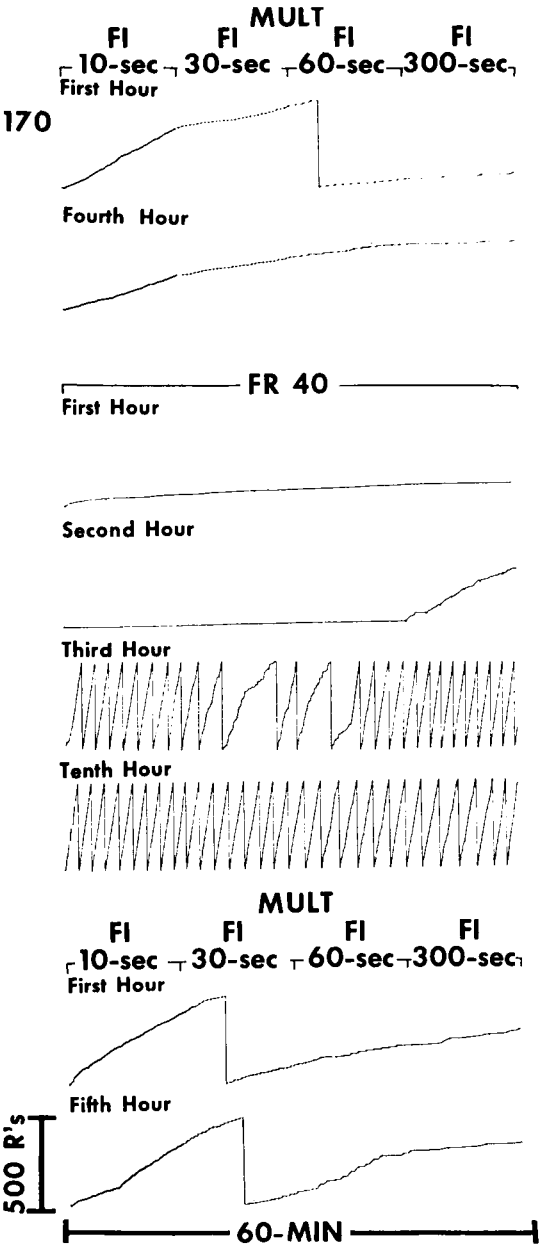

Fig. 10. Performances obtained from Subject 170 under the following sequence of schedules: *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec, FR 40, and *mult* FI 10-sec FI 30-sec FI 60-sec FI 300-sec. Vertical marks on the records indicate the occurrence of 100-point reinforcements.

ances under FI 10-sec, FI 30-sec, FI 60-sec, FI 300-sec schedules (Phase 1) and under an FI 10-sec cost schedule (Phase 2) after high-rate performances have been produced by an FR history. These data provide intra-subject replications of the data obtained in Exp. 2.

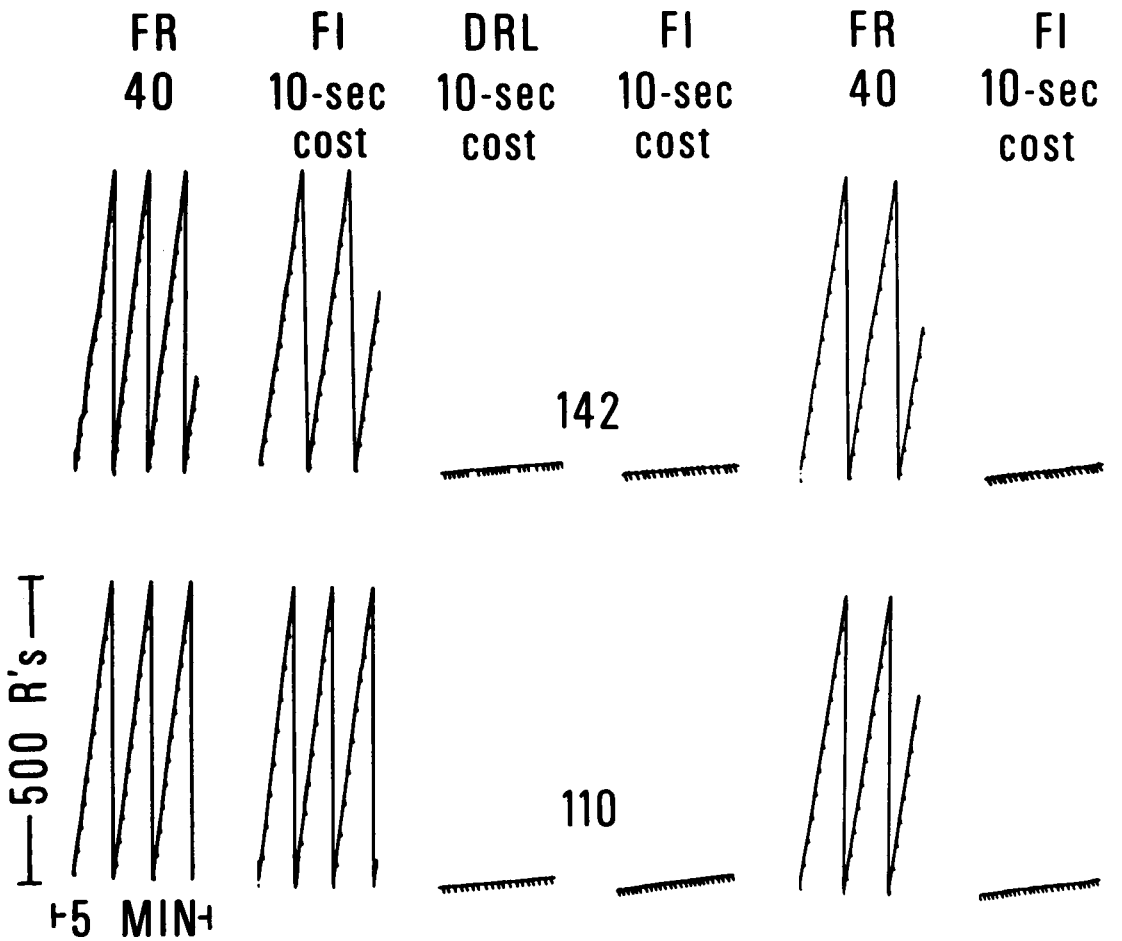

Fig. 11. Final performances obtained under the following sequence of schedules: FR 40, FI 10-sec cost, DRL 10-sec cost, FI 10-sec cost, FR 40, and FI 10-sec cost. Other details as in Fig. 1.

It was not possible to produce high-rate FI performances via FR conditioning after low-rate performances had been generated by DRL conditioning. This result is consistent with the finding in Phase 2 of Exp. 2 that FR responding will not generate high-rate performances under fixed-interval contingencies if subjects have a history of DRL responding.

In Phase 2 of the present experiment, FR 40-history subjects gave high-rate performances under FI 10-sec cost but responded at low rates under DRL 10-sec cost. It may be concluded, therefore, that the subjects maintained high rate performances under FI 10-sec cost following FR 40 because FI 10-sec cost, unlike DRL 10-sec cost, failed to make reinforcements contingent upon low rates of responding.

EXPERIMENT 4: ALTERING FR HISTORY EFFECTS BY ADDING ANOTHER HISTORY PRIOR TO HUMAN FI PERFORMANCE

Subjects who only have an FR history produce high-rate performances under FI 10-sec cost (Exp. 2-3). Low-rate performances occur under FI 10-sec cost when a DRL history is added to an FR history either before (Exp. 2) or after (Exp. 3) exposure to FI 10-sec cost.

The present experiment compares a DRL cost history with other history cost schedules in terms of their ability to prevent an FR history from generating high-rate performances under an FI 10-sec cost schedule. The history cost schedules compared with DRL cost were selected primarily because they permitted analysis of which aspects of DRL re-

sponding lead to low-rate performances under an FI 10-sec cost schedule.

To assess the importance of temporally-spaced responding, response-dependent reinforcements, and the reinforcement-postponement consequences of responding between reinforcements under DRL 10-sec cost, a fixed-time (FT, *cf.*, Zeiler, 1968) cost history (where points were delivered at specified times independently of behavior), and a differential-reinforcement-of-other-behavior (DRO) cost history (where delivery of points depended upon the absence of responses) were compared with DRL 10-sec cost in terms of their effects upon FI 10-sec cost responding. It was expected that, unlike a DRL cost history, FT and DRO cost histories would produce virtual cessation of responding just before FI 10-sec cost.

The effects of an extinction cost history (where no reinforcements were scheduled) upon FI 10-sec cost performances were also examined. As with the FT and DRO cost histories, little or no responding was expected under extinction cost. Thus, the importance of receiving or not receiving reinforcements in absence of responding under a history schedule could be assessed for possible differential effects upon FI 10-sec cost. In the event that the DRL, FT, DRO, and extinction cost histories all produced the same FI 10-sec cost performances, the extinction cost data would also provide information about how important reinforcements under DRL cost are for the production of low-rate performances under FI 10-sec cost.

Finally, DRL history schedules with different interreinforcement intervals and cost conditions were compared in terms of their effects upon FI 10-sec cost performances. Here the interest was to assess whether the ability of a DRL history to generate low-rate performances under FI 10-sec cost is a function of the similarities in response rates, reinforcement frequencies, and cost conditions under DRL and FI 10-sec cost.

Procedure

Different groups of subjects received one of the following six different history sequences: (1) FR 40 to DRL 10-sec cost (three subjects), (2) FR 40 to DRO 10-sec cost (three subjects), (3) FR 40 to FT 10-sec cost (four subjects), (4) FR 40 to extinction cost (four subjects), (5) FR 40 to DRL 1-sec cost (three subjects), and (6) FR 40 to DRL 10-sec (three subjects). Each sequence was followed by FI 10-sec cost.

The three new schedules inserted between FR 40 and FI 10-sec cost provided the following reinforcement contingencies; under the DRO 10-sec cost schedule, reinforcements occurred every 10-sec only if the subject made no response. Each response postponed reinforcement for 10 sec and cost the subject a point. The FT 10-sec cost schedule provided reinforcements every 10 sec independently of responding. Each response cost the subject a point. Under the extinction cost schedule, no reinforcements were scheduled and the subject was charged a point per response. Under the DRL 1-sec cost schedule, reinforcements were contingent upon an IRT of at least 1 sec. Each response emitted before 1 sec had elapsed from a previous response postponed reinforcement for at least 1 sec. Each response cost the subject a point. Finally, under the DRL 10-sec schedule, reinforcements were contingent upon an IRT of at least 10-sec. Each response emitted before 10-sec had elapsed from a previous response postponed reinforcement for at least 10-sec. Under DRL 10-sec, there was no cost for a response.

Results

Figure 12 presents the final performances of subjects under the different history schedules and under FI 10-sec cost. Under the FR 40-history schedule, all subjects responded at high constant rates. After FR 40, subjects emitted virtually no responses between reinforcements and responded at rates close to the minimum required for reinforcement under the DRL 10-sec cost (Fig. 12A), DRL 1-sec cost (Fig. 12E) and DRL 10-sec (Fig. 12F) schedules. Except for Subject 152, who responded at a high constant rate under FT 10-sec cost, all subjects virtually stopped responding under the DRO 10-sec cost (Fig. 12B), FT 10-sec cost (Fig. 12C), and extinction cost (Fig. 12D) schedules.

With one exception, subjects conditioned under the DRL 10-sec cost, DRO 10-sec cost, FT 10-sec cost, DRL 1-sec cost, and DRL 10-sec schedules gave low-rate performances under FI 10-sec cost. Subject 152, who emitted high constant responding under FT 10-sec cost, gave a high-rate performance under FI 10-sec cost.

In contrast, three of the four subjects with the extinction cost history produced high-rate performances under FI 10-sec cost. The fourth subject (197) gave a low-rate performance under FI 10-sec cost.

Discussion

FR 40-history subjects responded at low rates under DRL 10-sec cost and virtually stopped responding under FT 10-sec cost.

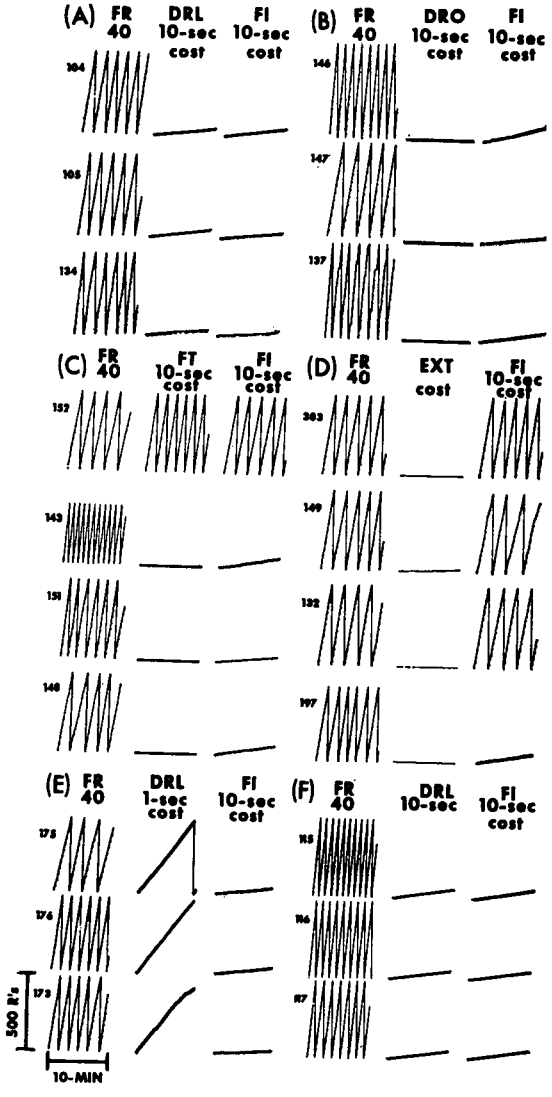

Fig. 12. Final performances obtained under the (A) FR 40 to DRL 10-sec cost (B) FR 40 to DRO 10-sec cost (C) FR 40 to FT 10-sec cost (D) FR 40 to extinction cost (E) FR 40 to DRL 1-sec cost or (F) FR 40 to DRL 10-sec sequences of history schedules and under the FI 10-sec cost schedule. Other details as in Fig. 1.

This suggests two reasons why FR 40-history subjects maintained high-rate performances under FI 10-sec cost in Exp. 2. First, FI 10-sec cost, unlike DRL 10-sec cost, failed to make reinforcements contingent upon low rates and a minimum IRT of at least 10-sec. A similar finding was obtained in Exp. 3. Second, FI 10-sec cost, unlike FT 10-sec cost, provided response-dependent reinforcements. It may be inferred that some type of induction of high-rate performance occurred from FR 40 to FI 10-sec cost because both of these schedules provide response-dependent reinforcements.

In the present experiment, subjects with the FR 40 to DRL 10-sec cost history gave low-rate performances under FI 10-sec cost. It may be suggested that the DRL 10-sec cost responding, rather than either FR 40 or the combination of FR 40 and DRL 10-sec cost responding, was responsible for the low-rate performances under FI 10-sec cost. Experiment 2 showed that subjects with only a DRL history or with both DRL and FR histories produced low-rate FI 10-sec cost performances; subjects who had only an FR history gave high-rate performances under FI 10-sec cost.

Which aspects of DRL 10-sec cost responding were responsible for the low-rate performances under FI 10-sec cost? Was the temporally-spaced responding, the response-dependent nature of reinforcements, or the reinforcement postponements for responding under DRL 10-sec cost important? Apparently not. All subjects who virtually ceased to respond under DRO 10-sec cost and FT 10-sec cost also produced low-rate performances under FI 10-sec cost.

Was the absence of responding *per se* under DRO 10-sec cost and FT 10-sec cost responsible for the low-rate performances under FI 10-sec cost? Probably not. Three out of the four subjects who virtually stopped responding under extinction cost produced high-rate performances under FI 10-sec cost.

DRL 10-sec cost responding did not produce low-rate performances under FI 10-sec cost because DRL 10-sec cost and FI 10-sec cost provided the same frequency of reinforcement and generated similar rates of responding. A DRL 1-sec cost schedule also produced low-rate performances under FI 10-sec cost despite the fact that it provided more reinforcements and generated higher rates of responding than FI 10-sec cost.

The cost contingency under DRL 10-sec cost was also not important for the production of low-rate performances under FI 10-sec cost. Like DRL 10-sec cost, a DRL 10-sec schedule also generated low-rate performances under FI 10-sec cost.

It may be suggested tentatively that the virtual absence of responding between reinforcements under DRL 10-sec cost was important for the production of low-rate performances under FI 10-sec cost. Unlike subjects who did not respond between reinforcements under DRL 10-sec cost, DRO 10-sec cost, or FT 10-sec cost, the subject who responded at a high constant rate under FT 10-sec cost gave a high-rate performance under FI 10-sec cost. That high-rate performances tend to occur under FI 10-sec cost when, following FR 40, a time-based history schedule generates high rates of constant responding between reinforcements is also supported by some data to be presented in Exp. 5. It will be shown that FR 40-history subjects who responded at high constant rates between reinforcements under an FI 10-sec schedule all produced high-rate performances under FI 10-sec cost.

The occurrence of reinforcements under DRL 10-sec cost also appeared to be important for the production of low-rate performances under FI 10-sec cost. Unlike DRO 10-sec cost and FT 10-sec cost histories, an extinction cost history, which like DRO 10-sec cost and FT 10-sec cost produced virtual cessation of responding but did not provide reinforcements, tended to be followed by high-rate performances under FI 10-sec cost.

EXPERIMENT 5: INTERACTIVE EFFECTS OF CONDITIONING HISTORIES AND COST UPON HUMAN FI PERFORMANCE

Because an FI 10-sec cost schedule was used in Exp. 2, 3, and 4, it was not possible to assess the extent to which the FR and DRL history effects obtained were due to the FI 10-sec contingency, the cost contingency, or both the FI 10-sec and cost contingencies. The present experiment sought to isolate and evaluate the separate and/or interactive effects of conditioning histories and cost by examining the effects of variations in history schedule parameters, type of history schedule (FR *versus* VR), and history schedule sequence upon both FI 10-sec and FI 10-sec cost performances.

Procedure

Subjects were conditioned under one of the following history schedules or sequences of history schedules: FR 1, FR 20, FR 40, VR 40, DRL 1-sec, DRL 5-sec, DRL 10-sec, DRL 20-sec, DRL 20-sec followed by FR 40, and FR 40 followed by DRL 20-sec. Seven subjects received the FR 1 or FR 20 history. Three subjects were conditioned under each of the other history schedules or sequences of schedules.

Except for the differences in ratio requirements and DRL values, the various FR and DRL history schedules in this experiment have been described previously (*cf.*, procedure section of Exp. 2). The VR 40 (variable ratio 40) history schedule provided reinforcements after a variable number of responses had been emitted. The number of responses required for reinforcement formed an arithmetical progression which ranged from 1 response to 80 responses. On the average, reinforcements occurred after 40 responses.

After their respective histories, all subjects were conditioned under FI 10-sec followed by FI 10-sec cost contingencies.

Results

Response rates as a function of the ratio requirement of an FR schedule, the type (FR *versus* VR) of ratio schedule, and the interreinforcement interval (DRL value) of a DRL schedule are plotted in Fig. 13. Except for the response rates under FR 40, all rates in Fig. 13 are those obtained from subjects who had only ratio or DRL histories. The response rates under FR 40 are those obtained from the FR 40 to DRL 20-sec history subjects. These rates were the most comparable to the FR 40 rates obtained from other subjects in Exp. 2-4.

Figure 13 shows that response rates did not vary systematically with the ratio requirement of the FR schedules. Rates were slightly higher under VR 40 compared to FR 40. Response rates under the DRL schedules were related to DRL values. The higher the DRL value, the lower the response rate.

The final performances of subjects under the different ratio or DRL histories and under FI 10-sec and FI 10-sec cost are shown in Fig. 14 and 15. Irrespective of ratio requirements and the fixed *versus* variable nature of

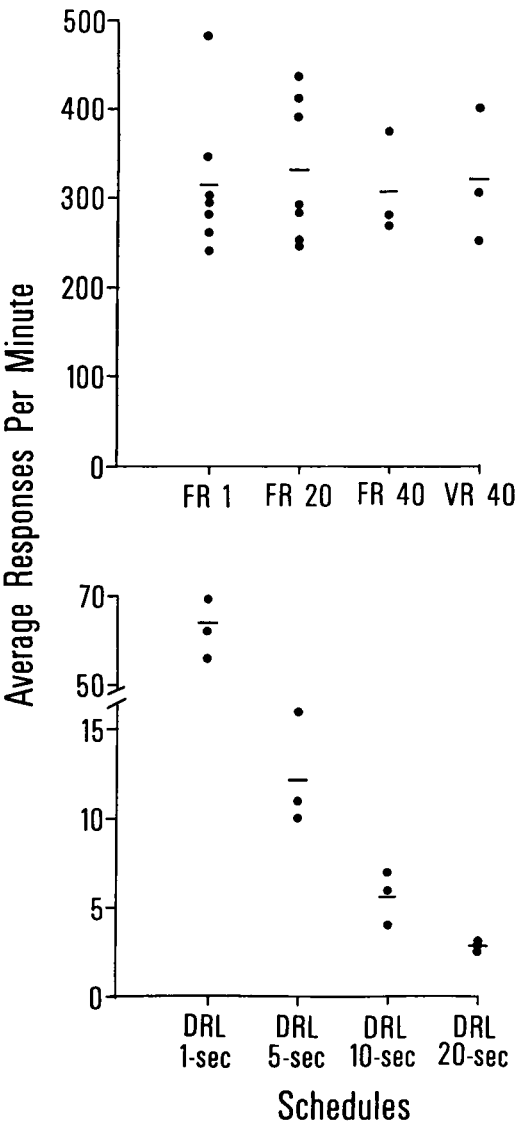

Fig. 13. Response rates as a function of the ratio requirement of an FR schedule, the type (FR 40 *versus* VR 40) of ratio schedule and the DRL value of a DRL history schedule. Data points represent mean rates for individual subjects and horizontal dashes indicate mean rates for all subjects under the different schedules. Different subjects were conditioned under each schedule. Other details in text.

such requirements, Fig. 14 shows that ratio histories tended to produce high-rate performances in 17 of 20 subjects. One of the FR 1-history subjects (406) gave a high-rate performance under FI 10-sec but produced a low-rate performance under FI 10-sec cost. A second FR 1-history subject (395) had low-rate performances under both FI 10-sec and FI 10-sec cost. One FR 20-history subject (554) also gave low-rate performances under FI 10-sec and FI 10-sec cost.

Ratio-history subjects maintained high-rate performances under FI 10-sec and FI 10-sec cost (1) despite decreases in reinforcement frequency, (2) despite changes from continuous reinforcement to intermittent reinforcement (when FR 1-history subjects moved to the FI contingencies), and (3) despite a change from variable-interval to fixed-interval reinforcements (when VR 40-history subjects moved to the FI contingencies).

Response rates under FI 10-sec and FI 10-sec cost did not appear to be a function of rates established during the different ratio histories. Furthermore, rates under FI 10-sec cost were sometimes higher and sometimes lower than respective rates under FI 10-sec.

Figure 15 shows that, irrespective of DRL values, the DRL schedules generated low-rate performances under FI 10-sec and FI 10-sec cost in 11 of 12 subjects. Subject 194, who had a DRL 10-sec history, gave a high-rate performance under FI 10-sec but a low-rate performance under FI 10-sec cost.

The DRL-history subjects gave low-rate performances under FI 10-sec and FI 10-sec cost (1) irrespective of the rate of responding and frequency of reinforcement under DRL, and (2) despite changes in response rates and reinforcement rates in moving from their respective DRL history schedules to FI 10-sec and FI 10-sec cost.

Unlike subjects with ratio histories, the DRL-history subjects had lower rates under FI 10-sec cost compared to respective FI 10-sec rates.

The effects of a DRL 20-sec to FR 40 or an FR 40 to a DRL 20-sec history sequence upon FI 10-sec and FI 10-sec cost performances are shown in Fig. 16. Like subjects who had only a DRL 20-sec history (*cf.*, Fig. 15), five of the six subjects with either the DRL 20-sec to FR 40 history or the FR 40 to DRL 20-sec history produced low-rate performances under FI 10-sec and FI 10-sec cost. One of the DRL 20-sec to FR 40-history subjects (138) gave a high-rate performance under FI 10-sec but produced a low-rate performance under FI 10-sec cost.

In view of the fact that one DRL 10-sec-history subject (194 in Fig. 15) and one DRL 20-sec to FR 40-history subject (138 in Fig. 16)

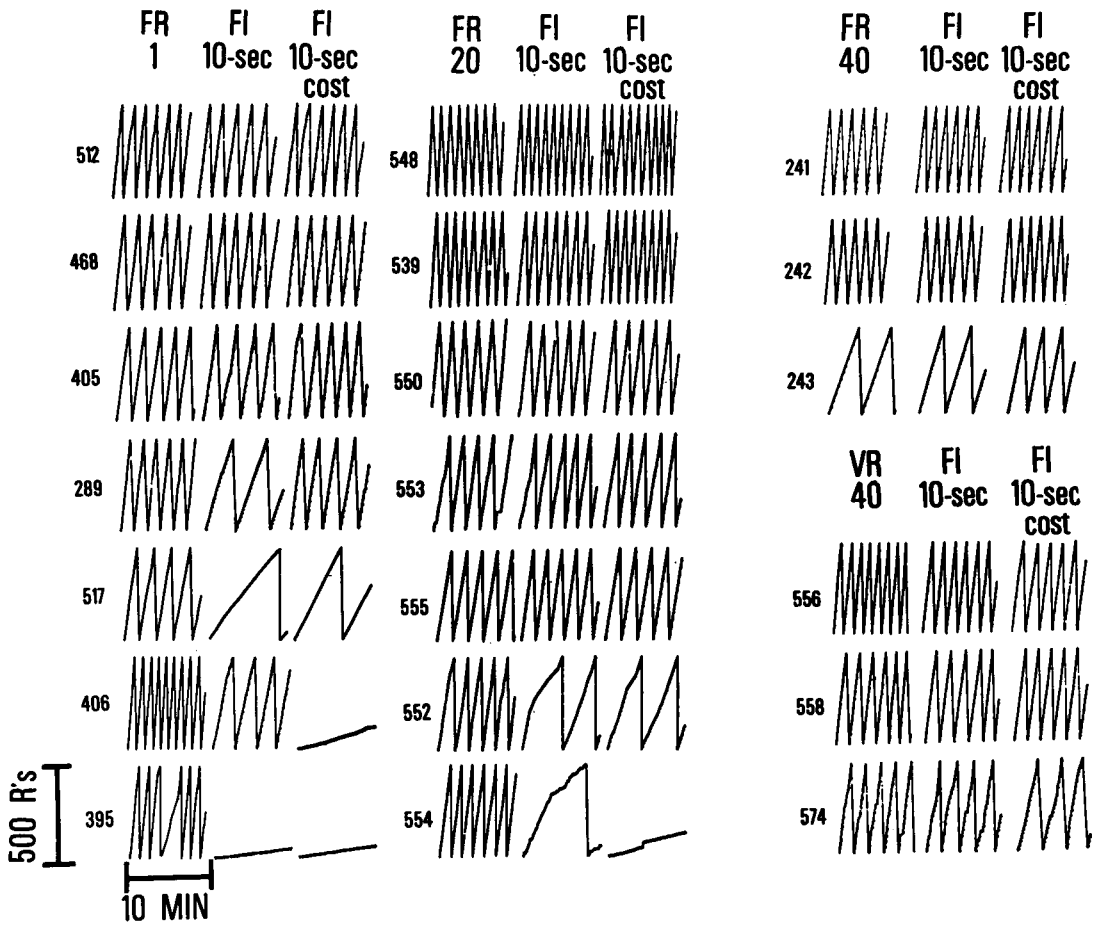

Fig. 14. Final performances under the FR 1, FR 20, FR 40, or VR 40 history schedules and under FI 10-sec and FI 10-sec cost. Other details as in Fig. 1.

gave a high-rate performance under FI 10-sec but a low-rate performance under FI 10-sec cost, it may be concluded that cost increases the likelihood of obtaining a low-rate FI performance after a DRL history.

Discussion

The effects of FR 40 and DRL 20-sec histories upon FI 10-sec responding obtained in this experiment replicate previous results (Weiner, 1964*b*). All other data in this experiment have not been obtained previously and permit the conclusion that FI 10-sec performances may be a joint function of conditioning histories and cost. Whenever subjects had a DRL or both DRL and FR histories, in any sequence, cost suppressed response rates and increased the likelihood of obtaining low-rate performances under FI 10-sec contingencies. Cost did not attenuate response rates consistently or produce low-rate performances under FI 10-sec when subjects had only an FR or VR history.

GENERAL DISCUSSION

In the absence of any scheduled conditioning history and cost, FI schedules did not generate low rates and post-reinforcement pausing (that is, low-rate performances) consistently with the present human subjects. Rather, most subjects responded at high constant rates without pausing after reinforcement (that is, gave high-rate performances) under FI 10-sec and FI 600-sec schedules. Cost was effective in generating low-rate performances under FI contingencies, but was also unable to eliminate high-rate performances entirely (Exp. 1).

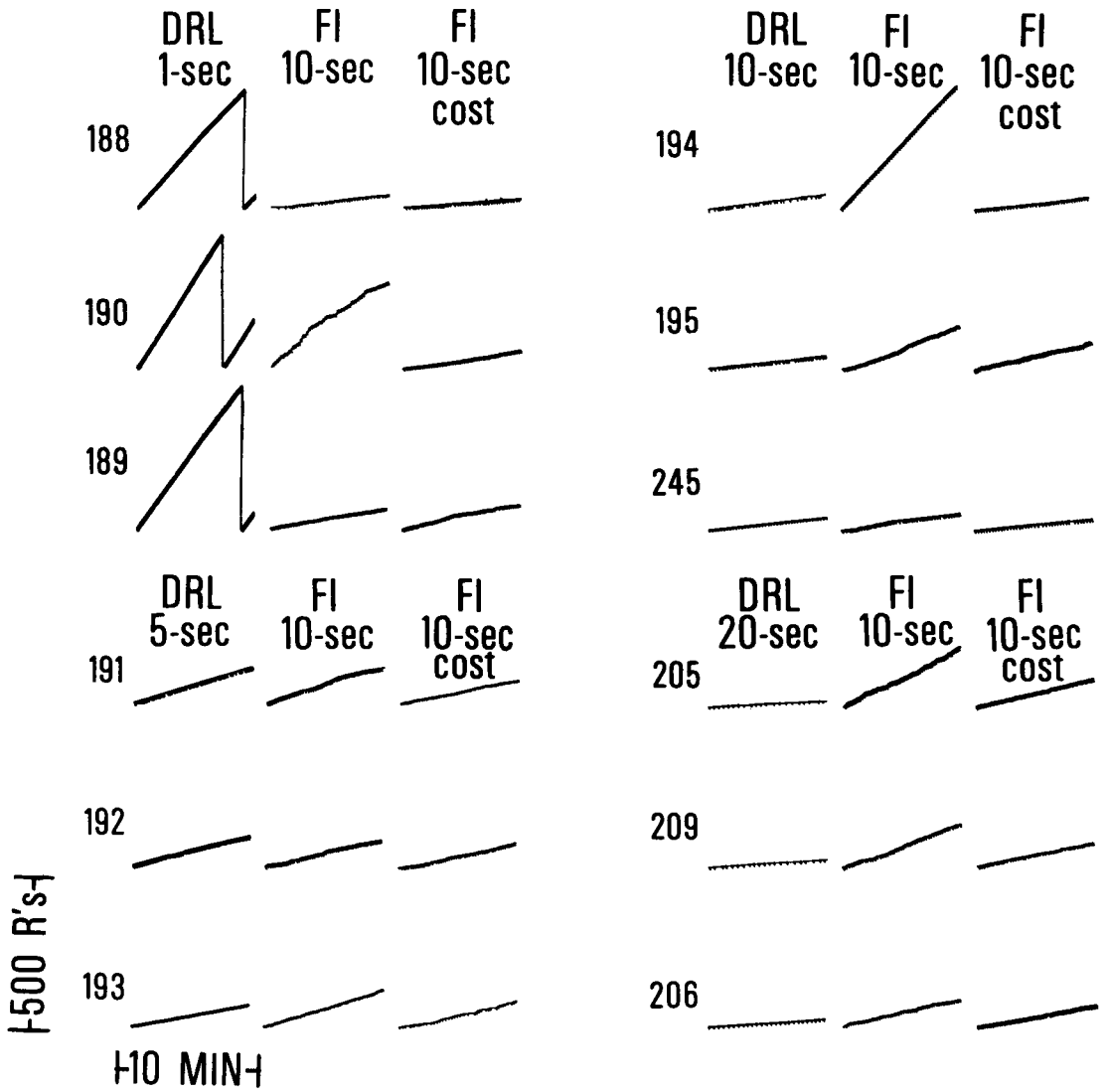

Fig. 15. Final performances under the DRL 1-sec, DRL 5-sec, DRL 10-sec, or DRL 20-sec history schedules and under FI 10-sec and FI 10-sec cost. Other details as in Fig. 1.

The likelihood of high and low-rate FI performance was shown to depend on the conditioning history of subjects. High-rate FI performances were obtained consistently from subjects given an FR history. Low-rate FI performances were obtained from subjects given a DRL or both DRL and FR histories (*e.g.*, Exp. 2). Cost increased the likelihood of obtaining low-rate rather than high-rate performances under FI following DRL or DRL and FR histories (Exp. 5). Thus, human FI performance was found to be a joint function of both the conditioning histories of subjects and cost conditions.

The FR-history subjects did not change their response rates and patterns in a consistent fashion when FI values were changed or when cost was added to an FI schedule. In contrast, increases in FI values and the introduction of cost, reduced responding consistently (primarily by increasing the incidence or duration of post-reinforcement pauses) when subjects had a DRL or both DRL and FR histories (*cf.*, Exp. 2 and 5).

The finding that response rates are unrelated to FI values after an FR history, but are related to FI values after a DRL history, is understandable if one assumes some type of

induction has occurred from the FR and DRL histories to the FI contingencies. Experiment 5 showed that FR response rates do not change systematically with changes in ratio requirements, whereas response rates decrease with increases in DRL values (*cf.*, Fig. 13).

Even marked changes in reinforcement frequency may not be sufficient to prevent FR and DRL histories from exerting their differential effects upon FI performances, whether such changes occur gradually (Exp. 2, Phase 1) or rapidly (Exp. 2, Phase 2), whether such changes are produced by keeping FR and DRL histories constant and increasing FI values (Exp. 2, Phase 1), or by keeping the FI schedule constant and changing the requirement of a ratio schedule or the DRL value of a DRL schedule (Exp. 5).

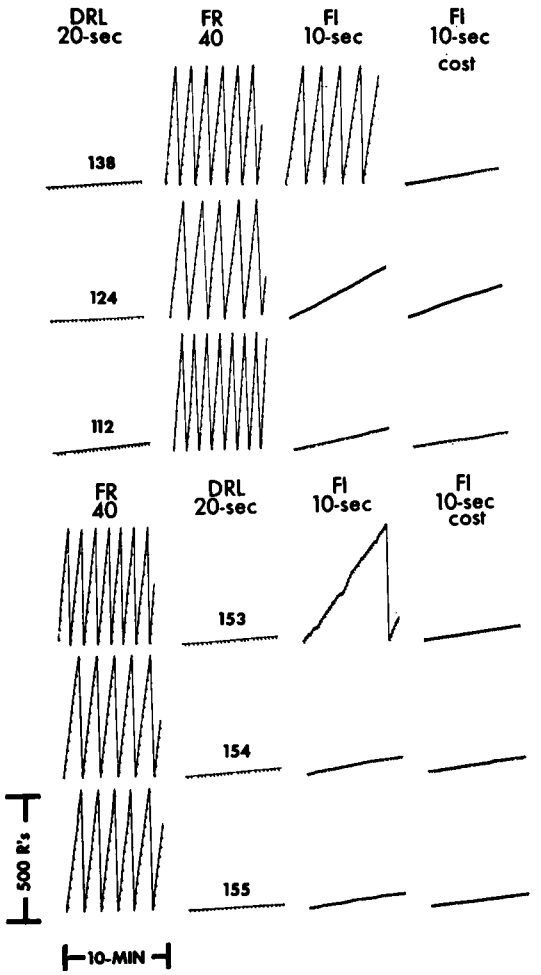

Fig. 16. Final performances under DRL 20-sec to FR 40 or the FR 40 to DRL 20-sec history schedule sequence and under FI 10-sec and FI 10-sec cost. Other details as in Fig. 1.

The fixed nature of the ratio requirement during FR did not appear critical for the production of high-rate performances under an FI schedule. Such FI performances were also obtained after a VR history (Exp. 5).

Two characteristics of an FI schedule apparently encourage the persistence of FR history effects. First, like FR, an FI schedule provides response-dependent reinforcements. Second, unlike a DRL schedule, an FI schedule fails to make reinforcements contingent upon a minimum IRT (Exp. 4).

Some data were presented (Exp. 4) which suggest that the occurrence of reinforcements after periods of virtually no responding during a DRL history was important for the production of low-rate performances under FI contingencies. Neither the temporally-spaced responding generated under DRL, the rate of DRL responding, the response-dependent nature of DRL reinforcements, the reinforcement-postponement consequences of responding under DRL, the frequency of DRL reinforcements, or the change in reinforcement frequency in moving from DRL to FI appeared to be important for the production of low-rate performances under FI.

Obviously, there are still gaps in our understanding of how performance established during FR and DRL schedules persists under FI schedules. It appears likely that some type of response induction is involved. It is clear, however, that such response induction processes are not simple ones. First of all, rates and patterns of responding established during FR and DRL histories may be quite different from the final performances these histories generate under FI schedules. For example, following a DRL history, response rates under FI may increase or decrease and the pattern of responding may be different from that emitted under DRL, in that an increase in responding occurs just before reinforcement under FI (*cf.*, Fig. 3). Secondly, histories such as DRL may determine final FI performances despite the fact that they are in the remote past and quite different rates and patterns of responding have been effected by intervening histories (*cf.*, Fig. 16). Lastly, final performances during FR and DRL histories may exert their effects under FI despite different acquisition characteristics under FR and DRL, and

despite different types of transitions from the FR and DRL histories to final FI performances (*cf.*, Fig. 7).

There was little reason to assume that the differential effects of FR and DRL histories upon FI performances were transitory in nature. Both FR and DRL histories produced differences in session-to-session response rates under FI schedules which did not appear to be disappearing over relatively long periods of time (*cf.*, Fig. 5).

The persistence of FR and DRL history effects under FI cannot be ascribed to the fact that, under all of these contingencies, subjects received only positive reinforcements in fairly fixed intervals of time. Previous studies (Weiner, 1965*b*, 1966) have shown that FR- and DRL-history effects also persist to control response rates and patterns under avoidance and escape schedules that deliver fixed-interval negative reinforcement and under VI schedules that deliver variable-interval positive reinforcements.

What is it about simple interval schedules of positive and negative reinforcement that make them so vulnerable to FR and DRL history effects? The present findings suggest that a major reason may be that these schedules usually fail to make the rate of reinforcement *contingent* upon restricted rates and patterns of responding between reinforcements. Rather, simple interval schedules usually provide only non-reinforcement for unnecessary responding between reinforcements.

In the case of FI schedules, this paper has shown that non-reinforcement for responding between reinforcements is not very effective in preventing the persistence of FR and DRL history effects with humans. The persistence of FR and DRL history effects is prevented by schedules that make reinforcement rate a direct function of each response between reinforcements. Thus, for example, this paper showed that FR 40 and DRL 20-sec history effects persist under FI 10-sec (Exp. 5), whereas FR 40 history effects do not persist under DRL 10-sec (Exp. 4) nor do DRL 20-sec history effects persist under FR 40 (*e.g.*, Exp. 2, Phase 2). Unlike an FI 10-sec schedule, changes in reinforcement rate under DRL 10-sec and FR 40 schedules are a direct function of each interreinforcement response. By providing correlations between positive and/or negative reinforcement rate consequences and each response, FR and DRL schedules apparently discourage the persistence of widely divergent history effects.

The data here emphasize that past behavioral repertoires interact with current contingencies of reinforcement. The importance of past behavioral repertoires for schedule-controlled behavior has tended to be neglected. Based upon their research with animal subjects, Morse and Kelleher (1966) suggested that this neglect has occurred because "people usually study schedule performances that are strongly determined and forced toward a particular pattern of responding (p. 1)."

The present data suggest that consistent patterns of responding under FI may be obtained from human subjects by appropriately manipulating their conditioning histories. Non-reinforcement, marked reductions in reinforcement frequency, and even punishment (cost) were not usually sufficient to generate low-rate performances under FI schedules when subjects either had no scheduled history or only an FR history. Low-rate performances were obtained from practically all subjects under FI after a history of DRL responding.

A comment about such phrases as "characteristic FI performances" or "FI schedule-control" seems appropriate here. Because low rates consisting of post-reinforcement pauses followed by positively accelerated terminal rates (that is, scalloped patterns) are common with animals under FI schedules, particularly those which use intervals of the order of minutes, such phrases as "the characteristic FI pattern" or "FI schedule-control" are frequently used when scalloping occurs under FI schedules, not only with animals but with humans as well. In the present experiments, a wide variety of stable response patterns were obtained from humans under both an FI 10-sec and an FI 600-sec schedule in the absence of any scheduled conditioning history and cost (Exp. 1). It is clear, therefore, that an FI schedule is not a sufficient condition for generating scalloping consistently with humans. It therefore seems unwise to view scalloping as "the characteristic FI pattern" with humans. It also seems unwise to view scalloping as particularly "FI schedule-controlled". This paper has shown that the consistent occurrence of low rates and post-reinforcement pauses (considered here as an approximation to scalloping) under FI schedules is contin-

gent upon the conditioning history of subjects and response cost conditions, rather than an FI schedule *per se*. In this author's opinion, scalloping under FI schedules with humans is best viewed, to use Morse and Kelleher's (1966) definition of a schedule-controlled performance, as "simply a reproducible ongoing pattern with a specifiable history (p. 2)."

The data concerning the importance of conditioning histories for the control of human FI performance in this paper, and for VI and avoidance and escape performances in other papers (Weiner, 1965*b*, 1966), support the recent suggestions made by Sidman (1960, pp. 384-387) and by Long (1962) that failures to obtain consistent schedule effects from different humans may be due to uncontrolled pre-experimental behavior histories. Fortunately, it appears that direct control of pre-experiment histories is not required. Conditioning histories provided in the laboratory seem to be capable of minimizing inter-subject variability and producing consistent schedule effects with humans.

It should be pointed out, however, that the price paid for controlling inter-subject variability may be high. There are times when minimizing inter-subject variability has detrimental consequences. For example, in Exp. 5, subjects who only had an FR 40 history showed minimal inter-subject variability under an FI 10-sec schedule, but failed to adjust effectively under an FI 10-sec cost schedule, that is, they maintained high-rate performances which resulted in unnecessary (avoidable) cost punishments (*cf.*, Fig. 14). On the other hand, subjects with a more varied history, like the DRL 20-sec to FR 40-history subjects in Exp. 5, produced marked inter-subject variability under FI 10-sec, but adjusted effectively under FI 10-sec cost; that is, they produced low rates and thereby minimized unnecessary cost punishments (*cf.*, Fig. 16).

Experiment 5 showed that subjects could be given only one history and yet still minimize inter-subject variability and produce low-rate performances under FI 10-sec cost. Subjects who were provided with only a DRL 20-sec history showed minimal inter-subject variability under FI 10-sec and yet incurred few unnecessary point losses under FI 10-sec cost. These DRL 20-sec-history subjects gave low rates under both FI 10-sec and FI 10-sec cost (*cf.*, Fig. 15).

While subjects who only have a DRL history may respond effectively under FI contingencies, they may not do so under VI contingencies. Weiner (1965*b*) has shown that subjects who were provided with a DRL 20-sec history obtained only about 50% of the available reinforcements under a VI 10-sec schedule due to low response rates and extended pauses between responses.

Whenever possible, it appears wise to avoid controlling inter-subject variability and producing consistent schedule effects by providing subjects with only one conditioning history. The ability to adjust effectively to changing environmental contingencies may be hampered by limited behavioral repertoires.

We are, of course, a long way from complete mastery over inter-subject variability under FI schedules with humans. But it has been shown that such inter-subject variability may be evaluated and controlled by experimental operant conditioning procedures rather than statistical manipulations. In doing so, we have demonstrated that inter-subject variability is not intrinsic to human operant behavior but is, rather, a lawful orderly function of manipulable variables such as response cost and conditioning history.

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