PAUSE RELATIONSHIPS IN MULTIPLE AND CHAINED FIXED-RATIO SCHEDULES[1]

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On a multiple fixed-ratio 10 fixed-ratio 100 schedule, pigeons pause for relatively long periods of time before the fixed-ratio 100 schedule. Only a short pause occurs before the fixed-ratio 10 schedule. A chain fixed-ratio 10 fixed-ratio 100 schedule produces the reverse pattern, i.e., a short pause before the fixed-ratio 100 schedule and a long pause before the fixed-ratio 10 schedule. Procedurally, the only difference between the two schedules is that the fixed-ratio 10 component is always terminated by some unconditioned reinforcer in the multiple schedule but never in the chained schedule. In the present experiment, the percentage of fixed-ratio 10 components which included reinforcement was gradually decreased for birds on the multiple schedule and gradually increased for birds on the chained schedule. It was found that percentage reinforcement within the fixed-ratio 10 component was inversely related to the duration of the pause before the fixed-ratio 10 component and directly related to the duration of the pause before the fixed-ratio 100 component. Thus, the relative rate of reinforcement paired with a particular stimulus was seen to be an important factor in determining response latency to that stimulus.

The current interest in latency as a reliable dependent variable in operant studies stems from the relatively recent recognition that systematic relationships can be established between latency and a number of reinforcement schedule parameters. Some of the clearest examples of such relationships have been reported in conjunction with fixed-ratio (FR) schedules of reinforcement. For example, Felton and Lyon (1966) found a direct correlation between FR size, i.e., the number of responses required to produce reinforcement, and the pause length following reinforcement. According to Sidman and Stebbins (1954), satiation produced an increase in pausing after reinforcement on an FR schedule. In both studies these latency measures were found to be consistently related to the experimental manipulation, whereas response rate, as measured from the first to last response, was not.

In more complex schedules, which combine FR components in various ways, changes in latency or intercomponent pausing reveal important sources of stimulus control within the schedule. Findley (1962) studied a schedule in which the FR value progressively increased for three components and then progressively decreased for the next three, etc. For example, in the presence of a red light a rat was exposed to FR 25, FR 75, and then FR 225. Then, during a green light, the progression was reversed, i.e., FR 225, FR 75, and FR 25. Responses in all components were reinforced in both colors. Findley reported that longer pauses occurred before the larger FR components, regardless of the position of a particular component within the sequence. Because each individual FR component did not contain a separate stimulus, Findley concluded that the pause-FR size relationship depended upon stimuli arising out of the animal's own behavior on the schedule.

When the components of a complex schedule are correlated with a separate stimulus, changes in pause length preceding each individual component are accentuated over those on comparable schedules without such stimuli. Kelleher and Fry (1962) compared the performance of pigeons on a *chain* FI 1 FI 1 FI 1 schedule with performances on a *tand* FI 1

FI 1 FI 1 schedule. In both schedules only the last fixed-interval (FI) component included reinforcement. The difference between the two schedules is that the components of the chained schedule have separate stimuli, whereas a single stimulus is present throughout all the tandem schedule components. Kelleher and Fry reported that prolonged pausing developed within and before the first and second components of the chained schedule. In the tandem schedule, on which the birds were initially trained, pauses of this sort seldom occurred. Thomas (1964) also compared chained and tandem performance as a means of investigating stimulus control. Similar to Kelleher and Fry's observations of FI performance, Thomas found that pigeons paused longer before the first component of a *chain* FR 60 FR 60 FR 60 schedule than before the first component of a *tand* FR 60 FR 60 FR 60 schedule.

If latency-type measures can differentiate various operations for bringing behavior under stimulus control, these same measures may also provide important information about the effects of other variables, *e.g.*, frequency of reinforcement. There is already some evidence on this point. Zimmerman (1960) reinforced rats for responding on an FR 10 schedule in the presence of a stimulus, an S^D. When the percentage of FR 10 reinforcement schedules was decreased, the latency between the onset of the S^D and the first response on the FR 10 schedule increased, as did the variability of this pause time. Stebbins and Lanson (1962) reported that the "reaction time" of a single response to an auditory S^D increased in value and variability when the percentage of reinforcement for the response was decreased below 100%.

Similar to the studies by Zimmerman (1960) and Stebbins and Lanson (1962) the present study examined the effects of intermittent reinforcement on latency. Instead of single FR 10 or FR 1 components, however, the effectiveness of latency measures in characterizing transitional states within two-component schedules was examined. Specifically, changes in latency within multiple and chained fixed-ratio schedules were of interest for the following reasons.

When the two components of a multiple (*mult*) FR 10 FR 100 schedule are alternated, a pattern of responding is produced which appears to be the converse of that maintained by a *chain* FR 10 FR 100 schedule. The multiple response pattern consists of a long pause before the first response of the FR 100 component (pre-FR 100 pause) and a relatively short pause before the first response of the FR 10 component (pre-FR 10 pause). In the chained response pattern, the pre-FR 10 pause exceeds the pre-FR 100 pause.

The stimulus conditions in the *mult* FR 10 FR 100 schedule and the *chain* FR 10 FR 100 schedule are identical. Thus, a different stimulus accompanies each component, and the two components alternate. However, the unconditioned reinforcement requirements differ. In the multiple schedule, responses in both components are reinforced; only responses in the last component (FR 100) are reinforced in the chained schedule.

Because the primary difference between the two schedules lies in whether or not responses in the FR 10 component are reinforced, the present study concentrated upon the role of this variable in maintaining the two distinct response patterns. Accordingly, it should be possible to transform the multiple pattern into the chained pattern by reinforcing responses in the FR 10 component at some value less than 100%. Also, if the chained pattern is taken as a starting point, it should be possible to establish the multiple pattern by increasing above 0% the percentage of FR 10 reinforcement components. Not only would reversing the relative magnitude of the pre-FR 10 and pre-FR 100 pauses in this manner illustrate the basis for a connection between the multiple and *chain* FR 10 FR 100 schedules, but the course of the transition itself might also suggest other important properties of multiple and chained reinforcement schedules in general.

METHOD

Phase I (Multiple-to-Chained)

Two male White Carneaux pigeons, E-17 and E-18, were used. Both had previously been exposed to FR schedules. The chamber was a standard operant-conditioning pigeon chamber, containing two plastic translucent keys transilluminated with different colored lights. The aperture to the feeder hopper was located below the key used for the food reinforcement schedules. A small watering device was posi-

tioned below the second key. Any time during the experimental session one peck on this key would produce about 2 ml of water. Electro-mechanical systems were used to program the various conditions and a PDP-5 computer recorded the data.

An experimental session lasted 2 hr each day, seven days a week. One bird's session followed the other's, and the starting time of each session was held approximately constant from day to day. The bird obtained its entire daily supply of food during a session by completing the appropriate schedules. No restrictions other than the 2-hr limit and the schedule requirements were placed upon the number of reinforcements.

Each bird was placed on a *mult* FR 10 FR 100 schedule with two alternating components. A red light transilluminated the key during the FR 100 component; the key was transilluminated by a green light when the FR 10 component was programmed. The completion of each component was followed by 3-sec access to the feeder hopper which contained Purina pigeon chow. Also, during this 3-sec interval, the hopper was illuminated and the key light was turned off.

When the performance of each bird had stabilized on the *mult* FR 10 FR 100 schedule, the following procedures were introduced. For both E-17 and E-18, responses in the FR 100 component continued to be reinforced every time that component occurred throughout the entire experiment. However, responses in the FR 10 component were reinforced less frequently (FR components containing no reinforcement were followed only by a darkening of the key for 3 sec) until the normal multiple response pattern was transformed into the typical chained response pattern. This type of intermittent reinforcement has been referred to as percentage reinforcement by Ferster and Skinner (1957, pp. 67-71). Then, this procedure was reversed. That is, the percentage of FR 10 components in which responses were reinforced was increased to bring about a recovery of the original multiple response pattern.

Responses in the FR 10 component were reinforced for E-17 according to the following sequence of percentages: (F)-100, (V)-33.3, 16.6, 7.14, 5.00, 2.56, 1.44, (F)-1.25, 1.05, 0.86, 0.66, 0.54, 0, and 100. The sequence for E-18 was: (F)-100, (V)-33.3, 16.6, 5.88, 3.84, 3.22, 1.30,

(F)-1.54 and 2.50. The terms F and V refer to fixed and variable reinforcement percentages respectively. Thus, if the reinforcement percentage was fixed (F) at 1.00%, responses in every one-hundreth FR 10 component would be reinforced. (The FR 100 and FR 10 components always alternated.) Assuming that a bird completed about 40 of each type of FR component in a single session, a reinforcement percentage of 1.00% would indicate that responses in an FR 10 component would be reinforced every 2.5 sessions. However, with a higher percentage of reinforcement, say 50% and fixed, responses in every other FR 10 component within a particular session would be reinforced. Under this condition, a discrimination might be formed between those FR 10 components which contained reinforcement and those which did not (*i.e.*, a long pause before nonreinforcement components and short pauses before reinforcement components). To prevent this type of discrimination at such high percentages the frequency of reinforcement was varied (V) and the mean percentage was calculated.

The change from one reinforcement percentage to the next depended upon the stability of the bird's performance. A minimum of 19 sessions was allowed for each value. If, during the last five sessions, no trend was visibly evident in the daily median pre-FR 10 pauses (Phase I) or pre-FR 100 pauses (Phase II), the percentage of reinforcement in effect was replaced by the next one in the series. In the majority of cases, 19 sessions were sufficient to achieve the steady-state condition. When this was not the case, the criterion period was extended until stability had been achieved, with a maximum limit of 76 sessions.

Phase II (Chained-to-Multiple)

Two naive, male White Carneaux pigeons, E-19 and E-20, were used. During the latter part of this experiment when the reinforcement percentage was 0.33%, E-20's weight began to drop, and 20 g of supplemental food was given in the home cage each day.
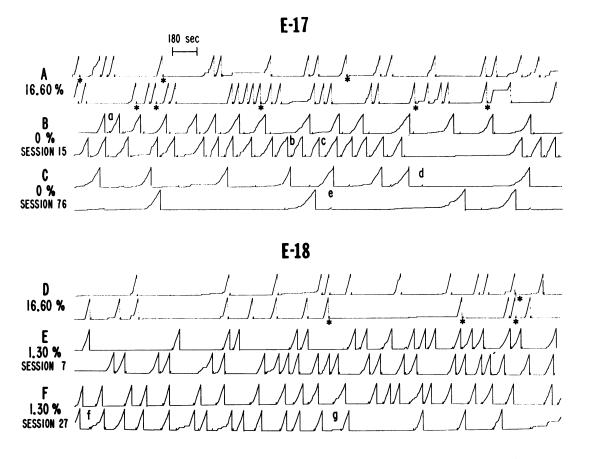
The procedures in the chained-to-multiple condition were the same as those in the multiple-to-chained condition with the following exceptions. Both E-19 and E-20 were trained on a *chain* FR 10 FR 100 schedule. Then, the reinforcement percentage for the FR 10 component was systematically increased in steps

until the chained pattern had been replaced by the multiple pattern. As in Phase I, FR 10 components in which responses were not reinforced were always followed by a darkening of the key for 3 sec. The final manipulation consisted of recovering the original chained pattern by reducing the percentage of reinforcement for the FR 10 component. In order, the reinforcement percentages to which E-19 was exposed were: (F)-0, (V)-0.80, 1.16, (F)-1.42, 1.66, 2.00, 1.00, 0.71, 0.33 and 0. The reinforcement percentages for E-20 were: (F)-0, (V)-0.81, 1.23, (F)-1.11, 0.90, 0.57, 0.33 and 0.

RESULTS

The cumulative response records exemplify the principal features of the transitions. Figure 1 contains the data from three sessions for Bird E-17 and for Bird E-18, the subjects in Phase I. The top record (A) in Fig. 1, which represents the last session at 16.6% reinforcement, shows the typical multiple pattern, i.e., one in which the pre-FR 10 pause was shorter than the immediately following pre-FR 100 pause. Pausing was minimal within the FR 10 component itself. Gradually, the percentage of reinforcement was decreased for E-17, but only when the FR 10 component was extinguished (0%) did clear signs of an intermediate transitional stage develop. In the second record (B), for E-17 in Fig. 1, the pre-FR 10 pause increased and occasional pausing occurred within the FR 10 component as shown at letter "a". Although the pre-FR 100 pause usually exceeded the pre-FR 10 pause, several instances of the chained pattern in which the pre-FR 10 pause exceeded the immediately following pre-FR 100 pause are clearly evident, e.g., "b" and "c". Finally, by the seventy-sixth

Fig. 1. Cumulative records show multiple-to-chained transition (Phase I). Pen resets after completion of all FR 100 and FR 10 components. An asterisk denotes an FR 10 component in which responses were reinforced.
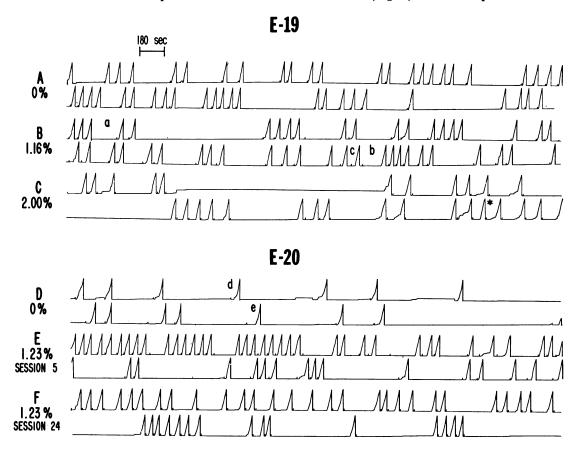
session of 0% reinforcement long pauses developed within and before the FR 10 component as shown in the third record (C) for E-17 in Fig. 1. In most cases the chained pattern can be seen, but there are several instances (see letters "d" and "e") where the pre-FR 100 pause still exceeded the pre-FR 10 pause.

The bottom half of Fig. 1 contains similar transitional data for the other animal in Phase I, E-18. However, the middle cumulative record (E) of this series indicates a somewhat different type of transition than that observed for E-17. During the seventh session at 1.30% reinforcement, the chained pattern can be seen in the early part of the session, but the multiple pattern predominates in the latter part of the session. Although the causes for this are not certain, this peculiar pattern may, in part, be attributable to a programming pecularity for that bird. That is, responses in the FR 10

component were seldom reinforced during the early part of E-18's session. By the twenty-seventh session (record F, Fig. 1) at 1.30% reinforcement the chained pattern occurred throughout most of the session, and pausing within the FR 10 component can be seen, *e.g.*, at "f" and "g".

In Fig. 2 the transition from chained to multiple pattern is illustrated in the cumulative records of E-19 and E-20. At the beginning of Phase II, responses in the FR 10 component had never been reinforced for these birds. The chained pattern which results from this procedure is shown in record A for E-19 and record D for E-20 (Fig. 2). Long pauses before as well as within the FR 10 component are evident in both records. Occasionally, a pre-FR 100 pause can be seen, especially in record D (see "d" and "e").

Record B (Fig. 2) for E-19 represents an in-

Fig. 2. Cumulative records show chained-to-multiple transition (Phase II). Pen resets after completion of all FR 100 and FR 10 components. An asterisk denotes an FR 10 reinforcement component.

termediate transitional stage and contains examples of chained ("a"), and multiple type patterns ("b"). In some cases the pre-FR 10 pause about equals the pre-FR 100 pause as at "c". A similar kind of performance is presented in record E for E-20. For both E-19 and E-20 pauses within the FR 10 component had almost disappeared at this point when compared to their performances in records A and D. Furthermore, when the percentage of reinforcement for the FR 10 component was increased to 2.00% for E-19 (record C, Fig. 2), the pre-FR 100 pause became longer than the pre-FR 10 pause in almost every instance (multiple pattern). The same sort of performance for E-20 can be seen in record F, Fig. 2. (Note that although E-20 received supplemental food, its performance was quite similar to that of E-19.)
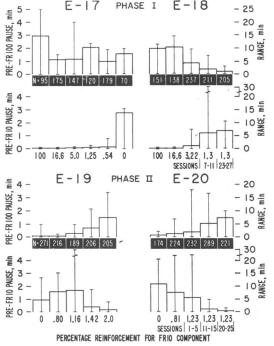

Fig. 3. Bar graph shows changes in the mean pre-FR 10 and pre-FR 100 pauses during the last five sessions unless otherwise indicated. The number of observations on which each mean is based and the range are also indicated.

A more detailed account of the two types of transitions is presented in the bar graph data of Fig. 3. Changes in both the pre-FR 10 and pre-FR 100 pauses are illustrated for all four birds. In each instance data from the last five

sessions at a particular reinforcement frequency were pooled and the mean was calculated. The ranges for this same terminal period accompany each mean as do the total number of both types of components which were completed. The actual reinforcement percentages shown in Fig. 3 were selected to represent major stages of the transitions.

The mean pre-FR 100 and pre-FR 10 pauses were inversely related, as suggested by the cumulative records, although not in a monotonic fashion. As the pre-FR 10 pause increased for E-17 and E-18 (decreased for E-19 and E-20) the pre-FR 100 pause shortened for these two birds (increased for E-19 and E-20). Also, the variability of either type of pause, as given by the range, appeared to increase as the absolute mean length of that pause increased.

It is important to recognize, however, that the number of FR 100 and FR 10 components completed within a 2-hr session could influence the values and variability of either the pre-FR 10 or pre-FR 100 pauses to a different degree at various points in the transition. For example, in the schedule where responses in all FR 10 components were reinforced, the pre-FR 10 pause was very short and invariant regardless of the number of FR 100 and FR 10 components the animal completed. In contrast, the pre-FR 100 pause was long and variable, and its value was largely dependent upon the number of completed components. If, for example, the animal worked through each component only twice in a 2-hr session, the mean pre-FR 10 pause would be about 1 to 2 sec, when responses in all FR 10 components were reinforced. However, the mean pre-FR 100 pause would be some value close to 60 min. If three of each type of component were completed, the mean pre-FR 100 pause would be approximately 40 min (120 min/3), excluding the actual time required to meet the component requirements, but the pre-FR 10 pause would be affected very little, if any. Thus, as the percentage of reinforcement for the FR 10 component was decreased, producing an increase in the pre-FR 10 pause and a decrease in the pre-FR 100 pause, the variable, number of components completed, began to have less effect on the pre-FR 100 pause and more effect on the pre-FR 10 pause. Finally, when the chained pattern was established, number of completed components primarily affected the pre-FR 10 pause.

In spite of the complications introduced when the animal was allowed to complete a varying number of components from session to session, the results in Fig. 3 suggest that changes in reinforcement percentage for the FR 10 component produced orderly shifts in the two types of pauses, eventually ending in the reversal of the two pause lengths.

Two exceptions can be found in the data for E-17 and E-19. As the reinforcement percentage was reduced for E-17 (see Fig. 3) the mean pre-FR 100 pause showed fluctuations consistent with the number of components the animal completed. However, although E-17 completed only 70 FR 10 and 70 FR 100 components during the last five sessions at 0% reinforcement, the mean pre-FR 10 pause increased considerably above the mean pre-FR 100 pause, as the cumulative record in Fig. 1 indicates. In the data for E-19, the mean pre-FR 10 pause increased before it started to decrease at 1.42%. Again this seemed to be correlated with a decrease in the number of components completed at the point in the transition where the pre-FR 10 pause was particularly sensitive to this variable.

The most striking observation based on the data in Fig. 3 is that the transitions occurred at very low reinforcement percentages. Furthermore, the direction of the transition seems critical. In order to transform the multiple pattern into the chained pattern (E-17, E-18) it was necessary to reduce the reinforcement percentage from 100% to a value below 3%. The transition from chained to multiple pattern (E-19, E-20), however, required only a slight increase in reinforcement percentage above the 0% baseline condition.

After the initial transition had been accomplished for all birds in Phases I and II, the percentage of reinforcement for the FR 10 component was increased for E-17 and E-18 (Phase I) and decreased for E-19 and E-20 (Phase II). The ultimate effect of reversing the direction of change in percentage reinforcement can be seen in Fig. 4. In all cases it was possible to restore the original performance, *i.e.*, multiple pattern for Phase I birds and chained pattern for Phase II birds.
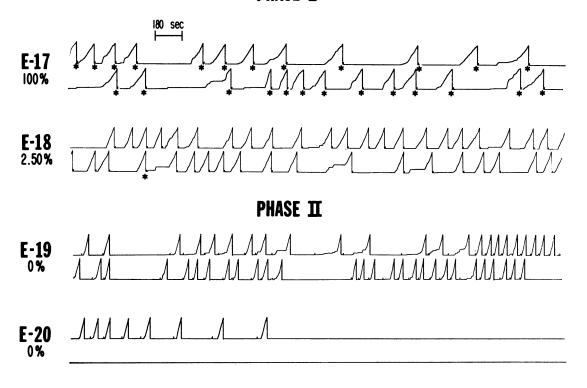
The number of responses on the water key did not appear consistently to reflect changes in reinforcement percentage for any of the four birds. However, as might be expected, the distribution of these responses throughout the session was affected by the transition. For example, in the multiple pattern, at 100% reinforcement of the FR 10 component, water responses occurred predominantly before and occasionally within the FR 100 component, but never before or within the FR 10 component. As the pre-FR 10 pause increased, the proportion of water responses during the two types of pauses gradually shifted. Eventually, when the chained pattern had been established, almost all water responses occurred before or within the FR 10 component; few, if any, such responses occurred during or before the FR 100 component.

DISCUSSION

These findings indicate that the pre-FR 10 and pre-FR 100 pause durations could be controlled by varying the percentage of FR 10 components which terminated in food reinforcement. As this reinforcement percentage was decreased the pre-FR 10 pause increased and the pre-FR 100 pause decreased (Phase I, multiple-to-chained). Increasing the percentage of FR 10 components containing reinforcement had the reverse effect (Phase II, chained-to-multiple). The close resemblance between the chained patterns in Phases I and II and the multiple patterns in Phases I and II indicates that the direction of the transition is a negligible factor in establishing one pattern or the other. That the multiple and chained patterns were completely interchangeable was further confirmed when the initial patterns were finally reinstated.

The percentage of reinforcement at which a transition occurred varied among the four birds, especially E-17 and E-18. In view of the differences between animals in terms of their histories, the variable number of reinforcements obtained per session, and the relatively long period of time over which the independent variable was acting, these discrepancies are not so surprising. However, the data clearly indicate that the increment in percentage of reinforcement necessary to effect the transition from chained to multiple pattern was much smaller than the reduction in this variable required for the multiple-to-chained transition. If the procedures of gradually reinforcing responses in a greater percentage (Phase II) or lesser percentage (Phase I) of FR 10 components are analogous to the proce-

124   E. K. CROSSMAN

PHASE I

PHASE II

Fig. 4. Cumulative records illustrate recovery of the original multiple (E-17, E-18) and chained (E-19, E-20) response patterns. Pen resets after completion of all FR 100 and FR 10 components. An asterisk denotes an FR 10 reinforcement component.

dures of conditioning and extinction, respectively, these findings substantiate a large body of data which show that conditioning proceeds at a faster rate than extinction.

Considering latency as a measure of rate, the divergence in the pre-FR 10 and pre-FR 100 pause durations in Phases I and II represents an example of "behavioral contrast" (Reynolds, 1961). Using a different procedure than the present one, Schuster (1959) reported a similar contrast in precomponent pausing on a multiple FR schedule. When a *mult* FR 20 FR 20 schedule was changed to *mult* FR 40 FR 20, Schuster found that the pre-FR 20 pause decreased, while the pre-FR 40 pause increased. In a mixed (mix) FR schedule, which is identical to the multiple schedule except that the same stimulus is presented during all components, Keehn (1963) reported a related finding. Rats were trained on a *mix*

FR 11 FR 22 schedule. When the schedule was changed to *mix* FR 5 FR 28 the pre-FR 5 pause decreased below the pre-FR 11 pause, and the pre-FR 28 pause increased above the pre-FR 22 pause. Although similar, these results are not strictly comparable with Schuster's data, since Keehn measured the pre-FR pause from the end of the reinforcement cycle until the second, rather than the first, response on the FR. Nevertheless, the current results and preceding data on multiple and mixed schedules imply that, in terms of producing a contrast in precomponent latencies, varying the size of an FR component is equivalent to varying the percentage of reinforcement for responses in that component.

On paper, the multiple and chained patterns appear to be the converse of one another. Rather than emphasizing this polarity, however, these particular schedules should be ana-

lyzed in the context of other related schedules. In doing so, a better idea can be gained of possible stimuli which control the location and magnitude of pausing.

Consider a sequence of 110 responses as a basic unit of analysis. In this sequence, a stimulus change (chained schedule) or a stimulus change plus reinforcement (multiple schedule) can be interpolated. If the sequence contains no stimulus change but is terminated by reinforcement, a simple FR 110 schedule is defined. Typically, response rate on a large FR schedule is positively accelerated: the animal tends to pause irregularly after the first few responses and then reaches a rate which is sustained up until reinforcement (Thomas, 1964). The finer details of this pattern are probably determined by deprivation, history, *etc.*

If, in recording this behavior, the recorder pen is reset to baseline after the tenth response and the one hundred and tenth response, this record resembles the chained pattern. The longest pause would precede the first response. Also, an occasional pause between the tenth and the eleventh response would probably be evident. However, if a green light is present for the first 10 responses and a red light during the remaining 100 responses, a *chain* FR 10 FR 100 schedule is defined. Pausing before the tenth response and between the tenth and eleventh response should be more prominent in the chain than in the FR 110 schedule (Thomas, 1964).

Since the second stimulus in a two-component chain is paired with unconditioned reinforcement, it would seem that this stimulus would be a conditioned reinforcer. Accordingly, responses in the first component of the chain should be at a faster rate than the first 10 responses in the FR 110 schedule which contains no such explicit conditioned reinforcing stimulus. However, this does not appear to be the case. Studies which have compared these two types of schedules find that relatively lower response rates are recorded during the early components of a chain (*cf.* Gollub, 1958; Kelleher and Fry, 1962). This can be interpreted to mean that the aversive characteristics of the early stimuli in a chain, owing to their lack of correlation with reinforcement, are more powerful than any conditioned reinforcement resulting from the appearance of the final stimulus in the chain which is consistently present at the time of unconditioned reinforcement. The implication is that in terms of maintaining FR behavior, it is better to present no exteroceptive stimulus at all than one correlated with a low or zero rate of reinforcement.

When, in the sequence of 110 responses, the key not only changed from green to red after the tenth response, as in the chained schedule, but unconditioned reinforcement also occurred at this point, as in the multiple schedule, then the pause between the tenth and eleventh response was much larger than the pre-FR 100 pause in the chain. In other words, even though the absolute rate of reinforcement in the red stimulus was the same in the chained and multiple schedule, the presence of another component with a rate of reinforcement 10 times that in the FR 100 component makes the red stimulus even more aversive in the multiple schedule.

Primarily, this accounts for the differences in pre-FR 100 pausing, but the same kind of analysis can also be applied to the stimuli which determine the pre-FR 10 pause. If the response rate during the simple FR 110 schedule is positively accelerated, then the pause between the one hundreth and one hundred and first response would be fairly short, but the pre-FR 110 pause would, of course, be long. A cumulative record of this performance, in which the pen reset after 100 responses and then after the one hundred and tenth response, would give the appearance of a multiple pattern. In fact, the pre-FR 10 pause time would be expected to be rather short since the stimulus conditions, although unspecified, which are present at this point in the FR 110 schedule are associated with both a high absolute and relative rate of reinforcement. If the stimulus conditions are made explicit by changing the key from red to green (*chain* FR 100 FR 10 schedule), then the pre-FR 10 pause should be even shorter yet. However, if both reinforcement and a stimulus change occur after the one hundredth response (*mult* FR 100 FR 10 schedule) the pre-FR 10 pause would be expected to be longer than in the FR 110 or *chain* FR 100 FR 10 schedule. This follows from the fact that the green stimulus, while correlated with an absolutely high rate of reinforcement, represents a lower relative reinforcement rate than the green stimulus in the *chain* FR 100 FR 10 schedule, or the unspecified stimulus condi-

tions which prevail after the one hundredth response in the FR 110 schedule. In all three schedules, the pre-FR 100 pause would clearly exceed the pre-FR 10 pause.

Therefore, this analysis suggests that the precomponent latency in a two-component multiple or chained schedule is primarily a function of the relative rate of reinforcement associated with that component. It also seems likely, however, that absolute reinforcement rate might be a factor in controlling pause length. For example, based upon the relationship between the size of a simple FR schedule and the pause length preceding the FR schedule, the pre-FR 10 pause in a *mult* FR 100 FR 10 schedule might be expected to be shorter than the pre-FR 50 pause in a *mult* FR 500 FR 50 schedule, even though the relative reinforcement rates for the FR 10 and FR 50 components would be the same (Felton and Lyon, 1966).

Although the present evidence supports the interpretation that rate of reinforcement is closely linked with pausing in the FR schedules, more information is needed about the basic properties of a simple FR schedule. When the value of an FR schedule is either increased or decreased, not only is reinforcement rate changed but so is the total number of responses required to produce reinforcement. The relevance of these two factors, and perhaps others, depends upon an experimental program which can isolate the contribution of each in the control of pause length and location. In any event, latency promises to be an important dependent variable where FR schedules are concerned.

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