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MULTIPLE BASELINE INVESTIGATION OF STIMULUS FUNCTIONS IN AN FR CHAINED SCHEDULE[1,2]

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The performance of pigeons was studied on a multiple schedule in which a three-member FR chained schedule alternated with a three-member FR tandem schedule. The chain and tandem schedules contained identical response requirements. In the chained schedule, more pausing and lower response rates occurred in the first and second components than occurred in the tandem control, in which the same exteroceptive stimulus was associated with all components. Because the reinforcement and response contingencies were identical in the chain and tandem schedules, differences in performances can be attributed to stimulus control.

In a fixed-ratio chained schedule, the *n*th response in the presence of one exteroceptive stimulus produces a second exteroceptive stimulus; the *n*th response in the presence of the second stimulus produces a third stimulus, and so forth. A primary reinforcement usually terminates the chain. Two stimulus functions (Skinner, 1938) which have importance in such a chain have been indicated by Kelleher and Fry (1962): (1) A specific rate and pattern of responding in one component may be reinforced and maintained by the production of the stimulus associated with the following component; (2) Stimuli in a chain also serve to be discriminative stimuli controlling a given rate and pattern of responding in their presence.

Because an FR tandem schedule and an FR chained schedule can have identical response requirements, the tandem schedule may be used as a control procedure for stimulus functions in the chained schedule (Kelleher and Gollub, 1962). In both schedules, reinforcement is programmed by the same succession of components, and proximity of any component to the terminal reinforcement is the same. Differences in response rates among the components of chain and tandem schedules reflect the specific exteroceptive stimulus control of behavior. This paper presents a multiple (chain FR)(tandem FR)baseline and indicates that the differences between chain and tandem schedules are present in this multiple procedure. Previous use of the tandem schedule as a control procedure has involved the investigation of the tandem schedule for a given period of time and then a switch to a chained schedule and observation of the changes in behavior (Kelleher and Gollub, 1962). This previous procedure does not control for drifts in performance over time under either one of the two conditions, or for any events which might accidentally be correlated with changes in the program. The multiple chain-tandem procedure allows for the measurement of the effects of stimulus control in the chain and tandem schedules within a single session. A disadvantage of the multiple procedure is that it introduces possible unwanted interactions between the components. Such interactions, however, may be explicitly studied.

METHOD

Subjects

Five adult White Carneaux pigeons were maintained at about 80% of their free-feeding weight. They had an extended history on various reinforcement schedules.

Apparatus

The experimental space for subjects T-16 and T-17 was a Foringer pigeon chamber, con-

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taining a single response key. The key could be illuminated by any of several different colored 115 v ac, 7-w key lights located behind it. The chamber was illuminated during the sessions by two 125 v ac, 6-w houselights on the wall opposite the key. For subjects T-4, T-7, and T-9, the experimental space was a picnic icebox similar in design to that described by Ferster and Skinner (1957). The icebox contained a single response key and a single 115 v ac, 7-w houselight located on the top left of the front wall above the response key. In both chambers the key light and the houselight went off simultaneously with the operation and illumination of the food magazine. Standard programming and recording equipment were used.

Procedure

Each session was preceded by a "blackout" condition. A session ended with a reinstatement of the blackout after 40 reinforcements. Each reinforcement consisted of a 4-sec access to grain. In the first part of this study, subjects T-16 and T-17 obtained a reinforcement upon the completion of an FR 60. This FR requirement was programmed under two different conditions. In one condition the response requirement was broken into three blocks of 20 responses, each block having its own exteroceptive stimulus. Responses 1 to 20 occurred in the presence of a red key light, and the 20th response produced a white key light. Responses 21 to 40 occurred in the presence of the white key light, and the 40th response produced a blue key light. The 41st to 60th responses were emitted in the presence of the blue key light, with the 60th response producing the food reinforcement. This is a *chain* FR 20 FR 20 FR 20 (Ferster and Skinner, 1957; Kelleher and Gollub, 1962).

The second condition also consisted of three component blocks of 20 responses, and changes from one component to the next were again contingent on every 20th response; however, the same exteroceptive stimulus (a yellow key light) appeared in all components. Each component followed the other in succession or tandem without correlated stimuli. This is a *tand* FR 20 FR 20 FR 20 (Ferster and Skinner, 1957; Kelleher and Gollub, 1962), although it may be viewed as a simple FR 60.

During a single experimental session, the chain schedule and the tandem schedule alternated unsystematically. This schedule of reinforcement is referred to as a *mult* (*chain*) (*tand*). Sessions were continued until stable behavioral performances were established. Following the above sessions, subject T-17's response requirement was increased from 20 responses in each component to 60 responses in each component. The schedule became a

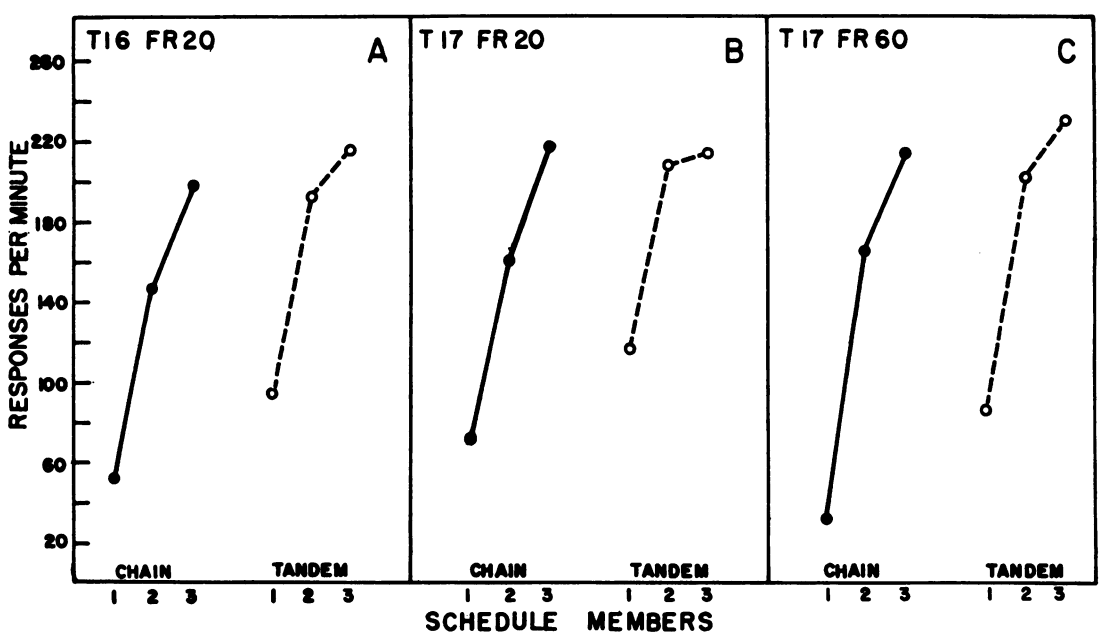

Fig. 1. T-16's and T-17's response rates in each of the components of the chain and tandem conditions.

mult (*chain* FR 60 FR 60 FR 60) (*tand* FR 60 FR 60 FR 60).

Subjects T-4, T-7, and T-9, also performed on the same general *mult* (*chain* FR) (*tand* FR) schedule. For T-4, the schedule components were FR 40 and then FR 60. T-7 responded on schedule components of FR 60 and FR 80. T-9 responded on schedule components of FR 40 and then FR 80.

RESULTS AND DISCUSSION

Rate of responding (responses per minute) for T-16 and T-17, in each of the components of the chain and tandem schedules, is presented in Fig. 1, A and B. Response rates in each of the chain components are connected by a solid line, and rates in the three tandem components are connected by a dotted line. With both T-16 and T-17, response rates in the first chain component were markedly lower than rates in the first tandem component. Long pauses often occurred in the first chain component. The second chain component also had a lower response rate than that of its tandem control, and brief pauses sometimes occurred at the start of the second chain component. There was little difference in response rates in the terminal components of the two schedules. Cumulative response records for T-17 can be seen in the top half of Fig. 2. Those excursions of the recording pen which contain pips and in which the bottom pen is up indicate chain schedules. The pips indicate the completion of each FR 20 component and the pen resets each time reinforcement occurs. The excursions without pips and with the bottom pen down are tandem schedules. The cumulative records show the lower response rates in the earlier components of the chain.

Response rates in the chain and tandem schedules for T-17 with the increased response requirement of FR 60 in each of the three components is shown in Fig. 1, C. There was a larger rate difference for this *S* between comparable first chain and tandem components than occurred with the lower response requirement. Longer pauses before responding begins occurred in the first chain component. Cumulative response records for T-17 with FR 60 as the schedule component may be seen in the bottom half of Fig. 2. Response rates in

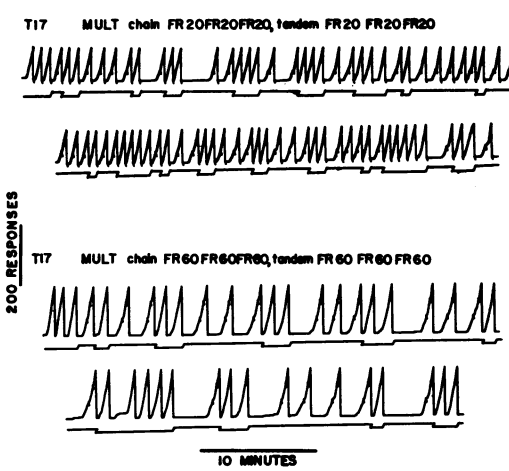

Fig. 2. (Top) Cumulative response records of T-17 for chain and tandem performance with FR 20 in each component. (Bottom) T-17's cumulative records of performances with FR 60 in each component.

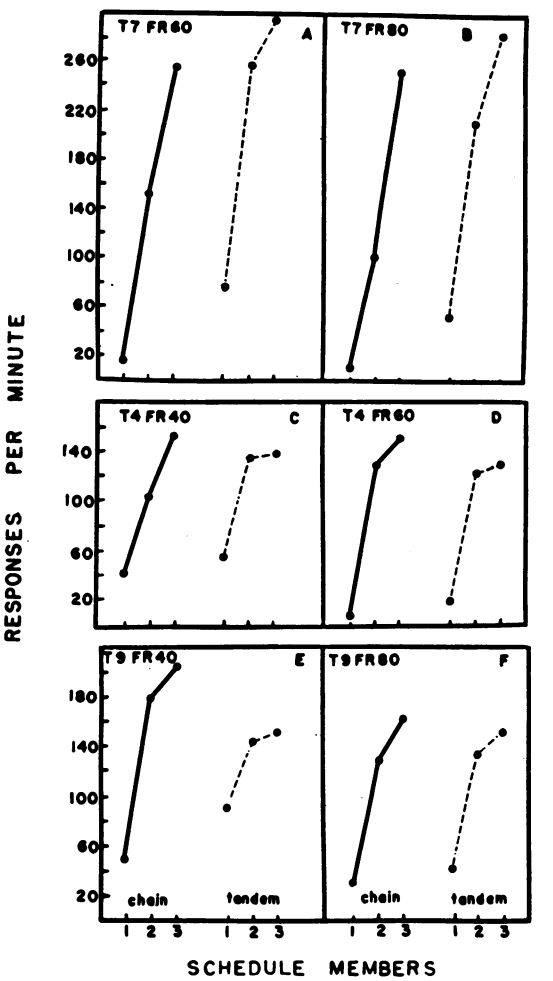

Fig. 3. Response rates in each of the components of the chain and tandem schedules for subjects T-4, T-7, and T-9.

the second and final chain components were also lower than that of their comparable tandem components.

Rate of responding for T-4, T-7, and T-9, with the first response requirement of each component in the chain and tandem schedules is presented in Fig. 3, A, C, and E. The figure shows that response rates in the first chain components were lower than rates in the first tandem components. The second chain components of T-4 and T-7 had lower rates than that of their comparable second tandem components. Increasing the response requirement produced lower response rates in both chain and tandem schedules but did not produce larger rate differences between comparable first chain and tandem components than occurred under lower response requirements. Figure 3, B, D, and F shows the response rates of these three *Ss* with the increased response requirements. Cumulative response records for T-7 with response requirements of FR 60 and FR 80 in each component are presented below in Fig. 4. Pen excursions in which the bottom pen is up indicate the chain schedules.

It should be noted that in both the chain and tandem schedules the first components have low response rates, the middle components have a higher rate, and the third components have the highest response rates. This suggests that a simple fixed-ratio is not run off at a constant terminal rate once responding has begun, but rather, involves an increasing rate throughout the ratio.

Although previous studies of FR chained schedules have not presented comparisons of component performances with tandem controls, the present results are in agreement with their general findings. Ferster and Skinner (1957) and Findley (1962) have reported substantial pausing during the first component and brief pauses at the start of other components in FR chained schedules. These authors also reported increased rates in the terminal FR chain component. Findley (1962) reported increased pausing and ratio strain with an increase in the FR requirement in each chain component. On large FR schedules of token reinforcement, in which chimpanzees had to obtain several tokens before exchanging them for food, prolonged pauses occurred during the period in which the first several tokens were being obtained (Kelleher, 1958). In all of these experiments, long pauses occurred in the presence of exteroceptive stimuli associated with initial components of chained FR schedules. Simple fixed-ratios of comparable response requirements do not produce such pausing.

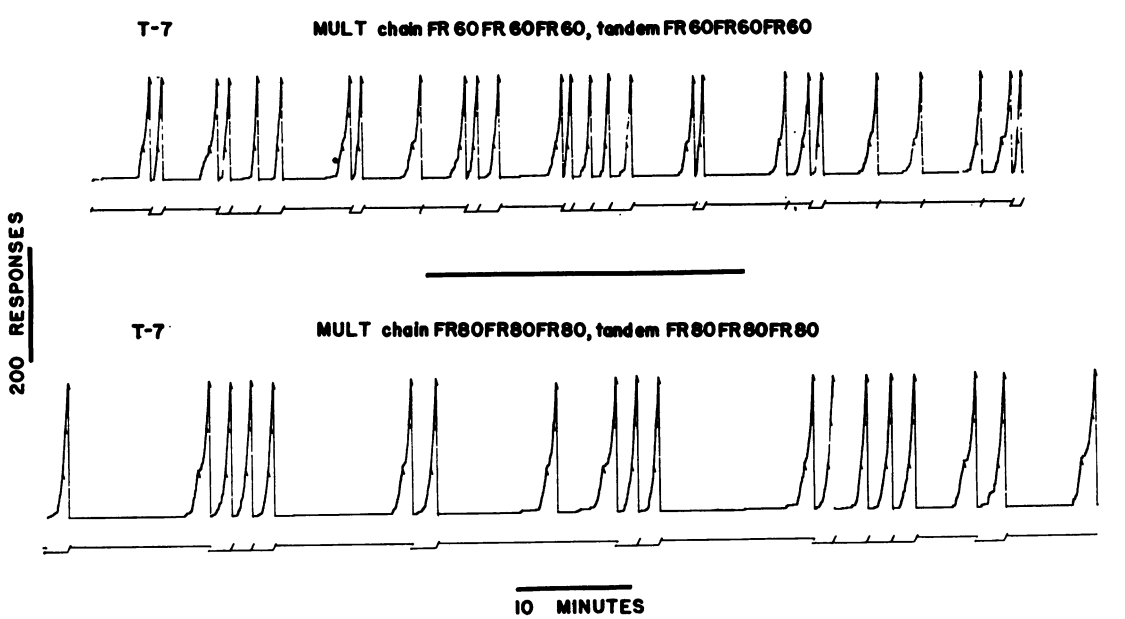

Fig. 4. (Top) Cumulative records of T-7's chain and tandem performance with FR 60 in each component. (Bottom) Cumulative records of performance with FR 80 in each component.

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