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AVOIDANCE OF A RETURN TO THE FIRST COMPONENT OF A CHAIN FROM THE TERMINAL COMPONENT[1]

JOHN R. THOMAS

INSTITUTE FOR BEHAVIORAL RESEARCH

Three pigeons were trained on a chained fixed interval-fixed ratio schedule. Avoidance behavior which postponed a return to the first chain component from the second component was maintained on a second response key concurrently with the second component. When the fixed interval length was increased, avoidance rates first increased and then decreased as a function of fixed interval length. As the fixed ratio requirement was increased for one subject, avoidance rates first declined and then increased at larger fixed ratio values. Avoidance behavior maintained by postponing the first chain component was similar to avoidance behavior maintained by postponing a time out period.

Behavior in the initial component of a chained schedule comes under the control of exteroceptive stimuli which have an unfavorable position in the overall reinforcement contingency. Behavior in the terminal component of a two-component chain is reinforced with primary reinforcement, while behavior in the first component is not. Findley (1962) demonstrated that pigeons performing on a chained fixed interval (FI) fixed ratio (FR) schedule would avoid a return to the FI from the FR component. In Findley's procedure, an avoidance contingency, during which a return to the FI could be avoided, was programmed concurrently with the FR on the same response mechanism. The behavior had many characteristics of concurrent FR shock avoidance behavior when both schedules are programmed on the same response apparatus (Kelleher and Cook, 1959) in that interresponse times immediately following reinforcement on the FR schedule could be changed as a function of the avoidance contingency.

The present study investigated maintenance of an independent avoidance response which postponed a return to the first component of a two-component chain. The avoidance contingency was programmed concurrently with the second chain component on a separate response key.

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METHOD

Subjects

Three adult male homing pigeons (21, 22, and 23) were maintained at approximately 80% of free feeding weight.

Apparatus

The experimental space was a Lehigh Valley Electronics pigeon chamber containing two response keys. Programming was accomplished automatically by a system of switching relays and timers. Data were recorded on magnetic impulse counters and cumulative recorders.

Procedure

Experimental sessions were run daily, five days a week. Each session lasted for 50 reinforcements or 2½ hr, whichever occurred first. Food reinforcement was a 4-sec presentation of grain. The key lights and the house light went off simultaneously with the operation of the food magazine and illumination of the food.

The subjects first performed on a *chain* FI 3 FR 50 on the right response key; that is the first response in the FI component after 3 min produced the FR component and the 50th response in the FR component produced food reinforcement. A green key light indicated the FI and a red key light the FR. After 26 sessions on the chained schedule, subjects were placed on the avoidance schedule. Concurrently with the FR component, the left response key was

illuminated with a yellow key light and an avoidance schedule was in effect on the left key. Responding in the FI component produced the concurrent FR avoidance schedules. The FR component now lasted for 30 sec. The avoidance schedule was such that if no response occurred on the left avoidance key during the 30-sec interval, the FI was reinstated. Each response on the avoidance key during the FR component postponed the return to the FI for 30 sec. The 30-sec interval was timed continuously during the FR component except during the 4-sec reinforcement presentations. A 3-sec delay interval was always programmed between a response on the avoidance key and the possibility of a reinforcement on the FR key.

The avoidance schedule was initially a discriminated avoidance schedule. During the last 10 sec of the 30-sec interval the FR key was illuminated with a white key light as well as the red key light. An avoidance response during the last 10 sec of the interval terminated the white key light and postponed the FI. After behavior was established on the avoidance key, the white key light was removed by gradually reducing its intensity over 10 sessions. The white key light was eventually removed from the program, which converted the avoidance schedule to a nondiscriminated avoidance schedule.

The FR requirement was then reduced to FR 40 and the above procedure was maintained for 32 sessions. The avoidance contingency was removed from the program for 11 sessions and then reinstated. The avoidance contingency was removed in a different manner than it is from shock avoidance schedule. The usual procedure is to omit scheduled shocks; the analogous procedure would be to leave the FR component in effect throughout each session. The present procedure is analogous to delivering shocks independently of responses at a frequency determined by the interval between shocks. The effect of FI length on avoidance behavior was systematically investigated. Subjects 21 and 22 were exposed to FIs of 0.5, 3, 5, 7, and 15 min. Subject 23 was exposed to FIs of 0.5, 3, 7, 15, and 25 min. The different FI lengths were investigated in a random order. The size of the FR was then manipulated for subject 23. The FI was maintained at 3 min and subject 23 was exposed to FRs, in order of exposure, of 40, 60, 80, 100, and 120 responses. During all of the above manipulations, each avoidance response postponed a return to the FI for 30 sec.

RESULTS

The discriminated avoidance behavior was established and maintained with all three subjects. Although FI and FR response rates varied somewhat, the avoidance behavior of all subjects occurred at about 3 responses per min. This is not really a rate measure, but actually represents good stimulus control over occurrence of behavior in the presence of the avoidance stimulus. Subject 21 had a mean avoidance rate with the nondiscriminated procedure of 1.8 responses per min, subject 22 of 3.1, and subject 23 of 3.2. The avoidance responses were restricted almost entirely to the pre-ratio pause of the FR. Once responding started on the FR key, responses seldom occurred on the avoidance key. A return to the FI usually occurred only after one or more reinforcements in the FR. When the avoidance contingency was removed, responding on the avoidance key dropped to zero in two sessions

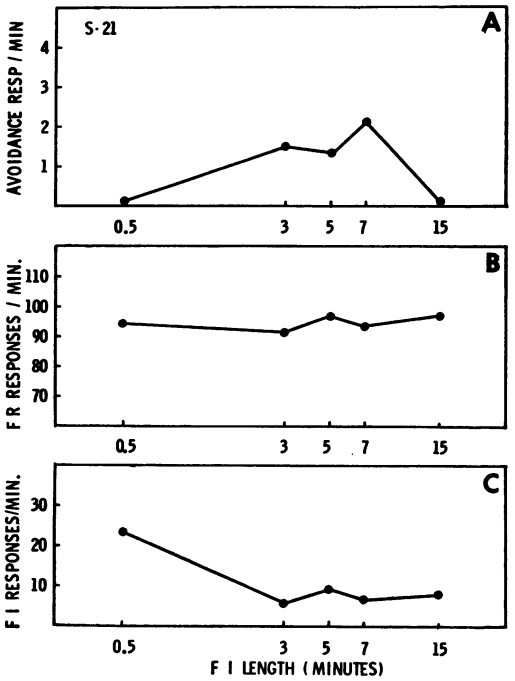

Fig. 1. (A) Avoidance responses per minute as a function of FI length for subject 21. (B) FR responses per minute as a function of FI length for subject 21. (C) FI responses per minute as a function of FI length for subject 21.

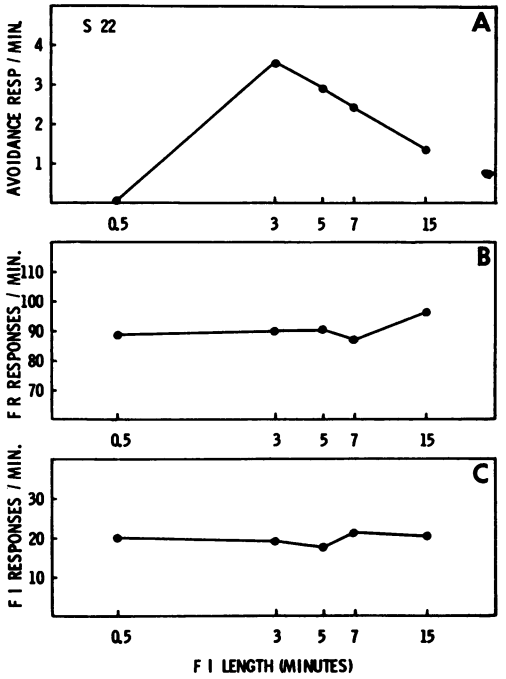

Fig. 2. (A) Avoidance responses per minute as a function of FI length for subject 22. (B) FR responses per minute as a function of FI length for subject 22. (C) FI responses per minute as a function of FI length for subject 22.

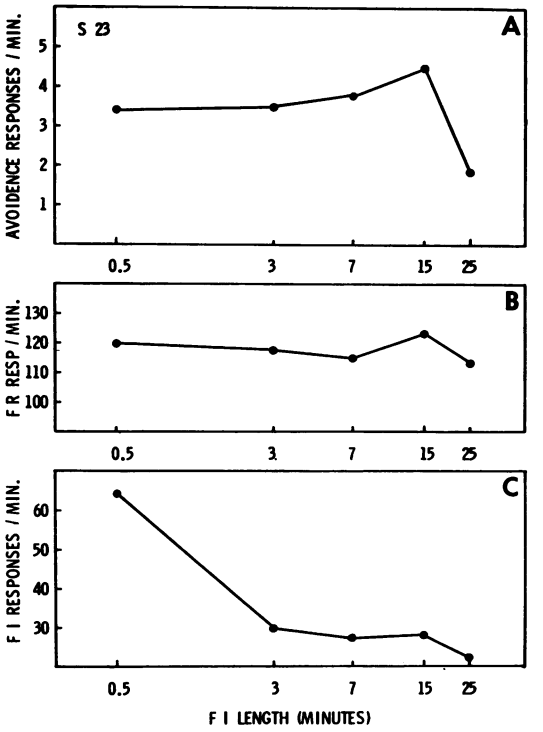

Fig. 3. (A) Avoidance responses per minute as a function of FI length for subject 23. (B) FR responses per minute as a function of FI length for subject 23. (C) FI responses per minute as a function of FI lengths for subject 23.

for subjects 21 and 22 and in six sessions for subject 23.

The effects of the FI length on avoidance performance of all subjects are shown in Fig. 1A, 2A, and 3A. For all subjects the avoidance rate first increased and then decreased as a function of FI length. The maximum avoidance rate occurred at different FI lengths for different subjects. Cumulative response records of subjects 21 and 23 at several FI lengths are presented in Fig. 4 and 5. The FR response rates remained fairly constant across the FI lengths for all subjects and showed no systematic relationship to FI length (Fig. 1B, 2B, and 3B). The FI rate of subject 21 declined from FI 0.5 to FI 3 and then remained relatively stable for the other FI lengths (Fig. 1C). The FI response rate of subject 22 was not systematically affected by changes in the FI length (Fig. 2C); the FI rate of subject 23 generally declined as the FI length was increased (Fig. 3C). Figure 6 shows the relationship of rate of avoidance responding to the overall frequency of reinforcement for the three subjects. Avoidance rates first increased as reinforcement frequency declined; with still further decreases in the overall reinforcement frequency, avoidance rates declined.

Figure 7A shows the effects of increasing the FR value on the avoidance rate of subject 23. Up to FR 80, avoidance rates declined. At the two larger ratios, avoidance rates increased. Cumulative records of performances of subject 23 for several different FR values are presented in Fig. 8. Often at FR 100 and FR 120 there was a return to the FI component before the ratio requirement was completed. At the two larger ratios, ratio responses occasionally did not occur during the 30-sec FR component. With the increase in avoidance rates at the larger FR values, both FI and FR performances decreased (Fig. 7B and C). Figure 9 presents the changes in frequency of reinforcement as the FR requirement was increased from 40 to 120. The solid line represents reinforcement frequency in the FR component; the dotted line represents the overall reinforcement frequency. The most marked decrease in reinforcement frequency in the FR component occurred as the requirement was

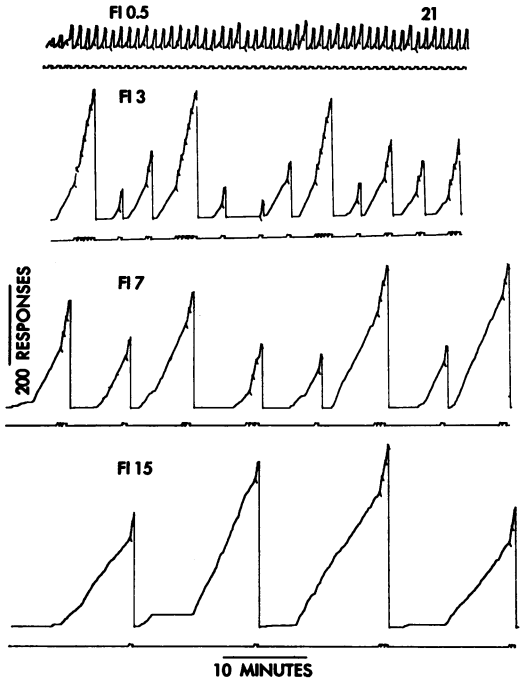

Fig. 4. Cumulative response records of chain performance of subject 21 at several FI lengths. The event pen is down during the FI component and up during the FR 40 component. The first pip in the excursion of the recording pen indicates the change from the FI component to the FR 40 component. Each pip of the recording pen during the FR component indicates a food reinforcement. Downward deflections of the event pen during the FR component indicate avoidance responses. The recording pen resets to the baseline when the FI component is reinstated.

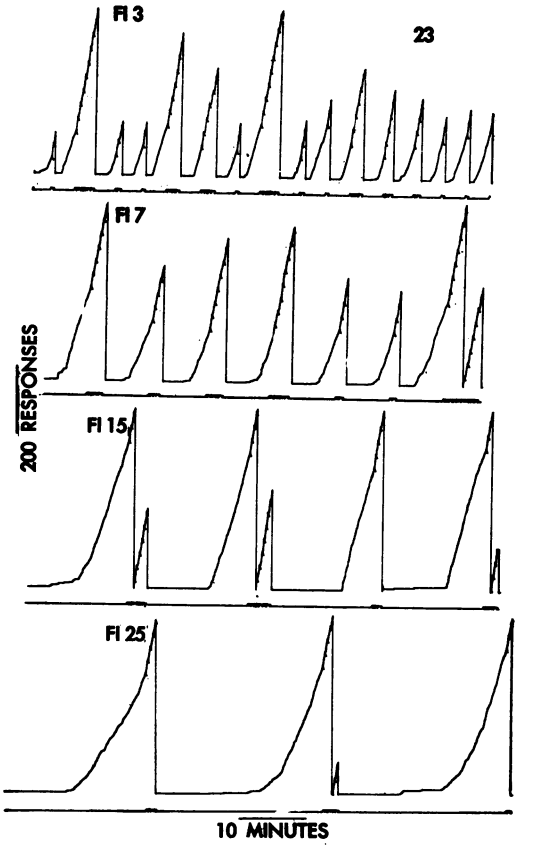

Fig. 5. Cumulative response records of chain performances of subject 23 at several FI lengths. The event pen is down during the FI component and up during the FR 40 component. The first pip in the excursion of the recording pen indicates the change from the FI component to the FR 40 component. Each pip of the recording pen during the FR component indicates a food reinforcement. Downward deflections of the event pen during the FR component indicate avoidance responses. The recording pen resets to the baseline when the FI component is reinstated.

increased from FR 80 to FR 100. Most of the avoidance behavior at the two larger FR values consisted of longer response bursts which occurred during the pre-ratio pause and into the ratio run. Cumulative records of avoidance performances of subject 23 at two FR values are shown in Fig. 10. By comparing, the two avoidance response records in Fig. 10, it may be seen that as the FR requirement was increased, performance changed from relatively constant avoidance responses to performance in which avoidance responses occurred in negatively accelerated runs, usually ending in a series of FI component occurrences.

DISCUSSION

Behavior was established and maintained which postponed a return to the first component of a two-component chain. As FI length was increased, avoidance response rate first increased and then decreased as a function of FI length. The increase in avoidance behavior followed by a decline as a function of FI length is similar to the effects of increases of

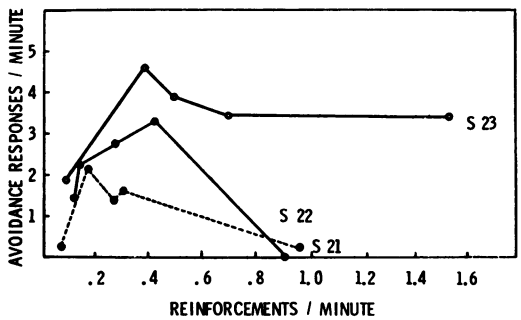

Fig. 6. Avoidance responses per minute as a function of overall reinforcement frequency (reinforcements per minute) for three subjects.

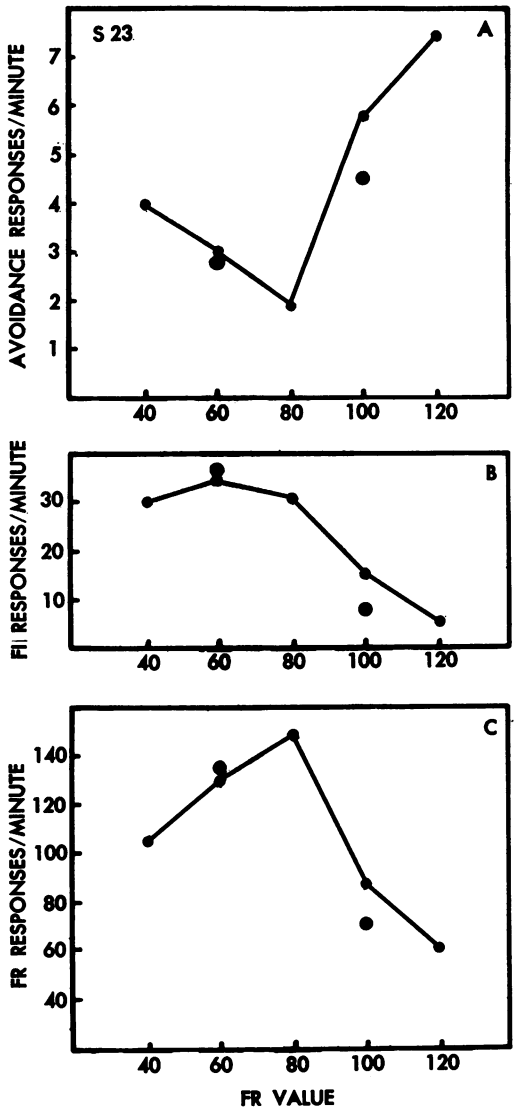

Fig. 7. (A) Avoidance responses per minute as a function of FR requirement for subject 23. (B) FI responses per minute as a function of FR requirement for subject 23. (C) FR responses per minute as a function of FR requirement for subject 23. Isolated points indicate second determinations obtained after exposure to all five FR requirements.

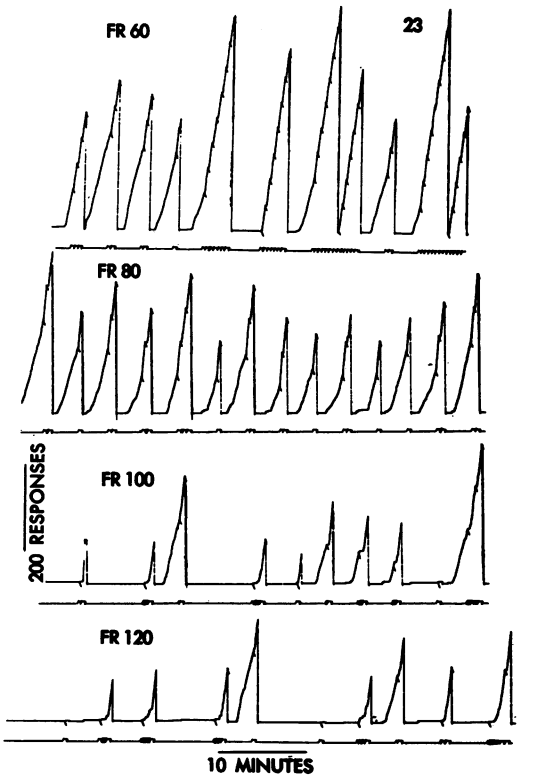

Fig. 8. Cumulative response records of chain performance of subject 23 for several FR values. The event pen is down during the FI 3 component and up during the FR component. The first pip in the excursion of the recording pen indicates the change from the FI 3 component to the FR component. Each pip of the recording pen during the FR component indicates a food reinforcement. Downward deflections of the event pen during the FR component indicate avoidance responses. The recording pen resets to the baseline when the FI component is reinstated.

time out (TO) length on TO avoidance behavior (Thomas, 1965a), although the TO avoidance behavior was discriminated avoidance. It was suggested that the decrement in TO avoidance behavior with longer TO values was due to a general effect on the overall disposition to respond. A similar suggestion has been made in respect to the disruptive effects of long TO durations on matching to sample behavior (Ferster and Appel, 1961). The suggestion of a general effect on the disposition to respond does not seem to apply to the decline in avoidance rates in the present study. As the FI length was increased, the FR response rates remained relatively constant. The FI response rates of two subjects declined with increases in FI length, while FI response rates for the third subject did not. The constancy of FR rates with increases in FI length is consistent with changes in performance on a chain FI FR schedule (Hanson, Campbell, and Witoslawski, 1962). In the study by Findley (1962) with concurrent FR avoidance schedules programmed on the same manipulandum, avoidance performance increased with increases in FI length up to a particular value. Increases in FI length beyond that value did not further increase avoidance performance.

Since most responses on the avoidance key were emitted during the pre-ratio pause of the FR schedule, the responses could be interpreted as a temporary loss of control by the FR schedule. The relatively weaker behavior on the avoidance key could occur during the pre-ratio pauses due to a temporary disruption in FR behavior. The interpretation does not apply to the present data because behavior ceased on the avoidance key during those sessions when the avoidance contingency was not programmed. Also, changes in behavior on the avoidance key with changes in FI length demonstrate that the behavior was under the control of the avoidance contingency. The occurrence of avoidance behavior during the pre-ratio pauses and early portions of the ratio run is somewhat typical of behavior programmed concurrently with FR schedules (Catania, 1966; Ferster and Skinner, 1957; Sidman, 1962). When behavior programmed concurrently with FR schedules occurs throughout the FR run, the behavior is engaged in less often as more of the ratio requirement is completed (Sidman, 1962). The longer bursts of avoidance responses which occurred during the programming of the large FRs were engaged in less often as more of the ratio requirement was completed.

As the FR requirement was increased, avoidance rates first declined. When the FR requirement was increased above FR 80, avoidance rates increased. The increase in avoidance rates at the two larger FR values can be related to the marked decrease in reinforcement frequency in the FR component. At FR 80 or below, decreases in reinforcement frequency were directly related to increases in the FR value. A single avoidance response or response burst during the pre-ratio pause or early in the ratio run effectively postponed the FI component long enough to complete the FR requirement at FR 80 or below. During the two larger FR values, there was often a return to the FI component before the ratio requirement was completed, which contributed to the reduction in reinforcement frequency. The increase in avoidance rates with a decrease in reinforcement frequency is similar to the increase in TO avoidance behavior with a decrease in overall reinforcement frequency (Thomas, 1964, 1965b). In the present study avoidance rates declined with still further decreases in reinforcement frequency. The decreases in FI performance with increases in FR value has been reported previously for a chain FI FR (Hanson and Witoslawski, 1959).

The similarities between avoidance behavior maintained by postponing a first chain component and avoidance behavior maintained by postponing a TO period suggests that stimuli associated with initial chain components and TO periods have similar properties. Findley (1962), with the single

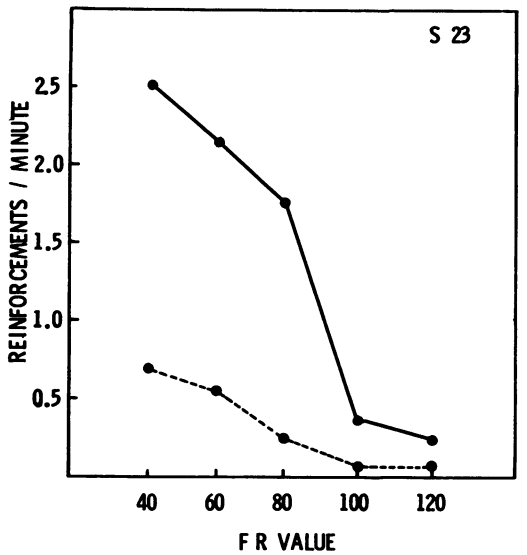

Fig. 9. Reinforcements per minute as a function of the FR requirement for subject 23. The solid line represents reinforcement frequency in the FR component; the dotted line represents overall reinforcement frequency.

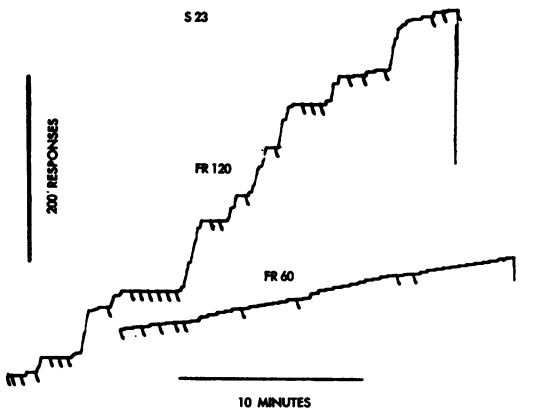

Fig. 10. Cumulative response records of avoidance performance of subject 23 for two FR values. Steps of recording pen indicate avoidance responses and pips indicate returns to the FI component. The paper drive did not run during the FI components.

manipulandum procedure, directly compared avoidance of FI lengths with avoidance of similar TO lengths and found comparable avoidance performances.

REFERENCES

Catania, A. C. Concurrent operants. In Honig, W. K. (ed.) *Operant behavior: areas of research and application.* New York: Appleton-Century-Crofts, 1966.

Ferster, C. B. and Appel, J. B. Punishment of S-delta responding in matching to sample by time out from positive reinforcement. *J. exp. Anal. Behav.*, 1961, **4**, 45-56.

Ferster, C. B. and Skinner, B. F. *Schedules of reinforcement.* New York: Appleton-Century-Crofts, 1957.

Findley, J. D. An experimental outline for building and exploring multi-operant repertoires. *J. exp. Anal. Behav.*, 1962, **5**, 113-166.

Hanson, H. M. and Witoslawski, J. J. Interaction between the components of a chained schedule. *J. exp. Anal. Behav.*, 1959, **2**, 171-177.

Hanson, H. M., Campbell, E. H., and Witoslawski, J. J. FI length and performance on an FI FR chain schedule of reinforcement. *J. exp. Anal. Behav.*, 1962, **5**, 331-333.

Kelleher, R. T. and Cook L. An analysis of the behavior of rats and monkeys on concurrent fixed-ratio avoidance schedules. *J. exp. Anal. Behav.*, 1959, **2**, 203-211.

Sidman, M. Time out from avoidance as a reinforcer: a study of response interaction. *J. exp. Anal. Behav.*, 1962, **5**, 423-434.

Thomas, J. R. Avoidance of time-out from two VI schedules of positive reinforcement. *J. exp. Anal. Behav.*, 1964, **7**, 168.

Thomas, J. R. Discriminated time out avoidance in pigeons. *J. exp. Anal. Behav.*, 1965a, **8**, 329-338.

Thomas, J. R. Time out avoidance from a behavior-independent contingency. *Psychon. Sci.*, 1965b, **3**, 217-218.

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