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TIME OUT FROM AVOIDANCE AS A REINFORCER: A STUDY OF RESPONSE INTERACTION[1]

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Monkeys could either postpone shock by pressing a lever or pull a chain to produce a period of time out from the avoidance procedure. The period of time out proved to be an effective positive reinforcer. Certain features of the animals' behavior were attributed to interactions between the two responses.

In this investigation, the animals could postpone shock by pressing a lever; or they could pull a chain and turn off the houselight in the experimental chamber to produce a period of time out from avoidance. When the houselight was off, the animals were never shocked. The study was concerned with the conditioned reinforcing function of the time out from avoidance. There is also a detailed account of some interactions between the animals' lever-pressing and chain-pulling behavior.

METHOD

Subjects and Apparatus

The subjects were three rhesus monkeys. Their experimental histories (Sidman, Herrnstein, & Conrad, 1957) will be noted briefly where they are relevant for the presentation of results.

Sidman, Herrnstein, and Conrad (1957) have described the experimental chamber and associated apparatus. However, the lever was changed to a modified telegraph key; a chain, also attached to a telegraph key, hung from the center of the ceiling. The houselight, which was turned off to signal periods of time out, was a 100-watt bulb located behind a frosted glass panel on the rear wall of the chamber.

Procedure

The procedure was a concurrent schedule; the animal postponed shock by pressing the lever, and produced periods of time out from avoidance by pulling the chain.

When the houselight was on, the animal received a brief (0.5 sec, 3-5 ma) shock every 20 sec unless it pressed the lever; each time it pressed the lever, it postponed the next shock for 20 sec (avoidance). When the houselight was off, there were no shocks, whether or not the animal pressed the lever (time out from avoidance). The monkey could turn off the houselight by pulling the chain a fixed number of times (fixed-ratio schedule), and so produce a period of time out from avoidance.

If the animal were to pull the chain and produce the time out immediately after it had pressed the lever, the time out might adventitiously reinforce it for pressing the lever. To prevent this, a delay requirement was added to the fixed ratio. The animal not only had to pull the chain the prescribed number of times to turn off the light, but it also had to allow a fixed period of time to elapse when it did not press the lever. Every lever press started the delay period, and only after the animal had stopped pressing throughout the delay could it produce the time out. Durations of the delay will be described below.

Experimental sessions for Monkeys R-10 and R-15 were on Mondays, Wednesdays, and Fridays; for Monkey R-17, they were on Tuesdays and Thursdays. Each session lasted 6 hr. The animals were fed each morning in their home cages, and received neither food nor water in the experimental chamber.

RESULTS AND DISCUSSION

Characteristics of the Fixed-ratio Performance

Immediately before this experiment, each monkey had been working on a concurrent

[1]The writer is grateful to Marie McArthur for her assistance in carrying out these experiments.

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schedule in which it could avoid shock by pressing the lever and produce food by pulling the chain. The food schedule was fixed ratio, with a value of 12 chain pulls per reinforcement for Monkeys R-10 and R-15, and 21 chain pulls per reinforcement for Monkey R-17. During these prior experiments, the houselight was turned off at the end of each session, and the monkeys had learned to stop responding as soon at the light went off.

Experiment I: Acquisition. When the time out from avoidance replaced food as the animals' reinforcement for pulling the chain, they showed considerable, although not complete, transfer of their fixed-ratio pattern of behavior. Figure 1 illustrates the earliest stage in the development of fixed-ratio behavior by Monkey R-10. This animal began the experiment with 5 chain pulls required to turn off the houselight, and with a delay requirement of 2 sec between the reinforced chain pull and the preceding lever press. Each period of time out lasted 5 min. In this and all subsequent figures, the movement of the recorder pen along the time axis was halted during the periods of time out.

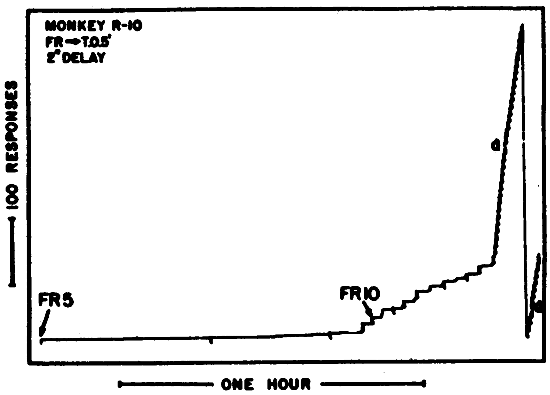

Fig. 1. Cumulative record of Monkey R-10's chain-pulling responses at the start of the experiment, showing the transition from a requirement of 5 to 10 responses per time out. The oblique markers indicate 5-min periods of time out.

The animal pulled the chain infrequently during the first hour, turning off the light only twice. (Responses before the first time out are not visible in Fig. 1 because of a recorder failure.) After pausing for several minutes before the third time-out period, the monkey suddenly began to pull the chain rapidly, and continued until it turned off the light. A similar pattern, with an even shorter pause, preceded the fourth time out; and the fixed ratio was then increased to 10 responses per time out.

The higher ratio requirement disrupted the animal's performance, and its response rate was irregular before the next 7 periods of time out. Then it suddenly began to pull the chain at a high, steady rate, which it maintained until the end of the session. At the two places on the record marked *a*, the animal pulled the chain several times while the light was off; this behavior was rare.

The monkey's high, stable rate of chain pulling is also typical of food-reinforced fixed-ratio behavior (Ferster & Skinner, 1957), and indicates that the time out from avoidance functioned effectively as a positive reinforcer. During the following sessions, the fixed ratio was increased gradually. Figure 2, 4 sessions after Fig. 1, shows the transition from a fixed ratio of 50 to the final requirement of 75 responses per reinforcement. Like previous increases in the ratio, this one temporarily disrupted the monkey's performance; but by the end of the session, the animal was again pulling the chain at a high rate. Brief periods of low rate were most conspicuous immediately after reinforcements.

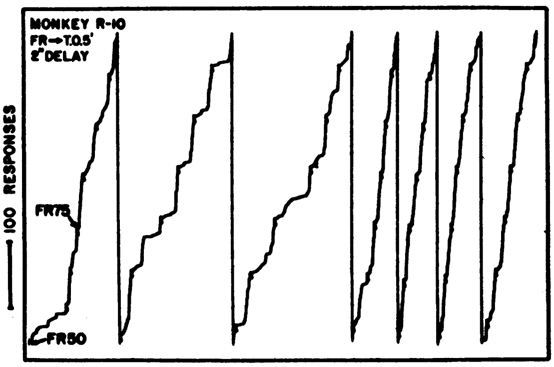

Fig. 2. Cumulative record of Monkey R-10's chain-pulling responses, showing the transition from a requirement of 50 to 75 responses per time out.

Figure 3 shows an example of Monkey R-10's final performance. Concurrent records of the animal's lever-pressing and chain-pulling responses are superimposed on the same coordinates to facilitate comparison. The numbers indicate successive segments of the chain-pulling record, and the letters denote the segments of the lever-pressing record. Except for certain details, to be described more fully below, the records are similar to those usually obtained by programming fixed-ratio and avoidance contingencies separately.

The fixed ratio for Monkey R-17 was gradually increased to 100 chain-pulling responses per time out, with a 2-sec delay requirement and a 5-min time out. Transition data were like those of Monkey R-10, and Fig. 4 depicts the final performance for a complete session. Lever-pressing and chain-pulling records are superimposed on the same time axis, and every fourth time out is numbered. Monkey R-17 usually did not pull the chain at all for a short period after the end of each time out.

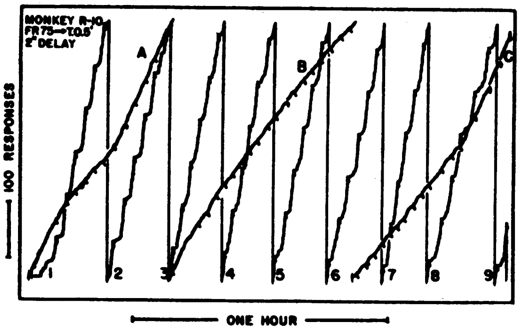

Fig. 3. Cumulative records of Monkey R-10's final performance when it produced the time out by pulling the chain 75 times. The numbers denote successive segments of the chain-pulling record, and the letters mark temporally corresponding segments of the lever-pressing record.

Monkey R-15, whose chain-pulling behavior was maintained by a fixed-ratio schedule of 20 responses per time out, yielded data like those of Monkey R-17. Records of Monkey R-15's behavior will appear in subsequent figures.

Experiment II: Extinction of Chain Pulling

Several extinction periods also indicated that the time out from avoidance resembled conventional reinforcers. Figure 5 shows a typical example. During this session, Monkey R-17 produced one time out, indicated by the arrow;

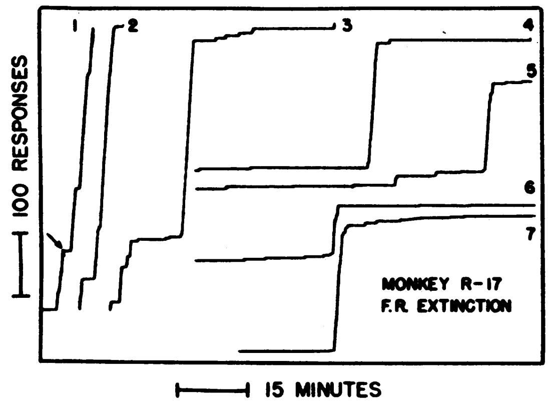

Fig. 5. Cumulative record of Monkey R-17's chain-pulling responses during extinction. After the arrow, the animal could no longer produce the time out.

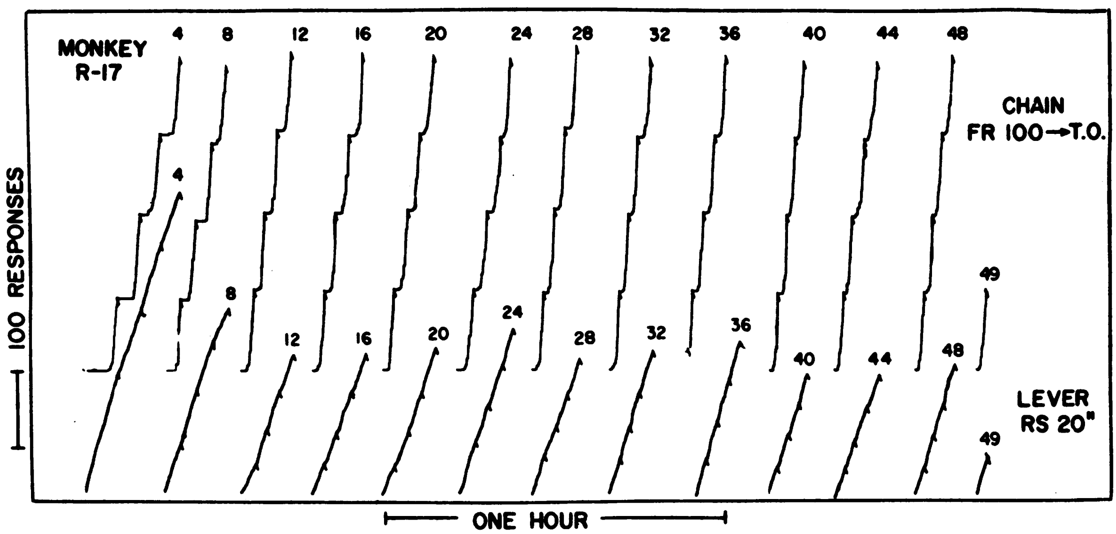

Fig. 4. Cumulative records of Monkey R-17's final performance when it produced the time out by pulling the chain 100 times. The periods of time out lasted 5 min, and every fourth time out is numbered. The upper record is chain pulling; and the lower, lever pressing.

but its chain-pulling responses were ineffective for the remainder of the session. The behavioral pattern—rapid bursts of responses alternating with periods in which the animal did not pull the chain at all—is also typical of extinction behavior after animals have been reinforced with food on a fixed-ratio schedule (Skinner, 1938).

Figure 6 shows an extinction curve for Monkey R-10. An apparatus failure at the

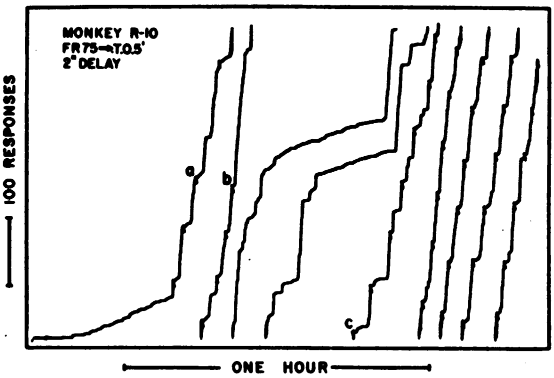

Fig. 6. Cumulative record of Monkey R-10's chain-pulling responses during extinction. The animal could not produce the time out for a short period after *a*, and for a longer period between *b* and *c*.

point marked *a* was corrected early enough for the animal to produce the next time out after it had pulled the chain approximately 200 times, and its behavior was not seriously disrupted. However, a second failure, at *b*, was not detected for nearly 30 min, and the animal could not produce another time out until *c*. This animal rarely ceased responding completely during extinction; instead, it alternated high rates of chain pulling with periods of low or gradually decelerating rates.

Experiment III: Analysis of Switching Behavior. With separate fixed-ratio schedules, animals rarely pause once they have begun to respond after each reinforcement. Close examination of the fixed-ratio records in this experiment reveals that the animals often paused briefly as they progressed in the ratio sequence. During these interruptions of chain-pulling behavior, they usually pressed the lever one or more times and postponed the shock.

More detailed analysis revealed additional features of the animals' pattern of alternation between chain pulling and lever pressing. During several later sessions, records were obtained of the number of times the animals pulled the chain before switching over to the lever, and the number of times they pressed the lever before switching back to the chain. For convenience, each set of consecutive responses can be called a "run." Figure 7 is a plot of the number of responses in each chain-pulling run as a function of the run's serial position in the ratio sequence, relative to the final reinforcement. The final run is indicated on the abscissa by F, the run preceding the final one by -1, the run preceding that one by -2, and so on as far back as the fifteenth run before the time out. Each point is the average run size for the complete session. The number of runs in each individual ratio sequence varied, but all sequences in a given session contained at least the number plotted in Fig. 7.

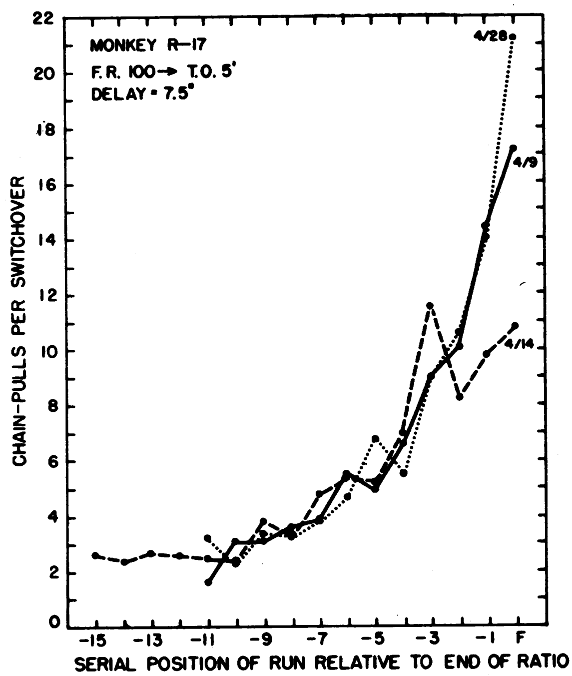

Fig. 7. The number of times Monkey R-17 pulled the chain before switching to the lever (chain pulls per switchover) when it was in different stages of the ratio sequence (serial position of run). The relation is shown for 3 sessions, indicated by date.

As the time out became more imminent, Monkey R-17 tended to pull the chain more often before switching to the lever. During the later stages of the ratio count, the animal was less likely to leave the chain and postpone shock by pressing the lever.

This increasing resistance of behavior to disruption as the occasion approaches for reinforcement is consistent with other data. When rats were pressing a lever for food on a fixed-ratio schedule, Boren (1961) gave the animals a discriminative stimulus for a different response; if he presented the stimulus late in the ratio sequence, the animals were less likely to leave the lever than if he presented the stimulus early in the sequence. Ferster, Appel, and Hiss (1962) found that pigeons were rarely able to avoid a time out from positive reinforcement if they gave them a warning stimulus late in the ratio sequence. Similar findings have been reported for rats reinforced for spacing their lever-pressing responses 20 or more sec apart; these animals were less likely to switch to a second response if the stimulus for that response was presented late in the 20-sec period than if it was presented early (Sidman, 1956).

As the animal progressed in its ratio sequence, then, it tended to pull the chain more often before switching to the lever. To complement this pattern, as the monkey progressed further into the ratio, it tended to press the lever less often before switching back to the chain. Figure 8 shows this for the same 3 sessions as Fig. 7. To reveal the trend most effectively, the lever-pressing runs are plotted in serial position from the end of the time out, instead of backward from the end of the ratio. Again, each point is the average run size for the complete session, and the number of runs plotted per session is the smallest number that occurred between any two periods of time out.

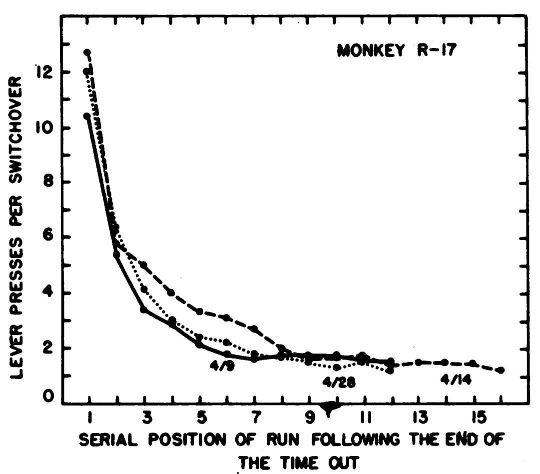

Fig. 8. The number of times Monkey R-17 pressed the lever before switching to the chain (lever presses per switchover) when it was in different stages of the ratio sequence (serial position of run). The relation is shown for the same 3 sessions as Fig. 7.

The longest run of lever-pressing responses always came before the animal pulled the chain—immediately after the time out. Thereafter, as the switchover occurred later in the ratio sequence, the monkey pressed the lever fewer times in each run.

Early in each ratio sequence, before the animal began to increase the length of its chain-pulling runs, it nearly always pulled the chain only once before switching to the lever and pressing it several times; late in the sequence, it reversed this pattern and pressed the lever only once before switching back to the chain and pulling it several times. The consistent pattern of one chain pull followed by several lever presses in the early stages of the ratio, and several chain pulls followed by one lever press in the late stages, will help explain the response interactions to be described below.

Monkey R-10's pattern of runs on the lever was similar to Fig. 8, but its chain-pulling runs showed an interesting variation. Figure 9 gives the size of each run of chain-pulling responses, averaged for each of 3 sessions and plotted in the same way as Fig. 7. By following the peaks in the curves, one can observe a trend like that

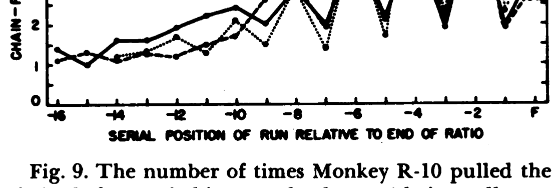

Fig. 9. The number of times Monkey R-10 pulled the chain before switching to the lever (chain pulls per switchover) when it was in different stages of the ratio sequence (serial position of run). The relation is shown for 3 sessions, indicated by date.

of Monkey R-17. But pronounced cyclic alternations between long and short runs are superimposed on the general trend. (It should be noted here that extra chain-pulling responses, necessary whenever the animal failed to meet the delay requirement immediately, are not included in Fig. 7 and 9. The length of the final run is therefore somewhat fortuitous, since it sometimes ended with a time out and sometimes with a switch to the lever.)

Monkey R-10's pattern of alternation between chain pulling and lever pressing took the following form in the late phases of each ratio sequence: Whenever it pulled the chain several times in succession, it then pressed the lever at least twice; on next returning to the chain, the monkey pulled it only once before switching again to the lever for a single response. For example, after pulling the chain 5 times, the animal might then press the lever twice, pull the chain once, press the lever once again, and then pull the chain 6 times. This would initiate another similar cycle, ending again with a longer run of chain pulls. It is as though the monkey, alarmed by the amount of time it took for a long run of chain pulls, had then to press the lever several times to ensure postponement of the shock, and still could not chance more than one chain pull until it had pressed the lever again.

Each run of several chain pulls thus came only after a sequence consisting of two or more lever presses, one chain pull, and one more lever press; hence, the alternation pattern of Fig. 9. The curves for the 3 sessions are so remarkably in phase with each other only because they have been plotted backwards from the end of each ratio sequence; the end of the ratio was most likely to come after the animal had pulled the chain several times in succession, and, as noted above, long chain-pulling runs were always preceded by single chain pulls. Because the ratio sequence did not inevitably end with a long run, the averaging process inflated the run size in the troughs of the curves above the modal value of one; the average values include some longer runs, which increased in size as the animal progressed in the ratio. Similarly, the averages in the peaks of the curves are reduced from their modal values.

Response Interactions

As the animals lengthened their chain-pulling runs late in the ratio sequence (Fig. 7 and 9), they also tended to accelerate their rate of lever pressing. This acceleration will appear more clearly in subsequent figures, but close examination reveals it even in the greatly reduced records of Fig. 3 and 4. Accidental pairings of lever-pressing responses and the time out might have caused the animals to increase the rate at which they pressed the lever when they approached the time out. Although the delay requirement was designed to prevent this from happening, the delay might not have been long enough. This possibility was investigated by systematically increasing the duration of the delay requirement.

Experiment IV: Manipulation of the Delay Requirement. Monkey R-17 had 7 consecutive sessions with each of 3 delay requirements, 2, 3, and 5 sec, in that order, and then 14 sessions with a 7.5-sec delay. Figure 10 shows

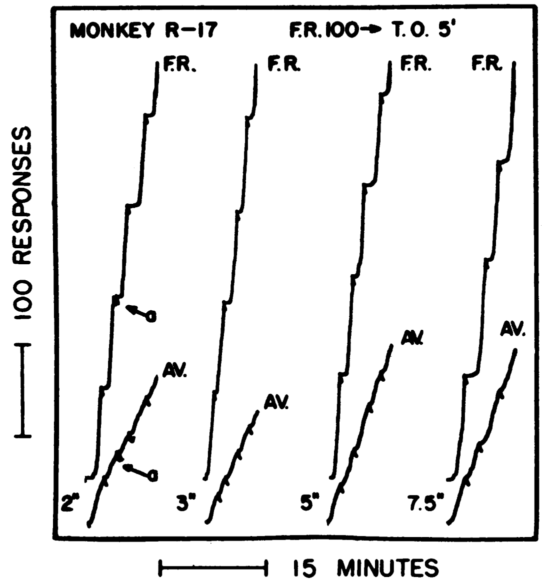

Fig. 10. Final segments of Monkey R-17's cumulative records from the last session at delay requirements of 2, 3, 5, and 7.5 sec. The chain-pulling records are labeled F.R.; and the concurrent lever-pressing records, AV.

final segments of the cumulative records from the last session at each of these values. The chain-pulling and lever-pressing curves are superimposed on the same time axis.

The 7.5-sec delay increased the number of times the animal had to pull the chain before it stopped pressing the lever long enough to meet the delay requirement and produce the time out. But longer delay requirements did not change the animal's lever-pressing behavior in any systematic way. Acceleration of the lever-pressing rate between reinforcements was pronounced, even with a delay requirement as long as 7.5 sec. Furthermore, the animal often distinctly slowed its rate of lever pressing during the few seconds immediately before the time out. Therefore, adventitious reinforcement by the time out probably was not responsible for the acceleration in the monkey's lever-pressing behavior.

Figure 11 shows the final segments of Monkey R-15's lever-pressing records at each

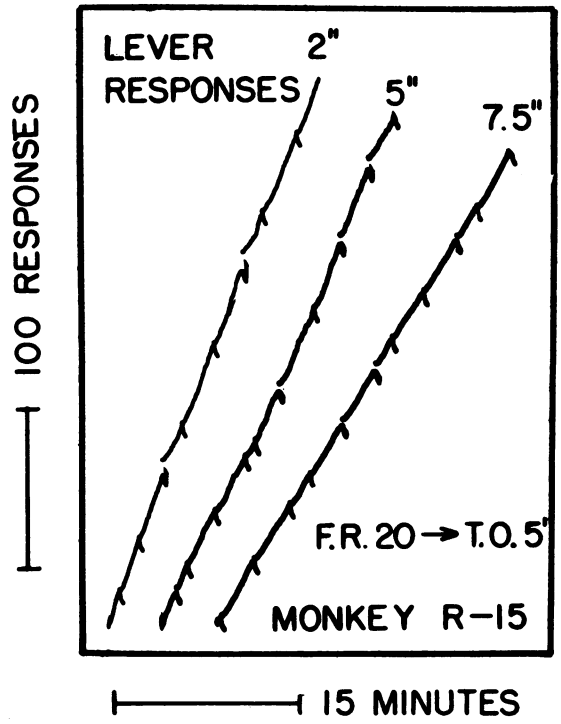

Fig. 11. Final segments of Monkey R-15's cumulative records of lever pressing from the last session at delay requirements of 2, 5, and 7.5 sec.

of 3 delay requirements. Like Monkey R-17, this animal continued to accelerate its lever pressing between reinforcements, even with longer delays. It may be noted, too, that Monkey R-15 tended to press the lever more often than the other animals during the periods of time out.

Between some of its exposures to different delays, Monkey R-15 had a number of sessions of avoidance extinction; these will be described in a subsequent section.

Monkey R-10 had 15 sessions each of 2- and 5-sec delays, and 20 sessions of 7.5-sec delays. The behavior which preceded the last 4 reinforcements in the 15th session at each of these values appears in Fig. 12, with the concurrent chain and lever records detached and paired to facilitate comparison.

With longer delays, Monkey R-10 paused for longer periods before it began to pull the chain after each time out. During these pauses, it continued to press the lever, so that its total response output increased with longer delays. Monkey R-10 accelerated its lever pressing between reinforcements considerably less than the other two animals; but like the others, it

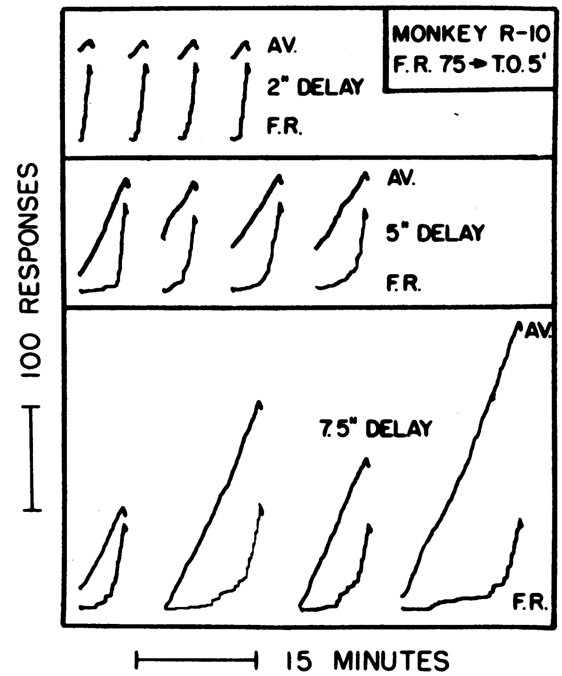

Fig. 12. Cumulative records of Monkey R-10's behavior before the last 4 periods of time out in the 15th session at delay requirements of 2, 5, and 7.5 sec. The lever-pressing records are uppermost in each pair and are labeled AV; the chain-pulling records below are labeled FR.

did not alter this feature of its behavior when longer delays were necessary.

Lengthening the delay interval, then, did not eliminate the periodic acceleration in the animals' lever-pressing behavior between reinforcements. This indicated that acceleration was not a consequence of adventitious reinforcement by the time out, and led to a search for interaction processes.

Experiment V: Avoidance Extinction. The animals began to alternate single lever presses with multiple chain pulls as they progressed in the ratio sequence (Fig. 7, 8, and 9). Ferster and Skinner's analysis of fixed-ratio behavior suggests that each response in the ratio sequence acts as a conditioned reinforcer for the preceding response (Ferster & Skinner, 1957). The possibility arises that the conditioned reinforcement supplied by the chain-pulling behavior might have extended adventitiously to the interspersed lever-pressing responses. Such conditioned reinforcement would provide a mechanism whereby the animals' lever-pressing responses could have become linked to its chain-pulling responses, and would explain the periodic acceleration in the animals' rate of lever pressing. To investigate the possibility more thoroughly, the shock was turned off and avoidance extinction instituted.

The remaining data will be confined to Monkeys R-10 and R-15, since the third animal was diverted to another investigation at this point. Also, before the experiments to be reported now, there was a period when the time out was increased to 20 min; but this operation had no detectable effect and will receive no further mention.

Immediately after the session of which a sample was shown in the 5-sec curve of Fig. 11, Monkey R-15 had 24 sessions in which the shock was turned off (avoidance extinction). Figure 13 shows the final extinction session. The records have been divided into 3 successive segments, and concurrent segments of lever-pressing and chain-pulling curves have been paired on the same time axis.

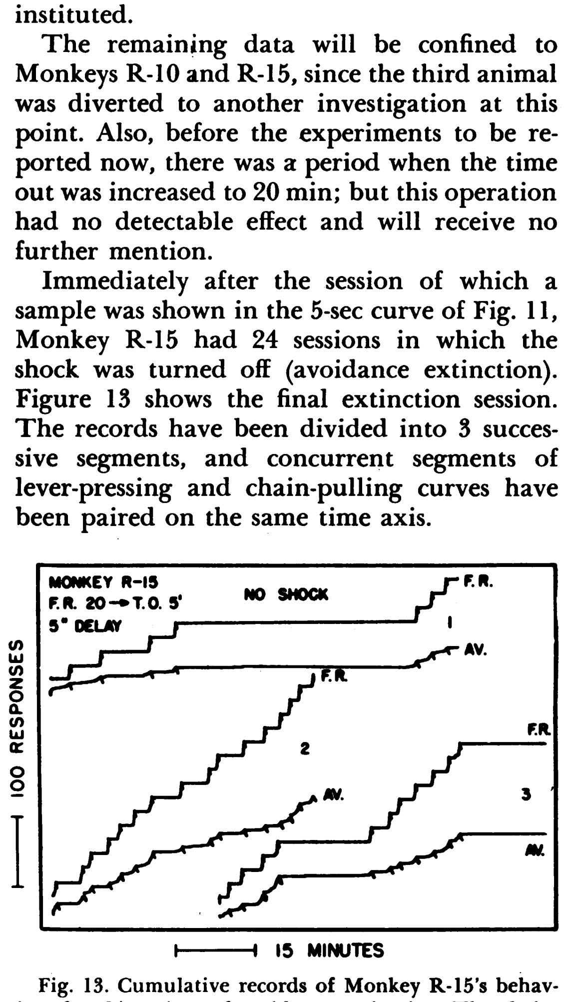

Fig. 13. Cumulative records of Monkey R-15's behavior after 24 sessions of avoidance extinction. The chain-pulling curves are labeled FR; and the lever-pressing curves, AV. Successive segments of the curves are paired and numbered consecutively.

The long postreinforcement pauses in the lever-pressing curve, and the low rate at which the animal pressed the lever after each pause, indicate that extinction had greatly weakened the avoidance behavior. Nevertheless, the final acceleration remained, and it even appeared accentuated against the base line of the animal's low rate of lever pressing (*cf.* Fig. 11). Also, the monkey usually resumed its rapid rate of chain pulling at the same time that it accelerated its lever pressing. These observations support the suggestion that adventitious correlation with chain pulling was responsible for the animal's high rate of lever pressing before each time out.

Experiment VI: Fixed-ratio Avoidance. In a previous experiment (Sidman, 1958), food-reinforced chain-pulling responses that a monkey occasionally interspersed among longer runs of avoidance responses were adventitiously reinforced by shock avoidance. This source of reinforcement was eliminated by placing the food reinforcement on a fixed-ratio schedule, so that the animal pulled the chain a greater number of times before switching to the avoidance response. Verhave (1959) has shown that a fixed-ratio schedule of avoidance will also increase an animal's rate of responding. The same technique was used here to increase the number of times the animal would press the lever before switching over to the chain. In this way, the involvement of single lever-pressing responses in the chain-pulling sequence might be prevented, and the acceleration of lever pressing between reinforcements might be eliminated.

After Monkey R-15's extinction series, the shock was reinstated, and the animal's behavior was reconditioned with a delay requirement of 7.5 sec. The postreinforcement pauses in the animal's chain-pulling behavior became shorter, and the avoidance acceleration returned to the level shown in the 7.5-sec curve of Fig. 11.

A fixed-ratio requirement was then added to the avoidance schedule. In other words, the animal had to press the lever more than once to postpone the shock, and the requirement was gradually built up from 2 to 6 lever presses per shock postponement.

Figure 14 shows one segment of the chain-pulling record during the first session in which the animal had to press the lever twice to postpone the shock, and three successive segments

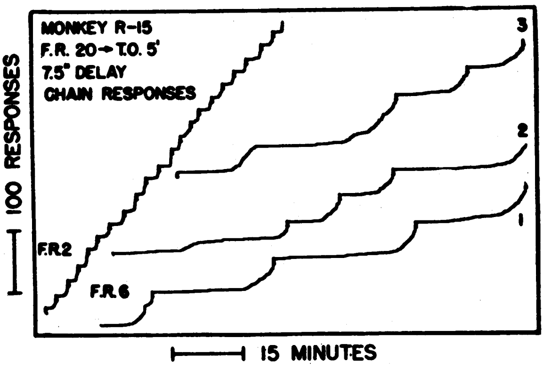

Fig. 14. Cumulative records of Monkey R-15's chain-pulling behavior when the animal had to press the lever twice (FR 2) and 6 times (FR 6) to postpone the shock. The numbers denote 3 successive segments of the record at FR 6.

of a record, 65 sessions later, in which the avoidance requirement was 6 lever presses per shock postponement. The fixed-ratio requirement on the lever produced long pauses in the animal's chain-pulling performance after each time out, and markedly lowered the rate at which the animal pulled the chain after each pause.

Figure 15 shows segments of Monkey R-15's lever-pressing records during the same sessions as in Fig. 14. With an avoidance ratio of 2 lever presses per shock postponement, the record still showed some acceleration between each time out. But when the animal had to press the lever 6 times to postpone the shock, there was no sign of acceleration. The animal maintained a high, stable rate of lever pressing, despite the long periods of time when it failed to pull the chain. The fixed-ratio avoidance requirement apparently served its function of eliminating the adventitious involvement of

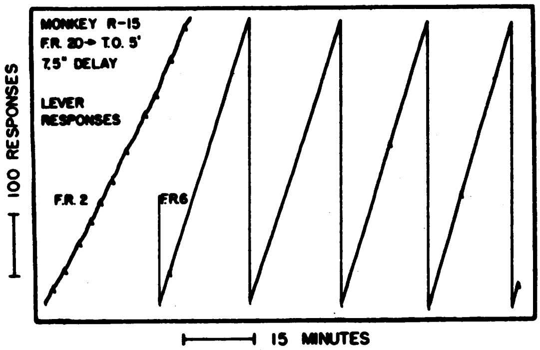

Fig. 15. Cumulative records of Monkey R-15's lever-pressing behavior during the same sessions as Fig. 14.

the monkey's lever-pressing responses in the chain-pulling sequence.

The delay interval for the other animal, Monkey R-10, was reduced to 3 sec after its series of exposures to different delay requirements; and it had to pull the chain only 50 times to produce the time out. Figure 16 shows

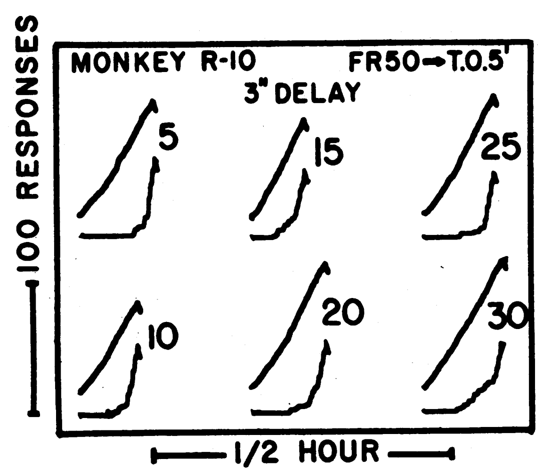

Fig. 16. Cumulative records of Monkey R-10's lever-pressing and chain-pulling behavior before every fifth time out, with a 3-sec delay and 50 chain pulls required to produce the time out. The upper record of each pair is lever pressing; and the lower, chain pulling.

the lever-pressing and chain-pulling behavior that preceded every fifth time out during the animal's last (ninth) session under these conditions. The upper record of each pair is lever pressing, and the lower, chain pulling. There is a distinct acceleration in the animal's lever-pressing records, although, again, it is less than that the other animals displayed.

Monkey R-10 was then placed on the fixed-ratio avoidance schedule. Figure 17 shows the performance when the animal had to press the lever 6 times to postpone the shock. The record strongly resembles that of Monkey R-15, with low rates of chain pulling after long postreinforcement pauses, and little evidence of acceleration in the high, stable rate of lever pressing.

Experiment VII: Extinction of Lever Pressing after Fixed-ratio Avoidance. The concurrent records of lever pressing and chain pulling suggest additional sources of interaction between the two responses. We note first (Fig. 3, 4, and 8) that the animals did not begin to pull the chain immediately after the periods of time out ended. Instead of working

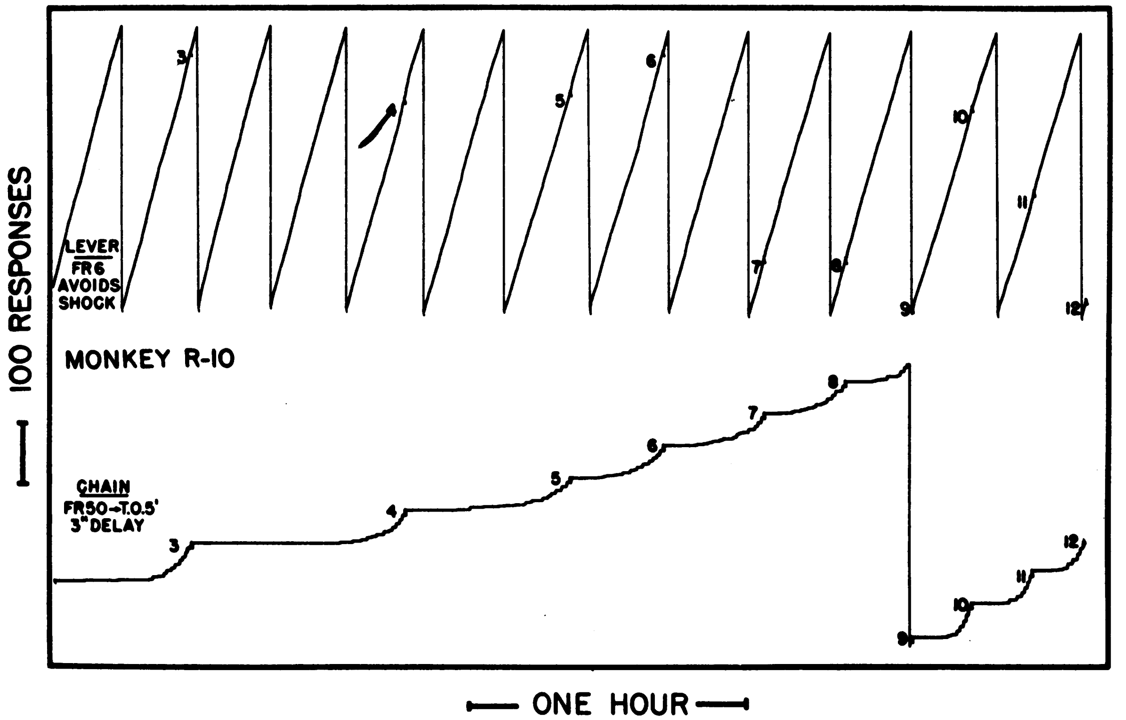

Fig. 17. Cumulative records of Monkey R-10's behavior when the animal had to press the lever 6 times (FR 6) to postpone the shock. The upper record is lever pressing; and the lower, chain pulling. Periods of time out are numbered on each record.

themselves closer to the time out, they pressed the lever and postponed the shock. It is as though a certain amount of avoidance behavior was necessary before the animals would begin to initiate escape behavior. In Fig. 13, too, after 24 sessions of avoidance extinction, the animal always began to press the lever before pulling the chain. The avoidance behavior itself possibly does form part of the stimulus complex from which the animal escapes by pulling the chain and producing the time out.

In avoidance extinction, the animal paused in its lever pressing after each time out. Because a certain amount of lever pressing seems to have been required before the animal would initiate the chain-pulling sequence, the post-reinforcement chain-pulling pause was correspondingly lengthened. But the rate at which the animal did pull the chain did not decrease once it had begun each ratio sequence (Fig. 13). In contrast, fixed-ratio avoidance, which also lengthened the pauses, caused a decrease in the animals' chain-pulling rates (Fig. 14 and 17), even without any postreinforcement pause in lever pressing. These differences suggest a second way in which the avoidance contingency might have influenced the animals' chain-pulling behavior. When the animal postpones the shock with every lever press, it can have as much as 20 sec of safe time when it switches to the chain. But with 6 lever presses required to postpone the shock, the animal can switch to the chain after as many as 5 ineffective lever presses, and will be correspondingly closer to the shock. The higher probability of shock after switching is probably responsible for the animal's lowered tendency to begin the ratio sequence on the chain and, once having begun, for its shorter runs on the chain and its longer periods of interspersed lever pressing.

Thus, in extinction after the regular avoidance schedule, the longer postreinforcement pauses in chain pulling are a consequence of the concurrent pauses in lever pressing. In fixed-ratio avoidance, however, the animal was more likely to be shocked while pulling the chain; this could account for its longer post-reinforcement pauses. Extinction of lever pressing after fixed-ratio avoidance nicely separates these two sets of processes.

Immediately after the sessions shown in Fig. 15 and 17, the shock was disconnected and extinction begun. Figure 18 shows the final segments of Monkey R-15's chain-pulling records in every fifth session of avoidance extinction. The curves are numbered consecutively, beginning at the bottom of the figure.

Even though the animal received no shocks, its postreinforcement pauses became shorter from Session 1 to 21. Also, the animal began its terminal rate more suddenly as extinction progressed, and the terminal rate became higher and more regular. These changes reflect the diminishing influence of the high probability of shock after switching which prevailed under the previous requirement of 6 lever presses per shock postponement.

After Session 21, the effects of avoidance extinction *per se* began to emerge. During these final sessions, the terminal response rate continued to increase, and its beginning became ever more abrupt; but the postreinforcement pauses again lengthened, reflecting the continued absence of shock. Also, as extinction progressed, and the influence of the previous fixed-ratio avoidance requirement grew less, pronounced acceleration reappeared in the lever-pressing records between reinforcements. This is illustrated in Fig. 19, which shows segments of the lever-pressing records from every tenth session of avoidance extinction.

Monkey R-10 followed a course similar to that of Monkey R-15 in extinction after fixed-ratio avoidance. Its postreinforcement chain-pulling pauses decreased at first as the influence of the animal's previous fixed-ratio history diminished; then, the pauses lengthened again under the influence of avoidance extinction. The animal's terminal rate of chain pulling became higher, more regular, and began more abruptly as extinction progressed.

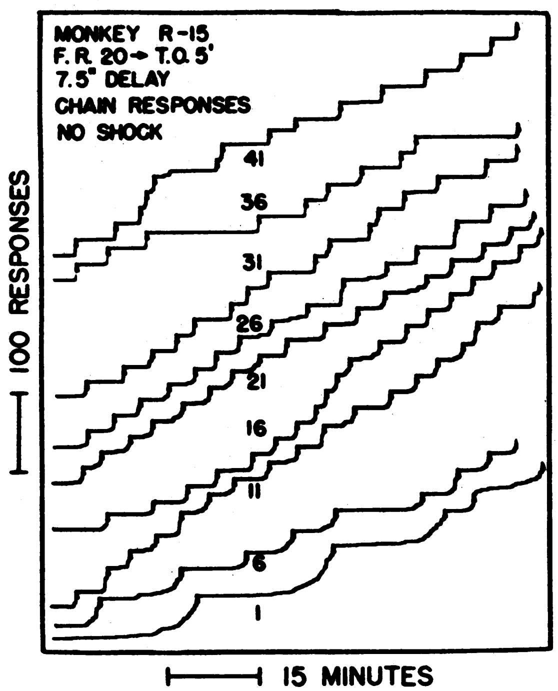

Fig. 18. Final segments of cumulative records of Monkey R-15's chain-pulling behavior from every 5th session of avoidance extinction after fixed-ratio avoidance.

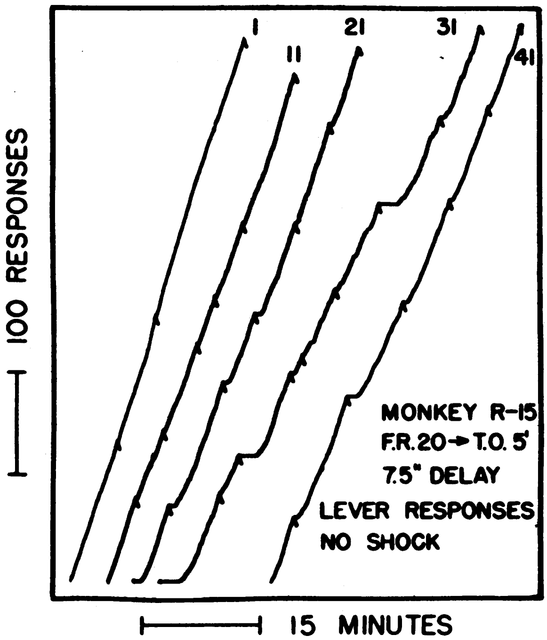

Fig. 19. Segments of cumulative records of Monkey R-15's lever-pressing behavior from every 10th session of avoidance extinction after fixed-ratio avoidance.

Summary of Response Interactions

The performances of the animals in Experiments I through VII permit a plausible reconstruction of the complex sequence of interactions between the lever-pressing and chain-pulling responses:

(a) After each period of time out, the animals at first confined their behavior exclusively to the lever. Some avoidance responding appeared to be necessary before the animals would begin to pull the chain and work themselves closer to the time out.

(b) When the animals ended their post-reinforcement pauses, they tended at first to pull the chain only once before returning to the lever and pressing it several times. This alternation pattern is one in which chain pulling may become adventitiously linked to lever pressing; avoidance of shock may reinforce the animal for the occasional chain pulls it intersperses among its lever-pressing responses (Sidman, 1958).

(c) Soon after the animals initiated their chain-pulling activity, the fixed-ratio contingency took control; they began to alternate multiple chain pulls with single lever presses, reversing the pattern they displayed at the start of each ratio sequence. The direction of the response linkage probably also reversed, and the conditioned reinforcement for chain pulling now probably extended adventitiously to the interspersed lever-pressing responses; hence, the acceleration in the animals' rate of lever pressing as they assumed their high terminal rate of chain pulling before each period of time out.

(d) The animals' chain-pulling behavior was adversely affected by the increase in the probability that they would be shocked after switching from the lever to the chain. This was demonstrated by requiring the monkeys to press the lever several times to postpone the shock, so that most of their avoidance responses were actually ineffective.

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