*A COMPLEX CONCURRENT SCHEDULE OF REINFORCEMENT*¹

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In a concurrent schedule of reinforcement with two keys, a major factor with pigeons or rats is the behavior of switching from one key to another produced by the special reinforcement contingencies of the schedule (Findley, 1958; Herrnstein, 1958; Sidman, 1958; Skinner, 1950; and Ferster & Skinner, 1957). Findley, for example, has explicitly studied the behavior of switching. Reinforcement on one key became progressively infrequent until responding on a second key returned the schedule of reinforcement to an original value. Most of the experiments reported to date with concurrent schedules of reinforcement reflect either the behavior of switching from one key to the other, or a very optimal schedule of reinforcement on one key so that most of the animal's performance is on that key. Concurrent performances may also be established by recording two responses that can be emitted simultaneously, or with minimum interference. Primates are especially convenient subjects for two-key experiments from the point of view of establishing a performance where the two components of the concurrent schedule may be maximally independent of each other. Such a performance has already been reported for the chimpanzee under a concurrent schedule composed of a fixed ratio of 150 on the right key and a variable-interval schedule with a mean of 4 minutes on the left key (conc VI 4 FR 150) (Ferster, 1957). The chimpanzee pressed the left key with its left hand and the right key with its right hand. The two responses showed considerable independence by the characteristic fixed-ratio performance on the one key and the simultaneous performance on the other key conforming to the variable-interval pattern. In the present experiment, the same subjects are used to investigate further the extent of the possible independence of two concurrent repertoires by observation of the transition to a complex schedule of reinforcement on the one key while the variable-interval reinforcement schedule was maintained on the other.

APPARATUS AND SUBJECTS

The subjects were two adult male chimpanzees, Yerkes No. 93 and 95. Their free-feeding weights were 98 and 102 pounds, respectively; and their running weights, 74 and 78 pounds.

The apparatus has been described in detail elsewhere (Ferster, 1958). The response keys were Switchcraft lever-action switches with click feedback, 6 inches apart and 30 inches from the floor. Reinforcement consisted of a buzzer and change in room illumination, followed by the delivery of approximately 40 k-cal portions of purina monkey chow and a whole wheat cracker, alternately. The stimuli were red and green lamps located between the two keys and behind 4-inch-by 4-inch translucent Plexiglas.

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PROCEDURE

Table 1 summarizes the experimental procedures. The experiment began with the subjects that had already developed a final performance on conc VI 4 FR 150. The schedule of reinforcement on the fixed-ratio key was then altered to mult FR 150 FI 10, a green and red light corresponding to the respective components. The red light associated with the fixed-ratio schedule was the same as the one present during the previous procedure under the conc VI 4 FR 150. Schedule changes occurred after reinforcements on the right key (multiple schedule). During the first part of the experiment the schedule changed on a semi-random program. During the latter part of the experiment the schedules alternated, except for two fixed-ratio reinforcements in a row every 33rd reinforcement. After reinforcement on conc (VI 4 mult FR 150 FI 10), the fixed-ratio was reduced to 70. Later, the mean of the variable-interval schedule was increased to 10 minutes.

TABLE 1
TABLE OF PROCEDURES

Left Key	Right Key	No. of Days		Illustrations
		93	95	
VI 4	FR 50-150	49	37	Fig. 1
VI 4	Mult FR 150 FI 10	12	12	Fig. 2, 3
VI 4	Mult FR 70 FI 10	15	13	
VI 10	Mult FR 70 FI 10	28	55	Fig. 4, 5
EXT	Mult FR 70 FI 10	29	26	Fig. 4, 5
EXT	Mult FR 70-475 FI 10	10	10	Fig. 6, 7
EXT	Mult FR 475 FI 10	13	12	Fig. 6, 7
VI 10	Mult FR 475 FI 10	10	8	Fig. 8, 9
EXT	Mult FR 475 FI 10	5	5	Fig. 8, 9
VI 10	Mult FR 475 FI 10	1	1	
VI 10	EXT	1	1	Fig. 10, 11
VI 10	Mult FR 475 FI 10	3	3	Fig. 12

The extent of the interaction among the component schedules was studied by extinguishing behavior on one key while recording the corresponding change on the second key.

After the conc (VI 10 mult FR 70 FI 10) schedule had been in effect, both the clicker and the schedule of reinforcement on the left key (VI 10) and the clicks produced by the left key were then discontinued. Extinction was continued until responding no longer occurred. The performance on the right key (mult FR 70 FI 10) was then examined without the interference of the concurrent responding on the left key. The size of the fixed ratio was increased to 475 over the next 10 sessions, and the variable-interval schedule and clicker were again reconnected on the left key to determine the extent to which the multiple-schedule performance on the right key

was influenced by the concurrent responding on the left key. The concurrent schedule was continued, and the effect of extinguishing the behavior on the left key was determined once more. After one session on conc (VI 10 mult FR 475 FI 10), the right-key schedule of reinforcement and clicker were discontinued to determine the extent to which the performance on the left key on the variable-interval schedule was influenced by the concurrent responding on the right key. This interaction was confirmed once again by returning to the concurrent schedule of reinforcement, with the variable-interval schedule in force.

RESULTS

Final Performance on Conc VI 4 FR 150.

Chimpanzee No. 95. Figure 1 shows the final performance for Chimpanzee No. 95 on conc VI 4 FR 150. The fixed-ratio performance on the right key, which is shown in the top curves of Record A, is standard for a fixed-ratio of this size. The pause after reinforcement varies from about 10 seconds, as at *a*, to almost a minute, as at *g*. Some segments show negative curvature, as at *a*, *d*, *e*, and *f*; but the typical performance is a pause immediately following reinforcement followed by an abrupt shift to a terminal rate, which is maintained until the next reinforcement, as at *g* and *h*. The concurrent VI 4 performance on the left key is a low over-all rate of responding, with short periods of responding during the pauses on the fixed-ratio key. However, the actual local rates of responding are moderate, as might be expected under the variable-interval schedule. This subject used its left hand on the left key and its right hand on the right key, but seldom pressed both keys simultaneously.

Figure 1. Chimpanzee No. 95. Final performance under concurrent VI 4 FR 150.

Chimpanzee No. 93. The final performance for Chimpanzee No. 93 has already been described in a previous publication (Ferster, 1957). In general, there was considerable independence between the behavior on the two keys, with many instances of simultaneous emission of the two responses.

Figure 2. Chimpanzee No. 95. First three sessions of the transition to the concurrent (VI 4 mult FR 150 FI 10). Records A-1, B-1 and C-1: First three sessions of the transition to the mult FR 150 FI 10 schedule on the right key. Records A-2 and C-2: Corresponding VI performances on the left key. Records D-1 and D-2: Complex concurrent schedule performance three sessions later.

Transition to Conc (VI 4 Mult FR 150 FI 10).

Chimpanzee No. 95. Figure 2 shows the transition from FR to mult FR 150 FI 10 on the right key and the final performance. Records A-1, B-1, and C-1 show the first part of the first three sessions; and Records A-2 and C-2, the corresponding VI 4 performances on the left key. In general, the first three sessions show a normal transition from FR to mult FR FI on the right key with little disruption by the concurrent variable-interval of the left key. Sustained responding at the fixed-ratio rate occurs in the early interval segments from *a* to *b*. Thereafter, the rate of responding during the interval segments shifts increasingly to a moderate rate of about 0.5 response per second, as in the interval segments ending at *g*, *h*, and *i*. Break-throughs at the fixed-ratio rate occur with decreasing frequency during the first three sessions, as at *c*, *f*, *h*, *m*, and *o*. The fixed-ratio components show little strain from the sustained responding during the fixed-interval components or disruption from the concurrent behavior on the variable-interval key except in the segments at *h*, *i*, *n*, and *p*. At these points, responding occurs predominantly at the fixed-interval rates, and the fixed-ratio running rate is reached for only short periods. Occasional segments, as at *p*, show rough grain due to pauses, probably from the competing variable-interval behavior. Most of the fixed-ratio segments begin with a pause or a

period of responding at an intermediate rate. The concurrent VI 4 performance on the left key continues to be unaffected by the fixed-ratio performance on the right key except for some suggestions of inductive effects from the multiple schedule, as at *r* and *s*. Here, the rate of responding increases temporarily to values in between the VI and FI rate and the FR rate. One single instance of a breakthrough at the fixed-ratio rate occurs at *q*.

The conc (VI 4 mult FR 150 FI 10) performance three sessions later is shown in Records D-1 and D-2. Bursts of responding of 80 to 170 responses still occur at the fixed-ratio rate during the early segments of the session, as at *t* and *u*. Responding during the fixed interval occurs at a low, constant rate, with no tendency for the rate of responding to increase as the interval elapses. The variable-interval performance in Record D-2 is a low, steady rate of responding, slightly higher than the fixed-interval rate. Many of the pauses occur during the simultaneous fixed-ratio responding on the other key. These can be seen in the vicinity of the vertical dashes which indicate reinforcements delivered on the other key.

Chimpanzee No. 93. The record of the first session of the transition to the multiple schedule was lost because of a recording failure. It consisted predominantly of responding on the right key at the fixed-ratio rate throughout the entire session. The second session of the transition to the conc (VI 4 mult FR 150 FI 10) is shown complete in Records A-1 and A-2 of Fig. 3. The performance is similar to

Figure 3. Chimpanzee No. 93. Record A-1: Right-key performance in the second session of the transition to mult FR FI. Record A-2: Concurrent VI 4 performance. Records B-1 and B-2: Concurrent (VI 4 mult FR 150 FI 10) performance six sessions after Record A.

that of Chimpanzee No. 95. During the early segments, responding is predominantly at the fixed-ratio rate (*a* to *b*), but longer and longer periods of responding at a low, steady rate emerge, as at *e*, *f*, and *g*. The fixed-ratio performance is stable except for some tendency to pause just after reinforcement during the fixed-ratio run (*a*, *c*, and *h*). By the end of the session, most of the interval segments, as at *i*, *m*, and *n*, do not show any effect of the fixed-ratio schedule. Record A-2 shows the concurrent variable-interval performance on the left key. Except for a tendency for the over-all rate of responding to fall toward the end of the session, in the region of *o* to *p*, responding is essentially at a low, constant rate of approximately 0.25 response per second, with no major interference from the performance on the other key.

Records B-1 and B-2 of Fig. 3 show the final performance after six more sessions of exposure to the conc (VI 4 mult FR 150 FI 10). By this time the high rates of responding during the interval segments have disappeared and the fixed-interval performance consists of an approximately constant, low rate of responding. There is little trend toward the emergence of a fixed-interval scallop, except in the intervals *q* and *r*. Many of the fixed-interval segments begin with responding during the very first seconds. The fixed-ratio performance is normal, with pausing ranging from only a few seconds to approximately a minute. There is some grain during occasional ratio segments as the result of the concurrent responding on the variable-interval key. In general, the fixed-ratio performance consists of a pause followed by an abrupt shift to a fixed-ratio rate of over 4 responses per second. The variable-interval performance remains a low, constant rate of responding, slightly higher than the simultaneous fixed-interval rates on the right key.

Transition from Conc (VI 10 Mult FR 70 FI 10) to Conc (Ext Mult FR 70 FI 10).

Chimpanzee No. 95. Records A-1 and A-2 in Fig. 4 show the final performance after 55 sessions under conc (VI 10 mult FR 70 FI 10). The mean interval of reinforcement on the variable-interval schedule was increased to 10 minutes in order to provide a longer experimental session. The size of the fixed ratio was reduced to 70 in an attempt to stabilize the fixed-ratio performance and hence reduce the variability in the multiple schedule. The fixed-ratio schedule produces its characteristic performance, but the fixed-interval performance is a low, constant rate with little or no evidence of a scallop. The variable-interval rate has risen even though the mean interval of reinforcement has been reduced to 10 minutes.

On the following session the variable-interval schedule and response feedback clicker were disconnected on the left key in order to see the extent to which the multiple performance on the right key was being influenced by the concurrent responding on the left key. The rate of responding during the fixed-interval segments began to increase almost immediately, with some scalloping occurring by the end of the first session. By the fourth session, essentially normal fixed-interval scallops began to emerge; and Record B shows the final performance after eight sessions, during which the rate of responding on the left key has reached zero. The fixed-interval segments now uniformly show an acceleration to a terminal rate of approximately 0.5 response per second, with a pause following reinforcement ranging from about a minute to 5 to 6 minutes. Many of the segments show a continuous

Figure 4. Chimpanzee No. 95. The effect of extinguishing the left-key performance. Records A-1 and A-2: Final performance under the mult FR 70 FI 10 schedule and VI 10 schedules, respectively, after 55 sessions of exposure to this schedule. Record B: Performance on the mult FR 70 FI 10 schedule, eight sessions after extinction was begun on the variable-interval schedule of the left key.

acceleration throughout the interval, while others show an abrupt shift to the terminal rate.

Chimpanzee No. 93. Figure 5 shows the comparable performance for Chimpanzee No. 93. Records A-1 and A-2 show the final performance on conc (VI 10 mult FR 70 FI 10). Here, the over-all rate of responding in both the fixed-interval and variable-interval schedules are considerably lower than with No. 95. Occasional fixed-interval segments are postponed beyond the designated 10-minute interval, as for example at *b* and *c*, because no response occurs when the reinforcement is available. As with No. 95, the rate of responding does not tend to increase during the fixed-interval segments. The variable-interval performance on the left key in Record A-2 is a very low over-all rate, declining continuously during the session. The performance consists of bursts of 2 to 10 responses separated by long pauses ranging from 30 to 60 seconds to over 10 minutes, occasionally. When the clicker and variable-interval schedule on the left key were disconnected and the variable-interval responding fell to zero, the fixed-interval rate of responding on the right key fell even lower. The final performance (11 sessions later) is shown in Record B, after the rate of responding on the left key had fallen to zero. Many of the interval segments are being prolonged beyond the designated 10 minutes, as for example, at *f* and *g*. In spite of the fall in the over-all rate of responding, however, intervals containing the larger numbers of responses occasionally show a scallop, as for example at *d* and *e*, even though a substantial terminal rate of responding is never reached.

Figure 5. Chimpanzee No. 93. The effect of extinguishing the left-key performance. Records A-1 and A-2: Final performance of the mult FR 70 FI 10 and VI 10 components of the concurrent schedule, respectively. Record B: Mult FR 70 FI 10 performance 11 sessions after reinforcement was discontinued on the left key.

Final Performance on Conc (Ext Mult FR 475 FI 10) and Transition to Conc (VI 10 Mult FR 475 FI 10)

Chimpanzee No. 95. Record A of Fig. 6 contains the final performance on mult FR 475 FI 10. The left key is still disconnected, and the size of the fixed ratio has been increased from the previous values over 8 sessions and maintained at the present value for 10 sessions. For compact presentation, the record has been broken into segments and moved to a common base. Except for occasional runs at the ratio rate, as at the 1st and 17th segments, the fixed-interval segments show a substantial pause and some acceleration to a low terminal rate. Typically, some 100 to 200 responses are emitted per segment. The fixed-ratio performance consists of sustained responding at about 4 responses per second, with a fairly uniform pause of about 60 seconds at the start of the ratio. When the VI 10 schedule of reinforcement was reconnected on the left key, in Record B-1, the effect on right-key responding (multiple schedule in Record B-2) was slight, consisting almost entirely of a small decline in the number of responses emitted during the fixed interval. The rate change during the fixed-interval segments is slightly less smooth, with frequent instances of negative curvature. The fixed-ratio segments remain unaffected by the concurrent VI responding, because of the cessation of responding on the variable-interval key during the fixed-ratio component of the multiple schedule rather than the non-interference between the two repertoires. The VI responding occurs during the fixed interval and during the pauses at the start of the FR segments, as inspec-

Figure 6. Chimpanzee No. 95. The effect of reconnecting reinforcement on the variable-interval key. Record A: Final performance on mult FR 475 FI 10. Records B-1 and B-2: First session of the concurrent VI 10 mult FR 475 FI 10 schedule.

tion of Record B-1 in the vicinity of the vertical dashes above the curves reveals. The VI responding is relatively constant during the fixed-interval scallop.

Chimpanzee No. 93. Figure 7 shows the comparable performance for Chimpanzee No. 93. The final performance on conc (ext mult FR 475 FI 10) is shown in Record A. The fixed-ratio segments are maintained with little or no pause after reinforcement, but slight pauses and rate changes occur after responding begins. The rate of responding during the fixed-interval segments approaches zero. However, responding is sufficient so that the reinforcement is never postponed more than a minute or two beyond the designated reinforcement interval. When the variable-interval schedule is reinstated on the following session (Record B-1), the rate of responding increases during the FI segments on the other key (Record B-2). The rate of responding tends to increase toward the end of the interval. The orders of magnitude of the terminal rates of responding, however, remain lower for a fixed-interval of this size than those obtained with No. 95, and the FR segments continue to show grain and slight pausing during the ratio as before. The concurrent VI performance, shown in Record B-1, consists of an extremely low over-all rate of responding, somewhat lower than had occurred previously and probably reflecting the large amount of extinction that had preceded during the development of the high fixed ratio of Record A.

Figure 7. Chimpanzee No. 93. The effect of reinstating the variable-interval schedule of reinforcement on the left key. Record A: Final performance on concurrent (ext mult FR 475 FI 10). Records B-1 and B-2: First session of the reinstatement of the variable-interval performance in the concurrent (VI 10 mult FR 475 FI 10) schedule.

Second Transition from Conc (VI 10 Mult FR 475 FI 10) to Conc (Ext Mult FR 475 FI 10).

Chimpanzee No. 95. Figure 8 contains the performance on the concurrent schedule, eight sessions after that shown in Fig. 6. The effect on the mult FR FI performance of the concurrent responding on the VI key was again determined by discontinuing both the schedule of reinforcement and the clicker. After four sessions, responding on the left key fell to zero and the resulting performance on the mult schedule was recorded in Record B, where every alternate segment has been deleted for more compact presentation. A comparison of Records A-1 and B of Fig. 8 suggests that the elimination of the concurrent variable-interval reinforcement produces a slight decline in the amount of responding in the fixed-interval segments and a slight lengthening in the pause at the start of the fixed ratio. The orders of magnitude of the effects are slight, if significant, however, and the main result appears to be that the performances on the two keys are almost independent of each other. As before, responding on the left key ceases during the fast responding on the right key in the fixed-ratio component of the multiple schedule. Responses continue to occur, however, during the pause at the start of the FR components.

Figure 8. Chimpanzee No. 95. Second determination of the effect of discontinuing reinforcement on the variable-interval schedule of the left key. Records A-1 and A-2: Multiple and variable-interval components, respectively, of the concurrent (VI 10 mult FR 475 FI 10) schedule. Record B: Mult FR 475 FI 10 performance four sessions after reinforcement is discontinued on the variable-interval key.

Chimpanzee No. 93. The performance on the conc (VI 10 mult FR 475 FI 10) schedule for No. 93 confirms its earlier performance. Discontinuing the variable-interval schedule weakened the performance on the multiple schedule. Responding on the left key under the variable-interval schedule (Fig. 9, Record A-2) is at a low, steady rate; and the rate of responding in the fixed-interval segments of the multiple schedule shown in Record A-1 is even lower. As before, the rate of responding tends to increase during the latter part of the fixed-interval segments in spite of the over-all low rate of responding. Record B shows the performance five sessions later, after the responding on the variable-interval key had reached near zero in extinction. As before, this animal showed a decrease in the amount of responding in the fixed-interval segments. The responding is still sufficient, however, especially toward the end of the fixed-interval segments, so that none of the intervals are postponed beyond the designated fixed interval.

The Effect of Extinction of the Multiple-schedule Performance on Responding on the Variable-interval Key.

Chimpanzee No. 95. Figure 10 shows the session in which the schedule of reinforcement and clicker on the right key were disconnected with the fixed-interval

Figure 9. Chimpanzee No. 93. Second determination of the effect of discontinuing reinforcement of the variable-interval schedule of the left key. Records A-1 and A-2: Multiple and variable-interval components, respectively, of the concurrent (VI 10 mult FR 475 FI 10). Record B: Performance on the mult FR 475 FI 10 schedule four sessions after reinforcement was discontinued on the left key.

Figure 10. Chimpanzee No. 95. Extinction is carried out on the FI component of the multiple schedule at the arrow. Record A: Variable-interval component, Record B: Multiple-schedule component of the concurrent VI 10 mult FR 475 FI 10.

color in force (at the arrow). Extinction on the right key (Record B) begins effectively after 10 minutes after the arrow, when the terminal rate of responding in the fixed interval is reached. The result is a continuous decline in the rate of responding, until it reaches essentially zero in about 30 minutes. The final part of the session, showing a zero rate, is not shown in the record. Simultaneous with the decline in the responding of the right key (Record A), the rate of responding on the left key increases from less than 0.1 response per second, when the multiple schedule was in force, to over 0.25 response per second, after the responding on the right key had fallen to near zero. Even higher rates of responding begin to emerge on the left key, although the rate of responding on the right key has already reached zero, as for example in the region *a* to *b* and *c* to *d*. Here, for periods of approximately 10 minutes, the over-all rate of responding reaches 0.5 response per second.

Chimpanzee No. 93. The extinction of the right-key responding, shown in Fig. 11B, confirms the general weakness of both the fixed-interval and variable-interval behavior that this subject has shown in the previous procedures. The extinction of the fixed-interval responding in Record B produced a prolonged extinction curve in which the rate of responding never increases beyond the low terminal rates observed during the previous mult FR FI performances. Correspondingly, the rate of responding in the variable-interval performances in Record A increases, but the order of magnitude is not nearly so large as with Chimpanzee No. 95.

The Effect of Reconditioning of the Multiple-schedule Performance of Responding on the Variable-interval Key.

The effect of the right-key responding (multiple schedule) on the VI performance on the left key is again demonstrated in Fig. 12, three sessions later when the

Figure 11. Chimpanzee No. 93. Extinction is carried out on the FI component of the multiple schedule at the arrow. Record A: Variable-interval component. Record B: Multiple component of the concurrent VI 10 mult FR 475 FI 10.

multiple schedule on the right key was again reinstated. Records A and C, for No. 95 and 93, respectively, show the variable-interval performances three sessions after the rate of responding on the right key had reached zero. Records B and D show the corresponding variable-interval performances after the multiple schedule is reinstated. Both animals confirm the effects previously demonstrated in Fig. 10 and 11. The increase in the responding on the right key under the multiple schedule produced a decrease in the variable-interval responding comparable with that obtained earlier under the concurrent schedule. Little change occurs in the performance of Chimpanzee No. 93, however, whose fixed-interval and variable-interval performances had previously shown neither substantial rates of responding or very much interaction.

Figure 12. Chimpanzees No. 93 and 95. The effect, on the variable-interval schedule, of reconditioning the multiple schedule on the right key. Records A and C: Final performances under the variable-interval schedule after the rate of responding under the multiple schedule approached zero. Records B and D: First session after reconditioning of the multiple schedule.

DISCUSSION

Both subjects showed considerable independence between their left- and right-key performances in the transition from the concurrent FR VI to the concurrent multiple FR FI schedule. Responding on the variable-interval performance on the left hand continued at approximately the same level as previously under the concurrent VI FR schedule, and showed almost no effect of the change in schedule on the right key, even though the right-key performance consisted of large-order-of-

magnitude rate changes. Conversely, the transition to the multiple FI FR schedule on the right key also proceeded without interference from the variable-interval performance on the left key. A rate of responding appropriate to the fixed-ratio schedule was sustained almost continuously during the early interval segments. Eventually, longer and longer periods of intermediate rates of responding appropriate to the fixed-interval schedule began to emerge, however, until the performance was a low, constant rate of responding in the fixed-interval schedule and a high, fixed-ratio rate of responding in the fixed-ratio stimulus. The fixed-ratio component showed some inductive effects from both the alternating fixed-interval schedule and the concurrent variable-interval schedule in the form of pauses during the fixed-ratio run and occasional periods of rates of responding somewhat less than the typical fixed-ratio value.

As the subjects were further exposed to the complex schedule, the performance remained stable and there was little tendency for scallops to form. There was no pausing after reinforcement or increase in rate of responding toward the end of the fixed-interval component, as might have occurred in a normal transition to this schedule without the concurrent variable-interval performance on the other key. A normal multiple-schedule performance in the fixed-interval component could possibly be produced, however, by extinguishing the behavior on the other key. After extinction had been complete on the left key (previously reinforced under the variable-interval schedule), the multiple schedule was continued until the normal performance emerged. Once the normal multiple schedule had developed, the variable-interval performance could be reinstated on the left key without disrupting the newly developed normal fixed-interval pattern. The concurrent variable-interval performance interfered with the normal transition to the multiple schedule, but did not interfere once the performance had been established. The effect was much more marked in No. 95 than in No. 93, whose fixed-interval and variable-interval rates of responding were of such a low order of magnitude that the fixed-interval scallop consisted of a long pause followed by only a few responses toward the end of the 10-minute fixed interval. When the variable-interval performance was extinguished, No. 93 also showed very severe inductive effects between the variable-interval performance on the left key and the fixed-interval performance on the right key. The extinction of the left-key performance produced a decrease in the level of responding on the multiple-schedule key instead of an increased rate of responding that might be expected if the behavior on the left key were no longer interrupting the right-key performance. This interaction suggests that the over-all frequency of reinforcement was important in maintaining the fixed-interval performance; and although the schedules of reinforcement on the two keys did not produce interfering patterns of responding, the effect of reinforcements occurring on the left key produced a generally increased disposition to respond on the right key.

It was possible to sustain very high fixed ratios (475) in both subjects with little pausing or any other sign of strain. Other experiments with chimpanzees do not suggest that these animals are especially able to sustain performances under unusually large fixed ratios. It is possible, of course, that the ability of these two animals to sustain performances under this large a fixed ratio represents a fortuitous occurrence especially characteristic of these two individuals and some inci-

dental feature of their history. Another possibility exists, however, that the concurrent reinforcement on the variable-interval schedule on the left key produced an inductive effect in the form of an ability to sustain the fixed ratio, even though the actual patterns of occurrence of the performances under the two keys were independent.

REFERENCES

- Ferster, C. B. Concurrent schedules in the chimpanzee. *Science*, 1957, **125**, 1090-1091.
- Ferster, C. B. Control of behavior in chimpanzees and pigeons by time-out from positive reinforcement. *Psychol. Monogr.*, 1958, **72**, whole No. 461.
- Ferster, C. B., and Skinner, B. F. *Schedules of reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Findley, J. D. Preference and switching under concurrent scheduling. *J. exp. anal. Behav.*, 1958, **1**, 123-144.
- Herrnstein, R. J. Some factors influencing behavior in a two-response situation. *Trans. N. Y. Acad. Sci.*, 1958, **21**, 35-45.
- Herrnstein, R. J., and Brady, J. V. Interaction among components of a multiple schedule. *J. exp. anal. Behav.*, 1958, **1**, 293-300.
- Sidman, M. By-products of aversive control. *J. exp. anal. behav.*, 1958, **1**, 265-280.
- Skinner, B. F. Are theories of learning necessary. *Psychol. Rev.*, 1950, **47**, 193-216.

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