

## INDEPENDENTLY DELIVERED FOOD DECELERATES FIXED-RATIO RATES<sup>1</sup>

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Following fixed-ratio baselines, the independent delivery of reinforcers was scheduled alone or concomitant with the fixed-ratio schedule for all subjects. Systematic manipulations of either the interreinforcement interval or the ratio size were also made during concomitant schedules. Response rates during the independent delivery of reinforcers did not decelerate until the subjects had been exposed for 50 or more sessions. Rates decelerated after a few sessions when the interreinforcement intervals were less than half of the original value and scheduled along with the ratio dependency. When both schedules were available, reductions in the ratio size resulted in slight deceleration of response rate when compared with the level of deceleration yielded by reductions in the independent reinforcement intervals.

Skinner (1948) reported that food delivered independently of behavior increased the probability of some response. Four of Skinner's six birds showed an increase in the frequency of some particular topography, *e.g.*, head bobbing, circling, neck stretching. These data suggest that many elements specified by a contingency need analysis in order to determine the manner in which contingencies control rate of response.

A first step in analyzing the role of contingencies in controlling rate of response was reported by Herrnstein (1966). He and Morse performed a study in which a pigeon's key pecks were reinforced on a fixed-interval 11-sec schedule of reinforcement (FI 11-sec). After nine days, food was delivered independently of key pecking every 11 sec. Herrnstein predicted that the response rate might not reflect the change from dependent food to independent food, at least initially. However, after continued exposure the pecking might disappear. The results show a drop in median response rate from 1.55 responses per second during the fixed interval to 0.6 responses per

second during the independent schedule. Certainly the independent delivery of food did maintain the response rate at some level, but the rates were not as high as those produced by the fixed-interval schedule both before and after the independence phase. Although the change in schedules is reflected in the response rate, the deceleration is not as great as that reported in Herrnstein's extinction data, where the median response rate was 0.19 responses per second.

Edwards, West, and Jackson (1968) reported a systematic replication of Herrnstein's pigeon study using both FI 11-sec and FI 60-sec with rats and pigeons. When the food was presented independently, response rates decelerated to zero in the FI 11-sec study and from 0.4 responses per second to 0.14 responses per second in the FI 60-sec study. When this deceleration is compared with that produced by the extinction procedure, the magnitude of change is comparable, but the extinction procedure resulted in more rapid deceleration.

The traditional test of a reinforcer has been an extinction procedure. If the behavior decreases in frequency when no food is available and increases when food is again available, the experimenter reports that the food is a functional reinforcer for his subject. Since extinction involves removal of both the dependency and the reinforcer, it is not clear which variable accounts for behavioral deceleration. If the independence procedure produces deceleration in response rate, the conclusion is that

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behavior is under the control of the schedule. However, comparison of Herrnstein's and Edwards *et al.* data indicates that deceleration may or may not occur when the relation is changed from dependent to independent. The nature of deceleration needs further analysis to evaluate the conditions under which independent presentations will in fact decelerate high response rates. The present study explored the effect of the independent delivery of reinforcers following establishment of fixed-ratio baselines in order to extend the information about the conditions under which independent presentations will decelerate response rates.

## METHOD

### Subjects

Five rats were maintained at 80% of their free-feeding weights throughout the experimental manipulations. Two of the five rats (Exp. I) were naive at the start of the study, while the others (Exp. II) had histories of discrimination training with fixed-ratio and extinction schedules alternating under stimulus control.

### Apparatus

Lehigh Valley Model 1316 two-bar rat boxes served as the experimental chambers. A 16% sucrose solution in the amount of 0.08 cc was delivered following completion of schedule requirements. All experimental operations were arranged with relay circuitry designed by Lehigh Valley and Grason-Stadler electronics companies. A Scientific Prototype CR2D cumulative recorder graphed responses across time. Daily session length was determined by the amount of time taken to receive 50 sucrose presentations.

## EXPERIMENT I: MANIPULATION OF INTERREINFORCEMENT INTERVALS OF INDEPENDENT SUCROSE, HOLDING RATIO SIZE CONSTANT

### Procedure

Table 1 shows the experimental design used in Exp. I. A baseline of fixed-ratio responding was established and maintained until response rates stabilized. Independent (NK) sucrose was then presented singly or simultaneously with

Table 1  
Experimental Manipulations for Exp. I

Rat 1	
Phase	Schedule
I	FR 35
II	NK 18 sec
III	FR 35
IV	NK 13 sec
V	FR 35
VI	FR 35 + NK 6.5 sec
VII	FR 35 + NK 13 sec
VIII	FR 35
IX	Extinction
Rat 2	
Phase	Schedule
I	FR 50
II	FR 50 + NK 42 sec
III	FR 50 + NK 21 sec
IV	FR 50 + NK 10.5 sec
V	FR 50 + NK 5 sec
VI	FR 50
VII	NK 28 sec
VIII	FR 50
IX	Extinction

dependent sucrose presentations (FR-NK). Independent sucrose presentations alone were continued until the response rate dropped to zero responses per minute. When dependent and independent sucrose presentations were simultaneously available, the interreinforcement intervals for independent presentations were systematically decreased until a zero response rate was reached.

Following this manipulation, responding was then reestablished in both rats; when these rates stabilized, both the dependency and the reinforcer were removed (Extinction).

The median interreinforcement interval during fixed-ratio responding was used as the interval between independent sucrose presentations in order to approximate the relationship between previous fixed-ratio responding and sucrose presentations. The median was compared with both the mean and the mode for the interreinforcement intervals from three sessions before each independency phase and was found to be the most representative measure.

## RESULTS

### Rat 1

Figure 1 presents daily response rates during the nine experimental phases. The first four

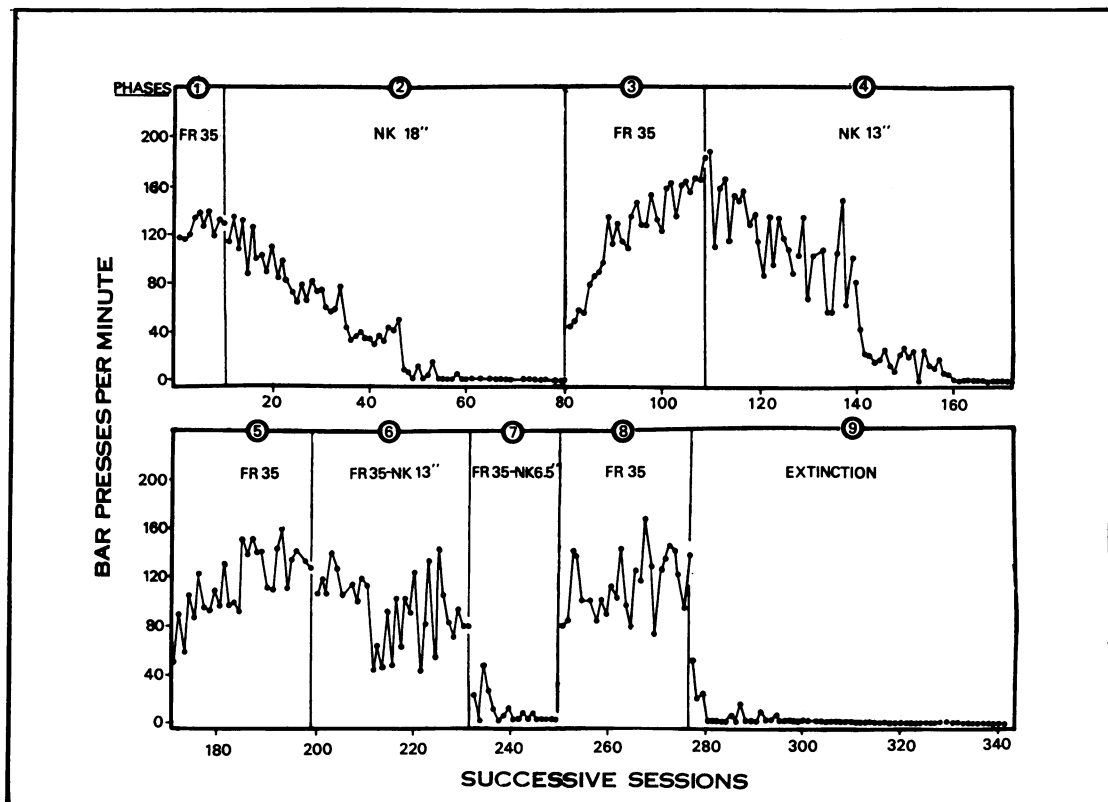


Fig. 1. Daily rates are plotted across all nine experimental conditions for Rat 1.

phases show high rates of responding during each FR 35 phase (Phases 1 and 3) and markedly reduced rates of responding during the independency phases (Phases 2 and 4). The reintroduction of FR 35 in Phase 5 produced a rapid acceleration in responding with day-to-day variability exceeding that which is evident in the initial FR 35 phase (Phase 1).

When Phase 6 was first introduced, some deceleration in responding occurred. However, when the size of the interreinforcement interval for independent sucrose was reduced by half (Phase 7), response rates decelerated to zero by the fourth day. Such a rapid deceleration occurred only during Phase 7 of the independent presentations.

Sample cumulative records during several of the nine phases are presented in Fig. 2. The first panel shows high stable response rates during FR 35. The NK 18-sec-A panel is taken from the first 37 days of the independence procedure and shows that ratio performance continues to dominate. Only three presentations of sucrose were made in the absence of a single

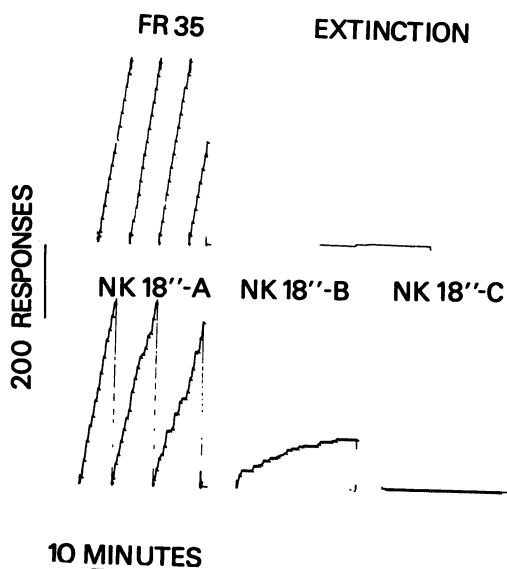


Fig. 2. Selected cumulative records representing fixed-ratio responding, typical patterns of response during independent sucrose deliveries, and extinction for Rat 1.

bar press during an independency interreinforcement interval. Panel NK 18-sec-B, selected from the middle 17 days, shows a large reduction in the overall rate of responding. The pattern is characterized by bursts of responses followed by pauses. Panel NK 18-sec-C selected from the last 12 days shows that no responses were made. Terminal performance rates during extinction were characterized by occasional bursts and discrete responses when the sucrose had been removed.

*Rat 2*

Figure 3 is a daily rate plot across all experimental manipulations. The rate did not decelerate to zero during Phases 2 to 5 until the independency interval was reduced to 5 sec, approximately one-eighth of the median de-

pendency interreinforcement interval. During Phases 6 and 7, response rates decelerated to zero. Reacquisition of ratio rates was achieved after several days (Phases 6 and 8), but with greater variability than found in the baseline ratio rate (Phase I). Response rates decelerated to zero by the sixth day during extinction (Phase 9).

Selected cumulative records are presented in Fig. 4. The FR 50 rate is high with only one post-reinforcement pause. The second panel shows the distribution of independent sucrose deliveries relative to on-going behavior. On several occasions two sucrose presentations would occur close together, but rarely did they occur when the rat was not pressing. The arrow marks the only instance in which a sucrose presentation occurred in the absence of a bar press.

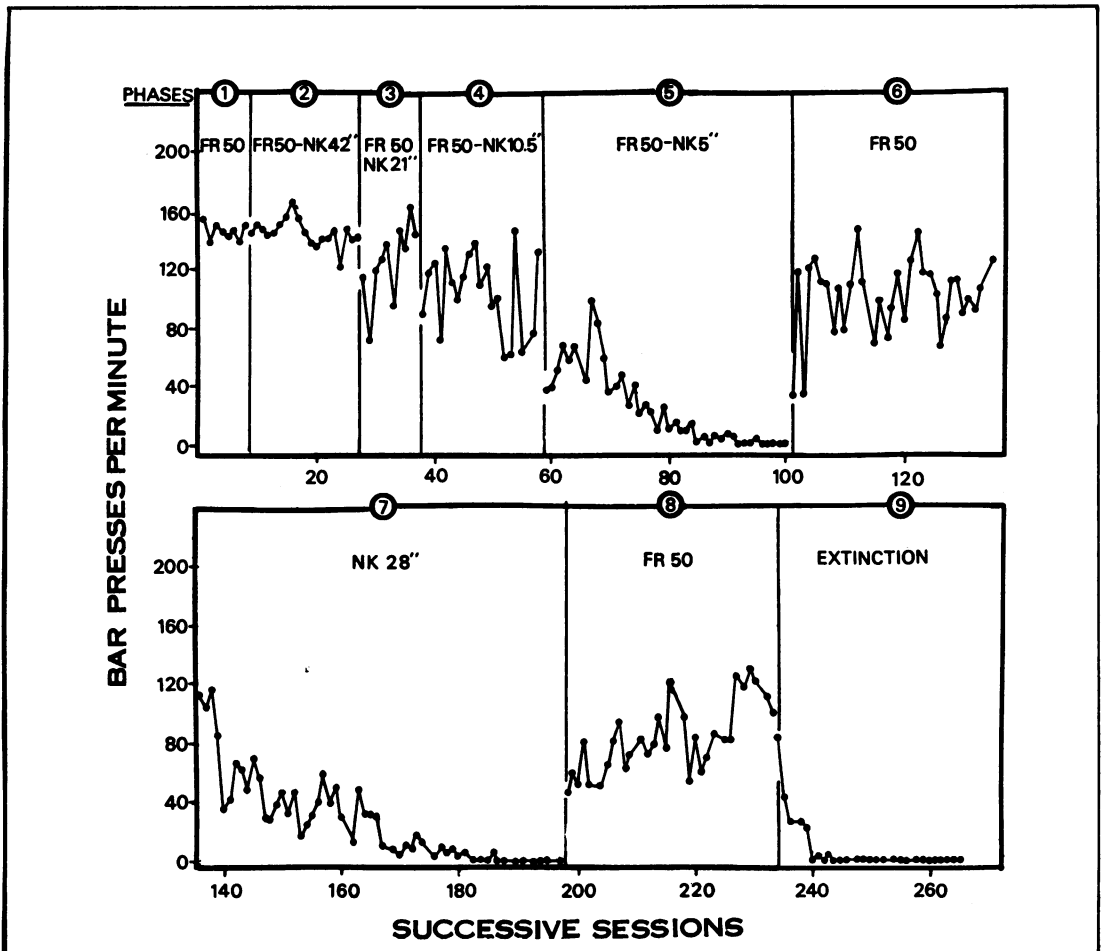


Fig. 3. Daily rates are plotted across all nine experimental conditions for Rat 2.

The third panel shows that when the independency interval was reduced by one half, several sucrose presentations occur in the absence of a single bar press toward the end of the session. When the independency interval is reduced by one-eighth, as shown in the fourth panel, a larger number of sucrose presentations occur in the absence of any bar press, again toward the end of the session. The fifth panel shows the last day of FR 50 and NK 5-sec during which there was only an occasional burst of behavior with most of the sucrose presentations occurring with no bar presses.

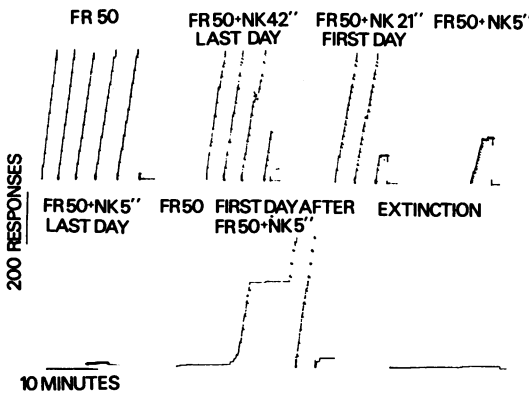


Fig. 4. Selected cumulative records representing fixed-ratio responding, simultaneous schedules of fixed ratio and independence at several different values, recovery of fixed-ratio responding, and extinction.

The next record represents the first day of the reintroduction of FR 50. After several small bursts of behavior, each followed by long pauses, the first ratio was completed. The next three ratios were emitted with typical ratio performance. A break in the ratio then occurs, followed by a long pause. More ratios are emitted, and finally, a burst and pauses occur near the end of the session. The final record presents behavior during extinction. Bar presses occur as either discrete presses or short bursts.

EXPERIMENT II: MANIPULATION OF RATIO SIZE HOLDING CONSTANT INTERREINFORCEMENT INTERVALS OF INDEPENDENT SUCROSE

Procedure

Fixed-ratio responding was stabilized for the three rats; the simultaneous presentation

of independent sucrose was then added. The independent reinforcers were delivered at the median interreinforcement interval of the fixed-ratio baseline to maintain the relationship between the previous fixed-ratio behavior and the sucrose presentations.

Fixed-ratio sizes were then systematically increased and decreased, while the interreinforcement intervals of independent sucrose were held constant. At least 10 days were given at each fixed-ratio size.

RESULTS

Table 2 presents the median response rates of each ratio manipulation for all three rats. With each decrease in the ratio size, the median

Table 2  
Schedules and Median Response Rates for Exp. II

Rat 3		Rat 4		Rat 5	
Sched-ule	Median Rate	Sched-ule	Median Rate	Sched-ule	Median Rate
FR 50	120	FR 50	160	FR 40	90
FR 50+		FR 50+		FR 40+	
NK 23 sec	130	NK 18 sec	150	NK 28 sec	65
FR 25+		FR 25+		FR 20+	
NK 23 sec	115	NK 18 sec	120	NK 28 sec	60
FR 12+		FR 12+		FR 80+	
NK 23 sec	95	NK 18 sec	95	NK 28 sec	65
FR 6+		FR 6+		FR 100+	
NK 23 sec	70	NK 18 sec	65	NK 28 sec	75

response rate also decreased to some degree. Increases in the ratio value yielded higher median response rates than the previous median response rate.

Figure 5 shows the response rates of the three rats decelerating as a function of reductions in ratio size. A comparison of rate decreases as a function of interreinforcement interval reductions (Exp. I) is also shown. Interval reductions yield lower rates than the same number of ratio reductions.

DISCUSSION

When schedules are changed from dependent to independent, response rates decelerate slowly across continued exposures to a zero level, a marked reduction in comparison to dependent rates of responding. These findings support Herrnstein's (1966) prediction that

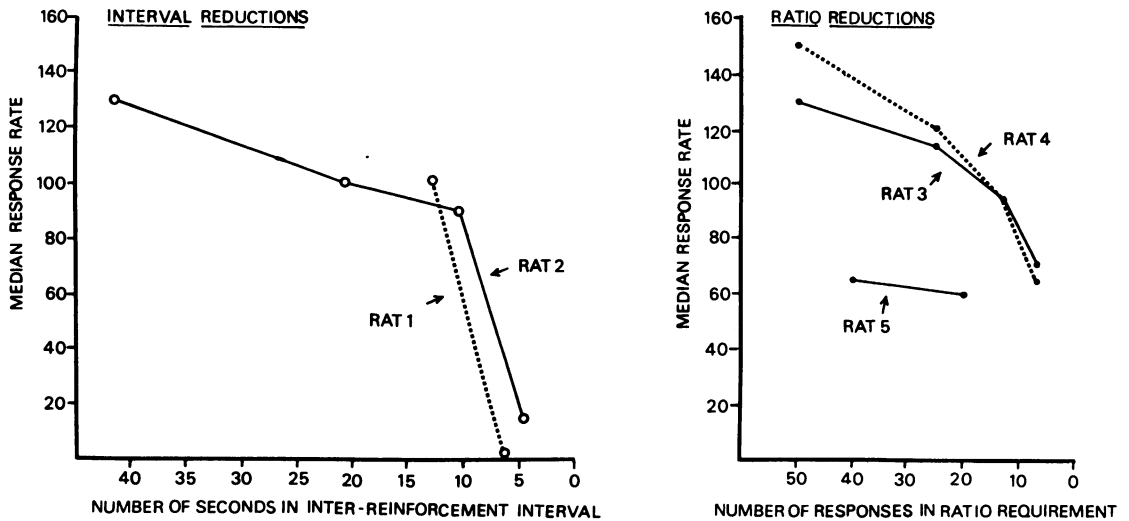


Fig. 5. Comparison of the behavioral effects when independence intervals or ratio sizes are systematically manipulated. See the procedure section for the exact value of the ratio requirement and the independence interval for any individual rat.

independent food presentations might produce behavioral deceleration under continued exposure.

The rate of deceleration is more rapid when independency schedules follow fixed-interval baselines than when they follow fixed-ratio baselines, but the terminal reduction in rate is comparable (Edwards *et al.*, 1968). This comparison suggests that the role of an independency schedule as a behavioral decelerator is determined by the baseline level of responding determined by the particular dependency used to build those baseline rates.

Reid (1958) reported an immediate increase in responding when a reinforcer was delivered following a period of no responding. The present data show samples of just such instances, and these may be responsible for the fact that final reductions happen only after continued exposure.

When reinforcers are independently superimposed on fixed-ratio behavior, there is initial variability with little reduction in overall response rate. When either the fixed-ratio size or the interreinforcement interval of independent reinforcement is reduced, the response rate is likewise reduced; the magnitude of deceleration depends upon the magnitude of change in either the fixed-ratio value or the interreinforcement interval value.

Comparing the reduction in the interreinforcement interval of independent reinforce-

ment with the reduction in the fixed-ratio size indicates that the interreinforcement interval manipulations produced a greater degree of deceleration. In both cases, the rate of reinforcement is increasing, but the changes in response rates indicate that the organism is differentially responding to changes in the interreinforcement intervals and ratio sizes. If it were merely rate of reinforcement, then one might expect the magnitude of response deceleration to be somewhat equivalent.

Studies that have assessed the role of rate of reinforcement in controlling rate of response report that as rate of reinforcement increases so does response rate (Clark, 1958; Wilson, 1954; Herrnstein, 1955, 1961). These studies always manipulated rate of dependent reinforcement. Since rate of reinforcement increased in the present study, but rate of response decreased, one might conclude that the independent delivery of sucrose was the controlling variable.

Both independence and extinction procedures produced a deceleration in rate of responding to zero. The data show that extinction produces a more rapid deceleration than independent reinforcers delivered at intervals equivalent to previous dependent deliveries. When independence interreinforcement intervals are reduced, both extinction and independence procedures produce a rapid deceleration of response rate.

It is suggested that a reinforcer delivered independently of behavior: (1) decelerates baseline response rates, (2) produces variability in return to dependent performance, (3) decelerates rates more rapidly if the independence interreinforcement interval is reduced, and (4) initially, has stimulating properties.

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