

## BEHAVIORAL CONTRAST IN RATS WITH DIFFERENT REINFORCERS AND DIFFERENT RESPONSE TOPOGRAPHIES<sup>1</sup>

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Experiment I demonstrated positive behavioral contrast in rats when one of two qualitatively different reinforcers (milk and pellets) was removed from a component of a multiple schedule. The contrast effect was larger and more enduring when milk was removed. Experiment II showed that the rats spent more time on the side of a shuttle-box on which milk was freely available than on the side on which pellets were freely available. Experiment III, a partial replication of Experiment I, failed to demonstrate the contrast effect of Experiment I. Experiment IV demonstrated contrast when two topographically distinct responses, nose-key poking and lever pressing, were required in different components of a multiple schedule. These results extend the conditions that generate behavioral contrast in rats.

*Key words:* behavioral contrast, pellet reinforcers, milk reinforcers, lever press, nose key, preference, rats

Positive behavioral contrast is usually defined as an increase in response rate in the unchanged component of a multiple schedule under conditions of a decrease in the frequency of reinforcement in an alternate component (Reynolds, 1961). Attempts to demonstrate contrast in rats have produced ambiguous results when the reinforcer and operant used in the components of a multiple schedule were the same (*cf.* Bernheim and Williams, 1967; Freeman, 1971; Pear and Wilkie, 1971). The present research dealt with the interaction of different operants. Since "... the topography and the consequences define an operant" (Skinner, 1969, p. 128), contrast with different operants was investigated when (a) operants of different topographies produce the same reinforcer and when (b) operants of the same or similar topographies produce different reinforcers.

Other investigators have been interested in

the questions to which the present research is addressed. Premack (1969) studied the interaction of topographically different operants and the interaction of similar operants maintained by different reinforcers. In a rather complicated experiment, he found that wheel running reinforced by milk increased in rate when the schedule of reinforcement for bar pressing was altered to make reinforcement (also milk) less frequent. An unusual feature of this experiment was that wheel running was trained in the morning and bar pressing occurred in the afternoon. In another study, he found that bar pressing reinforced by water increased in rate when bar pressing reinforced by the opportunity to run in an activity wheel was extinguished. This contrast effect seemed reasonably clear in three of four rats, although for all rats the rate of water-reinforced bar pressing increased throughout the experiment.

Beninger (1972) observed contrast in a multiple schedule in which responding was reinforced by milk in one component and electrical brain stimulation in another. Response rates in the milk component increased when bar pressing was extinguished in the component with brain stimulation as the reinforcer. In all of the studies employing two reinforcers, only one has been removed; as a result of this asymmetry, the effects of extinction of the second reinforcer (*e.g.*, milk in the Beninger experiment) are unknown.

Scull and Westbrook (1973) trained pigeons

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to press a bar in one component of a multiple schedule and to peck a key in an alternate component. The reinforcer in both components was food. They found (a) the key-pecking rate remained stable when bar pressing was extinguished and (b) bar pressing rates decreased when key pecking was extinguished. The latter finding would be characterized as induction (Reynolds, 1961). These results with pigeons do not support Premack's finding with rats. The fourth experiment in the present series may provide a better comparison, since it studied in rats the interaction of bar pressing and pressing a nose key.

### EXPERIMENT I

In Experiment I, rats were trained on a multiple schedule with random-interval (RI) components. Sweetened condensed milk was the reinforcer in one component and solid pellets in the other. The experiment was conducted to determine whether or not contrast would occur if a reinforcer was removed from a component, *i.e.*, if a component was changed to extinction, and whether the magnitude of the effect would depend on which reinforcer was removed.

### METHOD

#### *Subjects*

Five male rats of the hooded Long-Evans strain were maintained at 76 to 84% of their free-feeding body weights throughout the experiment. Rats H and I had had approximately 25 sessions of training on single RI schedules for milk reinforcement and Rats J, K, and L had had approximately 20 sessions of training on single RI schedules for pellet reinforcement before this experiment began.

#### *Apparatus*

The experimental chamber, manufactured by Lehigh Valley Electronics Company (model #143-25), had interior measurements of 24 by 30 by 26.5 cm. On one of the ends, a bar (lever), 2.5 cm long, was located 2 cm from the left side and 4 cm above the grid floor. The force requirement for the bar was 0.27 N. Three cuellights were situated 4.5 cm directly above the lever. A liquid feeder cup was located 5.5 cm to the right of the lever and 1.5 cm above the floor. A pellet dispenser opening

was located 3 cm to the right of the liquid feeder and 1.5 cm above the floor. The experimental chamber was enclosed in a sound-attenuating box (LVE model #132-02), ventilated by a small fan, and provided with constant masking noise.

Lehigh Valley Electronics solid-state switching and timing devices, located in the same room, were used to arrange the contingencies. A time-linked probability gate (model #335-11) was used to generate the RI schedules. Data were recorded on an elapsed-time meter, counters, and a paper-tape printout counter.

#### *Procedure*

Milk reinforcement consisted of a 5-sec dipper presentation of 0.1 cc of Nestle's Sweetened Condensed Milk mixed in 1:1 proportion by weight with water. Since the dipper presentation made little sound, the right cuellight was illuminated during this event to signal reinforcement. Pellet reinforcement consisted of the presentation of one 45-mg Noyes Precision Food Pellet. All five rats received several sessions (see Subjects section above) of training on an RI 30-sec schedule followed by training on a *mult* RI 30-sec (milk) RI 30-sec (pellets) schedule (*i.e.*, baseline schedule).

Each component of the baseline schedule was in effect for 2 min and was then automatically switched to the alternate component. For Rats H and I, the houselight was illuminated during the RI 30-sec (milk) component and was switched off during the RI 30-sec (pellets) component. For Rats J, K, and L these stimuli were reversed. Forty-minute daily sessions consisted of 10 cycles of the multiple schedule.

When responding on the baseline schedule showed no trend for five consecutive sessions, with a minimum of 25 sessions (for number of sessions for individual rats see Figure 1), one of the components was switched to EXT. For Rats H and J, the milk component was switched to EXT; for Rats I, K, and L, the pellets component was switched to EXT. During the final 10 sec of each extinction component, any response reset a 10-sec timer; this changeover delay (COD) was scheduled to prevent superstitious chaining. The *mult* RI 30-sec EXT schedule remained in effect for 15 sessions, after which the *mult* RI 30-sec (milk) RI 30-sec (pellets) schedule was re-instated.

When responding on the baseline schedule had again stabilized with a minimum of 15 sessions (for number of sessions for individual rats see Figure 1), the milk component was switched to EXT for Rats I, K, and L and the pellets component was switched to EXT for Rats H and J. A COD was again utilized at the end of EXT. The *mult* RI 30-sec EXT schedules remained in effect for 15 sessions, after which the baseline schedule was again re-instated for at least 12 additional sessions.

### RESULTS

The response rates (in responses per minute) for each phase for all rats are shown in Figure 1. Each point represents the response rate during the milk, pellets, or EXT component for one session. Note that the scale on the ordinate is doubled for Rats H, K, and L. Only the last five sessions of each baseline phase are shown; all 15 sessions of each *mult* RI 30-sec (pellets) EXT and each *mult* RI 30-sec (milk) EXT phase are shown. Phases are arranged in the order of presentation for each rat.

For all rats, the response rates during the pellets component increased above the baseline pellets rate when the baseline schedule was switched to *mult* RI 30-sec (pellets) EXT. For every rat, except Rat J, the rates showed a rising trend over the 15 sessions of the *mult* RI 30-sec (pellets) EXT phase. For Rat J, the rates levelled off after 11 sessions and remained about constant for the remainder of the phase. The response rates during the pellets component for three of the five rats (Rats I, J, and L) returned approximately to baseline during the last five days of the second baseline phase. For Rats H and K, the second baseline rates were higher than the original baseline rates.

Figure 1 shows that for all rats except Rat H, the response rate during the milk component increased above the baseline milk rates when the baseline schedule was switched to *mult* RI 30-sec (milk) EXT; the rates for Rat H decreased after the first session of *mult* RI 30-sec (milk) EXT. Closer examination of Figure 1 reveals, however, that with the possible exception of Rat J, the rates in the milk component did not continue to increase over sessions, as they did for the pellets component during the *mult* RI 30-sec (pellets) EXT phase. Instead, after an initial increase, the

rates in the milk component either levelled off (Rats I and J) or began to decrease (Rats H, K, and L). For Rats H and K, the response rate during the milk component of the second baseline phase fell below the initial baseline level, while the initial baseline rates were approximately reestablished for Rats I, J, and L.

Either the first or second baseline response rates for milk and for pellets differed for Rats H, K, and L. These differences made it unclear whether absolute increases or decreases in response rate could be compared meaningfully. It is possible that percentage change, rather than absolute change should be compared. Figure 2 shows the response rates of Figure 1 expressed as a percentage of the preceding milk or pellets mean response rate over the last five sessions of baseline. Figure 2 shows that for all rats, the magnitude of the contrast effect was greater when milk was withdrawn than when pellets were withdrawn.

### DISCUSSION

The data from Experiment I replicated previous results by Beninger (1972) and Premack (1969). In addition, the data provided evidence that the magnitude of contrast varies depending on which reinforcer is removed. Contrast effects were larger and more enduring when responding was extinguished in the milk component. When pellets were removed, one rat displayed induction, and the contrast effects for another two rats were temporary.

Pear and Wilkie (1971) observed that contrast may not endure in rats when extinction is put into effect in one component. Since our rats were given fewer sessions than theirs, it remains possible that the elevated response rate in the pellets component would have eventually returned to baseline levels. Data from pigeons have shown both that contrast effects disappear (Terrace, 1966) and that contrast does not disappear (Hearst, 1971).

Differences in the magnitude of the contrast effect were observed. These differences may be understood with reference to Herrnstein's (1970) treatment of responding in multiple and concurrent schedules. Basically, Herrnstein proposed that the rate of responding in one component of a multiple or concurrent schedule depends on the relative rate of reinforcement in that component. If the two components of a multiple schedule

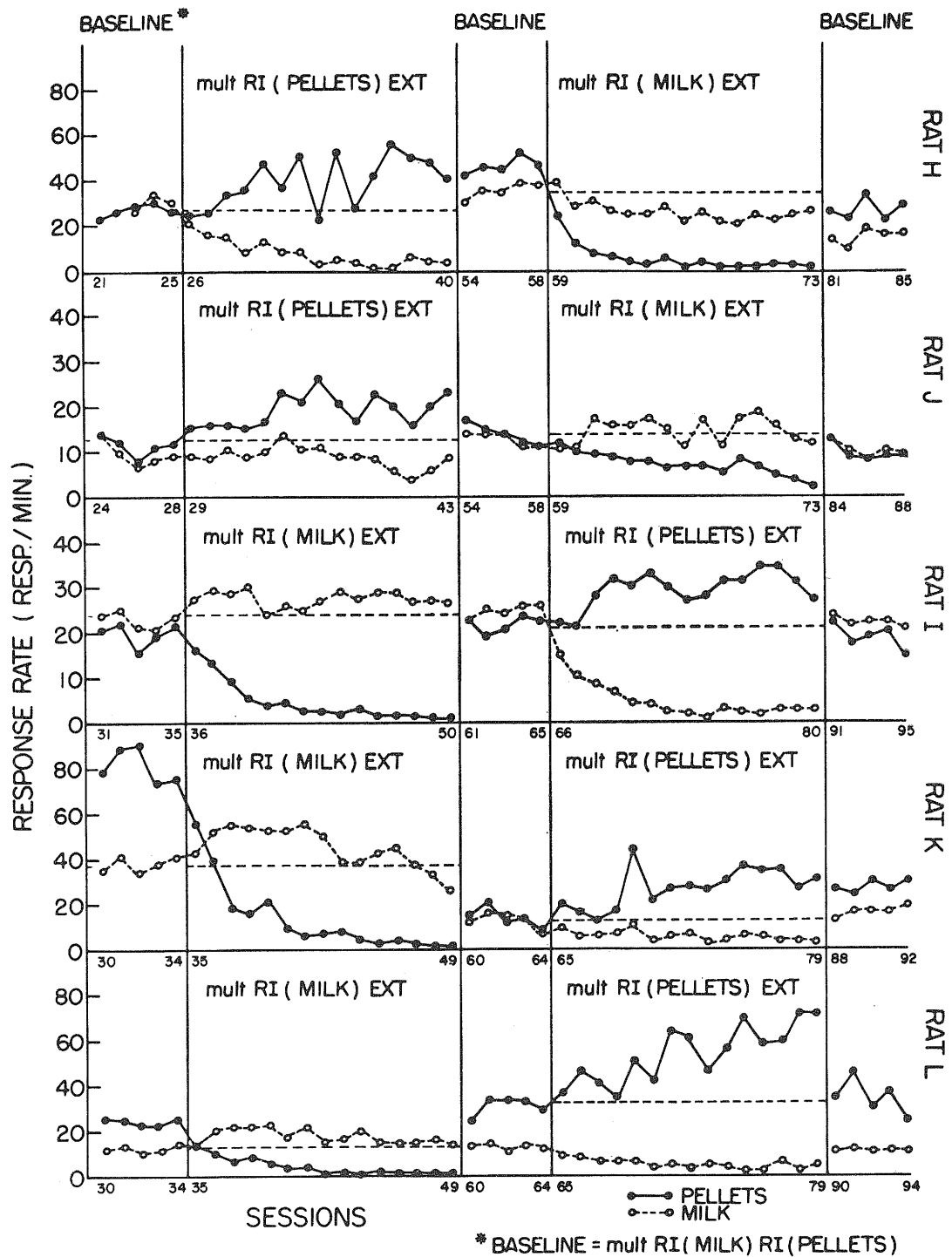


Fig. 1. Response rate (responses per minute) for each phase for all rats. Each point represents the response rate for milk, pellets, or extinction for one session. Only the last five sessions of each baseline phase are shown. The horizontal broken lines represent the mean response rate during the last five sessions of baseline in the component that was unchanged during the contrast phase. The scale on the y-axis has been doubled for Rats H, K, and L. Numbers along the x-axis indicate the session that the points represent.

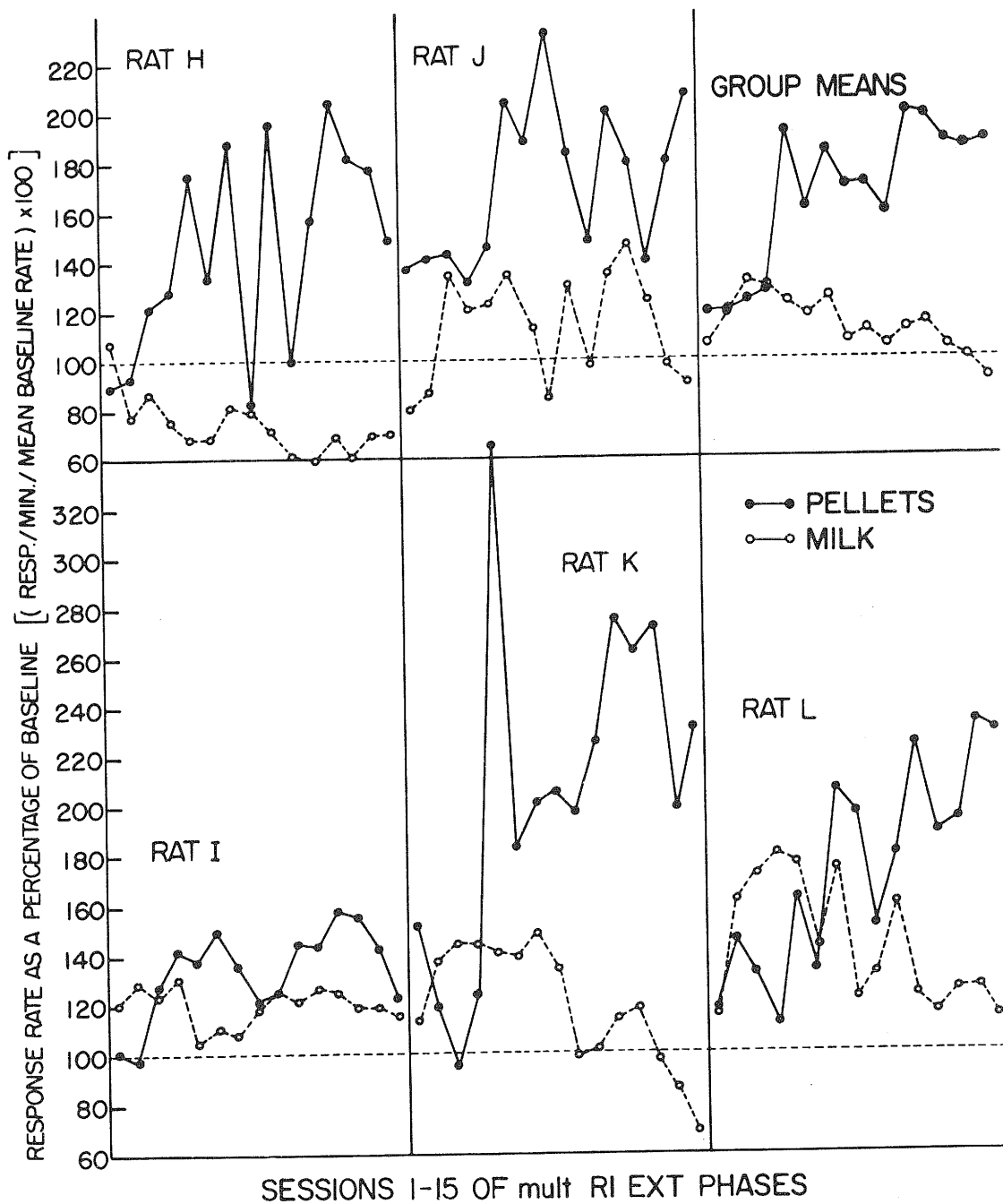


Fig. 2. Response rates (responses per minute) expressed as a percentage of mean baseline rate (mean of response rate in the last five sessions for the milk or pellets component during baseline) for each session of *mult* RI (milk) EXT and each session of *mult* RI (pellets) EXT for all rats. The upper-right panel shows the group means.

differ in their associated reinforcement rates, changing the component with the higher rate of reinforcement to extinction will produce a larger contrast effect than changing the com-

ponent with the lower rate of reinforcement to extinction (*cf.* Herrnstein's Equation 20). If quality and rate of reinforcement are interchangeable, as suggested by Hollard and

Davidson (1971) with reference to concurrent schedules, then removal of the more-valued reinforcer should produce a larger contrast effect than removal of the less-valued reinforcer. The difference in the magnitude of the contrast effects reported above would therefore be expected if the relative value of milk was greater than that of pellets.

## EXPERIMENT II

The contrast data of Experiment I are consistent with the notion that milk has a greater relative value than pellets. In Experiment II, milk was placed on one side of a shuttle box and pellets on the other; preferences were examined by measuring the relative time spent on either side.

### METHOD

#### *Subjects*

Four experimentally naive male Long-Evans hooded rats were maintained at approximately 80% of their free-feeding body weights throughout the experiment.

#### *Apparatus*

The experimental chamber was a Lehigh Valley Electronics rat toggle floor shuttle cage (model #146-04) with no hurdle separating the sides of the box. Mounted 4 cm above the floor on each end was a rectangular dish (approximately 5 by 8 by 1.5 cm deep). The experimental chamber was placed in a dark room and provided with constant masking noise. Standard electromechanical devices were used to arrange the contingencies.

#### *Procedure*

During Phase 1, the dish on the right side of the box was filled with Nestles' Sweetened Condensed Milk mixed in 1:1 proportion by weight with water and the dish on the left side of the box was filled with 45-mg Noyes Precision Food Pellets. Ten-minute daily experimental sessions consisted of placing the rat into the chamber where it was free to drink milk or eat pellets. Time spent on each side of the chamber was recorded on elapsed-time meters. For Rats 40 and 42, the cuelight was on when the animal was on the milk side and off when on the pellets side; for Rats 41 and 43, these stimuli were reversed. Phase 1 consisted of nine sessions, after which the milk

was switched to the dish on the left side and pellets to the dish on the right side for five additional sessions (Phase 2). No rat exhausted the supply of milk or pellets in an experimental session.

### RESULTS

The per cent of time spent on the milk side for each session for all rats is shown in Figure 3. These data suggest that the rats spent more time consuming milk than consuming pellets; illumination of neither the cuelight nor the side of the chamber on which milk was located affected the preference. The average time spent on the milk side for all rats during the last 10 sessions of the experiment was 73.8%.

### DISCUSSION

The finding that the rats spent more time on the side containing milk suggests that this factor may have produced the differences in the magnitude of contrast found in Experiment I. Since, however, the rats had free access to milk and pellets, and the amounts actually consumed were not measured, these data give little indication of the relative values of the particular reinforcers in Experiment I. Nevertheless, the findings of Experiment II are consistent with the interpretation of Experiment I offered above, at least as far as the magnitude of contrast is concerned.

## EXPERIMENT III

In Experiment I, all rats had received a number of sessions of training on RI schedules before the experiment was begun; data from these sessions were not available, however. If response rates during RI 30-sec (milk) or RI 30-sec (pellets) schedules presented alone were compared to the response rate during the schedule when it is a component of a multiple schedule, it could be determined if an interaction would appear with the introduction of an alternate component in a multiple schedule. For instance, if a rat is pressing on an RI schedule for pellets and the schedule is changed to a multiple with milk reinforcement in one component, will the rate in the pellets component decline? A decline might be expected if milk has a greater relative value than pellets. An asystematic investigation of this possibility was attempted in Experiment III.

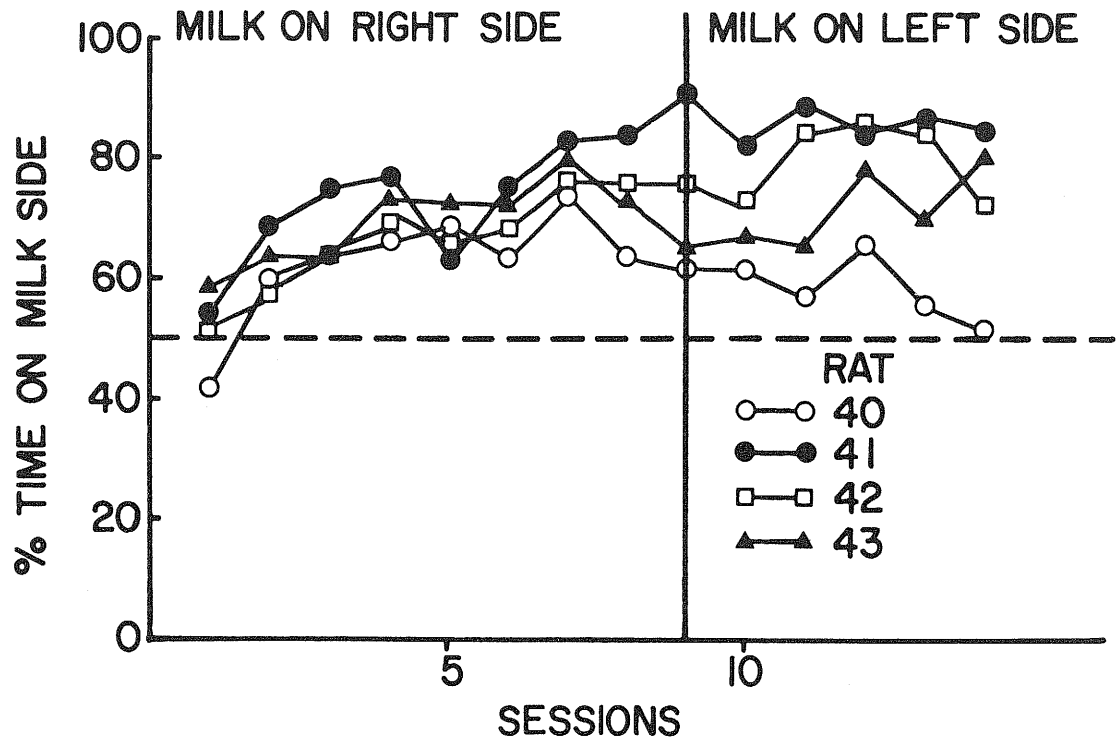


Fig. 3. Per cent of time spent on the milk side for all rats. Broken horizontal line represents level of no preference (50%).

In addition, a partial replication of Experiment I was carried out.

#### METHOD

##### Subjects

Six experimentally naive male Long-Evans hooded rats were maintained at 76 to 84% of their free-feeding body weights throughout the experiment.

##### Apparatus

The experimental environment and control equipment were identical to that described in Experiment I.

##### Procedure

Reinforcers and conditions of reinforcement were identical to those used in Experiment I. The lever-press response was shaped with milk for Rats 13, 14, and 15 and with pellets for Rats 16, 17, and 18. Following shaping, all rats except Rat 14 were exposed to 15 sessions of RI 30-sec. Rat 14 received 16 sessions. The reinforcer during these sessions was the same as that used for shaping. During RI training, the

houselight was illuminated for Rats 13, 14, 16, and 17 and was off for Rats 15 and 18.

Random-interval training was followed by 15 sessions of training on a *mult* RI 30-sec (milk) RI 30-sec (pellets) schedule (*i.e.*, baseline schedule) for all rats. Multiple-schedule components were of 2-min duration. The prevailing houselight conditions were in accordance with the original single-reinforcer random-interval schedule, *i.e.*, houselight illuminated during the milk component for Rats 13, 14, and 18 and during the pellets component for 15, 16, and 17. During the alternate component, the houselight was off. Forty-minute daily sessions consisted of 10 cycles of the multiple schedule.

All rats were given 15 sessions of the baseline schedule followed by 15 sessions of training on *mult* RI 30-sec EXT. Rats 13, 14, and 15 were placed on EXT in the pellets component and Rats 16, 17, and 18 were placed on EXT in the milk component. Thus, the reinforcer available during the *mult* RI 30-sec EXT phase was the one used in the original shaping procedure. During this phase, a changeover

delay was in effect for the final 10 sec of the EXT component. In the final phase, the baseline schedule was re-instated for 10 sessions.

### RESULTS

The response rates (in responses per minute) for each phase for all rats are shown in Figure 4. Each point represents the response rate during the milk, pellets, or EXT component for one session. Only the last five days of the RI 30-sec phase and the last five sessions of each baseline phase are shown; all 15 sessions of each *mult* RI 30-sec (milk) EXT and each *mult* RI 30-sec (pellets) EXT phase are shown.

For Rats 13, 14, and 15, a comparison of the response rates during the RI 30-sec schedule for milk when it was presented alone and when it was alternated with the pellets component in the baseline schedule, showed a small decrease in the milk response rate for Rats 13 and 14 and a small increase for Rat 15. When the milk component was alternated with EXT, the response rate initially decreased for all three rats and then increased either to baseline levels (Rat 13) or above (Rats 14 and 15). Figure 4 also shows that the milk response rate returned to baseline (Rats 13 and 14) or was lower than (Rat 15) baseline during the last five days of the second baseline phase.

For Rats 16, 17, and 18, a comparison of the response rates during the RI 30-sec schedule for pellets when it was presented alone and when it was alternated with the milk component in the baseline phase, showed that the pellets rates increased. When the pellets component was alternated with EXT, the response rate initially either decreased (Rats 16 and 18) or showed little change (Rat 17). The response rate for pellets for Rat 16 never increased to baseline during the *mult* RI (pellets) EXT phase; for Rats 17 and 18, the rates increased to above the baseline level by the end of the *mult* RI 30-sec (pellets) EXT phase. Figure 4 also shows that the pellets response rate fell below the initial baseline rate during the second baseline phase.

### DISCUSSION

Introduction of the second component of the multiple schedule produced no very marked effects in either the milk or the pellets group. Based on the data from Experiment II, plus the assumption that the response rate in the component with the less-preferred

reinforcer will decline, whereas the rate in the component with the more-preferred reinforcer will not, we might have expected a reduced rate in the pellets component in the group pretrained with pellets. However, there seemed to be at least a slight rise in response rate in the pellets component in that group. Similarly, introduction of pellets to the milk group might have increased the milk rates, with the pellets rate being lower. However, there were no consistent results from this group when pellets were introduced.

Comparison of the data from the first baseline, contrast test phase, and second baseline suggest that contrast appeared in three rats (15, 17, and 18) and perhaps in a fourth (Rat 14). It is clear that contrast did not appear in Rats 13 and 16. In fact, for Rat 16, as the rate decreased in the EXT component, it also decreased in the component in which reinforcement occurred. This would be classified as induction. These data are somewhat comparable to those of Pear and Wilkie (1971), who found contrast in only some of their rats.

At best, the contrast results only partially replicated the results of Experiment I. Experiments I and III differed in the number of sessions of training on RI 30-sec schedules before the first baseline phase and in the number of multiple-schedule sessions given in the first baseline phase. However, only in the latter case would a discrimination have been developing. Fewer baseline sessions were given in Experiment III (15) than in Experiment I (25 to 35). This factor may have attenuated the development of contrast. The rapidity of the development of contrast is related to the magnitude of the physical difference between the stimuli (Mackintosh, Little, and Lord, 1972) and may be related to other factors affecting stimulus control. A multiple schedule involving different reinforcers has two operants: in the present case, a milk operant and a pellets operant. They are similar topographically, but would become discriminated as training continued. We might hypothesize that insufficient training was given in Experiment III to allow a good discrimination to develop. Failure of contrast to occur, then, would be related to the failure of good stimulus control to develop.

This account has some obvious flaws. One is that, even though control over the separate operants may have been incomplete, reinforce-



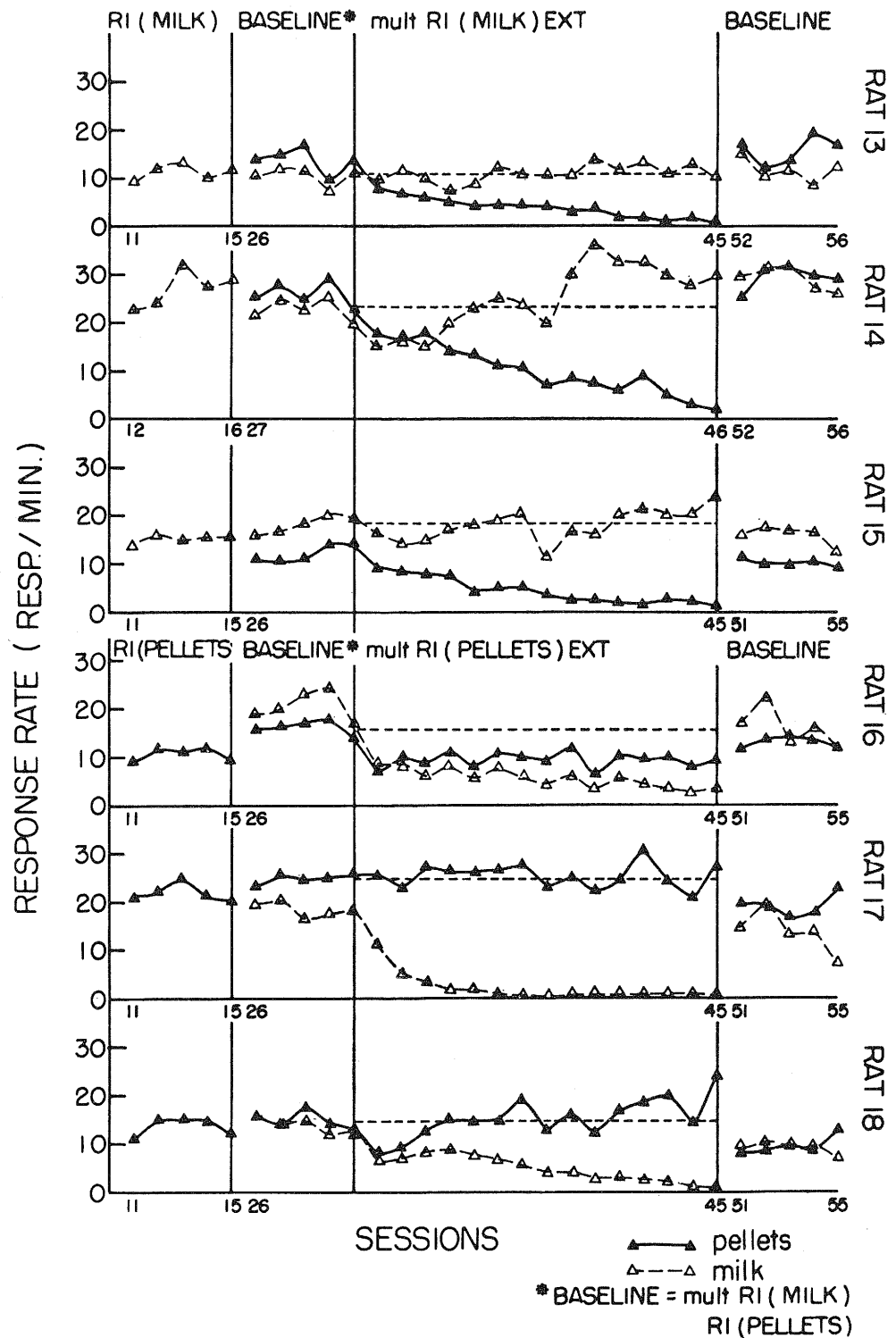


Fig. 4. Response rates (responses per minute) for each phase for all rats. Each point represents the response rate for milk, pellets, or extinction for one session. Only the last five sessions of each RI 30-sec phase and each baseline phase are shown. The horizontal broken lines represent the mean response rate during the last five sessions of baseline in the component that remained unchanged during the contrast phase.

ment was removed from one component under stimulus conditions (light/dark) that produced contrast in Experiment I. Thus, contrast should eventually have appeared. However, since Pear and Wilkie (1971) observed the eventual disappearance of contrast in all of their rats, it may be that, if the development of contrast is retarded for some reason, it will never occur in rats. This result would probably not be expected in pigeons, however, since there is at least some evidence that indicates contrast does not disappear with extended training, as was originally claimed by Terrace (1966) (Hearst, 1971).

Since contrast has occurred in several experiments besides Experiment I that involved two reinforcers (Beninger, 1972; Premack, 1969), we are inclined to view the results of Experiment III as due to some factor preceding the contrast phase, a factor that retarded or attenuated the development of contrast.

#### EXPERIMENT IV

Conflicting data exist on the interaction of topographically different operants (see above). Thus, Premack (1969) found evidence for contrast in rats when bar pressing and wheel running were the operants. Scull and Westbrook (1973) found either no contrast or induction when pigeons key pecked or pressed a bar. Experiment IV investigated the interaction of bar pressing and nose-key pressing in rats.

#### METHOD

##### *Subjects*

Six experimentally naive male Long-Evans hooded rats were maintained at 76 to 84% of their free-feeding body weights throughout the experiment.

##### *Apparatus*

The experimental chamber, manufactured by Lehigh Valley Electronics Company (model #143-23), had interior measurements of 25 by 30.3 by 25.7 cm. In the middle of one wall of the test chamber was a liquid feeder cup at a height of 1.5 cm above the grid floor. A 2.8-cm wide bar was located 8 cm to its left at a height of 3 cm. The force requirement for the bar was 0.30 N. At the same distance to the right of the feeder and at the same height was

a nose key (LVE model #121-15), mounted with its surface 0.5 cm behind a 3 cm horizontal by 1.5 cm rectangular hole. The force requirement for the key was 0.15 N. The experimental chamber was enclosed in a sound-attenuating box (LVE model #132-02), ventilated by a small fan, and provided with constant masking noise.

BRS-Foringer Electronics solid-state switching and timing devices, located in the same room, were used to arrange the contingencies. Data were recorded on an elapsed-time meter, counters, and a paper-tape printout counter.

##### *Procedure*

For Rats 25, 26, and 27 the bar-press response was shaped with reinforcement consisting of a 5-sec dipper presentation of 0.1 cc of Nestles' Sweetened Condensed Milk mixed in 1:1 proportion by weight with water. For Rats 28, 29, and 30, nose-key pressing was shaped with the same reinforcer. After shaping, all rats received 15 sessions of training on a VI 30-sec schedule. During this phase, the houselight was illuminated for Rats 25, 26, 28, and 29 and remained off for Rats 27 and 30.

After training on the VI 30-sec schedules, all rats received 15 sessions of training on a *mult* VI 30-sec (lever) VI 30-sec (key) schedule (*i.e.*, baseline schedule). Each component was in effect for 2 min and was automatically switched to the alternate component. For Rats 25, 26, and 30 the houselight was illuminated during the VI 30-sec (lever) component and was switched off during the VI 30-sec (key) component. For Rats 27, 28, and 29, these stimuli were reversed. Forty-minute daily sessions consisted of 10 cycles of the multiple schedule.

After 15 sessions of the baseline schedule, one of the components was switched to EXT. For Rats 25, 26, and 27, the lever component was switched to EXT; for Rats 28, 29, and 30, the key component was switched. A 10-sec COD was scheduled after 110 sec of each EXT component to prevent superstitious chaining. The *mult* VI 30-sec EXT schedules remained in effect for 15 sessions, after which the baseline was re-instated for 10 additional sessions.

#### RESULTS

The response rates (in responses per minute) for each phase for all rats are shown in

Figure 5. Each point represents the response rate during the lever, key, or EXT component for one session. Only the last five sessions of the VI 30-sec phase and of each baseline phase are shown; all 15 sessions of each *mult* VI 30-sec (lever) EXT and each *mult* VI 30-sec (key) EXT phase are shown.

For all rats, a comparison of the response rates during the VI 30-sec schedules of bar pressing or key poking when they were presented alone and when they were alternated with each other in the baseline schedule, showed no systematic change for either operant. When the baseline schedule was switched to *mult* VI 30-sec (lever) EXT for Rats 25, 26, and 27, the response rates during the lever component increased above the baseline bar-pressing rates. The lever response rates failed to return to their original baseline levels for Rats 25 and 27 during the second baseline phase. For Rats 28, 29, and 30, the response rates in the key component increased above the baseline key-pressing rates when the baseline schedule was switched to *mult* VI 30-sec (key) EXT. The key response rates returned to their original baseline levels for all rats in the return-to-baseline phase.

#### DISCUSSION

The data clearly showed that contrast may be obtained with topographically differing operants maintained by a common reinforcer, thus supporting the data of Premack (1969). There are, of course, several differences between the present research, that of Premack (1969), and that of Scull and Westbrook (1973). One, obviously, is the species difference. Another is the degree of topographical overlap. This is difficult to evaluate, but bar pressing, wheel running and nose-key pressing in rats are probably more similar than key pecking and bar pressing for a pigeon. Bar pressing and wheel running both involve the forelimbs of the rat. Bar pressing and nose-key pressing may both involve the head of the rat. Rats are observed to bite and sniff at bars they are pressing for food. (We have observed this on videotapes made by Dr. Douglas Reberg.) On the other hand, key pecking and bar pressing for food involve different parts of the body of the pigeon.

The preparedness continuum of Seligman (1970) may also be relevant to the interpretation of the data on the interaction of two

topographies. A prepared operant is one that is readily strengthened by the reinforcer selected by the experimenter; a contraprepared response is one that is strengthened only with more prolonged training (Seligman, 1970). Again, this is difficult to evaluate, but all of the rat behaviors studied, with the possible exception of wheel running would seem to be nonprepared. Of course, rats in a natural environment do not run in a wheel to get food, but they probably do run. On the other hand, key pecking is presumably highly prepared. The observations of one of the authors (SBK) in attempting to shape treadle pressing in pigeons indicate that this response is highly contraprepared, particularly when the bar was as high as 7 cm from the floor, as it was in the Scull and Westbrook experiment. Scull and Westbrook observed very large differences in absolute rate between key pecking and bar pressing in their birds.

Thus, we may conclude that contrast may occur when the extinguished operant is topographically different from the one that is maintained, but the variables responsible for differences between experiments remain unidentified.

#### GENERAL DISCUSSION

The present results may be summarized in the following way: (1) positive behavioral contrast may be obtained in rats when different reinforcers are employed in different components of a multiple schedule and behavior in one component is placed on extinction; (2) the magnitude of the contrast seems to be related to the type (milk or pellets) of reinforcer removed; (3) contrast may be attenuated by some unknown variables operating in Experiment III, most probably the amount of precontrast training; (4) contrast may be obtained when topographically different operants are employed in different components of a multiple schedule and one is placed on extinction.

The above findings extend and complement data from other studies. Experiments using two different reinforcers have been conducted by Beninger (1972) and by Premack (1969). The present data support these studies and further suggest that the relative value of the deleted reinforcer may be a factor in determining the amount of contrast. The more

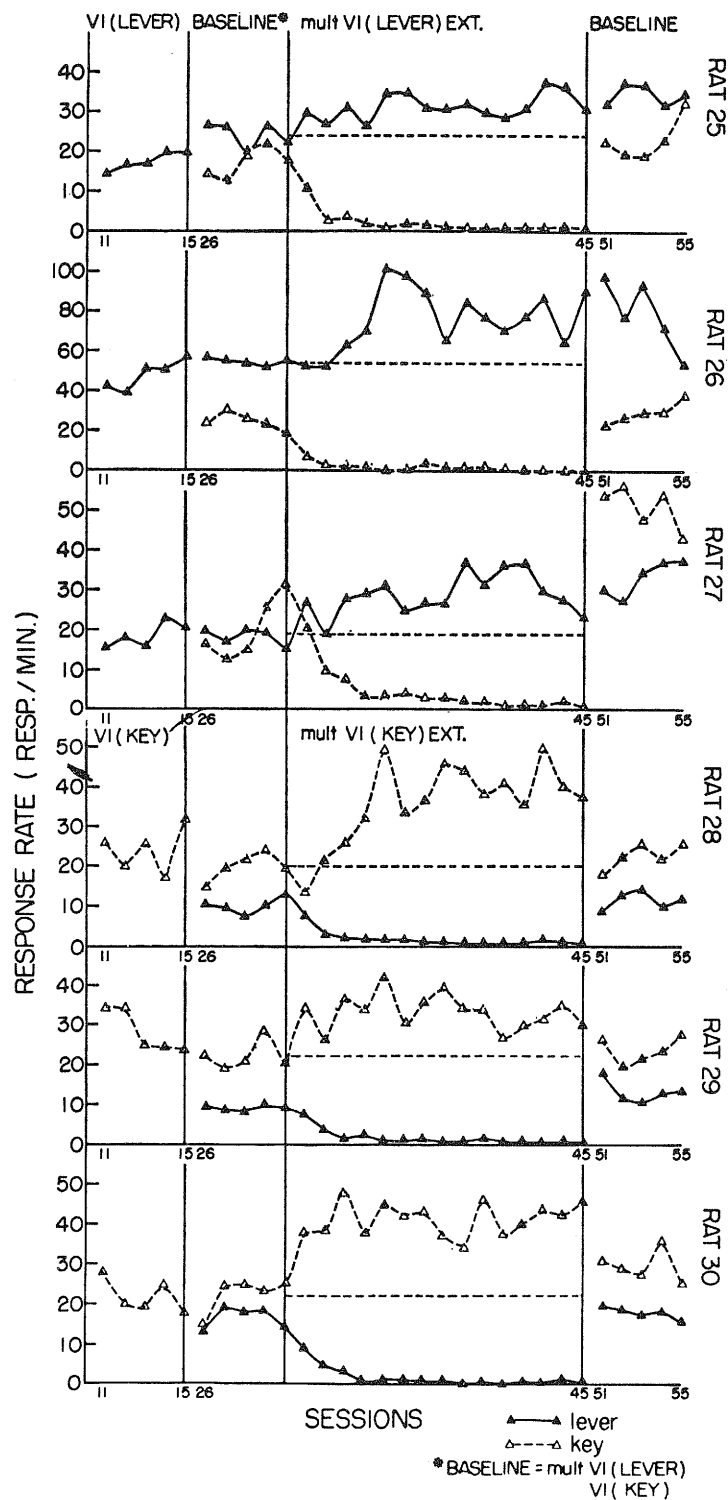


Fig. 5. Response rate (responses per minute) for each phase for all rats. Each point represents the response rate on lever, key, or extinction for one session. Only the last five sessions of each VI 30-sec phase and each baseline phase are shown. The horizontal broken lines represent the mean response rate during the last five sessions of baseline in the component that remained unchanged during the contrast phase.

valuable the reinforcer that is removed the greater the contrast effect.

The data from Experiment IV agree with those of Premack (1969) but not with those of Scull and Westbrook (1973). A number of factors may be responsible for their discrepancy, including species differences, differences in topographical overlap, and differences in preparedness of the particular operants.

In addition to demonstrating contrast with different operants, the data confirm that contrast may be obtained in rats. The most current data and theory on contrast center around contrast in pigeons (Gamzu and Schwartz, 1973; Keller, 1974; Rachlin, 1973; Redford and Perkins, 1974). Rachlin (1973), drawing on the Gamzu and Schwartz data, speculated, as did Gamzu and Schwartz, that contrast is induced by the relationship between the stimulus in which the higher rate of reinforcement is obtained and the reinforcement itself. Thus, autoshaping (Brown and Jenkins, 1968) becomes the basis for contrast in pigeons. Rachlin suggested that two factors simultaneously produce key pecking: (1) pecking is reinforced by food in most contrast experiments, and (2) pecking is induced by a stimulus-food relationship. Key pecks engendered by this latter source of control are called "extra" key pecks by Rachlin.

If this general approach to contrast is correct, and data from experiments with pigeons support it (Keller, 1974; Redford and Perkins, 1974), what is the source of the "extra" responses in contrast in rats? Unfortunately, animal watching does not seem to be a popular pastime among experimental psychologists (including us); therefore, no suggestions along these lines may be offered. However, it appears that the extra responses need not be directed toward the stimulus correlated with the higher density of reinforcement, as autoshaping research suggests. For example, Keller (1974) established pecking for food on a key that was lit a constant color while discriminative stimuli correlated with changes in the reinforcement schedules were provided on another key. When the stimulus key changed to a color associated with a high density of reinforcement, the birds often pecked the stimulus key, although it provided no food. However, in two of the three birds in Keller's Experiment I, there was some contrast on the key that provided food. A further example is

provided by Schwartz (1973), who demonstrated that a tone could control "autoshaped" responding to a key when the key was lit green both during a variable-time schedule and during extinction.

Keller's results are reminiscent of some rat data. Keller found that contrast on the non-changing food key (1) did not occur in all birds and (2) disappeared in the birds in which it did occur. The rat data of Pear and Wilkie (1971) displayed both of these features. The contrast effects in the present experiments did not disappear; however, this may have been a result of limiting the contrast phase to 15 sessions. If it could be shown that extended training in the contrast phase of an experiment similar to those reported here resulted in the disappearance of the contrast effect, then the present data would be consistent with previous reports of contrast in pigeons as well as in rats.

## REFERENCES

- Beninger, R. J. Positive behavioral contrast with qualitatively different reinforcing stimuli. *Psychonomic Science*, 1972, **29**, 307-308.
- Bernheim, J. W. and Williams, D. R. Time-dependent contrast effect in a multiple schedule of food reinforcement. *Journal of the Experimental Analysis of Behavior*, 1967, **10**, 243-249.
- Brown, P. and Jenkins, H. M. Auto-shaping of the pigeon's key peck. *Journal of the Experimental Analysis of Behavior*, 1968, **11**, 1-8.
- Freeman, B. J. The role of response independent reinforcement in producing behavioral contrast effects in rats. *Learning and Motivation*, 1971, **2**, 138-147.
- Gamzu, E. and Schwartz, B. The maintenance of key pecking by stimulus-contingent and response-independent food presentations. *Journal of the Experimental Analysis of Behavior*, 1973, **19**, 65-72.
- Hearst, E. Contrast and stimulus generalization following prolonged discrimination training. *Journal of the Experimental Analysis of Behavior*, 1971, **15**, 355-363.
- Herrnstein, R. J. On the law of effect. *Journal of the Experimental Analysis of Behavior*, 1970, **13**, 243-266.
- Hollard, V. and Davison, M. C. Preference for qualitatively different reinforcers. *Journal of the Experimental Analysis of Behavior*, 1971, **16**, 375-380.
- Keller, K. The role of elicited responding in behavioral contrast. *Journal of the Experimental Analysis of Behavior*, 1974, **21**, 249-257.
- Mackintosh, N. J., Little, L., and Lord, J. Some determinants of behavioral contrast in pigeons and rats. *Learning and Motivation*, 1972, **3**, 148-161.
- Pear, J. and Wilkie, D. M. Contrast and induction in rats on multiple schedules. *Journal of the Experimental Analysis of Behavior*, 1971, **15**, 289-296.
- Premack, D. On some boundary conditions of contrast.

- In J. T. Tapp (Ed.), *Reinforcement and behavior*. New York: Academic Press, 1969. Pp. 120-145.
- Rachlin, H. Contrast and matching. *Psychological Review*, 1973, **80**, 217-234.
- Redford, M. E. and Perkins, C. C. Jr. The role of auto-pecking in behavioral contrast. *Journal of the Experimental Analysis of Behavior*, 1974, **21**, 145-150.
- Reynolds, G. S. Behavioral contrast. *Journal of the Experimental Analysis of Behavior*, 1961, **4**, 179-208.
- Schwartz, B. Maintenance of key pecking by response-independent food presentation: the role of the modality of the signal for food. *Journal of the Experimental Analysis of Behavior*, 1973, **20**, 17-22.
- Scull, J. and Westbrook, R. F. Interactions in multiple schedules with different responses in each of the components. *Journal of the Experimental Analysis of Behavior*, 1973, **20**, 511-519.
- Seligman, M. E. P. On the generality of the laws of learning. *Psychological Review*, 1970, **77**, 406-418.
- Skinner, B. F. *Contingencies of reinforcement: a theoretical analysis*, New York: Appleton-Century-Crofts, 1969.
- Terrace, H. S. Stimulus control, in W. K. Honig, (Ed.), *Operant behavior: areas of research and application*, New York: Appleton-Century-Crofts, 1966. Pp. 271-344.

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