Fig. 1. Mean speeds for rat Ss during Phases I and 2. (Note: Data points for Phase 2 are based on three scores per S.)

rat Ss on R and N trials are presented in Fig. 1. Analyses comparing R vs N speeds (t tests for correlated samples) were performed on Days 1 and 12 of Phase 1, and Day 1 of Phase 2. the results of these analyses indicated that there were no significant differences on Day 1 of Phase 1 ($t = 1.23$, $df = 6$, $p > .30$), and Day 1 of Phase 2 ($t = .65$, $df = 6$, $p > .60$). A significant difference occurred on Day 12 of Phase 1 ($t = 4.55$, $df = 6$, $p < .01$).

The striking difference between R and N speeds that developed during Phase 1 would strongly suggest that the rat Ss were able to use odors emitted by the gerbil Ss as cues for appropriate responding. Additional support for the odor hypothesis is seen in Phase 2 responding. It should be remembered that during this phase the relationship between the goal event for the gerbil and that for the rat was not perfect (i.e., any distinctive cues associated with R and N are no longer effective for the rat Ss). During the initial stages of Phase 2 the R and N speeds become nondifferential due to inappropriate responding. This is more clearly seen in the Phase 2 portion of Fig. 1 by looking at N (rat) speeds following R (gerbil) trials, and R (rat) speeds following N (gerbil) trials. During the later stages of Phase 2, the discrimination acquired during Phase 1 is lost primarily due to an increase in speed following (gerbil) N trials. Presumably this reflects a lack of attention to odor cues on the part of the rat Ss. These results would also support an odor interpretation over

the alternative view that the rat Ss may in fact be discriminating between R and N goal events on the basis of odor or lack of it from the food itself.

Thus, it would appear that the present study supports and extends the generality of the odor hypothesis by showing that one species may use odors emitted by

another species as cues for appropriate responding in the runway. However, there is one notable difference between the present study and previous ones. The R-N discrimination during Phase 1 occurred very quickly and somewhat sooner in the present study than in previous studies (Ludvigson & Sytsma, 1967; Davis, in press). One possible explanation for this rapid discrimination might be that the odors emitted by a different species are highly distinctive and consequently more readily usable as discriminative stimuli. Obviously, further research is needed to clarify the operation of this potentially influential variable both between and within species.

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Behavioral-contrast in mixed schedules of reinforcement*

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Two rats were tested for behavioral contrast on two-component mixed schedules of reinforcement. The results suggest that contrast occurs in mixed variable-interval extinction schedules when the frequency of reinforcement in the variable-interval component is high.

Behavioral contrast may be defined as opposing rate changes in two

components of a multicomponent schedule that accompany changes in the rate of responding and/or reinforcement in one of the components. Contrast has been typically studied in multiple schedules in

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Fig. 1. Responding of S 1 and S 2 during the first eight sessions after the introduction of the mixed VI 30-extinction schedule. Each point represents mean responses per minute during each 1-min segment of the 10-min VI-extinction cycle. The dotted horizontal line represents the baseline level of VI 30 responding based on the last 3 days of VI 30.

which different stimuli are correlated with the different components (e.g., Reynolds, 1961). Contrast has also been observed in a modified multiple schedule in which only one component of a two-component schedule was signaled by an explicit discriminative stimulus (Pear & Wilkie, 1969). The present experiment sought to determine if contrast would occur in a two-component schedule in which neither component was correlated with an explicit discriminative stimulus, i.e., a mixed schedule of reinforcement (Ferster & Skinner, 1957).

SUBJECTS AND APPARATUS

Two naive male albino rats, 128 days of age at the start of the experiment, were reduced to 80% of their free-feeding weights by food deprivation.

A standard Lehigh Valley Electronics operant conditioning chamber contained a 7-W houselight, a lever requiring approximately 24 g of force to operate, and a dipper that delivered 0.01 ml of a 1:1 mixture of water and sweetened condensed milk. Standard relay programming equipment was located in a nearby room.

PROCEDURE

After initial lever training the Ss were gradually shifted to a variable interval (VI) 30-sec schedule. After six 1-h sessions on

VI 30, the Ss were placed on mixed VI 30-extinction in which the components alternated with each other every 5 min. Since S 2 began to extinguish on both components of the mixed VI 30-extinction schedule, S 2 was returned to a VI 20-sec schedule for four sessions and was then placed on mixed VI 20-extinction. S 1 was run on the mixed VI 30-extinction schedule for 49 sessions; S 2 was run on mixed VI 20-extinction for 33 sessions. Sessions in which mixed schedules were programmed were 69 min in duration, the first 9 of which were not recorded. The data for these sessions were recorded in 1-min segments of each 10-min VI-extinction cycle. All sessions occurred on alternate days.

RESULTS AND DISCUSSION

Figure 1 shows the first eight sessions on the mixed VI 30-extinction schedule for both Ss. The data are plotted in terms of the average rate over all 1-min segments of each 10-min VI-extinction cycle. Note that there appears to be an initial contrast effect for both of the Ss. That is, the response rate during the VI-30 component (first five points for each session) tends to exceed the VI 30 baseline rate. While S 1's rate showed a subsequent pattern of instability, S 2's rate showed a steady trend towards extinction in both components of the mixed schedule. In following sessions (see Fig. 2) S 1 showed a clear contrast effect: The rate in the VI component increased appreciably over the baseline rate.

After 11 sessions on the mixed VI 30-extinction schedule, S 2 was placed on VI 20 and later mixed VI 20-extinction. This change to a schedule that provided a greater frequency of reinforcement succeeded in producing contrast in this S. Figure 2 shows the data for S 2 after the change to the mixed VI 20-extinction schedule. It would appear from the behavior of S 2 that the frequency of reinforcement in the VI component may be an important determinant of contrast in mixed schedules. The reason for this may be that the occurrence of reinforcement at a high frequency can act as a discriminative stimulus, and that the establishment of a clear stimulus for reinforcement—in this case, a high enough density of reinforcement itself—is necessary for the development of contrast. With lower densities of reinforcement, the stimuli for the reinforcement and extinction components of a mixed schedule are more similar, and induction may occur, as was the case for S 2 on mixed VI 30-sec extinction. The two processes of contrast and induction may interact for a period of time before one or the other predominates, as indicated for both Ss in Fig. 1.

Fig. 2. Responding of S 1 and S 2 during the first 18 sessions after the introduction of mixed VI 30-extinction and mixed VI 20-extinction, respectively. Each point represents mean number of responses per minute during each 1-min segment of the 10-min VI-extinction cycle in a block of three sessions. The dotted horizontal line represents the baseline rate for the last three sessions on VI 30 (S 1) or VI 20 (S 2) alone.

After exposure for several sessions to the mixed VI-extinction schedule, a particular pattern of responding developed in the two components. The rate of responding in the first 1-min period of the VI component was generally lower than the rate in following periods. Peaks in the rate in the VI component generally occurred in the second or third 1-min period. The rate in the last one or two periods of the VI component tended to "anticipate" the onset of the extinction component. The rate in the first 1-min period of extinction tended to be considerably higher than later periods. For S 2 there appeared to be a degree of anticipation of the next VI component.

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