**DISCRIMINATION TRAINING, PARTIAL REINFORCEMENT, AND
INCREASES IN INTERTRIAL INTERVAL ALL REDUCE RESPONSE SPEED IN A
CONTINUOUSLY REINFORCED KEY-PECKING TASK**

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Pigeons were trained in a discrete-trial task in which a response to the center key obtained illumination of a side key and a single response to the side key terminated a trial with either reinforcement or nonreinforcement. Center-key speeds (i.e., reciprocals of latencies) declined with increases in intertrial interval, and it is argued that this effect is related to a decreased likelihood as intertrial interval increases that birds will be near the key at trial onset. Side-key speeds on trials with reinforcement decreased both with increases in intertrial interval and with shifts from continuous reinforcement to either a discrimination or a partial-reinforcement condition. The effects on side-key speeds are compared with effects observed in alley-running tasks using rats, and an interpretation in terms of frustration theory is offered for the results obtained in both types of task.

Key words: response speed, continuous reinforcement, discrimination training, partial reinforcement, frustration, key peck, pigeon

Behavioral contrast refers to a multiple-schedule interaction in which an increased response rate in a constant component results from a downshift in the rate of reinforcement in the other component (Reynolds, 1961a, 1961b). Testifying to the importance of this phenomenon, reviews and theoretical interpretations have appeared at regular intervals during the past 30 years (e.g., Dunham, 1968; Freeman, 1971; Rachlin, 1973; Schwartz & Gamzu, 1977; Williams, 1983, 1988). Perusal of the literature indicates that contrast has been most frequently investigated using free-operant schedules of reinforcement. Our interest in the present article focused on the effects of extinction or partial reinforcement in the devalued component of a discrete-trial continuous-reinforcement key-pecking task.

Terrace (1963) and Jenkins (1961) reported that the introduction of nonreinforcement (S-) trials resulted in an increase in pigeons' speed of response on reinforcement (S+) trials in which a single peck obtained reinforcement. Those results suggested that

an effect might be obtained in discrete-trial procedures that is analogous to behavioral contrast found in conventional multiple-schedule free-operant tasks. However, Mackintosh (1974) failed to replicate Terrace's (1963) finding, and both Scull and Macphail (1976) and Mackintosh (1974) have shown that Jenkins's (1961) result was attributable to differences in intertrial interval (ITI) between his experimental and control groups.

Mackintosh (1974) in fact obtained a not statistically significant slowing of response speed to S+ when a discrimination was introduced, and drew attention to the parallel between that finding and the fact that rats' running speed under conditions of continuous reinforcement in an alley tends to slow when running in another, discriminably different, alley is not reinforced (e.g., Mackinnon, 1967). As a consequence of failures to obtain speed increases in either key-peck or alley-running discrete-trial tasks, Mackintosh (1974) suggested that positive contrast is seen only in response rate and not in speed of initiation of response. But comparison of effects seen in conventional discrete-trial key-pecking tasks with those seen in alley-running tasks may not be valid. The difficulty is that an important determinant of response speed in key-pecking tasks may be the orientation and location of the subject at trial onset. Thus an increase in duration and unpredictability of the ITI may decrease response speed (Mackintosh, 1974; Scull & Macphail, 1976),

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because pigeons are less able to anticipate trial onsets and may be more likely to move (or look) away from the key during ITIs (see also Cohen & Campagnoni, 1989; Silva, Silva, & Pear, 1992; Staddon & Simmelhag, 1971). Terrace (1963) reported that responding to the unlit key during ITIs was considerably increased by the introduction of conventional discrimination training, so that it may be that the increase in S+ speed that he obtained was a consequence of an increased tendency to remain oriented to the key during ITIs when discrimination training was introduced. Such considerations do not apply to running speeds in alleys.

The present experiment eliminated the problem of orientation by using a discrete-trial task in which each trial was initiated by the subject with a response to a center key, which resulted in illumination of a side key on which S+ or S- was shown: The measure of interest is the speed of response to the side key. The central goal of the experiment was to obtain data that are free of the possible orientation artifact and that will answer the question: What is the effect on speeds to peck S+ in a discrete-trial key-pecking task of the introduction of nonreinforcement S- trials? A secondary issue concerns center-key speeds. If these are determined primarily by the orientation or location of the subject, then speeds to peck the center key would be expected to decrease as ITI is lengthened; there is no reason, however, to expect them to be affected by shifts among continuous reinforcement, discrimination training, and partial reinforcement.

The introduction of discrimination training inevitably has further consequences in addition simply to the occurrence of S- trials. Thus, the introduction of S- trials must (a) either reduce the mean ITI or increase the intervals between S+ presentations and therefore between reinforcers; (b) entail partial reinforcement across trials; and (c) result in some S+ trials that are (as in baseline training) immediately preceded by reinforcement trials and in some S+ trials that are preceded by nonreinforcement trials. It is clearly important to know which of these manipulations is causally related to any effects that may be obtained. Accordingly, we assessed the potential causal role of such factors by manipulating ITI, by introducing a partial-reinforce-

ment control condition, and by taking separate measures of performance on S+ trials preceded by S+ trials (S+/S+ trials).

METHOD

Subjects

Ten experimentally naive pigeons (*Columba livia*) were used. Their ad lib feeding weights ranged from 295 to 415 g, and the birds were maintained at 80% of those weights throughout the experiment. The birds were housed individually in a temperature-controlled (21°C) vivarium with a 12:12 hr light/dark cycle (lights on at 7 a.m.). All experimental treatments were performed during the light phase of the cycle. Water and grit were always freely available in the home cages.

Apparatus

Subjects were trained in one of two identical chambers (35 cm by 35 cm by 35 cm). Each chamber was placed in a sound-attenuating cubicle and contained three response keys, each 3 cm in diameter. The center key was mounted directly over a grain feeder at a height of 27.5 cm above the floor. The remaining two keys were mounted on either side of the center key at the same level. The keys were 11 cm apart, center to center. The right side key remained blank throughout the experiment, and responses to it were not recorded and had no programmed consequence. The center key could be illuminated from behind with the white light, and the left side key could be illuminated with either red or green light. There was a houselight mounted on the front wall of the chamber, 5 cm above the center key.

Control of the sequence of events in the chamber and collection of data were carried out by a Nova 3 computer. Programs were written in the Act-N language (Millenson, 1971).

Procedure

Birds were first trained to eat from the feeder and then, by the use of an autoshaping procedure (Brown & Jenkins, 1968), to peck the center key when it was lit. Birds were then assigned at random to one of two groups, Group DP (S1, S2, S3, S4, S5) and Group PD (S6, S7, S8, S9, S10), and baseline training

began. Both groups were treated identically during baseline training.

Each trial of baseline training began with the illumination of the center key with white light. A response to the key extinguished it and lit the left key with either red or green light. A response to the left key extinguished it and obtained 4-s access to grain, followed by the ITI (defined as the interval from hopper offset to onset of the center keylight). If no response was made to the side key within 10 s of its illumination, the keylight was extinguished and 4-s access to grain was provided. The first trial of each day was a red-key trial, and the data from that trial were discarded. The subsequent order of red-key and green-key trials was determined by a Gellermann (1933) sequence, so that no more than three consecutive trials of one color occurred; half the trials were red key and the other half were green key. The Gellermann sequence was entered at a different point each day. There were (excluding the first discarded trial) 40 trials each day, and the houselight was illuminated throughout except during food presentation.

Five ITIs were tested: 2, 6, 10, 30, and 60 s. A Latin square design was used, so that each bird experienced each of the five ITIs once during the five training sessions that were conducted each week, and 1 of the 5 birds of each group was assigned to one of the five different ITIs on a given day. Within a session, ITI was held constant. The same Latin square was used for each group, and the same sequences of ITIs were used throughout the experiment, so that a bird always experienced the same ITI on a given day of each week's training. Consequently, each subject experienced all five ITIs each week, albeit in different orders across subjects. Each center-key response latency was recorded and was converted to a speed (the reciprocal of latency); any response latency greater than 10 s was scored as 10 s to prevent extreme scores from making a disproportionate contribution to the session mean. Similarly, side-key latencies were recorded and were converted to speeds. On trials in which free access to grain had occurred, a latency of 10 s was scored.

Discrimination training. The general procedures used in the discrimination condition were identical to those used in baseline training, so that, in particular, birds continued to experience the same ITI as in baseline on a

given day within a week; in discrimination training, however, green-key trials were non-reinforcement trials and terminated, following either a response to the left key or the passage of 10 s, with a 4-s timeout, during which the houselight was extinguished. There were, then, (excluding Trial 1) 20 red-key reinforcement trials and 20 green-key nonreinforcement trials each day in this condition.

Partial-reinforcement training. The procedures used in the partial-reinforcement condition were identical to those used in discrimination training, except that the side key was red on both types of trials. There were (excluding Trial 1) 20 red-key reinforcement trials and 20 red-key nonreinforcement trials each day in this condition.

Experimental design. The experiment consisted of three stages, the first two of which consisted of two phases; each phase continued until informal inspection of data indicated that performance was stable in both groups. In the first phase of Stage 1, both groups experienced the baseline condition (for 15 sessions); this was followed in the second phase by discrimination (Group DP) or partial-reinforcement (Group PD) training for 15 sessions. In Stage 2, baseline (for 25 sessions) was followed by partial-reinforcement (Group DP) or discrimination (Group PD) training for 15 sessions. The only difference between Groups DP and PD was the order in which they experienced the discrimination and partial-reinforcement conditions. Stage 3 consisted of a further 15 sessions of baseline training. The data reported here are for the final five sessions of each phase (i.e., the last 40 trials at each ITI).

RESULTS

Center-Key Speeds

Figure 1 shows individual scores and group means for center-key speeds through the successive phases of the experiment. It can be seen that speeds usually declined with increases in ITI, and that there was little change in speeds between the baseline and the discrimination and partial-reinforcement phases. Analysis of variance of the data summarized on Figure 1 for Stages 1 (first pair of graphs for each group) and 2 (second pair of graphs for each group) was carried out with

Fig. 1. Center-key speeds (1/s) for individual subjects (and group means) in Group DP during Stage 1 (baseline and discrimination), Stage 2 (baseline and partial reinforcement), and Stage 3 (baseline), and in Group PD during Stage 1 (baseline and partial reinforcement), Stage 2 (baseline and discrimination), and Stage 3 (baseline). Data are from the final five sessions of each phase. Note: S6 produced a center-key speed of 5.73 on the 10-s ITI of Stage 2 discrimination training. For graphical purposes only, this single point was scored as 3.45. A speed of 5.73 corresponds to a latency of 0.17 s, which strongly suggests that S6 was pecking in anticipation of keylight illumination.

group as the between-subjects variable and phase (baseline vs. experimental condition), condition (discrimination vs. partial reinforcement), and ITI as within-subject variables. The analysis found a significant main effect of ITI, $F(4, 32) = 6.98, p < .001$.

Figure 1 also shows that speeds were somewhat lower in the baseline condition in Stage 1 (left side graphs) than in Stages 2 (center graphs) and 3 (right side graphs); however, an overall analysis of the baseline data for all three stages, with ITI, stage and group as variables, found only one statistically significant effect, that of ITI, $F(4, 32) = 9.20, p < .001$.

Side-Key Speeds

Figure 2 shows individual and group mean side-key speeds on red-key reinforcement tri-

als for the two groups over the course of the experiment. Inspection of the figure suggests that side-key speeds became slower as ITI increased, and that the introduction of either discrimination or partial reinforcement decreased speeds, especially compared to the last two baseline conditions.

Analysis of variance of the data shown on Figure 2 for Stages 1 (first pair of graphs for each group) and 2 (second pair of graphs for each group) found significant main effects of phase (baseline vs. discrimination or partial reinforcement), $F(1, 8) = 25.84, p < .002$, and ITI, $F(4, 32) = 8.18, p < .001$; there were significant interactions between phase and condition (discrimination vs. partial reinforcement), $F(1, 8) = 6.21, p < .04$, among

Fig. 2. Side-key speeds (1/s) on red reinforcement trials for individual subjects (and group means) in Group DP during Stage 1 (baseline and discrimination), Stage 2 (baseline and partial reinforcement), and Stage 3 (baseline), and in Group PD during Stage 1 (baseline and partial reinforcement), Stage 2 (baseline and discrimination), and Stage 3 (baseline). Data are from the final five sessions of each phase.

phase, condition, and group, $F(1, 8) = 6.24$, $p < .04$, and between phase and ITI, $F(4, 32) = 2.97$, $p < .04$.

In order to clarify this pattern of interactions, we subsequently carried out separate analyses, using the same variables, on data obtained at the short (2, 6, and 10 s) and the long (30 and 60 s) ITIs; we divided the ITIs in this way partly because inspection of the results suggested that the effects obtained at ITIs of 10 s and less were different in magnitude from those seen at the longer ITIs, and partly because Mackintosh, Little, and Lord (1972) had shown that behavioral contrast in a free-operant task was observed with a short (10 s) but not with a long (60 s) ITI. Analysis of the short-ITI data found statistically significant effects of phase, $F(1, 8) =$

29.91, $p < .001$, and ITI, $F(2, 16) = 8.97$, $p < .003$. Analysis of the long-ITI data found a significant main effect of phase, $F(1, 8) = 13.01$, $p < .01$, a significant Phase $\times$ Condition interaction, $F(1, 8) = 7.96$, $p < .03$, and a significant Phase $\times$ Condition $\times$ Group interaction, $F(1, 8) = 17.28$, $p < .01$. These analyses show that at short ITIs, where the effects of shifts from baseline to discrimination or partial reinforcement were most marked, there was no statistically significant difference between the partial-reinforcement and discrimination conditions; the long-ITI analysis appears to reflect the fact that both groups showed larger speed reductions in Stage 2 than in Stage 1 (perhaps because baseline speeds were lower in Stage 1 than in Stage 2). In summary, then, shifts to either

Fig. 3. Side-key speeds (1/s) on green reinforcement trials (baseline), green nonreinforcement trials (discrimination), and red nonreinforcement trials (partial reinforcement) for individual subjects (and group means) in Group DP during Stage 1 (baseline and discrimination), Stage 2 (baseline and partial reinforcement), and Stage 3 (baseline), and in Group PD during Stage 1 (baseline and partial reinforcement), Stage 2 (baseline and discrimination), and Stage 3 (baseline). Data are from the final five sessions of each phase.

discrimination or partial reinforcement produced decreases in response speed; the decreases were larger at short ITIs, possibly because baseline conditions resulted in faster speeds at short as opposed to long ITIs. Decreases in speed were larger following a shift to partial reinforcement than after a shift to discrimination, but this was neither a large nor a consistent difference.

Figure 3 shows individual scores and group means for side-key speeds for green-key reinforcement trials (baseline), green-key nonreinforcement trials (discrimination), and red-key nonreinforcement trials (partial reinforcement) for the two groups. Comparison of the data displayed in Figure 3 with the data presented in Figure 2 suggests that birds respond-

ed in baseline at similar speeds on green-key and red-key trials, and that they discriminated between red-key and green-key trials in the discrimination condition but not between reinforcement and nonreinforcement trials in the partial-reinforcement condition.

The possibility that these effects might reflect a transient influence on reinforcement trials of an immediately preceding nonreinforcement trial was examined by comparing speeds on reinforcement trials that immediately followed reinforcement trials with those for reinforcement trials immediately preceded by nonreinforcement trials. Frustration theory (e.g., Amsel, 1962) predicts that the energizing effects of nonreinforcement should be attenuated if (as in the discrimi-

nation phase) no reinforcer was anticipated. Accordingly, the data from the discrimination and partial-reinforcement conditions were considered separately. The overall mean speed on reinforcement trials that followed red-key nonreinforcement trials in the partial-reinforcement condition (pooled over the two groups and over ITIs) was 1.49; the corresponding speed on trials that followed reinforcement trials was 1.53. The overall mean speed on reinforcement trials that followed green-key nonreinforcement trials in the discrimination condition was 1.67; the corresponding speed on trials that followed reinforcement trials was 1.71. There was, then, a small decrease in speed on trials that followed both predictable and unpredictable nonreinforcement. In neither case was the difference between speeds on the two types of reinforcement trial statistically significant, both $t_s < 1.5$, $p > .1$. Frustration theory, however, also predicts that the energizing effect of nonreinforcement should dissipate rapidly over time: Support for this prediction was found by Robinson and Clayton (1963), who showed an energizing effect in a double runway of nonreinforcement that occurred 5 s but not 5 min previously. To determine whether a transitory energizing effect might have occurred in this study, we looked at speeds following reinforcement and nonreinforcement trials at the shortest (2 s) ITI. The pooled mean speed on reinforcement trials that followed red-key nonreinforcement trials in the partial-reinforcement condition at a 2-s ITI was 1.49; the corresponding speed on trials that followed reinforcement trials was 1.59. The mean speed on reinforcement trials that followed green-key nonreinforcement trials in the discrimination condition at a 2-s ITI was 1.75; the corresponding speed on trials that followed reinforcement trials was 1.85. In neither case was the difference between the two types of reinforcement trial statistically significant, both $t_s < 1.7$, $p > .1$; thus, even at a short ITI, there was no consistent effect of nonreinforcement on speed of response on the immediately succeeding trial.

Because reinforcement was available on all trials in the baseline condition but on only 50% of trials in the discrimination and partial-reinforcement conditions, the interreinforcement intervals (IRIs) were longer for a given ITI in the experimental conditions as

opposed to the baseline condition. The results show that as ITI (and so, IRI) increases, speeds usually fall. This raises the question whether the effects seen in the shift from baseline to discrimination or partial reinforcement may have been due to an increase in IRI. To approach this issue, we sought an ITI in the baseline condition that obtained an IRI of comparable duration in the experimental conditions at a shorter ITI. We recorded total session durations and found that the mean IRI actually experienced using a 30-s ITI in the baseline phases of Stages 1 and 2 (pooled over groups and stages) was 34 s; the mean IRI for the discrimination condition at the 10-s ITI (pooled over groups) was 37 s, and for the partial-reinforcement condition at the same ITI, it was 29 s. The mean IRI of the discrimination condition was longer than that of the partial-reinforcement condition because birds were slow to respond (if they did so at all) on green-key nonreinforcement trials in the discrimination condition, but were not slow on red-key nonreinforcement trials in the partial-reinforcement condition. Figure 2 shows that in fact speeds recorded in the discrimination and partial-reinforcement conditions at the 10-s ITI were generally slower than those in the corresponding baseline stages at the 30-s ITI, although the mean for Group DP in Stage 1 showed a small difference in the opposite direction. Analysis of variance of the data for Stages 1 and 2 for the baseline phases at the 30-s ITI and for the discrimination and partial-reinforcement phases at a 10-s ITI, with groups, phase, and condition as variables, found a significant effect of phase, $F(1, 8) = 12.17$, $p < .01$. We conclude, therefore, that the slowing of speeds seen when shifting from baseline (30-s ITI) to discrimination or partial reinforcement (10-s ITI) cannot be accounted for by the increase in IRI.

DISCUSSION

The results of this experiment show that increases in ITI caused decreases in speed of both center- and side-key responses, and the introduction of either discrimination training or partial reinforcement caused decreases in speed of side-key, but not of center-key, responses.

The decreases in center-key speeds caused

by increases in ITI agrees with the results of previous reports in which S+ or S- was displayed on the center key (Jenkins, 1961; Mackintosh, 1974; Scull & Macphail, 1976). One plausible account of the association between ITI and center-key response speed is that alluded to in the Introduction of the present report: It may be that the longer an ITI, the less likely a bird is to be close to the response key at trial onset. The effects of ITI on side-key speeds are not, however, so easily explained.

Two contemporary theories (Gibbon & Balsam, 1981; Jenkins, Barnes, & Barrera, 1981) of the growth of associative strength are explicitly concerned with the effect of variations in ITI. Those theories are concerned primarily with the acquisition of classically conditioned responding, and so may not be directly applicable to the present results, in which stimulus duration was determined by the subject and sustained operant performance was the focus of interest. However, it is clear that the pattern of results obtained is not in accordance with predictions generated from the basic principles underlying these theories. The theories, in effect, assume that as IRI increases, the validity of a conditioned stimulus of constant duration relative to the context as a predictor of the unconditional stimulus should increase. But in this experiment, as IRI increased, S+ response speed decreased, and a decrease in response speed would be expected to reflect a decrease, not an increase, in associative strength.

The demonstration of significant slowing in S+ speeds with the introduction of the discrimination condition in this experiment constitutes a confirmation of Mackintosh's (1974) finding of a trend towards slowing of speed when a discrimination was introduced. It appears, then, that positive behavioral contrast is not obtained in discrete-trial procedures; rather, quite the reverse occurs. The present experiment also shows, however, that the same effect is obtained if partial reinforcement is introduced. A number of contemporary theories of discrimination learning that are, again, primarily concerned with classical conditioning procedures agree in expecting a decline in associative strength upon the introduction of partial reinforcement (e.g., Mackintosh, 1975; Pearce & Hall, 1980; Rescorla & Wagner, 1972), and so might lead

to the prediction that speeds would decline in the partial-reinforcement condition of this experiment. Those theories, however, expect at the most a small decline (as a consequence of generalization from S- to S+) in the associative strength of S+ upon the introduction of a discrimination, but in this experiment, the effects of discrimination and partial reinforcement were largely indiscriminable. The Jenkins et al. (1981) and Gibbon and Balsam (1981) theories, on the other hand, would not expect any change in associative strength from the partial-reinforcement condition (because both mean IRI and conditioned stimulus duration were approximately doubled), but would expect an increase in associative strength in the discrimination condition (in which IRI was approximately doubled, but total conditioned stimulus duration remained the same). The results clearly contradict those predictions.

Mackintosh (1974) suggested that latencies could be seen as analogous to reaction times, and that a latency increase following introduction of discrimination training might reflect an increase in decision time, because reaction times increase as the number of alternatives increases (e.g., Hick, 1952). Similarly, Mackintosh cited evidence for increases in reaction time with increases in the duration and variability of foreperiods, and suggested that the decreases in speed that he found with increases in mean duration and variability of ITI could be a similar phenomenon. The analogy with reaction-time procedures, although it can provide a plausible account of the decrease in response speed following the introduction of discrimination training, has difficulty with the effects of both partial reinforcement and increases in ITI. It could be argued that the decrease in speed in the partial-reinforcement condition reflected simply a decrease in the associative strength of S+. But this suggestion faces the problem that the magnitudes of the effects obtained in the two conditions (discrimination training and partial reinforcement) were statistically indiscriminable, and this in a task in which their similarity could not be explained away by appeal to floor effects; in other words, this account must suppose that the identity in magnitude of the effects caused is coincidental. The analogy between the variability of foreperiods in the reaction-time task

and of ITIs in this task is, similarly, unconvincing, because in this study the foreperiod was fixed within a session and preceded the illumination of the center key, and there was no uncertainty concerning the time of onset of the side-key stimuli.

Because the introduction of either partial reinforcement or discrimination and increases in ITI cause decreases in response speed, it is of interest to ask whether all three manipulations have some feature in common that might be the causal agent responsible. One candidate can be found in the suggestion that both nonreinforcement trials and increases in ITI are frustrating events. Frustration theory holds that frustration is aversive and that it engages a tendency to withdraw (e.g., Amsel, 1992). The occurrence of a long ITI (in any condition) or nonreinforcement (in the discrimination and partial-reinforcement conditions) could generate frustration that might be conditioned to contextual cues; conditioned frustration would then cause a tendency to withdraw that would compete with the tendency to approach and peck.

A difficulty for this view emerges when one contrasts the results obtained in the partial-reinforcement condition of this experiment with the effects of partial reinforcement in another discrete-trial task, alley running. A number of reports (e.g., Goodrich, 1959; Wagner, 1961) have found that rats running in alleys under partial reinforcement run faster than rats running under continuous reinforcement (the partial-reinforcement acquisition effect). Frustration theory accounts for the partial-reinforcement acquisition effect by suggesting that the reinforcement obtained in the presence of conditioned frustration counterconditions the withdrawal response to frustration and allows the energizing effects of frustration to predominate and to enhance approach. Why, then, did the partial-reinforcement condition of the present experiment not result in enhanced responding? Similarly, if long ITIs are frustrating, why did responding not eventually become faster at long ITIs, given that in each case responding in the presence of frustration was reinforced? The answer may lie in the observation that the partial-reinforcement acquisition effect generally reflects an increased running speed in the initial section

of an alley that is in fact counteracted, but not outweighed, by a slowing of speed in the final (goal) section of the alley (e.g., Goodrich, 1959). In other words, the closer responding is to the goal, the more successfully does the withdrawal tendency compete with the approach tendency. In the discrete-trial key-peck task, the response is analogous to the response in the terminal part of an alley, and a decrease in speed is therefore not unexpected.

A further problem facing attempts to reconcile key-pecking data with alley-running data concerns the effects of discrimination training. Discrimination training slows S+ speeds in the present task and in alleys (e.g., Mackinnon, 1967). But in the free-operant tasks, discrimination training increases response rates and has no consistent effect on speed of response initiation (Mackintosh, 1974). Scull and Macphail (1976) suggested that positive contrast occurs only when responding to S+ has been intermittently reinforced; such a procedure, as argued above, allows the counterconditioning of the withdrawal response. Thus in discrete-trial tasks, response speed is reduced, and in tasks such as those using free-operant techniques in which intermittent reinforcement is available in S+, responding will be energized. Why, then, is the energizing effect in free-operant tasks seen in rate but not in speed measures? We propose that this is because the major determinant of response speed in conventional free-operant designs is the orientation of the subject at stimulus onset. Support for this view is provided by studies using a discrete-trial procedure similar to that employed in the present experiment, but in which a fixed-interval (5-s) schedule was in effect on the side key (which, as in the present experiment, was illuminated in response to a peck to the center key). Those studies (Macphail, 1972, 1975) found increases in side-key response speeds when either discrimination training or partial reinforcement was introduced (the magnitude of the effects being comparable in the two conditions). Thus, when the influence of the orientation of the bird is minimized by the use of a center-key response leading to side-key illumination, discrimination training (and partial reinforcement) does result in increases in both speed and rate of response in an operant task with

intermittent reinforcement. It is therefore possible to provide a coherent account in terms of frustration theory of the various effects of partial reinforcement and discrimination training in both key-pecking and alley-running tasks.

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