Performance in differential instrumental conditioning with infrequent S+ presentations*

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Thirty-two rats received 96 trials of differential reward magnitude training in a nonchoice brightness discrimination apparatus. The proportion of S+ trials to total trials (.25 or .50) as well as the magnitude of S— reward affected both S+ and S— performance levels. Results were interpreted as consistent with the viewpoint that uncertainty generates S+ and S— depression effects.

In differential instrumental conditioning, performance to a particular incentive condition associated with one discriminandum is depressed relative to that of nondiscrimination Ss which receive that incentive in both discriminanda. Performance to the large reward stimulus (S+) is depressed relative to control Ss which receive large reward in both "S+" and "S–," and performance to S– is depressed relative to that of small reward control Ss (cf. Black, 1968; McHose, 1970). Moreover, it is now apparent that both S+ and S– depression effects increase as the difference between S+ and S– incentives increases (cf. McHose, 1970).

While the incentive difference variable clearly influences the amount of depression within a discriminandum, recent data indicate that any theoretical account of these depression effects must also appeal to behavioral processes influenced by factors other than those related simply to discriminandum-specific incentives. Thus, McHose, McHewitt, & Peters (1972) found that, among discrimination groups which receive the same S+ and S– incentives, Ss which receive more frequent S+ than S– presentations display slower S– speeds and faster S+ speeds than Ss which receive equally frequent S+ and S– presentations. That is, a relatively high proportion of S+ trials apparently increases S– depression and attenuates S+ depression.

The McHose et al (1972) data are consistent with the viewpoint that S+ and S– depression effects result in part from S's uncertainty regarding the incentive outcome of a given trial, uncertainty generated by differential information provided by prediscrimination (e.g., startbox) as opposed to discriminandum cues. For groups which receive a high relative frequency of S+ trials, it may be assumed that startbox cues generate an expectancy of an S+ event. Subsequent exposure to the S+ stimulus would therefore produce a minimal degree of uncertainty (little S+ depression), while exposure to S– stimuli would result in a substantial S– depression effect. This notion, herein applied symmetrically to S+ and S– behavior, has theoretical antecedents in discussions intended to apply only to S+ behavior [Perkins's (1970) r_g-preparedness hypothesis] or to S– behavior (Ludvigson & Gay, 1967).

From this uncertainty framework, it should be apparent that a low relative frequency of S+ presentations should maximize S+ depression and minimize S– depression. The present study tests this implication of an uncertainty hypothesis by the comparison of groups which receive infrequent S+ trials to groups which receive equally frequent S+ and S– trials. For reasons to be discussed later, the magnitude of S– reward was also manipulated between groups.

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METHOD

The Ss were 32 naive male albino rats, 90-100 days old, obtained from the Holtzman Company, Madison, Wisconsin.

The differential conditioning apparatus consisted of a gray startbox (SB) and parallel flat black and flat white alley-goal sections. The SB could be aligned in series with either the black or the white alley-goal section. The SB, alley, and goal sections were 25, 80, and 25 cm long, respectively, with an interior width and height of 7 and 9 cm, respectively, throughout the apparatus. Opaque doors separated the SB and goal sections from the alley segment of the apparatus. Photocell-clock circuitry provided traversal times over the first two 15-cm and second two 30-cm segments of the alley.

Ten days prior to the first training day (Day 11), Ss were placed on a 23-h food-deprivation schedule maintained throughout the experiment. On Days 9 and 10, each S was handled for approximately 5 min, allowed 2 min exploration of the alley sections of the apparatus, and fed 20 45-mg Noyes pellets, identical to the subsequent reinforcement pellet, in addition to its regular 1-h feeding.

Eight Ss were assigned randomly to each of four groups labeled according to the number of pellets received in the negative discriminandum (e.g., white alley) and the proportion (times 100) of S+ to total trials: Groups 0-25, 2-25, 0-50, and 2-50. All Ss always received 12 pellets reward in the positive discriminandum (e.g., black alley). The brightness of S+ was counterbalanced within each group. All Ss received a total of 96 trials at the rate of 4 trials per day. The 25 groups were administered three S– (M) trials and one S+ (P) trial per day according to the following recursive schedule (for black-positive Ss): PMMM, MPMM, MMMP, MMPM, or (for white-positive Ss): MPMM, PMMM, MMPM, MMMP. The 50 groups received two black (B) and two white (W) trials per day according to the following recursive schedule: BWBW, WBBW, WBWB, BWWB.

Trials were administered to squads of eight Ss, one from each experimental condition (including the counterbalance factor). Each S within a squad received its first daily trial before any S received its second trial, etc., resulting in an intertrial interval of approximately 6 min. On each trial, the start door was opened

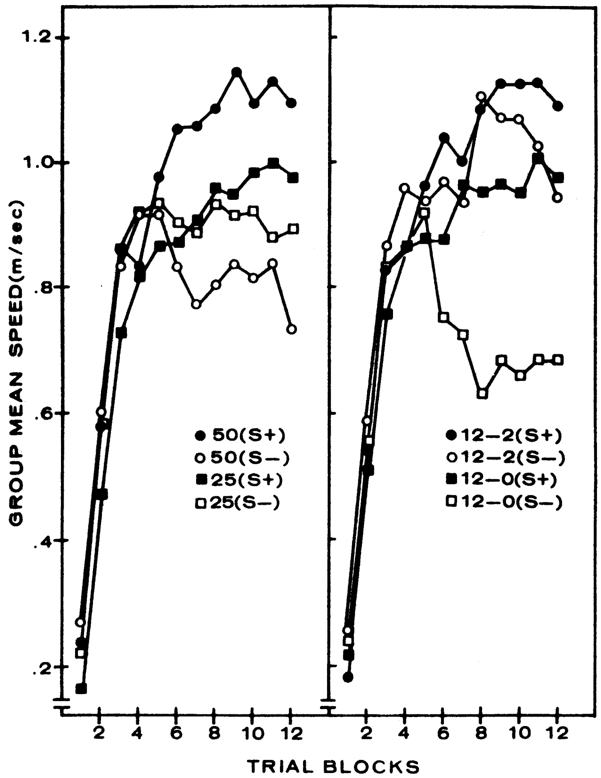

Fig. 1. Group mean speeds for the various conditions as a function of blocks of eight total trials.

after S had oriented toward the door for 3 sec and S was removed from the goalbox immediately after consuming the reward.

RESULTS

As was the case in previous data (McHose et al, 1972), the first three response measures yielded essentially the same information, with the early run (second 15-cm) measure proving most statistically reliable. Group mean early run speeds for the various groups are presented in Fig. 1, collapsed over the magnitude of S– reward variable (left panel) or the proportion of S+ trials variable (right panel). Each trial block contains the data over eight total trials, with speeds on S+ trials plotted separately from those on S– trials.

Looking first at the effects of the proportion variable, it can be seen in Fig. 1 that by the end of training, the 50 groups ran faster to S+ and slower to S– than did the 25 groups. Analysis of variance of the data over Blocks 9-12, including proportion S+, magnitude S–, brightness of S+, and discriminanda as factors, yielded a significant Proportion by Discriminanda interaction [$F(1,24) = 16.80$, $p < .001$]. Subsequent contrast comparisons indicated that the 50 groups ran significantly ($p < .01$) faster to S+ and slower to S– than did the 25 groups.

As may be seen in the right panel of Fig. 1, performance to both S+ and S– varied with the magnitude of S– reward such that, by the end of training, the 12-2 groups ran faster to each stimulus than did the 12-0 groups. The analysis reported above yielded a significant S+ Magnitude by Discriminanda interaction [$F(1,24) = 13.88$, $p < .001$], and subsequent contrast comparisons indicated that group differences were statistically ($p < .01$) reliable with respect to both S+ and S– performance levels.

Finally, two salient aspects of the data are not depicted in Fig. 1. First, all four groups ran reliably ($p < .01$) faster to S+ than to S–, as evidenced by postanalysis t tests. Second, the F ratios for the S– Magnitude by S+ Proportion interaction and the triple interaction of these variables with discriminanda were less than unity. Thus, the S– magnitude effects depicted in Fig. 1 are representative of the 50 and 25 groups, and, similarly, the proportion effects shown in Fig. 1 are representative of both the zero- and two-pellet S– reward conditions.

DISCUSSION

The effects of S+ frequency in the current study, as well as in the previous literature (e.g., McHose et al, 1972; Seymann, 1969) are consistent with the assumption (McHose et al, 1972) that S+ and S– depression effects result from the inhibitory effect of uncertainty as to the incentive outcome of a given trial, uncertainty generated by differential information or expectancies provided by prediscrimination (e.g., startbox) cues as opposed to discriminandum cues. Thus, for groups which receive a relatively high presentation frequency of a particular discriminandum, placement in the startbox might be expected to evoke an expectancy of the incentive event associated with that discriminandum and, consequently, minimal uncertainty if subsequently exposed to that discriminandum, but substantial uncertainty if exposed to the other stimulus. While the informational value of startbox cues may be manipulated by the relative frequency variable employed in the present study, correlating startbox brightness with alley brightness should reduce uncertainty in the alley portions of the runway, minimizing depression effects as typically measured, an expectation consistent with previous data (Ludvigson & Gay, 1967).

At this juncture it would appear that two incentive variables affect both S+ and S– performance in differential conditioning, in addition to the discriminandum presentation frequency variable. First, performance within a discriminandum is a positive function of the incentive (reward amount, delay, or percentage) associated with that stimulus. Second, performance within a discriminandum is an inverse function of the difference between the incentive associated with that stimulus and the incentive associated with the other stimulus. A simple theoretical model employing these incentive factors has previously been shown to adequately describe the effects of variation in S+ and S– incentives on both S+ and S– performance in the context of equiprobable S+ and S– presentations (Gavalek & McHose, 1970; McHose, 1970).

Insofar as incentive factors alone are concerned, the present data as well as previous findings are consistent with the model developed by McHose (1970). Thus, the current finding that S+ and S– speeds increased as S– reward magnitude increased is consistent with previous data for 50-type conditions described by this model (cf. McHose, 1970). The fact that the effects of S– reward magnitude were comparable for 50 and 25 groups, together with the observation that S+ magnitude of reward effects are invariant with the relative frequency of S+ trials (McHose et al, 1972), indicates that the theoretical description of the effects of these incentive variables previously applied to 50-type groups (McHose, 1970) will suffice for conditions in which S+ presentations occur either more or less frequently than S− presentations.[1]

Within the incentive model (McHose, 1970), S+ and S− depression or contrast effects result from the operation of the incentive difference variable. The present as well as previous data (McHose et al, 1972; Seymann, 1969) now indicate that these depression effects are also regulated by the relative frequency with which a discriminandum is presented. The present viewpoint is that these two factors which determine S+ and S− contrast effects are conceptually related in that they jointly determine uncertainty, U, which interferes with the ongoing instrumental response. Within this framework, U is an additive function of the degree and importance of uncertainty, with degree determined by variables such as the relative frequency of discriminandum presentation, as discussed previously, and importance regulated by the incentive difference variable. Such an approach will satisfactorily account for the present data as well as previous findings with regard to both S+ and S− incentive levels and relative frequency of S+ manipulations. This framework is, of course, noncommital with respect to the specific mechanisms whereby either prediscriminandum or discriminandum cues generate information or expectancies, but we see no current reason why the r_g mechanism of expectancy as applied to S+ contrast (Seymann, 1969) or S− contrast (Ludvigson & Gay, 1967) phenomena would not suffice in this regard.

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NOTE

1. While the effects of relative frequency of S+ trials on S+ and S— performance are clear, the present data in isolation do not establish the existence of the familiar S+ and S— depression effects in conditions which receive relatively infrequent S+ presentations, since neither S+ nor S— nondiscrimination "control" group was included in the present design. This design shortcoming is further complicated by the seeming necessity for two pairs of nondiscrimination control conditions, one S+ and S— pair for each (50 and 25) stimulus frequency condition. The previous literature, however, indicates that these problems are more apparent than real. First, Seymann (1969) has shown that the asymptotic performance levels of nondiscrimination control Ss are unaffected by the relative frequency of one stimulus to the other, precluding the necessity of two pairs of control Ss. Given the Seymann (1969) data, the present relationships between 50 and 25 groups sufficiently warrant the conclusion that both S+ and S— depression effects occur in the latter conditions. Previous studies have consistently shown that the S+ performance level of any 50-type discrimination group is depressed relative to that of an S+ control condition and, in fact, matches that of the S— control condition appropriate for that discrimination group. Thus, the observation that both the S+ and S— performance levels of the 25 conditions are reliably slower than the S+ performance level exhibited by the 50 groups is indicative of S+ and S— depression effects in the 25 conditions.

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