NOTES

1. A probe was inserted before the first outcome trial for

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A comparison of S+ and S- depression effects in differential conditioning*

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A total of 240 albino rats, across two experiments, received reward magnitude (differential or nondifferential) training in a nonchoice brightness discrimination apparatus. Results indicated significant S+ and S- depression effects and showed that variability (among Ss) in performance to S- was greater than that to S+ for the differentially rewarded Ss. Transformed speeds, taking into account the discrepant variances, indicated comparable S+ and S- depression effects. The results were discussed in terms of current models of differential conditioning.

In differential conditioning, the finding that the performance of rats receiving differential reward is depressed to the small (S-) reward stimulus relative to that of a condition that receives small reward in both discriminanda is well documented and has received considerable theoretical attention (cf. Black, 1968; McHose, 1970). The similar observation for performance to the large (S+) reward stimulus, speeds being depressed relative to those of a group receiving large reward in both "S+" and "S-," has only recently received primary theoretical attention (cf. McHose, 1970; Perkins, 1970). There are several possibilities for this earlier neglect. First, early investigators, perhaps influenced by the perception literature, were interested in symmetrical contrast effects, depressed S- speeds and elated S+ speeds; thus, equal and depressed S+ speeds may have been viewed as a failure to demonstrate S+ contrast (cf. Dunham, 1968). The graphical differences for these depression effects is perhaps yet another factor responsible for the emphasis on S- effects. S+ depression, based on mean speed differences, is much smaller than the similar comparison of S- speeds (Gavelek & McHose, 1970; MacKinnon, 1967; Matsumoto, 1969). Also, the initial investigation in this

area did not obtain a statistically reliable S+ depression effect (Bower, 1961). Finally, among the earlier approaches to these depression effects, one view is to attribute S- depression to the inhibitory properties of the small-reward stimulus. From this viewpoint, the inhibition is produced by discrepancies between the anticipated reward and that obtained in S-, that is, the inhibition is frustration-based and develops, in primary form, in S- (cf. Bower, 1961; MacKinnon, 1967; Black, 1968). Not surprisingly, then, a frequent interpretation of the S+ depression effect is that it is in some sense a secondary phenomenon, resulting not from any inhibition generated in S+, but from the generalization of inhibition which occurs in S- (e.g., Black, 1968; Henderson, 1966; Mackinnon, 1967); and, accordingly, the S- depression effect became the observation of primary theoretical interest.

As alternatives to the assumption that S+ depression is a secondary phenomenon, more recent models provide theoretical precedent for treating S+ depression as a phenomenon independent of S- depression (Perkins, 1970) and for the viewpoint that S+ and S- effects result from the same theoretical process (McHose, 1970; McHose, McHewitt, & Peters, 1972). According to the latter framework, the extent of S+ and S- depression is determined directly by the differences between the stimulus-specific incentives, and immediate implication being equal depression effects in performance to S+ and S-.

Given these recent theoretical considerations, the reliability and the magnitude of S+ depression should be firmly established. Theoretically, it would seem that, from one viewpoint, S+ depression should be less than S- depression, and from another, S+ depression should equal S- depression. As to the reliability of the effect, the most consistent finding is statistically reliable S+ depression (Gavelek & McHose, 1970; MacKinnon, 1967; Matsumoto, 1969); yet, one of the most frequently cited studies (Bower, 1961) obtained only a graphical or directional S+ depression effect. The present study, combining data from two large N experiments, contributes further information as to the reliability and magnitude of the S+ depression effect.

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Fig. 1. Group mean speeds in blocks of eight trials for the various conditions.

METHOD

The Ss were 240 naive albino rats, 120 days old at the beginning of each experiment, obtained from the Holtzman Company, Madison, Wis.

The apparatus consisted of a 25-cm midgray startbox and two 96-cm alleys; both alleys, which included 29½-cm goal sections, could be aligned with the startbox. One alley (including goal section) was painted flat black, the other flat white. For all sections, the inner height was 10 cm, and the inner width, 9 cm. A translucent Plexiglas covered all units of the apparatus. An opaque solenoid-operated door separated the startbox from the alleys. Clear Plexiglas, guillotine-type retrace doors separated the goal and runway sections of each alley. Photocell-clock circuitry provided traversal times over the first 90 cm, including a 30-cm start-time measure.

Approximately 9 days prior to the first training day, Day 10, Ss were placed on a 23-h food deprivation, free water access, schedule, which was maintained throughout the experiment. On Days 8-9, Ss were allowed to explore the start and run sections of the apparatus, and, upon the return to the home cages, Ss were fed approximately .5 mg of 45-mg Noyes pellets.

In Experiment I, 120 male Ss were randomly assigned to three groups, Groups 12-12, 12-1, and 1-1, designated according to the number of pellets received in S+ (e.g., black) and S- (e.g., white), S+ brightness being counterbalanced within each group. All Ss received four trials per day according to the following repeating cycle of black (B) and white (W) trials: BWBW, WWBB, WBBW, BBWW, WBWB, BWBW, for a total of 72 trials.

Ss were run in 20 squads of six Ss each, with the restriction that both S+ brightness conditions be present in any squad. Each S in a squad received an initial trial before any S received the second trial, etc. The intertrial interval was approximately 6 min. On each trial, the start door was opened after S had oriented toward the door for 3 sec, and the S was removed from the goal region immediately after reward consumption.

In Experiment II, 120 females served as Ss, with procedure otherwise not differing from that in Experiment I.

RESULTS AND DISCUSSION

Group mean start speeds collapsed over Experiments I and II are plotted as a function of blocks of eight trials in Fig. 1. For Groups L-L and S-S, "S+" and "S-" speeds did not differ and were collapsed into one trend

line for each group.

As may be seen in Fig. 1, Group L-S eventually developed faster speeds to S+ than to S- and, in terms of differences between means, S- speeds are depressed more than S+ speeds relative to the appropriate controls. A four-way analysis of variance over Blocks 8-9, which included groups, S+ brightness, replications, and discriminanda as factors, yielded a significant ($p < .01$) Groups by Discriminanda interaction, $F(2,228) = 69.7$. The replications factor and interactions with this factor were not significant; thus, all further analyses are for the combined data of Experiments I and II. Subsequent pair comparisons (Tukey A) of S+ and S- speeds indicated that only Group L-S ran significantly ($p < .01$) faster to S+ than to S-, that S- speeds for Group L-S were depressed relative to Group S-S ($p < .01$), and that speeds on S+ trials for Group L-S were significantly below those of Group L-L ($p < .01$). A comparison (t test) of S+ speeds for Groups L-S and S-S was not significant. This pattern of results is consistent with the bulk of previous differential conditioning data (McHose, 1970). The depressed S+ performance supports previous studies demonstrating S+ depression (Black, 1968; Gavelek & McHose, 1970; MacKinnon, 1967; Matsumoto, 1969) and the directional, but not reliable, S+ depression obtained by Bower (1961).

Of initial interest to the present evaluation of S+ and S- depression effects is the extent to which heterogeneity of variance is present, as discrepant variances would question the use of simple mean difference comparisons for evaluating the relative extent of S+ and S- depression. Comparisons (F-max) indicated that the variability of S- performance, among Ss, for Group L-S was significantly ($p < .01$) greater than the variance among Ss in performance to S+. Comparisons for and between Groups L-L and S-S did not reach conventional significance levels. Since the variance heterogeneity is present, it is necessary to "standardize" the depression effects in some fashion in order to evaluate the relative extents of S+ as compared with S- depression effects. One possibility is to express the performance differences for the differential and nondifferential reward conditions in terms of the combined variances of the conditions involved in the depression effect comparisons. Accordingly, from the performance of each S in Group L-S on both S+ and S- trials, the appropriate control mean was subtracted. This difference was then expressed as a proportion of the combined variances (actually, the standard error). Thus, for S+ performance, the performance of each S in Group L-S on S+ trials, relative to the mean performance of Group L-L on "S+" trials, was divided by the standard error of the difference for the S+ performance of Groups L-S and L-L, i.e., the S+ depression effect was "standardized." The transformation was repeated for the S- performance of each S in Group L-S, substituting the mean performance of Group S-S and S- performance variances. Mean ratio scores, resulting from the

transformation, for both the S+ and S- performance of Group L-S over Blocks 8-9 (Days 15-18) are plotted in Fig. 2.

As may be seen in Fig. 2, little difference exists between S+ and S- depression effects following the transformation. A *t* test of this difference over Days 15-18 was not significant. The present data, then, indicate that, when the difference in variability (among Ss) on S+ as compared with S- trials is taken into account, S+ and S- depression effects are of an equal magnitude. Also, these data demonstrate explicitly the discrepancy in previous studies between levels of statistical reliability and the relative magnitudes of mean speed differences for S+ and S- depression (e.g., Gavelek & McHose, 1970; Matsumoto, 1969).

While one might question the form of the present transformation, it is the present viewpoint that this finding, equal S+ and S- depression, is inconsistent with theoretical positions that assume that S- depression results from a generalized form of inhibition (e.g., Black, 1968; MacKinnon, 1967), since, in their present form, these approaches would expect S+ depression to be of a lesser magnitude than S- depression. Such an approach could, however, interpret S- depression effects alone, dropping the notion that S+ depression is produced by a generalized form of the mechanism for S- depression. Similarly, separate or independent approaches to S+ depression, the *r_g*-preparedness notion for example (Perkins, 1970), are of course not contradicted by the present data. It is perhaps more reasonable, given the equal depression effects, to assume that they result from the operation of one and the same theoretical process. The McHose (1970) model takes this approach, assuming that both S+ and S- depression result from the operation of an (inhibitory) incentive difference variable, expecting comparable S+ and S- depression effects. From this framework, neither the S+ nor the S- depression effect receives secondary, or separate,

theoretical treatment, both effects being described by the same set of incentive equations.

Although the present study clearly demonstrates a variance difference between S+ and S- performance, it does not, of course, provide any empirical or theoretical insight as to the reason for greater variability between-Ss on S- as compared with S+ trials. Such a difference could be related to greater trial-to-trial differences in S- as compared with S+ performance during discrimination learning, a source of variance the subject of theoretical attention elsewhere (cf. Amsel & Ward, 1965). It should be emphasized, however, that, regardless of the ultimate explanation of the variance difference, the present data demonstrate comparable S+ and S- depression effects when the discrepant variances are taken into account.

Finally, because of the statistical power inherent in the present study, one other aspect of the present data should be mentioned. The performance of Group L-S on S+ trials did not differ from the "S+" performance of Group S-S, a finding consistent with a number of previous studies with less power (e.g., Ludvigson & Gay, 1966; Matsumoto, 1969; McHewitt & McHose, 1970). This equivalence is predicted by, and critical to, the McHose (1970) model of differential conditioning, such a prediction being peculiar to this theoretical approach. While previous failures to obtain a difference could possibly be attributed to a lack of statistical power, and thus of no particular theoretical importance, the present data are not reasonably subject to this possibility.

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Fig. 2. Transformed scores for Group L-S on both S+ and S- trials.

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