numerosity. Why this accentuation is more pronounced with respect to changes in duration than in numerosity is not clear. However, it can be reasonably concluded that the monotonic effect of numerosity on temporal judgment is independent of temporal discriminability.

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Contrast effects with shifts in punishment level

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The present experiment was designed to investigate the effects of shifts in punishment level using a successive shift procedure. Rats were given a constant reward (two pellets) throughout training but received varying intensities of brief electric shock (punishment) in the goalbox. During preshift, subjects ran for 40 trials to either .1, .4, or .8-mA shocks in the goalbox. All subjects were then shifted to .4 mA in the goalbox for 40 trials. The results showed that subjects shifted to a higher intensity shock ran slower than subjects originally trained on that higher intensity shock (negative contrast). There was no evidence of a corresponding positive contrast effect. The data were discussed with respect to their implications for theories that attempt to treat reward and punishment in comparable theoretical fashion.

A positive contrast effect is said to occur when subjects shifted from a small magnitude of reward to a large magnitude run faster than subjects which have received only the large magnitude of reward. A negative contrast effect involves the converse situation (subjects shifted from large to small magnitude of reward run slower than subjects which have received only the small reward magnitude).

Evidence for contrast effects when positive incentives are manipulated is voluminous, recent studies indicating that positive contrast (Mellgren, 1971, 1972; Nation, Wrather, & Mellgren, 1974; Shanab & Ferrell, 1970; Shanab, Sanders, & Premack, 1969) and negative contrast effects (cf. Black, 1968) have occurred with some regularity.

Although there are functional and theoretical precedents for treating punishment and reward as joint determinants of the same theoretical construct (e.g., Logan, 1969), the effects of increases and decreases in punishment have apparently received little attention in recent years. In fact, other than a few conceptually related punishment studies (e.g., Church, 1969) there do not appear to be any available punishment studies specifically relevant to contrast.

The purpose of this study was to provide further information regarding the effects of shifts in punishment (negative incentive), holding positive reinforcement constant. One shifted group receive .1-mA shock in the goalbox during Phase 1, then .4 mA during Phase 2 while the other shifted group received .8-mA shock during Phase 1 followed by .4 mA in the second phase. The control group received .4-mA punishment throughout training. All groups received a constant reward consisting of two food pellets on each trial throughout the experiment.

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METHOD

Subjects

The subjects were 30 male albino rats of the Sprague-Dawley strain purchased from the Holtzman Company. They were approximately 100 days old at the start of the experiment and were randomly assigned to one of three groups (N = 10/group). All subjects were housed individually with water continuously available.

Apparatus

The apparatus consisted of a commercially made straight alley runway manufactured by the Hunter Company described elsewhere in detail (Nation, Wrather, & Mellgren, 1974). Start, run, and goal times, and their sum (total) were converted to reciprocals for analyses. A scrambled shock was administered to the goalbox through a Model 700 Grayson-Stadler shock generator when the subject entered the goalbox. A teaspoon mounted in the middle of the far end of the goalbox served as the foodcup.

Procedure

A 12-g food depriviation schedule (adjusted for amount of food received in the runway) was established during the 7 days prior to the start of the experiment. During this time all subjects were handled and marked for individual identification.

Preshift Training

The subjects were divided randomly into three groups of 10 in each group. All groups received 40 preshift trials (four trials per day) with two 45-mg Noyes food pellets in the foodcup. Although the amount of food reward was held constant for all groups during training the three groups differed with regard to the intensity of shock experienced in the goalbox, i.e., subjects within a group received either .1-, .4-, or .8-mA shock (1-sec duration) in the goal section of the runway. The procedure was identical for all groups in the preshift and postshift phases of the experiment (with the exception of the differing shock intensities). The subjects was placed in the startbox facing the startbox door. Three seconds later the door was opened and the subject was allowed to traverse the runway and enter the goalbox. After the subject entered the goalbox the door was immediately closed to prevent retracing and a shock (either .1, .4, or .8 mA) was delivered to the goal section. The subject was then given time to consume the two pellets in the food cup. Subjects were run in squads of six (two from each group) thus creating an intertrial interval (T) of 4-5 min.

Postshift Training

The group running to .4-mA shock in the goalbox during preshift was maintained at this shock level throughout the postshift phase of the experiment (.4–.4). The group that received .1-mA in preshift was shifted to .4 mA in postshift (.1–.4). This shift was directed toward a demonstration of a negative contrast effect since a shift from .1 to .4 mA is analogous to a shift from high to low reward. Similarly, the group receiving .8-mA shock in preshift was shifted to .4 mA in postshift in an effort to show a positive contrast effect (.8–.4). In postshift, as in preshift, all subjects were given two 45-mg Noyes pellets on each trial. The postshift phase of the experiment lasted 10 days (four trials per day) for a total of 40 postshift trials.

RESULTS

Preshift

Clear preshift differences due to differential shock levels in the goalbox developed over the 40 preshift trials. An analysis of variance on the last 4 days of preshift for total speeds revealed a highly significant main effect for preshift shock level (F = 24.38, df = 2/27, $p < .001$), with each group differing from the others ($p < .01$ in all cases). The same result was evident in the fractioned speed measures (Fs = 19.14, 11.75, 19.12 for start, run, and goal, respectively; df = 2/27, $p < .01$ in all cases). Both the days main effect and the Preshift Shock Level by Days interaction failed to reach significance in any of the measures thus indicating that all groups were relatively stable at the end of preshift.

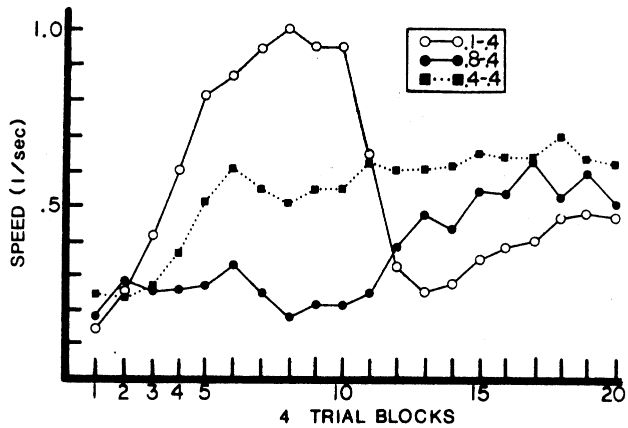

Figure 1. Mean total running speeds for preshift (first 10 days) and postshift (last 10 days).

Postshift

The running speed for the total measure are shown in Figure 1, and a negative contrast effect is graphically indicated. In order to investigate the statistical reliability of this effect, a 3 by 10 analysis of variance was performed on the postshift data with preshift shock level and days (blocks of four trials) being the variables. The analysis revealed a nonsignificant main effect of preshift shock level (F = 1.64, df = 2/27, $p > .01$) but showed a significant Preshift Shock Level by Days interaction (F = 2.14, df = 18/243, $p < .005$). The days main effect was also shown to be significant (F = 2.54, df = 9/243, $p < .01$) but the finding of a significant interaction makes this result unimportant. Post hoc analyses (via Tukey's procedure) were performed on the interaction means. The results indicated that Group .1–.4 ran significantly slower than Group .4–.4 on all postshift days except Day 11 (all ps < .05). This finding indicates that a negative contrast effect occurred after the first postshift day and remained throughout the experiment. The interaction results also indicated that while Group .8–.4 was significantly below Group .4–.4 in the early stages of postshift (ps < .05 for Days 11 and 12), the difference between the two groups at the end of postshift was nonsignificant (ps > .05 for Days 17-20). These findings statistically demonstrate a rather obvious failure to show a positive contrast effect.

The fractioned speed measures revealed further information concerning the effects of shifts in different shock intensities. The analysis of goal speed showed essentially the same result as that for total speeds. The main effect for groups was significant ($F = 3.99$, $df = 2/27$, $p < .05$) with Group .1–.4 running significantly slower than Group .4–.4 (negative contrast). The other possible comparisons on the preshift shock level main effect failed to reach an acceptable level of significance (all $ps > .05$). The days main effect was shown to be nonsignificant ($F = 1.27$, $df = 9/243$, $p > .05$) but the finding of a significant Preshift Shock Level by Days interaction ($F = 2.33$, $df = 18/243$, $p < .01$) further supports the presence of a negative contrast effect, i.e., post hoc comparisons indicated Group .1–.4 was significantly below .4–.4 on Days 12-20 (all $ps < .01$). The analysis on start and run speeds failed to reach acceptable levels of significance on either the main effect or interaction comparisons (all $ps > .05$). These findings indicated that the difference in total speed between Groups .1–.4 and .4–.4 (negative contrast) was entirely a result of goal performance.

In summary, a negative contrast effect appeared early in postshift and was shown to be primarily a result of goal speed differences. There was no evidence, in any measure, of a corresponding positive contrast effect. The negative contrast effect was shown to be relatively durable and in that respect is consistent with some previous data (e.g., Collier & Marx, 1959; Mellgren, 1971; Nation et al., 1974), but not consistent with other studies (Dunham, 1968).

DISCUSSION

The present results clearly demonstrate that increases in intensity of shock depress performance relative to that displayed by subjects trained and maintained on the higher intensity of shock, i.e., negative contrast effects occur following shifts in punishment level. There was no evidence of a corresponding positive contrast effect with shifts in punishment level.

The findings of this study in combination with previous research have implications for theoretical formulations which treat punishment and amount of reward in a comparable theoretical fashion (e.g., Logan, 1960; Logan & Wagner, 1965; Milleson & deVilliers, 1972). These investigators suggest that punishment of a given magnitude can be conceptualized to subtract a constant amount of excitation regardless of the magnitude of positive reinforcement, i.e., punishment and reward are assumed to combine algebraically. It would be predicted that the same behavioral consequences would occur following changes in punishment with reward held constant as occur following changes in reward with punishment maintained at a constant level. The present data are not totally consistent with such a prediction. In the present experiment which manipulated magnitude of punishment while holding positive reinforcement constant, asymmetrical contrast effects emerged, i.e., negative contrast was obtained but there was no indication of a positive contrast effect. Thus, it appears that shifts in punishment produce performance changes which are only partially consistent with predictions derived from an algebraic incentive theory (e.g., Logan, 1969, Logan & Wagner, 1965; Millenson & deVilliers, 1972).

Another theoretical position relevant to the present experiment is the "incomplete shift" or "inertia" hypothesis (Church, 1969). The inertia hypothesis states that if a subject has learned to perform in a certain manner in the presence of one stimulus configuration, it will perform in a similar manner in the presence of other similar stimuli. This seems to be particularly true in situations involving the presence of a second intensity shock, where it has been show that subjects tend to persist in the performance learned in the context of the first intensity shock (Raymond, 1968). In the present study, the failure to find a positive contrast effect is consistent with the inertia hypothesis, but the fact that negative contrast was found would seem to demand an alternative explanation or at least a modified version of the original positon.

In explaining the present data, one potentially useful hypothesis concerns the inherent relationship between punishment and response events. It is logical to assume that the introduction of punishment is disrupting and, in fact, such findings have been thoroughly documented in the punishment literature (Church, 1969) The effects of the termination or reduction in punishment are less well understood. When a punishment event is either introduced for the first time or is intensified, the effect is to produce certain unlearned responses (e.g., crouching, jumping, etc.) that are incompatible with an instrumentally reinforced running response. However, there do not appear to be any corresponding unlearned reactions to the termination of punishment which might serve to facilitate performance. Thus, response disruption following an increase in punishment intensity might be expected to occur more readily than response facilitation following a decrease in punishment intensity. The present results are certainly in accord with this line of thinking.

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