EFFECTS OF AMOUNT OF POSTSHIFT TRAINING ON RESISTANCE TO EXTINCTION

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The investigation sought to examine resistance to extinction (Rn) as a function of previous experience with downward shifts in reward magnitude. It was suggested that previous research conducted within the framework of the Spence-Amsel frustration hypothesis and the sequential hypothesis failed to administer sufficient postshift trials to adequately establish the relationships that may exist.

Under one condition, four groups of rats received twenty extinction trials following forty postshift trials. Under another condition, four groups were extinguished following eighty postshift trials. An inverse magnitude of reward effect occurred in the preshift phases, however, which prevented an adequate analysis of either the shift or the Rn data. This unexpected effect was discussed within the framework of Black's incentive-motivation interpretation of reinforcement.

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EFFECTS OF AMOUNT OF POSTSHIFT TRAINING ON RESISTANCE TO EXTINCTION

Within the context of appetitive instrumental learning, shifts in the magnitude of food reward (Wg) will produce abrupt changes in performance if the change in Wg is sufficient. Following acquisition training in a straight runway, subjects (Ss) shifted to a small Wg may perform at a lower level than unshifted control Ss trained with the small Wg. Following an upward shift in Wg, Ss may perform at a higher level than unshifted Ss trained with the large Wg. Crespi (1942) originally labeled these phenomena as "depression" and "elation" effects, respectively, but more recent literature generally refers to each as "negative contrast effects" (NCE) and "positive contrast effects" (PCE), respectively.

Recent reviews in this area of learning (Black, 1968; Dunham, 1968; Bitterman & Schoel, 1970) pointed out that the occurrence of the NCE is well established, while the occurrence of the PCE is relatively rare. Spence (1956), in discussing his significant NCE results, but no PCE, suggested that earlier studies reporting PCE (e.g., Crespi, 1942; Zeaman, 1949) had inadequate preshift training. The number of preshift trials in both Crespi's (1942) and Zeaman's (1949) experiments was insufficient to attain asymptotic running speed, and subsequently, the increase in running speed following the upward shift in Wg may have been a function of both the shift in Wg and the continued training in the runway.

Although it is well established in the literature, the NCE has failed to occur under some circumstances. Gonzalez, Gleitman, and Bitterman (1962) reported that a large decrement in Wg produced with successive small decrements (over a series of trials) produces a gradual decline in performance and does not produce NCE. Shelton (1970), however, produced NCE with a decrement from large to medium Wg and another, subsequent, NCE with a second decrement from medium to small Wg. Mikulka, Lehr, and Pavlik (1967) found that partial reward in the preshift phase of training will either delay or eliminate the NCE. Under transfer shift conditions, where the Ss have had prior experience with the postshift Wg, the NCE does not occur (Capaldi & Lynch, 1967). Cleland, Williams, and DiLollo (1969) and Ehrenfreund (1971) reported the failure to obtain significant NCE under low-drive conditions while obtaining significant results under high-drive conditions. Other instances where the NCE has failed to occur could be cited, but in general it may be predicted under conditions of continuous reinforcement and high drive level in a nontransfer shift from large to small Wg.

The negative contrast phenomenon is apparently of a transitory nature. Although Black (1968) and Dunham (1968) contended that the phenomenon exhibits persistence following a shift in Wg, recent evidence (e.g., Shelton, 1970; E. D. Capaldi, 1970) has indicated that the Ss' performance will recover (or adapt) to the level of the unshifted control animals if sufficient postshift trials are given. As Shelton (1970) pointed out, the phenomena of persistent NCE are a function of the amount of decrement in Wg, the number of preshift trials, and the number of postshift trials. The larger the decrement and the greater the number of preshift trials, the greater the probability that the performance will fail to recover with any given number of postshift trials.

Resistance to extinction (Rn) following complete reward reduction may be a function of these variables also. The literature, however, has yet to clarify the functional relationships that may exist between Rn and such varied conditions of reward that will produce NCE.

Two of the hypotheses that have been formulated to account for both contrast effects and resistance to extinction following varying conditions of reward are the Spence-Amsel frustration hypothesis (Spence, 1956; 1960; Amsel, 1958; 1962) and the sequential hypothesis (Capaldi, 1967). Both are associational in nature, and in many instances they make identical predictions. The present investigation sought to test certain assumptions underlying both theories.

As originally stated, the frustration hypothesis pertained only to the emotional consequences of nonreward following experience with reward. Bower (1961) extended the hypothesis to include the consequences of less-than-complete reductions in reward magnitude. Within this framework, the NCE is attributed to a consequential "frustration response" occasioned by the reduction in Wg. The theoretical chain of events may be illustrated by using the successive contrast paradigm as an example. It begins with a classically conditioned anticipatory goal response (rg) being formed as a part of the instrumental sequence involved in the acquisition (or preshift) phase of runway training. Once formed, the rg "moves forward in time and, through its feedback stimulation (sg), becomes part of the mechanism for the evocation of the instrumental response [Amsel, 1967, p. 7]." Reward-incentive motivation is said to be in operation at this point, affecting the instrumental response. When the reward-incentive motivation is operating (e.g., at the end of the preshift phase) and a downward shift in Wg is introduced (the postshift phase), a primary frustration response (R_F) is evoked. With the R_F serving as the unconditioned response (UCR) to the small Wg, an anticipatory frustration response (*rf*) is classically conditioned as a part of the instrumental sequence involved in the postshift phase. The *rf* is assumed to move backward along the instrumental sequence to affect the instrumental response through its feedback stimulation (*sf*). The *sf* is assumed to elicit responses incompatible with the instrumental approach response and is thus antagonistic to the influence of *rg*. The NCE is hypothesized to occur due to the conflicting responses evoked by the *rg*-*sg* and *rf*-*sf* mechanisms.

With continued postshift training, recovery of the running response to the level of unshifted control *S*s would be predicted. The *rg* is assumed to be a fractional component of the primary goal stimulus (R_G), which was large Wg in the preshift phase. During the postshift phase, only small Wg is presented, and the *rg* adapts or "extinguishes" over a series of trials until its strength is appropriate to the small Wg. The magnitude of the R_F also decreases since R_F evocation is contingent upon the presence of *rg* in the absence of R_G. Once *rg* has adapted to the small Wg, *rf* will extinguish in the absence of the UCR, the R_F.

Amsel (1967; Amsel & Ward, 1965), in discussing these mechanisms as they pertain to partial reinforcement, suggested that at the stage where *rg*-*sg* and *rf*-*sf* are mediating competing responses, continued training will lead not only to *rf* extinction, but the anticipatory frustration-produced cues will become counterconditioned to the instrumental running response in the process. It is this <u>sf</u> $\longrightarrow R_{running}$ mechanism which is used to account for the greater resistance to extinction exhibited by <u>S</u>s trained under a partial reinforcement schedule than by <u>S</u>s continuously reinforced. In common sense terms, the animals have learned to continue running in the face of cues to nonreward.

In 1969, Amsel extended the frustration hypothesis to a general theory of persistence which suggests that the action of a mechanism such as <u>rf</u>-<u>sf</u> may underlie the learning of all persistent behavior. He hypothesized that when any response (So $\longrightarrow$ Ro) is maintained in the presence of any stimulus (Sx) evoking competing response tendencies (Rx), some degree of Sx $\longrightarrow$ Ro counterconditioning will occur. Subsequently, So $\longrightarrow$ Ro will become less subject to disruption by stimuli of the Sx class.

Three possibilities were suggested by Amsel (1969; Glazer & Amsel, 1970) concerning such an underlying mechanism: (<u>a</u>) Sx $\longrightarrow$ Ro counterconditioning adds to a nonspecific persistence pool and thereby to general persistence of the organism; (<u>b</u>) there are different, but overlapping, systems controlling persistence, and Sx $\longrightarrow$ Ro counterconditioning may only partially transfer between related systems; or (<u>c</u>) specific Sx become counterconditioned to specific Ro, with no transfer from one response system to another. Within the context of these possibilities, responding to a smaller Wg would be a different response system than responding to nonreward.

The frustration hypothesis and the sequential hypothesis view reward magnitude as influencing the growth of associative strength. However, where the frustration hypothesis views the reinforcing effect of any one level of Wg as dependent upon the context in which it occurs, the sequential hypothesis (Capaldi, 1967; Capaldi & Lynch, 1967) views each level of Wg as a distinctive stimulus that is independent of other levels in the series. Each stimulus (e.g., S^{RL} large reward, S^{RM} medium reward, S^{RS} small reward, S^{N} nonreward) is related only to the absolute properties of reward, such as its size. Thus, where the frustration hypothesis conceptualizes small Wg following large Wg as occasioning frustration and its various associated effects, the sequential approach views this event as the introduction of a second stimulus which will acquire associative strength (habit) independently of the previous stimulus. In other words, S^{RS} replaces S^{RL} on its first presentation and will acquire habit strength ($\underline{H}$) independently of the effects of prior experience with S^{RL}. With repeated trials, $\underline{H}$ is assumed to grow by the simple positive growth function described by Hull (1943).

The sequential approach yields a different theoretical chain of events in its account of the NCE. It assumes that the $\underline{S}$ begins acquiring $\underline{H}$ with each trial of large Wg in the preshift phase of runway training. The magnitude of the reward involved in this training is assumed to "energize" habits or reactions. The larger the Wg the greater the intensity of the stimulus and the greater its strength to energize the reaction. This stimulus intensity ($\underline{V}$) interacts multiplicatively with $\underline{H}$ to determine reaction potential (E):

$$E = \underline{H} \times \underline{V}.$$

Shifting the $\underline{S}$ from S^{RL} to S^{RS} reduces the stimulus intensity for large Wg to that for a small Wg, which results in less E. The shift leaves associative strength (H) for large Wg unchanged, and the S begins acquiring H for the small Wg on the first postshift trial. For the shifted S, E is now a function of V for small Wg and of the amount of generalized habit strength ($\bar{H}$) to S^{RS} from S^{RL}. Since the shifted S has only a generalized habit to elicit the running response following the first postshift trial, an NCE may be predicted. The NCE is hypothesized to occur due to the generalization decrement.

The magnitude of the NCE is postulated to be a function of (a) the degree of stimulus change, (b) the amount of generalization decrement, and (c) the learning rate (F). The greater the degree of stimulus change, with any given generalization decrement rate, the greater the probability of an NCE since $\bar{H}$ would be correspondingly smaller. For the same reason, the greater the generalization decrement rate, with any given degree of stimulus change, the greater the probability of the NCE. In regards to the learning rate, Capaldi (1967) suggested that "other things equal, the slower the learning rate, the larger the negative contrast effect, and the greater the number of trials required to overcome it [p. 109]." As regards the magnitude of the NCE, it is unclear why this is postulated. Recalling that H is assumed to grow by the simple growth function described by Hull (1943), it is reasonable to assume that "other things equal," H will be less for any given number of trials with a slow F than with fast learning, and $\bar{H}$, consequently, will be correspondingly smaller. However, H acquired by the control Ss, a comparison with which will define the NCE, will also be smaller with a slow learning rate. It seems more reasonable to assume that the magnitude of the NCE is a function of the stimulus change factor and the rate of generalization decrement, while the rate of recovery from the NCE is a function of F, and the number of trials to recovery is a function of F and the magnitude of the NCE. With a high rate of learning, an NCE should be overcome rapidly due to the rapid growth of H in postshift training. These assumptions that center on F may be tested following the occurrence of an NCE by making a median split of the group experiencing the shift in Wg and analyzing the depth of the NCE and the rate of recovery of the slow versus the fast learners.

Within the context of the successive contrast paradigm, where a preshift block of continuously reinforced trials is followed by a block of continuously reinforced trials with a different level of reward, it has been found that Rn is inversely related to postshift Wg (E. D. Capaldi, 1970; Spear & Spitzner, 1968; Leonard, 1969). Neither hypothesis being considered here has difficulty in accounting for this. The relationship between Rn and preshift magnitude of reward is less clear, however. Metzger, Cotton, and Lewis (1957), using 10 preshift and 10 postshift trials, and Spear and Spitzner (1968, Exp. I), using 20 preshift and 24 postshift trials, reported that Rn is independent of preshift magnitude of reward. E. D. Capaldi (1970) increased the number of trials to 35 in both phases and reported a significant effect on Rn of the preshift magnitude, but only in the case of the upward-shifted Ss. The Ss which experienced a downward shift in Wg did not differ in Rn from the control Ss trained only with small Wg.

Shelton (1970) investigated the effect of preshift Wg on subsequent Rn following both single and multiple downward shifts. He administered 40 trials in each of 3 phases to groups that received the following sequences of Wg: Group LMS received large Wg in Phase 1, medium Wg in Phase 2, and small Wg in Phase 3; Group LLS, in the same manner, received a large-large-small sequence; Group MMS received a medium-medium-small sequence; and Group SSS received small Wg in all 3 phases. Following the third phase, extinction trials were begun. Groups LMS and SSS did not differ in Rn, but both were significantly greater in Rn than Groups LLS and MMS, which did not differ from each other. Shelton acounted for these results within the framework of Amsel's (1969; Glazer & Amsel, 1970) general theory of persistence by assuming that the third and most restrictive possibility is valid, namely, that there was no transfer of persistence among the specific disrupting stimuli of reward decrement and of nonreward. The question remains, however, why there were differences between any of the groups if no transfer occurred. Shelton suggested that at the end of Phase 3, *rg* may not have completely extinguished to the small Wg level in the case of Groups MMS and LLS, which suggests that nonreward evoked a greater R_F in those *S*s, thereby hastening extinction.

These Rn data, especially E. D. Capaldi's (1970) and Shelton's (1970), also pose questions for the sequential hypothesis. The literature specific to the sequential approach (e. g., E. J. Capaldi, 1967; 1970; Capaldi & Lynch, 1967; Leonard, 1969; E. D. Capaldi, 1970) is very unclear in these regards. Following training with two or more levels of Wg, two or more generalized habit strengths are assumed to "summate" at S^N, and this composite $\bar{\underline{H}}$ determines Rn. The literature, however, is not specific about how the two or more $\bar{\underline{H}}$s summate. What is assumed in connection with asymptotic $\bar{\underline{H}}$ is very unclear, especially at S^N. If it is assumed that two or more generalized habits summate in the manner described by Hull (1943), then for any given Wg, a physiological limit (Hull's *M*) applies to the calculation of *H* and, consequentially, to the summation of any two or more *H* values. Whether or not there is a limit or "ceiling effect" on $\bar{\underline{H}}$ at S^N is crucial to any predictions that may be made regarding Rn if two or more generalized habits are assumed to exist at S^N at the beginning of the extinction phase. In order to illustrate how one given combination of reward results in greater $\bar{\underline{H}}$ at S^N than will another combination, the sequential literature has generally used arbitrary asymptotes of *H*, assumed distances along the stimulus continuum from one stimulus to another, and assumed generalization decrement rates. In terms of prediction, however, such an a posteriori technique has little or no value.

This investigation sought to explore the relationship between preshift Wg and subsequent Rn with the postshift number of training trials independently varied. In terms of the frustration hypothesis, such a procedure should either support or oppose Shelton's (1970) speculation about *rg* extinction in the postshift phase. Except for using different amounts and type of Wg, one of the two conditions used in this research was identical in method to that used by Shelton, and although this could not be considered an attempt to replicate, it was hypothesized that the results under this one condition (the limited condition) would be in full agreement with Shelton's results. The second condition (the extended condition) of this investigation extended the number of postshift trials by an additional 40 trials which, if *rg* extinction or adaptation actually occurs, should be sufficient to test Shelton's speculation.

In terms of the sequential hypothesis, the extended postshift training allowed an analysis of extinction data in an effort to clarify the summation of H values at S^N (discussed above). With extended training at small Wg in the third phase of all Ss, at least one of the H values entering into the calculation of $\bar{H}$ at S^N would be asymptotic. If summation is still assumed to occur, the sequential approach would have predicted that the groups would be ranked in greatest Rn as a function of H acquired in the preshift phases (Phases 1 and 2). A finding that the groups did not differ in Rn following extended postshift training would indicate that summation is somehow limited and that Rn is independent of preshift Wg when postshift H is asymptotic. The latter instance would be in agreement with Shelton's speculation in terms of prediction, and it would oppose the assumption that summation occurs when $\bar{H}$ from S^{RS} to S^N is asymptotic.

Method

Subjects

The Ss were sixty-four experimentally naive, female albino rats purchased from Sprague-Dawley. The Ss were approximately 40 days old upon arrival and were housed in individual cages. They were approximately 115 days in age at the beginning of acquisition training.

Apparatus

The apparatus was a straight-alley runway, consisting of an 11-in. start box (SB), an 87-in. alley, and an 11-in. goal box (GB). Inside dimensions were 4 in. by 4 in. in all sections. Two guillotine doors separated the SB and GB from the alley; each were operated manually. The entire apparatus was painted flat gray except for a clear plastic covering over all sections. A stainless steel food plate, 3 in. in diameter and with a 3/16-in. lip, was attached to the GB floor against the end wall.

Three Lafayette 0.01-sec. timers recorded running speeds. Clock 1 was activated when S interrupted a photobeam 12 in. from the inside end wall of the SB. Clock 1 was stopped (start time) and Clock 2 was activated when S interrupted a second photobeam 12 in. from the first photobeam. Clock 2 was stopped (run time) and Clock 3 was activated when S interrupted a third photobeam 62 in. from the second photobeam. Clock 3 was stopped (goal time) when S interrupted a fourth photobeam 12 in. from the third photobeam.

The apparatus was constructed to allow tilting the runway away from the floor to allow periodic cleaning. The floor was wiped clean with a slightly damp cloth after every four trials throughout the experiment.

Procedure

Experimental design.--The sixty-four Ss were randomly assigned to eight groups of eight Ss each on the day preceding pretraining. Each group was randomly assigned to one of four sequences of Wg under one of two training conditions. The limited training condition (lm) consisted of 40 trials in Phases 1, 2 and 3, followed by 20 extinction trials; the extended training condition (ex) consisted of 40 trials in Phases 1 and 2, 80 trials in Phase 3, followed by 20 extinction trials. Within each training condition the four sequences of Wg were: Large-Medium-Small (Groups LMS-lm and LMS-ex); Large-Large-Small (Groups LLS-lm and LLS-ex); Medium-Medium-Small (Groups MMS-lm and MMS-ex); and Small only

(Groups SSS-lm and SSS-ex). The large Wg consisted of 11 .075-gm. Noyes pellets. The medium Wg was 8 pellets, and small Wg was 4 pellets.

Pretraining.--Throughout the experiment the Ss were housed in individual cages with ad lib water. Nine days prior to the beginning of acquisition training the Ss were placed on a 23-hr. deprivation schedule. Each S was given free access to Purina Laboratory Chow for 1 hr. at a time of day to coincide with its scheduled time in the apparatus during acquisition training. This maintenance schedule was maintained throughout the experiment, and each S was weighed on Days 1, 10, 20, and 30 of the experiment for a test of weight differences.

During the nine pretraining days, each S was individually habituated to the experimental situation by systematic handling by the experimenter (E). From the fifth through the eighth day of pretraining, the Ss received individual exposure to the runway for two min. each. On the last day of pretraining, each S received two 30-sec. direct placements in the GB with the Wg it was to receive during Phase 1 training. The direct placements were separated by approximately 15 min.

Phase 1.--Forty acquisition trials were given to all Ss beginning on the day following pretraining. Four trials were given to each S each day. A trial was initiated with the placement of the S in the SB; both guillotine doors were raised approximately 5 sec. later. Each door was lowered as the S passed under in order to prevent retracing. The S was removed from the GB after consuming its Wg or after 20 sec., whichever was longer, but in no event was allowed to remain in the GB longer than 90 sec. Intertrial intervals were approximately 10 min.

The Ss were trained in squads of eight each, with an animal from each group composing each squad. Assignments to the squads were randomly made within the foregoing limitation. Squads were run in the same order each day, with four squads being run in the early morning and four in the mid-afternoon, but the order within each squad was randomized each day. The Ss in each squad received their daily access to food following the last trial of the day for that squad.

Phase 2.--The procedures followed in Phase 1 were followed in Phase 2 except that Groups LMS-lm and LMS-ex received medium Wg instead of the large Wg that they received in Phase 1. Forty trials were given to all Ss in this phase.

Phase 3.--On Day 21 of the experiment all Ss began receiving small Wg. Forty trials were given to the Ss under the limited condition, and eighty trials were given to the Ss under the extended condition. All other procedures, except as outlined below, remained the same.

Extinction phase.--Extinction trials began on Day 31 for the Ss under the limited condition and on Day 41 for the Ss under the extended condition. Ss were retained in the empty GB for 20 sec. on each of 20 trials. The trials were given at the rate of four daily, and the 10-min. intertrial interval was maintained.

Because Ss from both conditions were represented within each squad, the 31st through the 35th day posed a special problem and required a slight change in procedure. It was felt that rats on extinction may leave an odor cue that could affect the performance of the rats still receiving a reward under the extended condition. In order to control for this, the four Ss within a squad under the same condition were run one after another, and then before the four *Ss* of the other condition were run, the floor of the runway sections was cleaned. Other procedures remained the same.

Results

The running times of each *S* on each trial were converted into speeds (ft/sec), and all analyses were conducted on the speeds. The groups were collapsed across conditions in all analyses covering the first thirty days of the experiment since the conditions variable had no bearing on the tests for reward magnitude effects or for negative contrast effects. One *S* (from Group SSS-ex) died during the course of the experiment, and its data were excluded from all analyses.

Due to a sticking electromagnet in Clock 3 which wasn't discovered until well into the experiment and which resulted in randomly misrepresented running times in the goal section, the goal speed data were discarded. Total speed was redefined as the ft/sec ratio over the combined start and run sections of the runway.

Phase 1

The performance of each group by runway section and total for each of the days in Phase 1 is illustrated in Figure 1. An analysis of variance on first-day speeds indicated that differences were significant in the start and total, but not in the run section. Start, F (3, 248) = 3.26, $p < .05$; run, F (3, 248) = .86, $p > .05$; total, F (3, 248) = 2.82, $p < .05$. A Newman-Keuls test indicated that Group LMS ran faster than Group MMS in start and total, and Group LLS ran faster than Group MMS in the start section (all $ps < .05$). No other differences were significant at the .05 level. An analysis of variance over all days of Phase 1

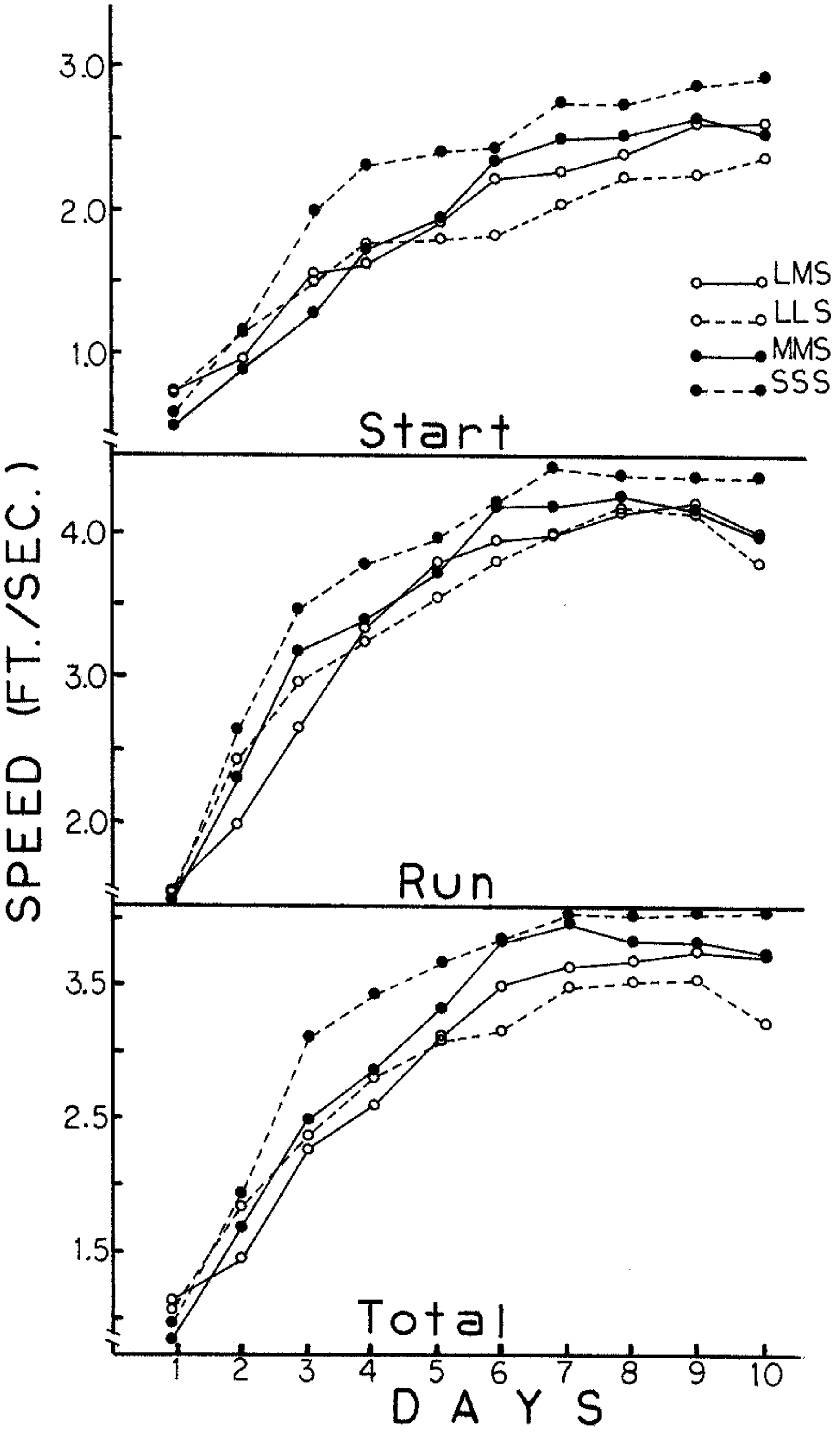

Fig. 1--Mean speeds during Phase 1 for each day (blocks of four trials) for the start, run, and total runway measures.

yielded a significant magnitude of reward effect, but it was contrary to the expected direction. Start, $F\ (3, 2516) = 20.44$, $p < .0001$; run, $F\ (3, 2516) = 9.79$, $p < .0001$; total, $F\ (3, 2516) = 15.34$, $p < .0001$. A Newman-Keuls test indicated that Group SSS ran significantly faster than all other groups in all sections, that Group LMS was faster than Group LLS in the start section, and that Group MMS was faster than Group LLS in the total (all $ps < .05$). Other comparisons were not significantly different. An analysis of variance of the speeds over the last two days of Phase 1 also yielded a significant magnitude of reward effect in all sections. Start, $F\ (3, 500) = 13.58$, $p < .0001$; run, $F\ (3, 500) = 4.91$, $p < .01$; total, $F\ (3, 500) = 9.35$, $p < .0001$. A Newman-Keuls test indicated that the effect was in the unexpected direction with Group SSS running significantly faster than the other groups in all sections and with Group LMS and MMS running significantly faster than Group LLS in the start and total (all $ps < .05$). No other comparisons indicated significant differences.

Phase 2

The performances of each of the groups in each of the alley sections on each day of Phase 2 are shown in Figure 2. Because of the inverse reward magnitude effect that developed and was maintained in Phase 1, the usual procedure of testing for an NCE by comparing the downshifted group's speeds to those of the unshifted controls was not meaningful in this case. Instead, an analysis of variance was performed on the daily mean speeds of Group LMS from Day 9 to Day 20 to determine if the downshift had any effect. As might be surmised from an examination of Figure 2, the analysis of variance yielded no significant effects of the downshift.

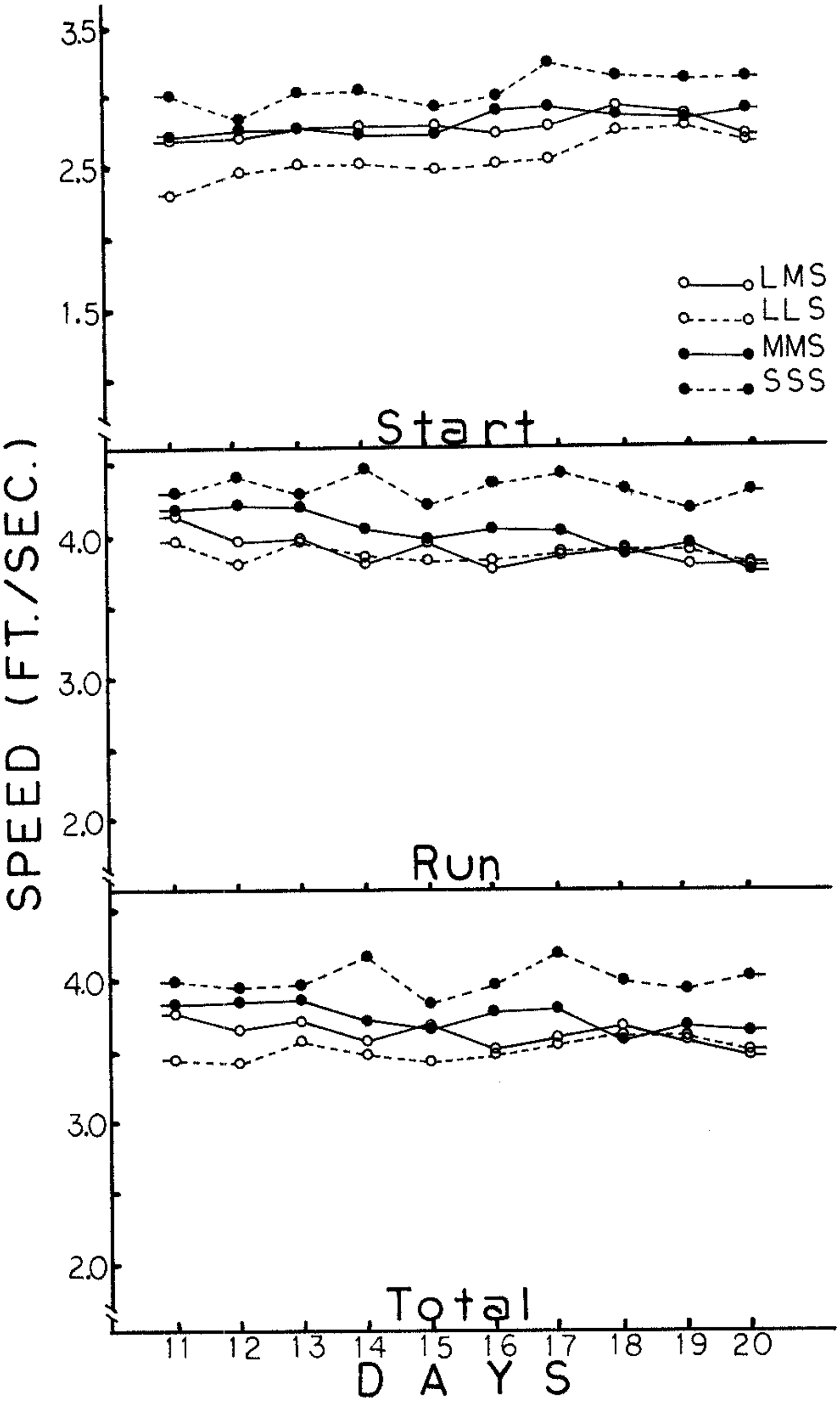

Fig. 2--Mean speeds during Phase 2 for each day (blocks of four trials) for the start, run, and total runway measures.

Start, F (11, 756) = .823, $p > .05$; run, F (11, 756) = 1.44, $p > .05$; and total, F (11, 756) = .609, $p > .05$.

Analyses of variance were performed for each day of Phase 2, along with Newman-Keuls tests, and the general picture that emerged was that the differences between Groups LMS, LLS and MMS disappeared early in Phase 2, while Group SSS continued to run significantly faster than the other groups on most of the Phase 2 days. On Day 19, the differences were not significant between any of the groups in any section. Start, F (3, 248) = 2.576, $p > .05$; run, F (3, 248) = 2.28, $p > .05$; and total, F (3, 248) = 2.18, $p > .05$. On Day 20, however, the last day of Phase 2, the analysis of variance indicated significant differences in all sections. Start, F (3, 248) = 4.79, $p < .01$; run, F (3, 248) = 6.58, $p < .001$, and total, F (3, 248) = 5.85, $p < .001$. A Newman-Keuls test indicated that Group SSS ran significantly faster than Groups LLS and LMS in the start section and significantly faster than all groups in the run and total (all ps $< .05$). No other differences were significant.

Phase 3

Because the inverse reward magnitude effect was still present on the last day of Phase 2, the effects of the downward shift to small Wg for Groups LMS, LLS and MMS were analyzed on the basis of daily changes in mean speeds (as in Phase 2 for Group LMS) instead of the customary comparison with the control group. The analyses of variance were performed on the daily mean speeds of each shifted group from Day 19 to Day 30. No significant speed changes occurred following the downshift in the case of Group LMS or Group MMS in any of the runway measures over these days. In the case of Group LLS, however, a significant effect was obtained in

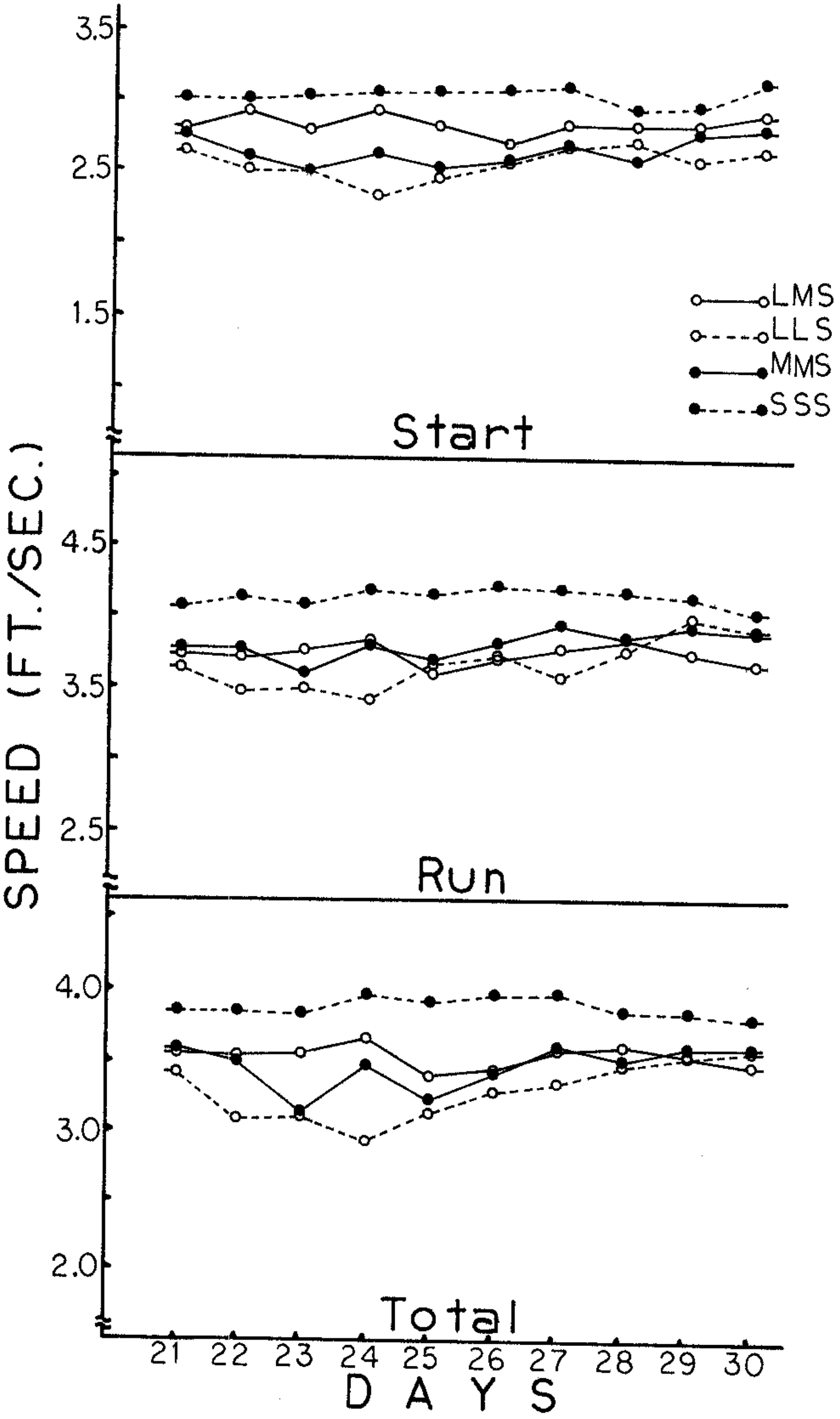

Fig. 3--Mean speeds during the first 10 days of Phase 3 (blocks of four trials) for the start, run, and total runway measures.

the run and total measures. Start, F (11, 756) = 1.204, $p > .05$; run, F (11, 756) = 2.42, $p < .005$; total, F (11, 756) = 2.346, $p < .01$. A subsequent Newman-Keuls test indicated that Group LLS ran significantly slower on Day 24 than on Day 19 in the total section ($p < .05$) with no other total comparisons being significantly different. For the run measures the Newman-Keuls test indicated that Group LLS was significantly slower on Day 24 than on Day 29 ($p < .05$) with no other run-section comparisons being significantly different. This effect is demonstrated graphically in Figure 3, which shows the performances of each of the groups in each alley section for each Phase-3 day, and by reference to Days 19 and 20 in Figure 2. It appeared that each of the shifted groups slowed somewhat following the Phase-3 downshift, but as discussed above, only Group LLS's slowing and subsequent recovery exhibited statistical significance.

Analyses of variance were also performed for each day of Phase 3, along with Newman-Keuls tests, through Day 30. The general picture that emerged was that the inverse reward magnitude effect present on the day preceding the shift and the slowing of the shifted groups following the downshift combined to maintain Group SSS's superiority of performance through Day 28. On Day 29, all differences between groups disappeared in each runway measure. Start, F (3, 248) = 2.45, $p > .05$; run, F (3, 248) = 2.51, $p > .05$; and total, F (3, 248) = 1.91, $p > .10$.

Beginning on Day 30 of Phase 3, the groups were split into the two training conditions for all subsequent analyses. Under the limited training condition Day 30 was the last day of training preceding extinction trials, and an analysis of variance for that day indicated no significant differences between groups in the run and total measures. Run, $\underline{F}$ (7, 244) = 1.233, $\underline{p} > .25$; total, $\underline{F}$ (7, 244) = 1.175, $\underline{p} > .30$. In the start section the differences were significant on Day 30: $\underline{F}$ (7, 244) = 3.71, $\underline{p} < .001$. A Newman-Keuls test indicated that Groups SSS and LMS were running significantly faster than Group LLS ($\underline{p} < .05$) with no other comparisons being significantly different.

From Day 31 through Day 40 the $\underline{S}$s under the extended condition received an additional 40 trials of training with small Wg. The performance of each group is illustrated for each of these days in Figure 4. The drops in speed that occurred on Day 33 may have been due to an "odor effect" as a function of the limited-condition $\underline{S}$s' extinction trials

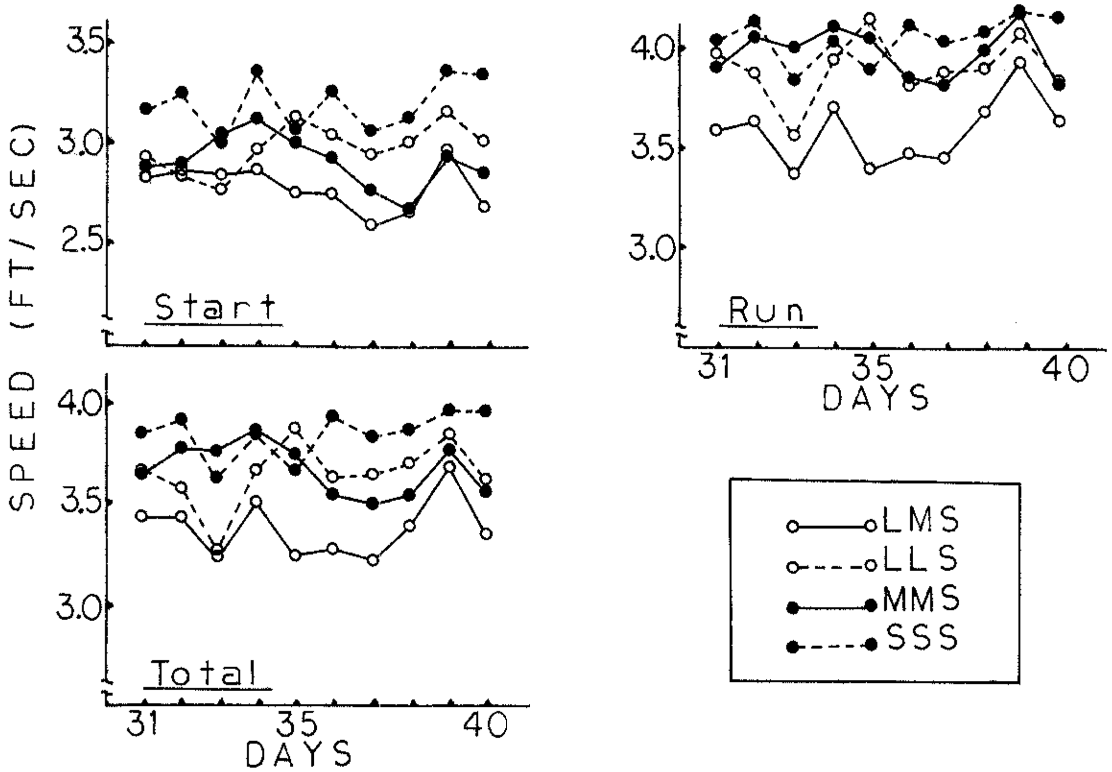

Fig. 4—Mean speeds during last 10 days of Phase 3 (blocks of four trials) for the start, run and total runway measures.

during this part of Phase 3. The E noticed that the Ss still receiving reinforcement on Day 31 began some "stopping behavior" in the runway much in the same manner that the Ss undergoing extinction exhibited. Beginning on Day 32 a tally of complete stops in the runway was maintained until Day 36. It was observed that the frequency of stops per group per day corresponded closely to the performance curves in Figure 4. However, since no tally was obtained prior to Day 31 and subsequent to Day 36, no real support was offered by these observations that an "odor effect" actually occurred.

Beginning on Day 37 a break in procedure occurred due to the E becoming ill. On Day 37 and again on Day 38 the afternoon squads were not run, but were maintained on their deprivation schedules. There then occurred a four-day break in procedure in which no trials were given, but in which the deprivation schedule was maintained by the E's associates. Following this break in procedure, the experiment was reinstituted with Day 39 for the morning squads and Day 37 for the afternoon squads. No other breaks occurred through completion.

The analyses of variance over each day of the extended training period revealed that no differences in speeds occurred in the run section on any day except Day 35. F (3, 120) = 3.44, $p < .05$. The Newman-Keuls test indicated that Groups LLS and MMS ran faster than Group LMS on that day, with no other comparisons being significantly different. In the start section during the extended period, significant differences occurred on Days 34, 36, 39 and 40. All Fs (3, 120) = 3.22, 2.92, 3.31, and 4.95, respectively, and all ps $< .05$. The Newman-Keuls test indicated that Group SSS ran faster than Group LMS on each of these days in the start section and faster than Group MMS on Days 39 and 40 ($\underline{p}$s $< .05$). No other comparisons were significantly different. In the total measure, significant differences occurred only on Days 35 and 40. On Day 35, $\underline{F}$ (3, 120) = 2.97, $\underline{p} < .05$; and on Day 40, $\underline{F}$ (3, 120) = 2.76, $\underline{p} < .05$. The Newman-Keuls test indicated that on Day 35, Group LLS ran significantly faster than Group LMS, and on Day 40, Group SSS ran faster than Group LMS ($\underline{p}$s $< .05$). No other comparisons were significantly different.

Extinction Phase

Limited condition.--The performance of the four groups under this training condition for each of the extinction days (Days 31-35) in each of the runway measures is shown in the left half of Figure 5. The terminal acquisition speeds (Day 30) are also shown for each group.

An analysis of variance over all days of extinction for the limited condition indicated a significant difference among the groups in each runway measure. In the start section, $\underline{F}$ (3, 636) = 9.71, $\underline{p} < .0001$; run, $\underline{F}$ (3, 636) = 5.96, $\underline{p} < .001$; and total, $\underline{F}$ (3, 636) = 7.84, $\underline{p} < .0001$. A Newman-Keuls test indicated that in the start section, Group LLS ran significantly slower than the other groups, and Group MMS ran significantly slower than Group LMS ($\underline{p}$s $< .05$). Other comparisons were not significantly different. In the run section, Group SSS ran faster than Groups LLS and MMS, and Group LMS ran faster than Group LLS ($\underline{p} < .05$), other differences being nonsignificant. In the total measure, Groups SSS and LMS ran significantly faster than Groups LLS and MMS ($\underline{p} < .05$), other differences being nonsignificant.

Extended condition.--The performance of the four groups under the extended training condition for each of the extinction days (Days 41-45)

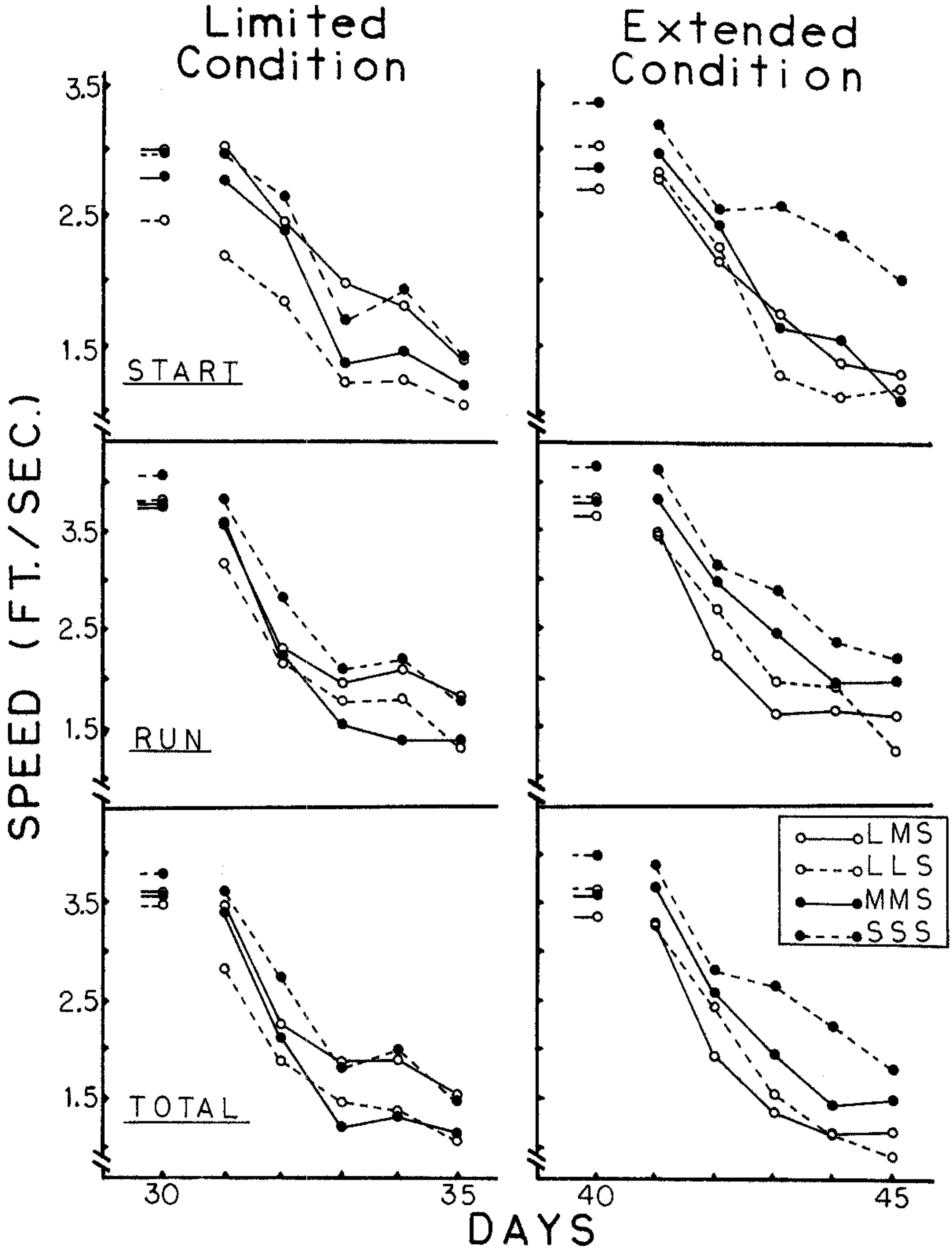

Fig. 5—Mean speeds during extinction (blocks of four trials) for the start, run and total runway measures, along with terminal acquisition speeds, for each of the training conditions.

in each of the runway measures is shown in the right half of Figure 5, along with terminal acquisition speeds (Day 40).

An analysis of variance over all days of extinction for the extended condition indicated significant differences in each of the runway measures. In the start section, F (3, 616) = 11.13; run, F (3, 616) = 10.37; and total, F (3, 616) = 12.93; all ps $< .0001$. The Newman-Keuls test indicated that in the start section, Group SSS ran significantly faster than all of the other groups ($p < .05$); no other comparisons were significantly different. In the run section, Groups SSS and MMS ran significantly faster than Groups LLS and LMS, while other differences were nonsignificant. In the total, Group SSS ran significantly faster than all of the other groups, and Group MMS ran significantly faster than Groups LLS and LMS ($p < .05$). No other comparisons were significantly different.

Factorial analysis.--Following the one-way analyses of variance discussed above, a 2 X 4 (Conditions by Groups) factorial analysis was

TABLE I

SUMMARY OF ANALYSIS OF VARIANCE OF EXTINCTION
DATA: DAYS 31-35 AND 41-45

Source	df	Start		Run		Total	
		MS	*F*	MS	*F*	MS	*F*
Conditions (A)	1	5.16	3.30	18.56	9.81*	4.85	2.64
Groups (B)	3	27.72	17.72***	22.09	11.67***	28.98	15.79***
A by B	3	6.34	4.05*	10.22	5.40*	11.23	6.12**
Error	1,252	1.56	...	1.89	...	1.83	...

* $p < .01$ ** $p < .001$ ***$p < .0001$

performed on the extinction data over Days 31-35 and Days 41-45. Table I summarizes the results from the factorial analysis. The main effects reported here are not meaningful, and the simple main effects were discussed in the preceding sections. The primary concern or emphasis in this analysis was in the significant interaction that appeared in each runway measure, which indicated an effect of the extended postshift training on extinction performance. Figure 6 illustrates these interactions by depicting the mean running speed for each group in each runway measure for each condition. While the extended training had the anticipated effect on Groups LLS, MMS and SSS (increased Rn), the rather marked decrease in Rn exhibited by the LMS groups was unexpected.

Weight Differences Among and Within Groups

In order to determine if weight changes as a result of the deprivation schedule became a confounding factor in the experimental results, each _S_'s weight was measured on the first day of acquisition training and every ten days thereafter through Day 30. An analysis of variance was performed on the groups' mean weights on each of these days, and it was found that no significant differences developed (all _F_s < 1, _p_s $> .05$). In addition, an analysis of variance was performed on each group's mean weights over these days to determine if any significant within-group weight changes occurred. None of the differences were significant (all _F_s < 1, _p_s $> .05$).

Discussion

A crucial presumption underlying this investigation's design was that a characteristic magnitude of reward effect would occur such that the larger levels of Wg would produce the fastest running speeds, thereby

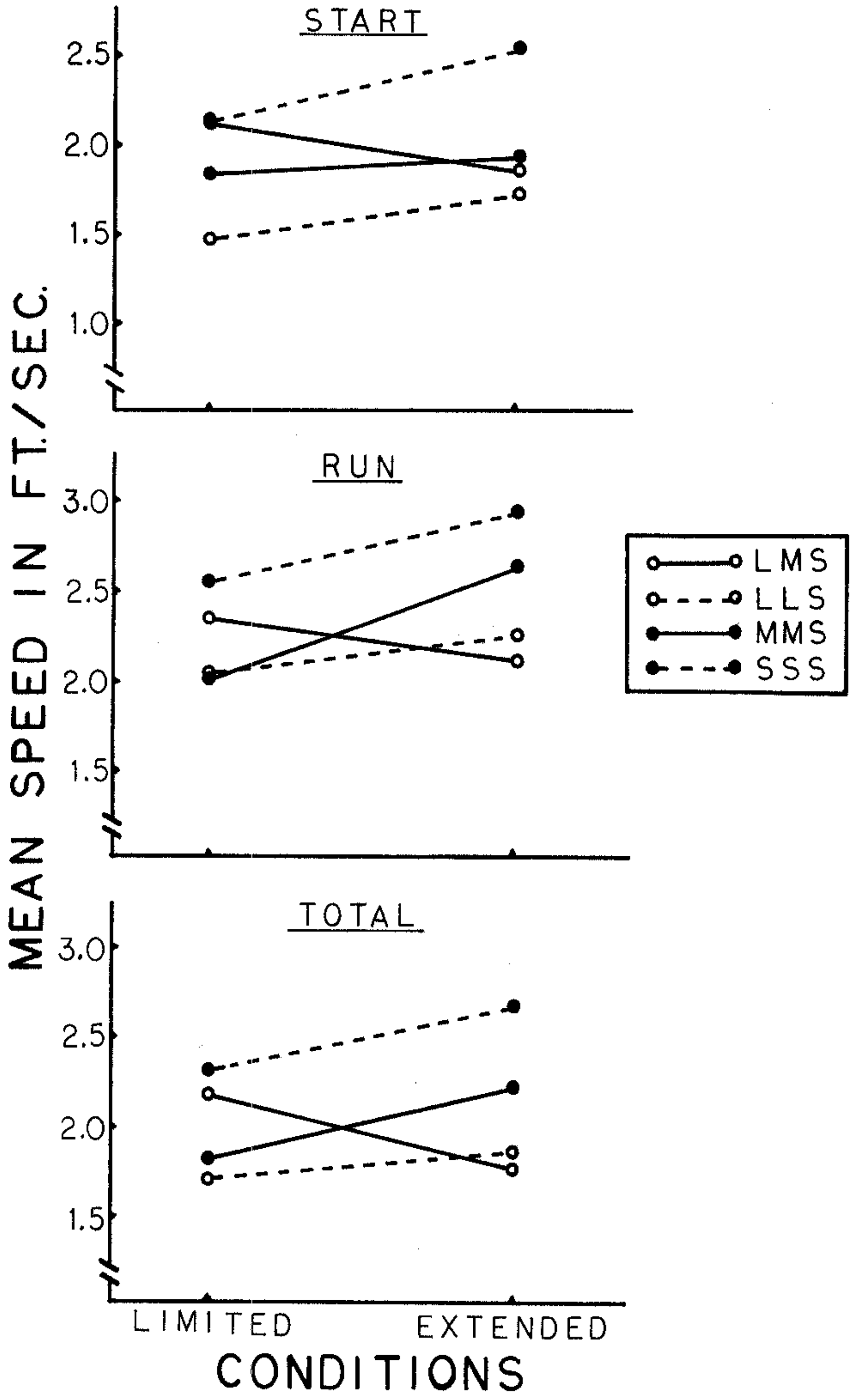

Fig. 6--Mean running speeds of each group under each condition during extinction (blocks of 20 trials) for start, run and total measures.

allowing a theoretical analysis of the shift and extinction effects of the pre- and postshift levels of Wg. The inverse effect that was obtained here was completely unexpected, since the typical effect is so well established in the literature (e.g., see Pubols, 1960). Also, the same presumption underlies both of the hypotheses under consideration here (Amsel, 1958; Capaldi, 1967), as well as a number of other general approaches (e.g., Gonzalez, Gleitman, & Bitterman, 1962; Collier & Marx, 1959; Helson, 1964). This experiment, therefore, did not allow any adequate tests of the questions posed earlier, and any discussion of the results must focus on the inverse reward effect.

The inverse magnitude of reward effect obtained here was not without precedent. Black (1969), in his analysis of the concept of reinforcement, cited a number of studies (e.g., Black & Elstad, 1964; Elstad & Black, 1965; Hiers, 1968) in which the inverse effect appeared. After a review of the factors that were cited by Black as influential in the inverse effect and of the procedures used in the present study, it appeared that his conceptualization best accounts for the results obtained here.

Black & Elstad (1964) had trained two groups of rats under the same deprivation schedules to run a straight alleyway, each group to a different level of Wg. One group (G10) received access to wet mash for 10 sec. (small reward), and the other group (G30) received 30 sec. access (large reward). A preshift phase was to establish differential running speeds before shifting each group's "drive level" (change in deprivation). However, because of an inverse magnitude of reward effect, those Es were unable to test their hypothesis. Black (1969) suggested that there are two plausible interpretations of the Black and Elstad (1964) results:

> First, it may have been the case that the animals in G10, which ate at a higher average rate than those in G30, might have engaged in more "vigorous" consummatory activity--that is, a more "vigorous" Rg was occurring in the goal box and becoming conditioned to goal box cues. In this case, an incentive theory such as Spence's analysis of incentive motivation would predict that these Ss would have developed a stronger rg-sg mechanism which would result in a higher level of K and, therefore, more rapid performance. An alternative interpretation might assume that Ss in G10 ate more "consistently" rather than more "vigorously" than those in G30. If this were indeed the case, then Ss in the latter group would have had the greater opportunity to engage in nonconsummatory activity, which, in terms of an associative theory such as Guthrie's, could have led to "deconditioning" of the instrumental response [pp. 105-107].

In an effort to experimentally test these alternative hypotheses, Black and Elstad (1965) conducted a series of studies involving different levels of Wg, again using exposure to wet mash for varying amounts of time as the reward. This study, however, allowed a measure of both the "vigor" of the consummatory response ("momentary eating rate" and "amount consumed per bite") and the "consistency" of the consummatory behavior ("average eating rate" and "consistency of eating"). In addition to obtaining an inverse magnitude of reward effect, these Es found that the average eating rate and the consistency of eating decreased as the length of access to wet mash increased. Also, they found no relationship between performance and the "vigor" measures, which was contrary to what Spence's (1956) approach would have predicted.

Other investigations reviewed by Black (1969) provided further information about these variables. Of particular importance to the present investigation's results were the general findings that eating behavior tends to occur in "bursts" in the goal box, where the Ss follow a relatively short period of consummatory activity with a period of nonconsummatory behavior (such as exploration or grooming), followed by another burst of eating, and so on. Such variable behavior results in an important methodological problem in studies of instrumental appetitive learning, namely, the confounding of three separate variables: actual amount of reward, amount of consummatory behavior, and amount of nonconsummatory behavior.

Black (1969) concluded that "the apparent reinforcement value of a reward appears to depend not only on its magnitude or the amount of consummatory behavior it evokes but upon the consistency with which such behavior occurs [p. 132]." To account for the fact that reward effects are so readily reversible (e.g., decremental shifts in Wg have repeatedly been shown to result in "appropriate" adjustments in performance), Black suggested a hypothetical "incentive-motivation variable which depends on the quality or quantity of reward but _the strength of which is not always directly reflected in instrumental performance_ [p. 132]." This amounts to a "two-factor" interpretation of reinforcement wherein "increasing reward magnitude or the amount of consummatory activity facilitates performance. Decreasing the consistency of consummatory activity, or, conversely, increasing the amount of nonconsummatory activity, depresses performance and the [apparent reinforcement value] of the reward [p. 132]."

In the present investigation, the rule whereby the _S_s were removed from the goal box may have contributed to or resulted in the conditions necessary to produce the inverse reward effect. The _S_s were removed from the GB at the end of a 20-sec. period (at which time a signal was flashed to the _E_ by a light on the apparatus) or upon completely consuming the reward, whichever came last, with an overall limit of 90 sec. in the GB.

With the exception of two instances on the first day of acquisition training, all of the Ss consumed the reward within the 90-sec. limit. Although no systematic records were kept at the time, the E's recall of GB events during Phases 1 and 2 was that the control animals (Group SSS), with few exceptions, consumed the small reward within the first 20 sec. and were removed only after 20 sec. had elapsed. Many of these Ss had already consumed their reward and were engaged in various nonconsummatory activities (such as grooming, examining the GB door, etc.) at the time the signal flashed. All of the other Ss were either receiving 8 or 11 pellets during Phases 1 and 2, and they were always still in the process of eating at the signal, requiring the E to wait varying lengths of time before removing them. At first it was believed that this state of affairs should have resulted in ideal conditions to produce the slowest running speeds in the control Ss since their nonconsummatory activities were obvious at that period of time when E began observing their behavior. However, it is entirely possible that relative to the control Ss the large reward Ss engaged in a greater proportional amount of nonconsummatory behavior, thereby depressing the apparent reinforcement value of the reward. It was observed that the Ss, after eating the first pellet or two by "biting" it directly on the food plate, would pick up the next and succeeding pellets with their forepaws and would consume them by biting off pieces. This was probably a function of the relatively large pellets (.075 gm.) used in this study. The vast majority of research in this area has used .045-gm. pellets, which are normally eaten "whole" and directly from the food plate in the GB. This method of consuming the reward may have interacted with the "bursts of consummatory behavior" noted by Black (although not specifically observed here) to create greater opportunities for the large-Wg animals to engage in nonconsummatory activity. Or, in relation to the small-reward Ss, it may have produced a much greater inconsistency of consummatory activity by the large-reward Ss.

Another factor is suggested by the results obtained by Verplanck and Hayes (1953). They found that rats under a deprivation schedule very similar to that imposed on these Ss only drank forty per cent of the amount of water drunk by rats which are not food deprived. Similar findings were also reported by Hamilton and Flaherty (1973). The implications for the present study are that all of the Ss utilized here were not only food-deprived, but water-deprived as well, in spite of water being freely available during the experiment. This may account for why the dry food used here failed to produce comparable results to Shelton's (1970), since Shelton used wet mash, and other conditions were essentially the same. Shelton's Ss may have more readily consumed the wet mash, with less intervening nonconsummatory activity, than these Ss consumed the large, dry pellets. This, of course, is an empirical question and is subject to further investigation.

One notable exception in the psychological literature stands out as a problem for the foregoing account of the inverse reward effect obtained here. DiLollo (1964) used .08-gm. pellets, which were even larger than those used in this study, and obtained a significant magnitude of reward effect between a group receiving 16 pellets per trial and another group receiving 4 pellets per trial. There was no effect between the 4-pellet group and a 1-pellet group, however. DiLollo's Ss were placed under a

$22\frac{1}{2}$-hr. deprivation schedule, and thus the "thirst" factor discussed by Verplanck and Hayes (1953) should have been in operation during his study. According to the concepts discussed here, DiLollo's procedures were suitable for producing an inverse magnitude of reward effect, but it failed to occur. To account for this, one possibility may center around DiLollo's rule for removing his Ss from the GB. It was not reported, however.

Despite the ability of Black's (1969) hypothesis to account for the results obtained here, the relationships that exist between varying conditions of reward such as was examined here and subsequent Rn are still basically unknown, or at best, unclear. It remains an empirical question whether extended training will result in "adaptation" of rg to a smaller Wg or whether other processes are involved. Further research, however, will need to take into consideration the problems encountered in this study, either by systematic variation of the variables involved or by some other means of direct or indirect control.

References

Amsel, A. The role of frustrative nonreward in noncontinuous reward situations. *Psychological Bulletin*, 1958, *55*, 102-119.

Amsel, A. Frustrative nonreward in partial reinforcement and discrimination learning: Some recent history and a theoretical extension. *Psychological Review*, 1962, *69*, 306-329.

Amsel, A. Partial reinforcement effects on vigor and persistence. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation*. New York: Academic Press, 1967.

Amsel, A. Behavior habituation, counter-conditioning and persistence. In A. Black & W. K. Prokasy (Eds.), *Classical conditioning II*. New York: Appleton-Century-Crofts, 1969.

Amsel, A., & Ward, J. S. Frustration and persistence: Resistance to discrimination following prior experience with the discriminanda. *Psychological Monographs*, 1965, *79* (4, Whole No. 597).

Bitterman, M. E., & Schoel, W. M. Instrumental learning in animals: Parameters of reinforcement. In P. H. Mussen & M. R. Rosenzweig (Eds.), *Annual review of psychology*. Palo Alto, Calif.: Annual Reviews, Inc., 1970.

Black, R. W. Shifts in magnitude of reward and contrast effects in instrumental and selective learning. *Psychological Review*, 1968, *75*, 114-126.

Black, R. W. Incentive motivation and the parameters of reward. In W. J. Arnold & D. Levine (Eds.), *Nebraska symposium on motivation*. Lincoln: University of Nebraska Press, 1969.

Black, R. W., & Elstad, P. Instrumental and consummatory behavior as a function of length of reward period. *Psychonomic Science*, 1964, *1*, 301-302.

Bower, G. H. A contrast effect in differential conditioning. *Journal of Experimental Psychology*, 1961, *62*, 196-199.

Capaldi, E. D. Effect of an initial reward magnitude on subsequent resistance to extinction. *Journal of Experimental Psychology*, 1970, *86*, 283-287.

Capaldi, E. J. A sequential hypothesis of instrumental learning. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation*. New York: Academic Press, 1967.

Capaldi, E. J. An analysis of the role of reward and reward magnitude in instrumental learning. In J. H. Reynierse (Ed.), Current issues in animal learning. Lincoln: University of Nebraska Press, 1970.

Capaldi, E. J., & Lynch, D. Repeated shifts in reward magnitude: Evidence in favor of an associational and absolute (noncontextual) interpretation. Journal of Experimental Psychology, 1967, 75, 226-235.

Cleland, E. A., Williams, M. Y., & DiLollo, V. Magnitudes of negative contrast effect in relation to drive level. Psychonomic Science, 1969, 15, 121-122.

Collier, G., & Marx, M. H. Changes in performance as a function of shifts in the magnitude of reinforcement. Journal of Experimental Psychology, 1959, 57, 305-309.

Crespi, L. P. Quantitative variations in incentive and performance in the white rat. American Journal of Psychology, 1942, 55, 467-517.

DiLollo, V. Runway performance in relation to runway-goal-box similarity and changes in incentive amount. Journal of Comparative and Physiological Psychology, 1964, 58, 327-329.

Dunham, P. J. Contrasted conditions of reinforcement: A selected critique. Psychological Bulletin, 1968, 69, 295-315.

Ehrenfreund, D. Effect of drive on successive magnitude shift in rats. Journal of Comparative and Physiological Psychology, 1971, 76, 118-123.

Elstad, P., & Black, R. W. Running speed as a function of duration of reward and various parameters of consummatory activity. Unpublished Master's thesis, University of Iowa, 1965.

Glazer, H., & Amsel, A. Transfer of persistence effects from frustration produced by blocking to frustration produced by nonreinforcement. Psychonomic Science, 1970, 18, 311-312.

Gonzalez, R. C., Gleitman, H., & Bitterman, M. E. Some observations on the depression effect. Journal of Comparative and Physiological Psychology, 1962, 55, 578-581.

Hamilton, L. W., & Flaherty, C. F. Interactive effects of deprivation in the albino rat. Learning and Motivation, 1973, 4, 148-162.

Hiers, J. M. An investigation of the persistence of negative contrast effects in reward magnitude in instrumental conditioning. Unpublished Ph.D. dissertation, University of South Carolina, 1968.

Helson, H. Adaptation-level theory. New York: Harper & Row, 1964.

Hull, C. L. *Principles of behavior*. New York: Appleton-Century-Crofts, 1943.

Leonard, D. W. Amount and sequence of reward in partial and continuous reinforcement. *Journal of Comparative and Physiological Psychology*, 1969, *67*, 204-211.

Metzger, R., Cotton, J. W., & Lewis, D. J. Effect of reinforcement magnitude and of order of presentation of different magnitudes on runway behavior. *Journal of Comparative and Physiological Psychology*, 1957, *50*, 184-188.

Mikulka, P. J., Lehr, R., & Pavlik, W. B. Effects of reinforcement schedules on reward shifts. *Journal of Experimental Psychology*, 1967, *74*, 57-61.

Pubols, B. H. Incentive magnitude learning and performance in animals. *Psychological Bulletin*, 1960, *57*, 89-115.

Shelton, B. W. Persistence of the negative contrast effect and resistance to extinction. Unpublished Master's thesis, North Texas State University, 1970.

Spear, N. E., & Spitzner, J. H. Residual effects of reinforcer magnitude. *Journal of Experimental Psychology*, 1968, *77*, 135-149.

Spence, K. W. *Behavior theory and conditioning*. New Haven: Yale University Press, 1956.

Spence, K. W. *Behavior theory and learning*. Englewood Cliffs, N. J.: Prentice-Hall, 1960.

Verplanck, W. S., & Hayes, J. R. Eating and drinking as a function of maintenance schedule. *Journal of Comparative and Physiological Psychology*, 1953, *46*, 327-333.

Zeaman, D. Response latency as a function of the amount of reinforcement. *Journal of Experimental Psychology*, 1949, *39*, 466-483.