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THE ROLE OF SEQUENTIAL VARIABLES IN SUCCESSIVE CONTRAST EFFECTS

By

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Theoretical formulations of successive contrast effects in instrumental learning have generally been limited to effects due to simple shifts in reward magnitude. A recent reinforcement level theory advanced by Capaldi purports to be capable of dealing with a much broader range of experimental manipulations than previous theories.

One set of predictions from this theory is that shifts from shorter to longer N-lengths in reinforcement schedules produce negative contrast and the opposite shift results in positive contrast. A study which, on the surface, appears to confirm these predictions was critically reviewed and found to be deficient in several important respects. The experiment was re-designed such that the sources of confound in the original study were eliminated. Two groups of rats were given seven trials per day, four of which were rewarded, in a straight alley. One group was trained using an N-length of three, and the other using an N-length of one. After 20 days, one-half of each groups was shifted to the opposite N-length for an additional 20 days, while the remainder of the animals continued as in the first phase for this period. Finally, all four groups received five days of extinction (nonreward) training. There was no evidence for either positive or negative contrast. In addition, there were no group differences during the extinction phase. The data were discussed as posing problems for the reinforcement level theory, but supportive of an "incentive averaging" approach to contrast effects.

ACKNOWLEDGEMENTS

I would like to express my gratitude to my thesis director, Dr. Nabil Haddad, who instructed me in the art of rat running. His continual help and encouragement throughout the project was a prime source of motivation.

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The time, effort, and help from the other members of my committee, Dr. Laurence Berger and Dr. Sally Slocum (Anthropology) are greatly appreciated. I am especially grateful for the participation of Dr. William Stoner (Education) who served as Dr. Slocum's replacement.

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Abstract

The present experiment was designed to investigate the effects of successive shifts in N-length in a simple instrumental (runway) task. A recent theory (Capaldi, Note 1) predicts positive contrast effects due to a shift from a longer to a shorter N-length and negative contrast resulting from the opposite shift. Two groups of rats were given seven trials per day, four of which were rewarded, in a straight alley. One group was trained using an N-length of three, and the other using an N-length of one. After 20 days, one-half of each group was shifted to the opposite N-length for an additional 20 days, while the remainder of the animals continued as in the first phase for this period. Finally, all four groups received five days of extinction. There was no evidence for either positive or negative contrast. In addition, there were no group differences during the extinction phase. The data were discussed with respect to theories that attempt to predict the conditions necessary for instrumental contrast effects.

The Role of Sequential Variables in Successive Contrast Effects

John Walkenbach

University of Montana

The literature on contrast effects in instrumental conditioning has generally been limited to the effects of shifts in reward magnitude. Specifically, subjects shifted from a large to a small magnitude of reward run slower than subjects maintained on the small magnitude (e.g., Capaldi and Lynch, 1967; DiLollo and Beez, 1966; Gonzales, Gleitman, and Bitterman, 1962). This phenomenon is termed the negative contrast effect (NCE). A positive contrast effect (PCE), on the other hand, is observed when subjects shifted from a small to a large magnitude of reward run faster than subjects which received the large magnitude throughout. (e.g., Mellgren, 1972; Shanab and Biller, 1972).

On the basis of literature reviews, both Black (1968) and Dunham (1968) concluded that the NCE is a relatively robust phenomenon, whereas the PCE is elusive, and quite likely artifactual. Many investigators have demonstrated an NCE under a variety of conditions, but failed to show a PCE using analogous procedures (e.g., Bower, 1961; DiLollo, 1964). Recent evidence however tends to disconfirm these conclusions with respect to the PCE. It was originally postulated by Bower (1961) that ceiling effects may be operative in many situations in which the PCE fails to appear. That is, it is quite likely that the subjects are responding at their maximal level during preshift which would prevent responding at a higher level during postshift. Several lines of research, the goal of which was to decrease responding to below this upper limit, have confirmed this hypothesis (Logan and Spanier, 1970; Mellgren, 1972; Mellgren, Nation, Wrather, and Jobe, Note 2; Seybert and Mellgren, 1972; Shanab and Biller, 1972; Weinstock, 1971; Wollach and Seres, 1971).

While contrast effects have most often been investigated using reward magnitude shifts, other techniques have occasionally been employed. Until recently, theoretical accounts of contrast effects have been sparce and generally limited to the effects of shifts in reward magnitude. This is the primary reason for the general lack of research concerned with methods other than reward magnitude shifts. A quantitative model recently advanced by Capaldi (Note 1) attempts to deal with acquisition, extinction, and various contrast data on a trial-by-trial predictive basis. According to this view, increments in habit strength are a function of reward expectancy. If an animal receives a larger than expected reward, large increments in habit strength occur. Expectancy is built up over time and becomes increasingly stable as conditioning progresses. Inhibition, a process antagonistic to habit, occurs when reward magnitude is less than the level of expectancy. This reinforcement-level view, in conjunction with the sequential theory of Capaldi (1967) promises a new predictive power beyond that of most competing theories.

For example, reinforcement-level theory predicts several other means of producing contrast effects in addition to procedures using shifts in reward magnitude. According to the model, shifts in percentage of reinforced trials should produce both positive and negative contrast effects. The scant literature in this area tends to support this prediction (Leung and Jensen, 1968). Another technique, based on seqential reasoning (Capaldi, 1967) will be considered in detail.

N-length is defined as the number of nonreinforced (N) trials which precede a reinforced (R) trial in a schedule of reinforcement. An N-R transition refers to an R trial which follows one or more N trials. It is on these N-R transitions that conditioning is said to occur. An N-length produces an internal stimulus to which running becomes conditioned on an N-R transition. For example, the schedule RNNR contains an N-length of two, and produces the stimulus S(N2). On the final trial running is conditioned to S(N2) via a reinforcement mechanism.

The reinforcement-level theory (Capaldi, Note 1) predicts contrast effects as a result of shifts in N-length while maintaining a constant reward magnitude and percentage of reward. The reasoning behind these predictions will be discussed in detail below. To date, only one study (Fox, 1972) has been reported in which this manipulation was made. As predicted by the model, both an NCE and a PCE were obtained. There are some methodological problems with this study however, and the primary purpose of the present investigation was to assess the effects of N-length shifts using an unconfounded design.

The Fox (1972) study referred to above employed four groups of rats designated 1-1, 3-3, 1-3, and 3-1. Each group name indicates the N-length in pre- and postshift respectively. For example, Group 3-1 was originally trained under the schedule NNNRNNNR (N-length of three) and then shifted to the schedule NRNR (n-length of one). As indicated above, this study resulted in both a strong PCE and a strong NCE. Positive contrast was found in Group 3-1 with respect to Group 1-1; negative contrast was evident in Group 1-3 relative to Group 3-3.

Capaldi (Note 1) cited this investigation as supporting his reinforcement-level theory. The reasoning behind these predictions is as follows. At the beginning of postshift, the stimulus S(N1) has acquired a stable expectancy of nonreward in Group 3-1. During postshift, S(N1) will acquire large increments in habit strength when running is reinforced in its presence. Therefore, the theory predicts a PCE in Group 3-1 with respect to Group 1-1. The NCE is predicted in a similar manner. During preshift in Group 1-3, S(N1) acquires a large expectancy of reward which generalizes to S(N2) and S(N3) to some extent. During the postshift phase, S(N1) and S(N2) acquire inhibition and habit growth to S(N3) is somewhat retarded. Therefore a decrement in response strength should appear in Group 1-3 relative to Group 3-3.

Based on the brief description of the Fox (1972) study given above, it may be noticed that although reward magnitude was constant throughout, percentage of reinforced trials was shifted along with N-length. That is, the schedule for N-length of one was comprised of 50% reinforced trials while that for N-length of three had only 25% reinforced trials. Since shifts in percentage of reinforced trials have been shown to produce contrast effects (Leung and Jensen, 1968), this is a serious source of confounding. A related issue concerns the number of trials given daily. As outlined above, the N-length of one condition consisted of four alternating N and R trials per day, whereas the N-length of three condition was composed of eight daily trials, two of which were rewarded. This particular method does have one advantage, namely providing an equal number of N-R transitions in both conditions. At asymptotic habit strength however, the number of N-R transitions becomes irrelevent (Capaldi, 1966). In this light, the absolute number of trials given becomes an important issue. For example, Group 1-3 can be viewed as being shifted from four to eight trials per day, a manipulation which may in itself (through perhaps some type of expectancy learning) be responsible for the observed response decrement. Similarly, Group 3-1 was shifted from eight to four daily trials, again the effects of which are not immediately apparent. Although no specific empirical data concerning shifts in the number of trials have been reported, there is some evidence (Davis, Memmott, and Hurwitz, 1975) that animals are capable of "keeping track" of the number of experimental events which have occurred and adjusting their behavior accordingly.

Another problem with the Fox study is the possibility of the occurance of patterned responding. That is, the same sequence of N and R trials were given daily, always beginning with an N trial. That rats quickly learn to pattern responding, especially in a single alternation schedule (the N-length of one condition) is well known (e.g., Katz, Woods, and Carrither, 1966). In particular, Capaldi and Stanley (1963) found significantly more patterning of responses using an intertrial interval of 15 sec, the parameter used by Fox (1972). Indeed, Fox noted that all rats ran appreciably slower on the first daily trial (always N), and consequently these data were excluded from the data analyses. In this context, another aspect of this research takes on major importance, namely that Fox's data analyses were based only on the R trials. Capaldi's (Note 1) reinforcement-level model does not include patterning effects and hence all empirical support for the model must be based on all the trials, not just those which may be subject to differential responding via patterning.

Still another problem with the Fox (1972) investigation concerns delay of reward. During preshift all reinforcements were given immediately upon entry into the goal box. During postshift however, all rewards were delayed 20 sec. This is a serious source of confound since shifts from immediate to delayed reward and known to produce contrast effects (Shanab and McCuiston, 1970).

Capaldi's (Note 1) model also makes predictions regarding extinction following the postshift phase. The model predicts Group 3-1 to be most resistant to extinction because this groups will possess excess habit strength following the shift to N-length of one. Due to the differential amount of training received by each of his four groups, Fox could not include an extinction phase in his study.

It should be noted that the original purpose of the Fox investigation was not concerned with contrast phenomena. It is in this light that the forementioned criticisms must be viewed. For example, some of the methodological problems are no longer valid in the context of the original intent of the study. But before these data are widely accepted as supporting Capaldi's reinforcement-level theory, clearly a replication must be undertaken.

The present investigation was designed such that both the N-length of one and the N-length of three conditions had an equal number of trials, while at the same time maintaining an equal percentage of R trials. In addition, a 20 sec delay of reward was used in both the pre- and postshift phases for all groups to hold down running speeds which may obscure the observation of a PCE. Finally, an extinction phase was given following postshift training.

Method

Subjects. The subjects were 40 naive male albino rats, 90-100 days old at the start of the experiment, purchaseed from the Holtzman Co., Madison, WI. They were housed individually with water continuously available in the home cages. Throughout the experiment the colony room was maintained under conditions of 24 hr light.

Apparatus. The conditioning apparatus consisted of a straight alley (146 X 10 X 14 cm high) constructed of clear Plexiglas with a grid floor. Cardboard strips, painted flat gray, were mounted on all sides. The alley consisted of three sections: a start box 28 cm long; a run section 88 cm long; and a goal box 30 cm long. The runway was equipped with photocell and clock circuitry (Hunter Mfg. Co.) accurate to .01 sec. Raising the start box door operated a photorelay and started the first of three clocks. When the subject broke the first photobeam 19.5 cm into the run section, the first clock stopped (start time) and the second began. Breaking another photobeam 69 cm into the run section stopped the second clock (run time) and initiated the third, which was stopped when the last photobeam 12 cm into the goal box was interrupted (goal time). When the final photobeam was broken a guillotine door was manually lowered to prevent retracing. Timing circuitry was activated for use in timing the delay of reward (see Procedure). At the end of the goal box and recessed 4 cm was a Plexiglas food cup which could be either concealed or exposed by means of another opaque guillotine door.

Individual times for all three sections, in addition to total traversal time (the sum of all three times) were recorded on each trial. Fractionated and total times were converted to reciprocals (1/sec) and all results are reported in terms of this speed measure. Lighting conditions in the experimental room consisted of a single 100-Watt bulb suspended 80 cm above the center of the runway, providing a dim, relatively even illumination throughout the apparatus.

Procedure. A 12 gm food deprivation schedule (Purina Rat Chow) was established ten days before the training began and was maintained throughout the experiment with adjustments made for food consumed in the goal box. During the initial deprivation period, the subjects were handled daily before receiving their food ration.

A pretraining and habituation period followed immediately and lasted for three days. This consisted of five reinforced trials with the times recorded, but not used in the analyses. One trial was given on the first day, and two on each of the remaining two days.

Preshift Phase. Initially, the subjects were randomly divided into two groups of 20 subjects each, designated N1 and N3. During this phase each subject received 20 days of seven trials per day reinforced (where appropriate) with three pellets of Purina Hog Starter (approximately 90 mg each). Throughout the experiment all reinforcements were available following a 20 sec delay upon entry into the goal box. This delay was imposed to counteract any ceiling effects (Bower, 1961) on running speed which may conceal positive contrast effects. The two groups differed only with respect to the N-length of the partial reinforcement schedule to which they were trained. That is, percentage and magnitude of reward were the same for both groups. The schedules, which were repeated every seven days, are provided in Table 1.

Insert Table 1 about here

On each trial the subject was placed in the start box facing the start box door. After 2 sec of orientation toward the door, the door was manually raised and the subject was allowed to traverse the runway and enter the goal box, whereupon the goal box door was lowered. On R trials the subject was removed from the goal box and returned to the holding box after the pellets were consumed. On N trials the subjects were removed after 35 sec (i.e., the 20 sec delay period + 15 sec). Subjects were run in squads of four animals each, with each squad consisting of two animals from each group. Each subject received trial 1 before the first received trial 2 and so on, defining an intertrial interval of approximately 5 min.

Postshift Phase. Following the 20 days of preshift training, the two groups were subdivided into two more, creating four groups of ten rats each. Division of the two original groups was based on a matching process using the last four days of preshift such that terminal preshift speeds were equivalent for the subgroups. These four groups were designated N1-N1, N1-N3, N3-N3, and N3-N1, representing the N-length in pre- and postshift respectively. The same schedules as in the preshift phase were used, maintaining the same rotation. Groups N1-N3 and N3-N1 were shifted to the opposite set of schedules , and Groups N1-N1 and N3-N3 remained on the same set as in preshift. During the postshift phase each squad consisted of one subject from each group. Training continued as in the first phase for 20 days.

Extinction. Following postshift training, an extinction phase was immediately imposed. During this phase the subjects received seven N trials per day for five days. Timing criteria were as follows: a maximum of 60 sec were allowed in any one section of the runway, whereupon the animal was removed and placed in the goal box for the standard 35 sec period. For example, if the subject did not leave the start box in 60 sec, it was removed to the goal box and assigned a time of 60 sec for each section (180 sec total).

Results

Preshift Phase. At the end of the preshift phase, the two groups (N1 and N3) were performing at the same asymptotic level, as may be seen in the left frame of Figure

1. This was confirmed by a *t*-test on the last day of Phase 1 (Day 20). The daily data point for each subject consisted of the average of all seven trials. Since all four speed measures yielded essentially the same information, only the total speeds are graphed. For start, run, goal, and total, the *t*'s were: .0609, .5535, .0025, .6876 (*df* = 38, *p*'s > .10).

The data were also analyzed using only the R trials following one or more N trial. For the N1 condition the daily data point consisted of the average of the three R trials following an N trial. For the N3 condition, the data point was simply the R trial following the three N trials. Again, *t*-tests revealed no significant differences in any of the measures on Day 20 (*t*'s = .1125, .6875, .0433, .7644; *df* = 38; *p*'s > .10). The left frame of Figure 2 depicts the total speeds during Phase 1 based on the R trials following one or more N trials.

Insert Figures 1 & 2 about here

Postshift Phase. No evidence for either positive or negative contrast was found in any of the four measures using either the average of all seven trials or the R trials on the N-R transitions. Four separate 4 (groups) X 20 (days) repeated measures analyses of variance were performed for the start, run, goal, and total speeds. The analyses revealed nonsignificant main effects for groups using the average (F's =.032, .048, .330, .091; df = 3,36; p's > .10) and the N-R transitions (F's = .036, .050, .291, .101; df = 3,36; p's > .10). The right frames of Figures 1 and 2 depict the mean total speeds for the four groups during postshift using both methods of data reduction.

Extinction. In this final phase, all four groups extinguished at the same rate. Four 4 (groups) X 5 (days) repeated measures analyses of variance revealed no significant main effects for groups in any of the four measures (F's = .102, .213, .143, .045; df = 3,36; p's > .10). The average running speeds for the total measure during extinction are shown in Figure 3.

Insert Figure 3 about here

Discussion

Since there was no hint of either a PCE or an NCE during the second phase, the outcome of the present experiment contrasts sharply with that of Fox (1972). There are several possible explanations based on procedural differences which may account for the discrepant findings. A prime possibility concerns the use of delay of reward. In the present study, delayed reward was used throughout the study, whereas in the Fox investigation, a delay was imposed only during the second phase. It is quite possible that his outcome was the result of an interaction between delay of reward shift and shift in N-length.

Another possibility involves the simultaneous shift in the number of daily trials as well as the shift in percentage of reinforced trials Fox used. Both of these variables were held constant during both phases in the present experiment.

Since the null hypothesis of no differences between the groups was not rejected, a note on the power (i.e., the probability of rejecting the null hypothesis, given that it is false) of the test is in order. Due to the difficulty of calculating power when the F values are less than one (c.f., Kirk, 1968) an alternative approach was taken. Mean square error terms obtained in the present experiment compare favorably with those obtained in similar studies from our laboratory. Thus, it appears there is no serious problems regarding the power of the test.

The outcome of this study appears to present problems for Capaldi's (Note 1) reinforcement-level theory, since it clearly predicts a PCE in Group N3-N1 and an NCE in Group N1-N3 using the present procedures. These data however are consistent with an "incentive averaging" approach advocated by McHose and Peters (1975). This view de-emphasises sequential variables and instead centers on averaging various sources of incentive. Accordingly, the N1 and N3 conditions would be viewed as equivalent with respect to incentive, and no contrast effects would be expected.

Perhaps the most surprising aspect of these data is the lack of an N-length extinction effect. That is, it is generally found (e.g., Capaldi, 1967) that subjects exposed to longer N-lengths are more persistent in the face of nonreward. This clearly was not found in the present experiment. All four groups extinguished equally fast. These results can be explained most readily by a discrimination explanation (e.g., Mowrer and Jones, 1945). That is, after 40 days of reinforcement (albeit partial reinforcement) the first day with continuous nonreward is easily discriminable and responding rapidly ceases. The assumption here is that this discriminability is equally salient for all four groups.

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Table 1

Schedules of Partial Reward (by days) for Conditions N1 (top) and N3 (bottom)

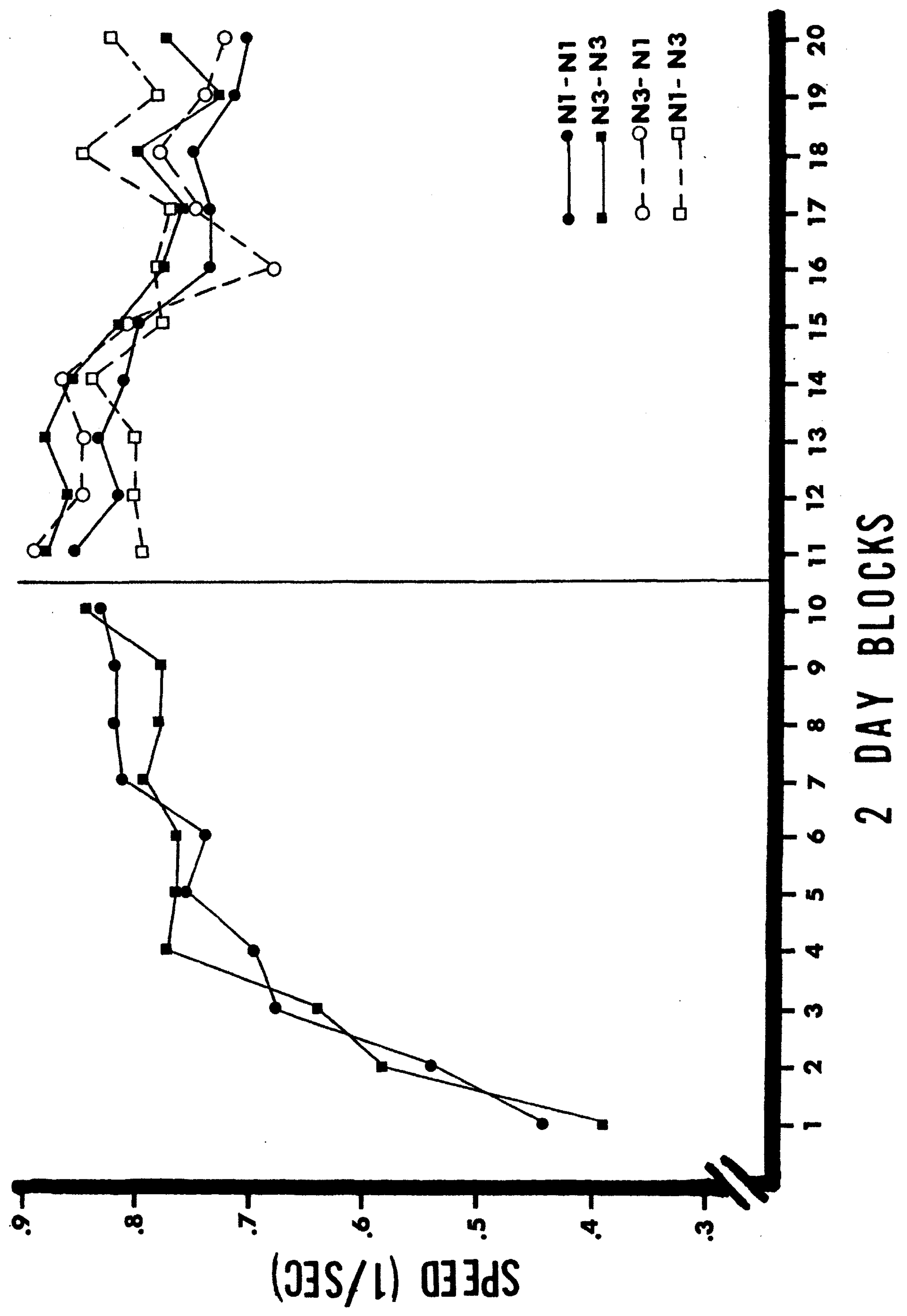
Days					Trials						
					1	2	3	4	5	6	7
1	5	9	13	17	R	N	R	N	R	N	R
2	6	10	14	18	N	R	R	N	R	N	R
3	7	11	15	19	R	N	R	N	R	N	R
4	8	12	16	20	N	R	N	R	R	N	R
1	5	9	13	17	R	R	N	N	N	R	R
2	6	10	14	18	R	N	N	N	R	R	R
3	7	11	15	19	N	N	N	R	R	R	R
4	8	12	16	20	R	R	R	N	N	N	R

Figure Captions

1. Mean total running speeds for preshift (left frame) and postshift (right frame) in two day blocks based on the average of all seven daily trials.

2. Mean total running speeds for preshift (left frame) and postshift (fight frame) in two day blocks based on the R trials on N-R transitions.

3. Mean total speeds for the five days of extinction based on the average of all seven daily trials.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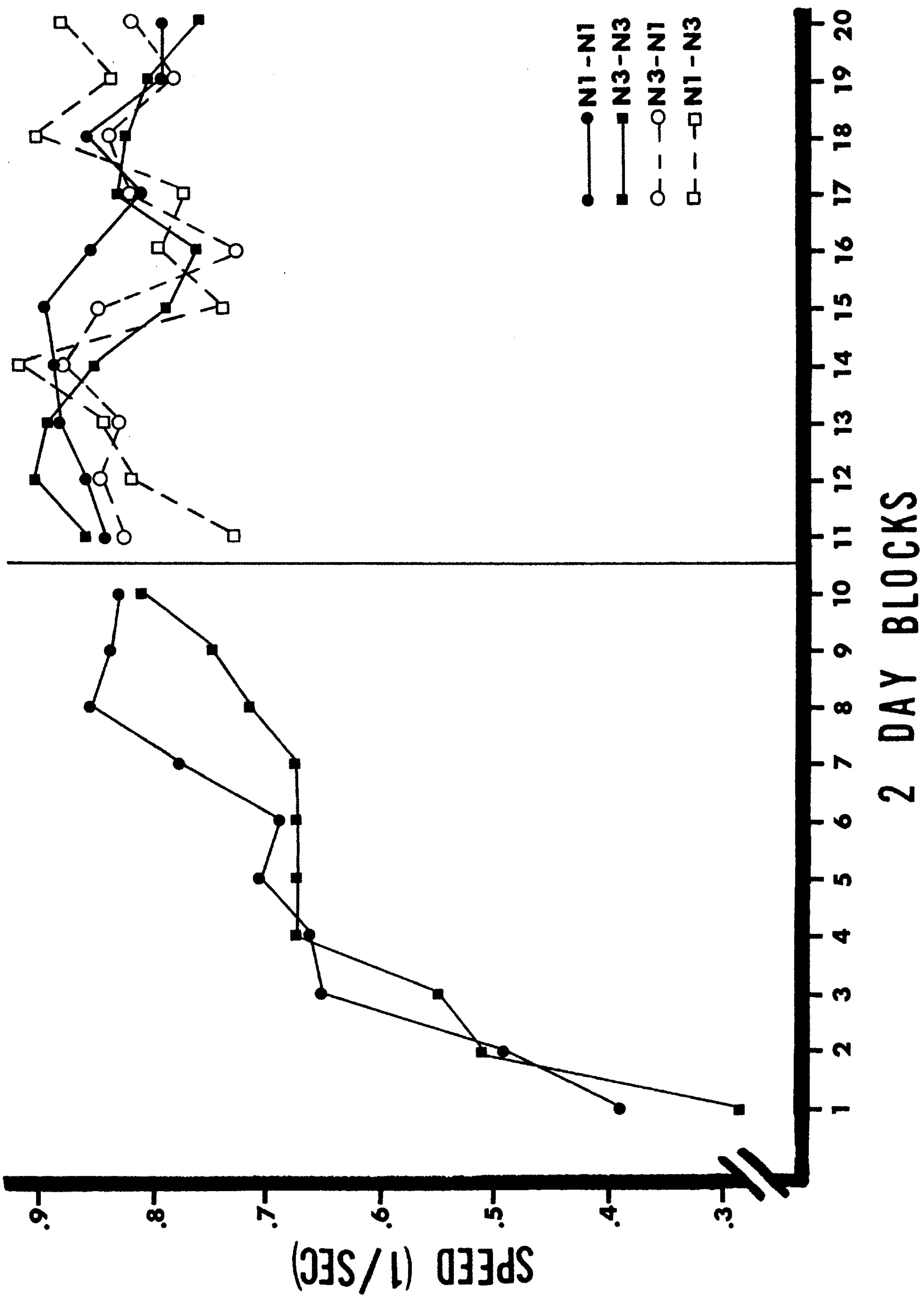
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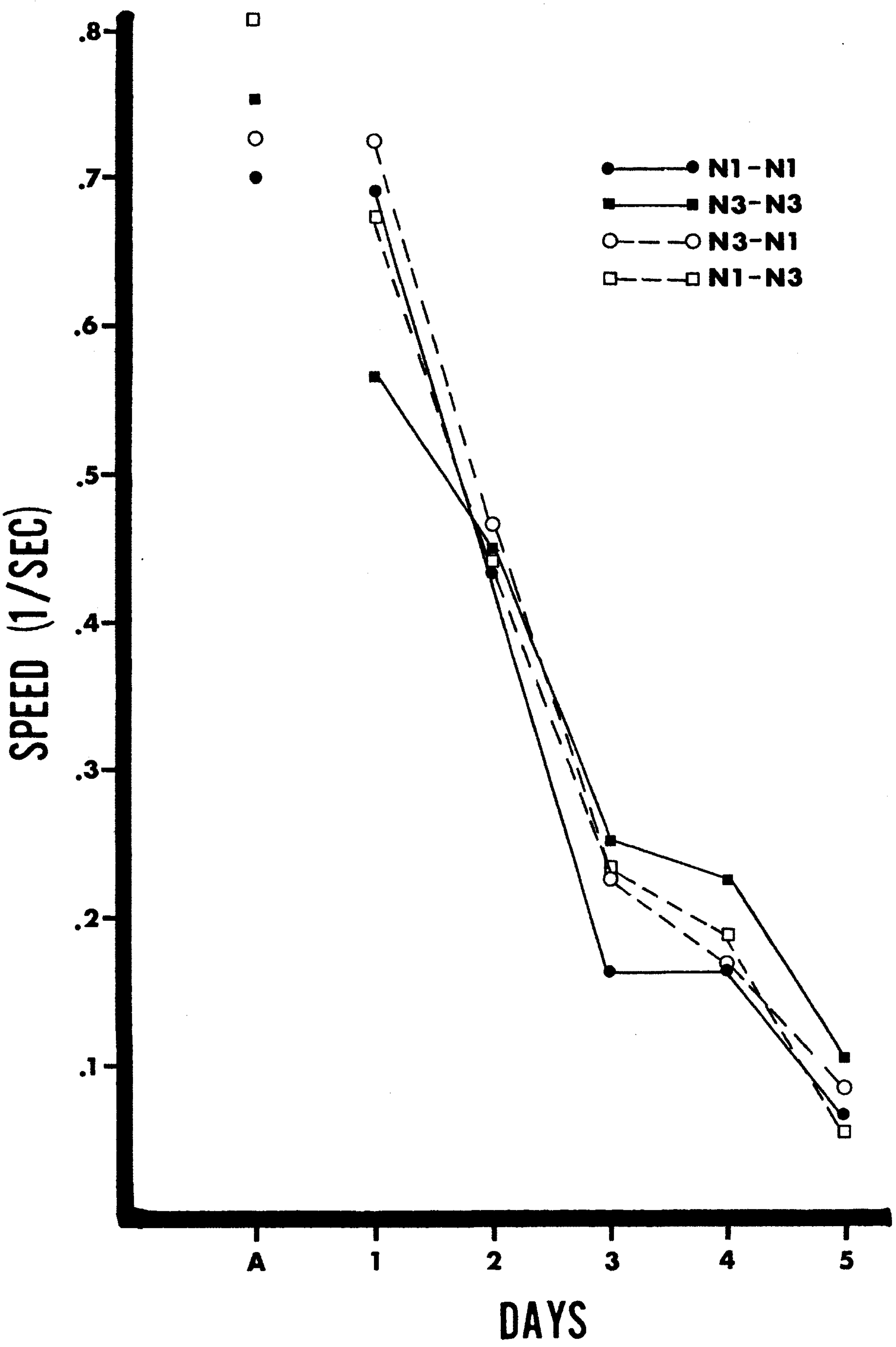

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DAYS

APPENDIX A

LITERATURE REVIEW

Contrast Effects Involving Procedures Other Than Appetitive Reward Magnitude Shifts: A Review of the Literature

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Since the publication of the early incentive shift studies by Crespi (1942) and Zeaman (1949) reporting contrast effects, papers have appeared with increasing frequency in an attempt to delineate the critical factors involved in these phenomena. Contrast effects can be of two types. A negative contrast effect (NCE) is characterized by a decrement in some performance measure due to past experience with a more favorable condition of reinforcement. The analogous increment in performance attributable to prior exposure to a less favorable reinforcement condition is termed a positive contrast effect (PCE).

Experimental paradigms investigating contrast effects can be conviently grouped into three categories (c.f., Mackintosh, 1974). Transient contrast effects are, as the name implies, relatively short-lived facilitations or decrements in responding due to the immediately preceeding conditions of reinforcement. Transient effects often take the form of a slight overshooting or rebound to a response level above or below normal. The most obvious example is induction as seen in classical conditioning (Pavlov, 1927,

p. 188).

A second classification is simultaneous contrast, which has representative examples in both the operant and discrete trial literature. In the operant case, in which the phenomena are often termed behavioral contrast, identical reinforcement conditions are initially arranged in a multiple schedule. Reinforcement in one component of the schedule is made either more or less dense. Contrasted responding generally ensues (see review by Rachlin, 1973). In the discrete trial simultaneous contrast paradigm, subjects usually receive training in two discriminably different runways, each consistently associated with a different reinforcement condition. Contrast effects are shown when differential responding in one apparatus occurs as a result of experience with the other.

In the third category, successive contrast, subjects receive consistent experience with one condition of reinforcement before being shifted to a different condition, still in the same apparatus. As will become apparent, this paradigm allows for the investigation of many variants of the basic procedure. Behavioral and simultaneous contrast are believed to have a common basis (e.g., Padilla, 1971), but successive contrast appears to involve a different process (e.g., Mackintosh and Lord, 1973). In order to limit its scope, the remainder of this paper will be concerned primarily with successive contrast effects, but will include some representative examples from the simultaneous literature as well. Unless otherwise noted, all cited literature is concerned with successive contrast effects using albino rats in a straight alley, with running speed as the dependent variable of interest.

In order to unambiguously demonstrate a successive contrast effect, the general procedure is to invoke a shift in reinforcement conditions (either positive or negative) after an ample amount of experience with the preshift conditions, and compare postshift performance with a control group given the postshift reinforcement conditions from the beginning. The "shift in reinforcement conditions" can refer to any of a number of different manipulations. While magnitude of reinforcement has been most commonly used, procedures using shifts in variables such as delay of reward, punishment, schedules of partial reinforcement, percentage of reward, quality of reward, etc., have also been reported. The present review is intended to examine the data on contrast effects using procedures other than appetitive reward magnitude shifts. For a review of reward magnitude shift studies see Black (1968), Dunham (1968), and Cox (1975).

<u>Delay of Reward</u>.

It is well known (e.g., Logan, 1960) that introducing a delay before the delivery of the reward has adverse effects on instrumental responding. Delay of reward is widely treated as an incentive variable (Renner, 1964), and therefore would be expected to play a role in the study of incentive contrast effects. In the successive contrast literature, delay was first used as a method to hold down running speed to avoid a "ceiling effect" (Pereboom, 1957; Bower, 1961) which may be responsible for the failure to find a PCE in some situations. That is, it is quite likely that subjects are responding at their maximal level at the end of preshift training which would prevent responding at a higher level during the postshift phase. With the introduction of a delay of reinforcement, responding will be reduced to a sub-maximal level and positive contrast effects will be free to appear. This ceiling effect hypothesis has been supported by the use of delay of reward (Mellgren, 1972) and other response limiting procedures (e.g., Seybert and Mellgren, 1972; Shanab, Sanders, and Premack, 1969; Weinstock, 1971; Mellgren, Nation, Wrather, and Jobe, Note 1; Wallach and Seres, 1971).

There is however a fair amount of evidence against the ceiling effect hypothesis. A recent report by Moore and McHose (1975) found that incorporating a delay of reinforcement with a decrease in reward magnitude also enhances the NCE, an outcome not readily derivable from the ceiling explanation. In addition, the common finding of a partial reinforcement acquisition effect (c.f., Robbins, 1970) tends to discredit this hypothesis since the "ceiling" of the continuous reinforcement group is asymptotically exceeded by the partial reinforcement group. The ceiling explanation is probably a misnomer and it is likely that delay of reward has interactive effects with reward magnitude shifts beyond that of simply holding down running speeds. Consistent with this notion is the recent reinforcement level theory advanced by Capaldi (Note 2). The exact function of delay of reward is still a major issue and far from being resolved. Research involving shifts in delay are beginning to get at this problem more clearly.

Hull (1943) interpreted the effects of delay of reinforcement as analogous to reduction in the size of reward. Both were seen as producing a reduction in motivation. In light of this analysis, it is not surprising to expect contrast effects due <u>only</u> to shifts in delay. That is, a shift from a short to a longer delay may be expected to produce an NCE, whereas a PCE may result from a long to a shorter delay shift. There are a fair amount of data concerned with shifts in delay, and the following is a summary of the findings.

Shanab and McCuiston (1970) used a three phase design to assess the relative contributions of delay and reward magnitude to contrast effects. Phase 1 consisted of a 3 (delay of 0, 15, or 30 sec) X 2 (1 or 12 pellets) factorial arrangement producing six groups. In Phase 2, all groups received 12 pellets with the same delay as in Phase 1. In Phase 3, again 12 pellets were given to all groups, but this time with a constant 15 sec delay of reward. For purposes of the present discussion, Phase 3 data are of primary interest, since delay was shifted while reward magnitude was held constant. An NCE was found in the group shifted from 0 to 15 sec delay in both the 1 and 12 pellet conditions. No PCE was obtained. These results suggest that a shift in delay produces an NCE but no PCE.

This finding is supported by McHose and Tauber (1972) who also manipulated pre- and postshift delay of reward. Subjects shifted from 10 to 30 sec delay (with reward magnitude held constant) exhibited an NCE relative to a group which received the 30 sec delay throughout. No PCE was shown in any group shifted from 30 sec to 10 sec delay.

In a related study, Shanab (1971) shifted subjects from a partial delay (i.e., delayed on some, but not all trials) to a continuous delay and from immediate reinforcement to continuous delay. An NCE was found only in the latter group, suggesting that some exposure with the postshift delay conditions may be sufficient to prevent the occurance of an NCE.

While all of the formentioned investigations have reached more or less the same conclusions, this has not always been the case. Shanab, Rouse, and Cavellero (1973) failed to find any evidence for either an NCE or a PCE using shifts from 0 sec to 30 sec delay and vice versa, with reward magnitude held constant at either 1 or 22 pellets.

Similarly, McCain, Boodee, and Lobb (1977) using a multiple shift procedure failed to find contrast using delay parameters of 10 and 30 sec. This finding is at odds with a previous report from the same laboratory (McCain, Lobb, Almand, and Leck, 1976) which did obtain an NCE with a delay shift from 10 to 30 sec.

Shanab and Biller (1972) failed to find a PCE as a result of a simple upshift in reward magnitude or a simple decrease in the delay interval. A PCE was found however using a shift from small to large reward magnitude only when it was accompanied by a shift in delay from 30 sec to 15 sec. In the same study an NCE was reported due only to a shift in delay from 30 to 10 sec.

To date, there has been only one study which reported a PCE resulting only from a shift in delay. Sgro and Weinstock (1963) found a PCE in a shift from 30 sec to 0 sec delay. A major difference in this study however was the use of water reinforcement. It has been found (Logan, 1960) that water reward leads to a lower asymptotic running speeds, precisely the condition in which PCE's are generally found.

In the simultaneous contrast literature, Beery (1968) obtained an NCE using a differential conditioning paradigm. It was found that speed of running to S(1) signalling a 10 sec delay of reinforcement was an inverse function of the delay length concurrently in effect in S(2). Similar results have been reported by Chechile and Fowler (1973) and by Sgro, Glotfelty, and Podlesni (1969). In a study directly comparing simultaneous and successive contrast produced by delay, Mackintosh and Lord (1973) found an NCE using the simultaneous procedure but not in the successive paradigm. The lack of an NCE in the latter case involved a shift from 0 to 15 sec. This finding is at odds with the Shanab and McCuiston (1970) study which used the same delay parameters.

The results of studies which employed shifts in delay while holding reward magnitude constant appear to be somewhat consistent, but the many failures to replicate suggest that these phenomena are not overly robust. When the length of the delay interval preceeding reinforcement is increased, negative contrast effects are observed. When the delay interval is decreased, positive contrast effects do not appear, except possibly in the case of water reinforcement. It may be noted that the delay intervals used in the forementioned investigations were of a rather limited range (0 to 30 sec). Perhaps the use of longer delays may be illuminating, particularly with respect to the PCE.

Aversive Conditioning.

Since there are both functional and theoretical precedents for treating punishment and reward as symmetrical opposites, it is not surprising that shifts in punishment level may be expected to produce contrast effects. In the runway, there are three possible techniques for studying the effects of punishment shifts with respect to contrast effects.

The first of these is escape conditioning. In this paradigm the entire runway, with the exception of the goal box is electrified. The running response is reinforced by shock offset upon reaching the goal box. Only one experiment provides data using this procedure. Nation, Wrather, and Mellgren (1974) initially trained three groups of rats to escape either .2, .4, or .8 mA shock. All groups were then shifted to .4 mA shock escape. Results of the study indicate a reliable PCE in Group .2-.4 as well as a significant NCE in Group .8-.4.

An earlier study by Bower, Fowler, and Trapold (1959) exemplifies another technique for studying contrast effects with aversive conditioning. In this study reinforcement consisted of shock reduction rather than shock escape. Two levels of shock reduction were employed: a 200 V reduction from runway to goal box (high incentive) and a 50 V reduction (low incentive). After an initial period of training, each group was shifted to the opposite condition. No evidence for either a PCE or an NCE was found. There is a serious source of confound in this study however, as pointed out by Nation _et al_ (1974). Since the subjects were removed from the apparatus following each trial, the shock level was in effect reduced to zero. Subjects were experiencing repeated shifts in reinforcement magnitude, a technique in which the observation of contrast effects may be obscured in the appetitive case (see Capaldi and Lynch, 1967).

A similar study by Howe (1961) which used the same shock reduction parameters and obtained the same results as Bower _et al_ (1959) is also subject to this same criticism. In addition, the lack of control groups makes this study particularly ambiguous.

A third technique involves shock in the goal box just prior to the subject's consumption of food reward. In an unpublished Doctoral dissertation, Nation (Note 3) shifted subjects from .1, .4, or .8 mA goal box shock to .4 mA shock in Phase 2 with food reward magnitude held constant throughout. His results indicate an NCE in Group .1-.4, but no PCE in Group .8-.4.

Another method of producing aversive conditioning has been used in a series of studies by Woods. Escape conditioning using a runway filled with cold water with warmer water in the goal section is conceptually analogous to shock reduction. Using two levels of cold reduction (25°C to 27°C, or 25°C to 41°C) Woods (1967) reported negative contrast but no positive contrast. The NCE was later replicated by Woods (1973) using shifts from 15°C to 19°C and 15°C to 39°C. These studies also must be viewed with caution for the same reasons as discussed above. Folllowing each trial, the animals were removed from the water, thereby making it a repeated shift in reinforcement level (i.e., from cold water to warmer water to no water). Perhaps a better design would involve escaping from different temperatures of water, analogous to the Nation *et al* (1974) design.

Still another attempt to show contrast effects with aversive conditioning was reported by Olson and Elder (1973) using a shock-avoidance paradigm. Subjects were trained to avoid shock of either .4 mA or 1.2 mA and were then switched to the opposite level. No reliable contrast effects were obtained in the dependent measure, anticipatory responses.

Finally, McAllister, McAllister, Brooks, and Goldman (1972) used still a different procedure. Subjects were first given classical fear-conditioning trials in one side of a two-way shuttle box. They were then allowed to jump a hurdle to the other side and escape the fear-eliciting stimuli. Reinforcement magnitude (defined in terms of fear reduction) during the hurdle jumping phase was either large or small throughout (the control groups) or it was increased for one group while it was decreased for the other. Although there was no evidence of positive contrast, there was a clear demonstration of an NCE.

In summary, very few data exist which contribute to contrast effects in aversive conditioning. The study by Nation _et al_ (1974) shows both a PCE and an NCE with escape conditioning. The other two similar studies which failed to find contrast effects are ambiguous due to the problems discussed above. Nation (Note 3) found an NCE but no PCE in a punishment shift study. The aversive water studies by Woods (1967; 1973) are also difficult to interpret because of methodological problems. Simply not enough data are available to draw any conclusion regarding aversive or fear conditioning. Based on this limited evidence, it would appear that escape conditioning is analogous to appetitive conditioning in that both a NCE and an PCE are obtainable, with the former being more robust than the latter. This does not seem to be the case however when punishment preceeding appetitive reinforcement is used.

<u>Shifts in the Percentage of Rewarded Trials</u>.

Contrast effects have been investigated using shifts in percentage of rewarded trials from a number of different perspectives. One line of investigation (McHose and Peters, 1975) has approached this from an "incentive averaging" viewpoint in which the subjects are presumed to average the incentive value of reinforcement over a number of trials. Preliminary evidence for this approach was given in McHose and Peters (1975, Expt. 5). Four groups were arranged, only two of which are relevent to the present discussion. A group was shifted from 75% rewarded trials to 25% rewarded trials with reward magnitude held constant at 15 pellets. An NCE was demonstrated relative to a group which received the 25% condition throughout. It should be noted that the schedules of partial reward were counterbalanced across days, and therefore sequential effects (Capaldi, 1967) were not experimentally controlled for in this experiment.

In another percentage shift study, Leung and Jensen (1968) shifted subjects from partial to continuous reward (P-C) and vice versa (C-P). In the P conditions, several values of percentage of reinforcement were used. Reward magnitude was constant across all conditions. In addition, a group was run which received continuous reinforcement throughout (C-C). An unusually large number (30) of massed (15 sec intertrial interval) daily trials were given in this study, a procedure inconsistent with most of the contrast effects literature. All of the P-C groups with the exception of the 0% group (i.e., no reward during preshift) ran faster than the C-C group during postshift, thereby demonstrating PCE's. In the C-P groups, reduction in speed during the second phase was observed only in the groups which received 0% or 16% rewarded trials during postshift. These findings are unusual since a reliable PCE was found in the absence of an NCE. It is important to note however that the proper control groups for the C-P manipulation were not run, and the failures to note NCE's were based only on intergroup comparisons. This is a serious shortcoming given the relatively unusual training procedures. Again, the partial reward schedules were arranged based on a random procedure.

A related methodological aspect may be considered at this point. It is clear that shifts in percentage of reinforced trials my be accomplished in two ways. The first of these is to hold the number of trials constant and vary the number of reinforced trials. The other is to vary the number of trials while maintaining a constant number of reinforced trials. The behavioral effects of each of these procedures is by no means clear. This will become apparent when the data reported by Fox (1972) are considerd.

Fox (1972) employed shifts from one value of partial reinforcement to another with regard to percentage of reinforced trials. Unlike the Leung and Jensen (1968) procedure, Fox's shifts were accomplished by varying the number of trials in pre- and postshift, while keeping the number of rewarded trials constant. In addition, the shift was accompanied by a shift from immediate reinforcement to 20 sec delayed reward in Phase 2. His data indicate a strong PCE as a result of a shift from 25% to 50% reinforced trials and an equally reliable NCE when the shift was in the opposite direction. How much of this effect can be attributed to the change in the number of trials is unknown since these controls were not included. This point, while central to theoretical accounts of partial reinforcement and contrast effects, has received no empirical attention. The Fox (1972) data have been interpreted in a quite different manner by Capaldi (Note 2), and will be discussed in this context in a later section.

In a study employing multiple shifts, McCain, Lobb, and Newberry (1976) reported an NCE in a shift from 75% to 25% reinforced trials, but only after the second shift. The groups were designated LSLS and SLSL, where S represents 25% and L indicates 75% reinforced trials. No PCE was found in the shifts from S to L. One rather surprising outcome of this experiment was the finding that in Group LSLS running speed actually increased following the first shift from 75%

to 25%. The authors were unable to give a theoretical account of these findings.

Finally, Lehr (1974) reported a PCE in a percentage shift study using a constant 20 sec delay to control for ceiling effects. Four groups were arranged in a 2 X 2 factorial design varying percentage (50% or 100%) and reward magnitude (1 or 8 pellets) in preshift. During the second phase all subjects received 100% rewarded trials with 8 pellets. A PCE was found in the group shifted in percentage with constant magnitude as well as in the group shifted in magnitude with constant percentage. These findings were replicated in a second experiment employing rats of both sexes and a longer preshift period.

The literature on shifts from continuous reinforcement to partial reinforcement is replete with conflicting results. Mikulka, Lehr, and Pavlik (1967) noted a decrease in speeds as a result of this shift, while Badia (1965) observed an increase in speeds. To confuse the issue even more, Rashotte, Adelman, and Dove (1972) failed to find any significant effect.

It would seem that much more research is needed to uncloud several issues fundamental to percentage shifts. Certainly sequential effects deserve attention as well as shifts in the number of trials as reported by Fox (1972). As it stands, nothing conclusive can be stated as to the status of percentage shifts with respect to contrast effects.

Schedule Effects.

Several investigations have implicated schedules of partial reward as having an important influence on contrast effects (e.g., Mikulka, Lehr, and Pavlik, 1967; Bohmer and Ison, Note 4; Capaldi and Ziff, 1969), but these have all incorporated reward magnitude shifts interaction effects, and are therefore not relevent to the present discussion. Shifts in partial reward schedules within the context of percentage of reinforcement were discussed in the previous section. One study (Fox, 1972) which found both a PCE and an NCE resulting from percentage shifts has been reinterpreted by Capaldi (Note 2) in a quite different context. Capaldi views the contrast effects as being due to the sequential aspects of the schedules involved. The schedules used by Fox were NNNRNNNR (25%) and NRNR (50%). Note that the first schedule contains an N-length of three (see Capaldi, 1967 for a definition of terms) and the latter schedule an N-length of one. According to Capaldi's (Note 2) reinforcement level hypothesis, the contrast effects observed were the result of shifts in N-length. There is of course no way to distinguish between the two alternative explanations based only on the Fox (1972) study, since percentage, number of trials, and several other variables were confounded.

A recent study by Walkenbach (Note 5) repeated the Fox manipulations using a design in which N-length was shifted, while both percentage and number of trials were held constant. No evidence for either an NCE or a PCE was found. Further research is needed to clarify this area.

Shifts in Quality of Reward.

It is clear that changes in reward may be either quantitative or qualitative. The former is generally investigated, but the latter has received considerably less attention in the contrast literature. For a review of the interactive effects of quality and quantity of reward, see Taylor (1977). The first study which investigated shifts in quality of reward was published by Elliott (1928). The dependent variables were number of errors and time of traversal in a complex maze. In previous research it was found that rats prefer wet bran mash over sunflower seeds. In a shift from mash to seeds, a decrement in performance was noted in both measures relative to a control group which received seeds throughout. Since both quality and quantity were confounded, little can be concluded from this investigation. The study remains to be of historical interest however since it predates what is generally believed to be the first incentive shift study (Crespi, 1942) by well over a decade.

Since then, the predominate substances used in quality-shift studies have been sucrose and saccharin solutions. The obvious advantage is that concentrations can be changed while holding quantity constant.

In one of the first sucrose quality-shift studies, Collier and Marx (1959) employed a bar press task. Subjects were first magazine trained with a sucrose concentration of either 4%, 11.3%, or 32%. Then the three groups were trained to lever-press on a VI-1 min schedule for an 11.3% solution. Positive and negative contrast effects were observed in the groups magazine trained to 4% and 32%, respectively.

However, Dunham and Kilps (1969) point out that the Collier and Marx (1959) data were the result of confounded weight differences in preshift training. The original experiment was repeated with deprivation levels closely monitored and held constant at 80% of free-feeding weight. No contrast effects were found.

In another study, Marx (1969) employed a different type of quality shift. Subjects under low (2-3 hr) deprivation conditions were shifted from food pellets to 32% sucrose pellets (the preferred food) in a discrete-trial bar-pressing task. A significant PCE was obtained in the shifted group. Another group in the same study was shifted from an 8% to a 32% pellet concentration and showed no evidence of contrasted responding. These data were interpreted as a demonstration that positive contrast is obtainable, but only if the incentive change is sufficiently large.

A good number of studies hav investigated downshifts in sucrose concentration in the runway. The overwhelming conclusion is that the NCE does not appear. Rather, the downshifted animals show a gradual decrease in speed and eventually reach the asymptote of the unshifted controls, but do not subcede it (Collier, Knarr, and Marx, 1961; Goodrich and Zaretsky, 1962; Homzie and Ross, 1962; Rosen and Ison, 1965; Spear, 1965; Rosen, 1966; Flaherty, Riley, and Spear, 1973).

In addition to running and bar-pressing, other performance measures have been employed to study successive contrast effects due to quality shifts. One such procedure is the measurement of lick rate. Subjects are simply allowed to lick a tube from which a liquid reinforcer is available and the number of licks is taken as the degree of performance. Some writers (e.g., Collier et al, 1961) have suggested that lick rate is a more sensitive measure than running speed.

Using lick rate as the dependent measure, Panksepp and Trowill (1971) shifted sucrose concentrations from 12% to 35% and vice versa. Both positive and negative contrast effects resulted under conditions of both 21 hr and 1 hr food deprivation. In this situation, contrast effects are often short-lived. In the Panksepp and Trowill study, the effects disappeared after about 1 min. Similar results were reported by Flaherty and Largen (1975). An NCE and a PCE in both lick rate and latency to lick appeared following a shift from 32% to 4% sucrose concentration.

Vogel, Mikulka, and Spear (1968) also reported an NCE in lick rate resulting from a shift from 32% to 4% sucrose concentrations, but not in a shift in the same concentrations of saccharin.

Another line of research was undertaken by Trowill and his associates involving shifts from sodium-saccharin to tap water and back to sodium-saccharin. The dependent measure was simply amount consumed within a certain period of time. In several studies (Gandelman and Trowill, 1969; Ashton, Gandelman, and Trowill, 1970a; Dube, Ashton, and Trowill, 1970) it was found that the amount of saccharin consumed following the interpolated one day shift to tap water was significantly higher than on the previous saccharin days, thereby demonstrating a successive PCE. These results were not obtained using a sucrose solution in place of the sodium-saccharin however (Ashton, Gandelman, and Trowill, 1970b).

In summary, evidence for both PCE's and NCE's using consummatory measures seems to be strong and replicable. On the other hand, contrast effects based on instrumental responses appear to be non-existant in the runway and equivocal in bar-pressing paradigms. Flaherty and Caprio (1976) pointed out that this discrepancy is inconsistent with several theories of behavior which emphasize the relationship between consummatory and instrumental responding (Spence, 1965; Sheffield, 1966). Consequently, these authors designed several expriments to compare the two response systems within a single study. An experiment was arranged such that instrumental responding in a runway could be measured in addition to consummatory licking in the goal box. Results were consistent with previous literature: an NCE was obtained in the latter measure, but none in the former. In addition, no correlation was found between running speed and lick rate. A second experiment used longer pre- and postshift periods and also included an upshifted group. Again, an NCE was found in lick rate, but not in running speed. A reliable PCE was not found in either measure. In agreement with the first experiment, no statistically significant correlations were found between running speed and lick rate. Flaherty and Caprio reached the conclusion that instrumental responding and consummatory responding are not necessarily related, consistent with the approach taken by Bindra (1974). It would appear that instrumental behavior is related to associations between the signaling stimuli and the stimulus properties of the reward, rather than stimuli and consummatory responses.

Shifts in Deprivation Level.

The interactive effects of drive and incentive have long been a source of controversy in psychology (e.g., Hull, 1943; Spence, 1956). A common incentive-motivational mechanism has been proposed (Revusky, 1968) in which incentive is viewed as an increasing function of deprivation. If this is the case, contrast effects should be evident following shifts in drive. Drive, of course, must be operationally defined and at least three methods are in use. The first is a time-based measure based on the elapsed time since the subjects were last exposed to food. The second is based on percentage of free-feeding weight. The third involves feeding a standard amount of food to each subject daily, regardless of its normal weight. All three methods have their advantages and disadvantages, and all have been used in successive contrast drive-shift studies.

Zaretsky (1966) published a study investigating the effects of shifts in various combinations of drive and incentive. Two conditions are relevent to the present discussion, those in which the reward magnitude was held constant, but drive was shifted. High drive was defined as 22 hrs deprived; low drive was 1.5 hrs deprived. Under conditions of low reward magnitude (1 pellet) a PCE was observed when drive was shifted from low to high. An NCE was found under conditions of high reward magnitude (6 pellets) in a deprivations level shift from high to low.

Capaldi (1971) defined high drive as 11 gm of food and low drive as 20 gm per day. Using a 10 pellet reward magnitude, no NCE was found in a shift from high to low drive.

In a later study, Capaldi (1973) used a different method of inducing differential drive. High drive was defined as 75% of ad lib body weight; low drive was 90% free-feeding weight. An NCE was found in a shift from high to low drive only when a large magnitude of reward was used. That is, the effect was present when 22 pellets were used, but absent when reward magnitude consisted of only 1 pellet. It may be noted that the method of drive induction used here necessarily demanded a long interval (18 days) between pre- and postshift.

Mollenauer (1971) defined high drive as 22-22.5 hrs deprivation. A 30-60 min deprivation period defined the low drive condition. Shifts in drive after 23 trials produced a gradual approach to the appropriate performance level. However, shifts after either 75 or 105 trials produced significant contrast effects in both directions.

The results of the successive deprivation shift studies have been relatively consistent in finding both positive and negative contrast effects resulting from these shifts. The difference between successive and simultaneous contrast can be exemplified by citing the results of Eisenberger, Myers, and Kaplan, (1973). High and low drive conditions consisted of 24 hours deprivation or 24 hours free feeding, respectively. Using a single trial per day in two discriminably different runways, superior performance was shown under low deprivation conditions in the discrimination group relative to the control group which was run under constant low deprivation. This is exactly opposite of the predicted effects based on the successive contrast literature. This suggests that caution must be used when generalizing between the two types of procedures.

Intercranial Stimulation Effects.

Intercranial stimulation (ICS) of the brain occupies a unique position among experimental manipulations in that it is an incentive which can be studied independent of drive or deprivation conditions (Trowill, Panksepp, and Gandelman, 1969). A few successive contrast studies using shifts in the current of ICS have been reported.

The first clear-cut demonstration was reported by Panksepp and Trowill (1969) using a bar press situation. Rats were trained to respond on a CRF schedule for .5 sec lateral hypothalamic stimulation with either a high or low current. When responding stabilized the groups were shifted to the opposite incentive condition. Although no control groups were included in the design, the changes in performance between pre- and postshift were dramatic. Both positive (low to high stimulation) and negative (high to low stimulation) contrast effects appeared and lasted for approximately 15 min.

In a later study (Panksepp and Trowill, 1970) the same authors attempted to replicate the effect using three different procedures. A PCE was shown using a descending method of limits for determining ICS threshold. That is, current was initially set at a suprathreshold limit and systematically decreased until responding ceased. After a time-out period, the subjects were allowed to resume bar pressing, again beginning at the original suprathreshold value. Response rates were significantly higher following a time out than for a control group with no time-out.

A second experiment involved giving an ascending series of ICS currents within a continuous test sequence. Although response rates increased with current intensity, the authors' conclusion of a PCE is unwarranted since control groups were not employed.

The third experiment was concerned with time to complete an FR requirement under various levels of ICS. Using preshift rates for baselines, a PCE was found in that time to complete the FR requirement significantly decreased from baseline when current was increased.

Using a different apparatus and stimulation site (medial hypothalamus and ventral thalamus), Atrens, Von Vietinghoff-Riesch and Der-Karabetian (1973) reported both a PCE and an NCE in a shuttlebox task. One response was required to initiate ICS and another to escape it. Thus, both rewarding and aversive stimulation were studied in the same situation. Three intensities of ICS were presented in a randomized sequence. Positive contrast was found since high intensity ICS preceded by either medium or low intensity produced more vigorous responding when compared to high intensity followed by high intensity. When low intensity ICS was preceded by either medium or high, the animals responded much less vigorously to obtain it. These results were taken to indicate both positive and negative contrast effects in the rewarding situation. In the aversive case, when high intensity ICS was preceded by either medium or low intensity, the animals escaped more slowly compared to the noncontrasted case (NCE). No corresponding PCE was found however, since latency to escape low intensity ICS was not affected by the preceding conditions.

Miscellaneous.

There are several other studies deserving of mention which do not fit conviently under any of the previous categories, but nevertheless are of some relevence to this discussion. One area of research involves giving equal incentives (by weight or volume) but in a different form, or number of "goal units." Several investigators have noted the fact that equivalent amounts of food reward support different levels of responding. That is, rats (Logan, 1960, p. 35; McCain, 1969) and chickens (Wolfe and Kaplon, 1941) run differentially to obtain food depending on the manner in which the reward is divided. For example, in the McCain (1969) study, one group of subjects (MS) were rewarded with 22 45 mg pellets (990 mg total) and then shiftd to a single 1000 mg pellet. A second group (SM) was exposed to the reverse conditions. During preshift, Group MS ran significantly faster than Group SM, but the opposite was true during postshift. Although the proper control groups were not included to assess any contrast effects, the results strongly suggest that factors other than traditional incentive variables are operative in contrast phenomena. It may be parenthetically noted that the analogous effects using different units of liquid sucrose was not obtained (Flaherty, Riley, and Spear, 1973).

In a related study, Daly (1972) originally trained three groups of rats to run for one 500 mg pellet (Group 1L), 25 20 mg pellets (Group 25S), or one 20 mg pellet

(Group 1S). Then Groups 1L and 25S were shifted to the 1S condition. Negative contrast was shown in both groups, but Group 25S showed a much larger NCE, again implicating the importance of goal units on contrast effects.

These studies all point to the possibility that an important variable determining contrast effects is the animal's perception of the incentive rather than the incentive *per se*. Clearly, more research is needed in this potentially fruitful area of research.

Summary and Conclusions.

Due to the wide variety of empirical manipulation discussed in the previous sections, few generalized conclusions can be drawn. It is clear that incentive is a multi-dimensional concept and must be viewed in a relative, as opposed to an absolute manner. The paradigms used to investigate contrast effects are an excellent tool for delineating some of the crucial aspects fundamental to the concept of incentive.

In most reviews of this sort, the primary conclusion is the general need for more research. This paper is no exception. A case in point is the section dealing with shifts in delay of reward. As noted, the literature is replete with positive results, negative results, and failures to replicate both. There is an obvious need for parametric investigations in which such parameters as reward magnitude, delay intervals, and number of trials are manipulatd.

The literature concerned with aversive conditioning is even more ambiguous and incomplete. In view of the large amount of research done with avoidance conditioning, it is surprising that such few attempts at shifting shock levels have been made.

An area which undoubtedly will receive more attention in the future is schedule effects, particularly those concerned with the sequential aspects of schedules. It would not be surprising to learn that sequential aspects of reward schedules affect contrast effects equally as much as they do extinction phenomena (Robbins, 1970). Related to this is shifts in percentage of reward. The interaction between percentage shifts and sequential effects is a prime source of meaningful research as well as theoretical development.

Another area that deserves more attention is response systems in general. This should be clear from the section on quality of reward shifts in which contrast effects are readily observable with consummatory, but absent with instrumental responses.

Finally, much more work is needed to determine the differences between simultaneous and successive contrast effects. Although the former have been de-emphasized in this paper, it should be noted that the results using analogous procedures in the two paradigms fail, as often as not, to coincide with each other. More studies directly comparing the two are in order.

Perhaps the single greatest factor impeding contrast research has been the lack of well-specified theories. Hopefully, the comprehensive reinforcement level theory recently advanced by Capaldi (Note 2) will be an impetus to expand current alternative conceptions and develop new ones.

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APPENDIX B

ANOVA SUMMARY TABLES

SUMMARY TABLE FOR 4 (GROUPS) X 20 (DAYS) ANALYSIS OF VARIANCE DURING POSTSHIFT TRAINING (AVERAGE OF SEVEN DAILY TRIALS)

	Source	MS	df	F	
Start:	A (groups)	.073	3	.032	
	Error	2.295	36		
	B (days)	.263	19	3.862	***
	AB	.071	57	1.036	
	Error	.068	684		
Run:	A (groups)	.161	3	.048	
	Error	3.361	36		
	B (days)	1.284	19	19.020	***
	AB	.076	57	1.119	
	Error	.067	684		
Goal:	A (groups)	4.669	3	.330	
	Error	14.144	36		
	B (days)	1.536	19	6.588	***
	AB	.271	57	1.154	
	Error	.234	684		
Total:	A (groups)	.050	3	.091	
	Error	.553	36		
	B (days)	.086	19	7.760	***
	AB	.015	57	1.326	
	Error	.011	684		

*** $p < .001$

SUMMARY TABLE FOR 4 (GROUPS) X 20 (DAYS) ANALYSIS OF VARIANCE
DURING POSTSHIFT TRAINING (R TRIALS FOLLOWING ONE OR MORE N TRIALS)

	Source	MS	df	F	
Start:	A (groups)	.083	3	.036	
	Error	2.305	36		
	B (days)	.293	19	4.069	***
	AB	.071	57	.986	
	Error	.072	684		
Run:	A (groups)	.172	3	.050	
	Error	3.412	36		
	B (days)	1.432	19	20.754	***
	AB	.082	57	1.188	
	Errror	.069	684		
Goal:	A (groups)	5.012	3	.291	
	Error	17.211	36		
	B (days)	1.549	19	4.780	***
	AB	.292	57	.901	
	Error	.324	684		
Total:	A (groups)	.062	3	.101	
	Error	.612	36		
	B (days)	.087	19	7.250	***
	AB	.014	57	1.116	
	Error	.012	684		

*** $p < .001$

SUMMARY TABLE FOR 4 (GROUPS) X 5 (DAYS) ANALYSIS OF VARIANCE DURING EXTINCTION (AVERAGE OF SEVEN DAILY TRIALS)

	Source	MS	df	F
Start:	A (groups)	.099	3	.102
	Error	.976	36	
	B (days)	13.955	4	32.726 ***
	AB	.148	12	.876
	Error	.159	144	
Run:	A (groups)	.153	3	.213
	Error	.715	36	
	B (days)	10.826	4	71.169 ***
	AB	.131	12	.864
	Error	.152	144	
Goal:	A (groups)	.391	3	.143
	Error	2.733	36	
	B (days)	36.879	4	89.133 ***
	AB	.346	12	.836
	Error	.414	144	
Total:	A (groups)	.006	3	.045
	Error	.133	36	
	B (days)	2.208	4	99.790 ***
	AB	.017	12	.780
	Error	.022	144	

*** $p < .001$