CONTRAST AND RESISTANCE TO EXTINCTION IN THE RAT: A TEST OF

INCENTIVE AVERAGING AND REWARD LEVEL MODELS

by

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Two theories, Capaldi's (1975,Note 1) reward level theory and McHose & Moore's (1976) incentive averaging theory, which attempt to predict contrast effects and differential resistance to extinction are reviewed. Predictions derived from McHose & Moore's (1976) incentive averaging theory were tested in a three phase runway experiment with rats. To do this, three reward conditions, equivalent in terms of average incentive value (1 pellet continuous reward, 3 pellet 40% partial reward and 20 pellet 20% partial reward), were derived from the model. Three separate groups received one of the schedules throughout acquisition. Four additional groups received one phase of the continuous schedule either before or after a phase of one of the partial reward schedules. Since all schedules are assumed to support the same average incentive value the theory predicts equivalent performance for all groups in all phases of the experiment. The acquisition results generally supported this prediction, with no contrast effects observed. However, the extinction results did not support the theoretical predictions, as large group differences were found, including a strong partial reinforcement extinction effect. Capaldi's (1975, Note 1) reward level theory is shown to be compatible with the present extinction results.

CONTRAST AND RESISTANCE TO EXTINCTION IN THE RAT: A TEST OF
INCENTIVE AVERAGING AND REWARD LEVEL MODELS.

Discrete trial alley running has been one of the most
extensively studied responses in the animal learning literature.
The apparatus is simple, a straight, narrow runway, varying in
length from 1 to about 6 m. The subjects used are typically
albino or hooded rats. The dependant variable is usually running
speed, defined as the reciprocal of the latency to traverse some
portion or all of the runway. Measurement is almost always
automated, with timers accurate to .01 sec or better starting or
stopping as the subject intersects photocell beams. This appara-
tus has been used primarily to investigate the role of reward in
instrumental conditioning. Two phenomena in particular have held
special interest for researchers: incentive contrast and the
partial reinforcement extinction effect (PREE).

If a subject which receives a change in reward magnitude shows
a change in performance to a level beyond the level displayed by
a control subject that received only the second reward magnitude
the effect is called incentive contrast. For example, if the
performance of a group of subjects shifted from a 10 pellet
reward schedule to a 1 pellet reward schedule, drops below the
level of performance of a group maintained on the 1 pellet
schedule throughout the experiment the effect is labelled nega-
tive contrast (NCE). Conversely, if a group was shifted from 1
pellet to 10 pellets, and performed at a higher level following
the shift than a a control group receiving 10 pellets throughout
the experiment, the effect is labelled positive contrast (PCE).

The PREE is observed when a group that received reward on some but not all of the learning trials is found to be more resistant to extinction than a group that received reward on all learning trials.

Resistance to extinction was hypothesized to be a measure of response strength or amount of learning, while acquisition performance was proposed to be more indicative of incentive or motivation (Spence, 1956). The PREE is of theoretical interest then because, subjects that received fewer rewards exhibit greater response strength. This was problematic because response strength was assumed to increase only on reward (R) trials but subjects that received fewer R trials exhibited greater resistance to extinction and therefore presumably greater response strength. The contrast effects similarly were troublesome for theory because subjects shifted from one reward magnitude to another performed at levels different from control subjects maintained on the second reward magnitude. Because acquisition performance was assumed to indicate incentive, which is a function of reward magnitude and percentage, subjects receiving the same reward schedule were expected to show the same level of performance, regardless of previous history of reward schedules. The fact that these phenomena were at variance with early conditioning theories is in part responsible for the empirical activity invested in them. More recent theoretical approaches to instrumental conditioning have largely been built around these phenomena. Thus contrast and extinction have evoked a great deal of interest in most students of conditioning.

<u>Incentive Contrast.</u>

There are two types of contrast effects, initially described by Crespi (1942) as elation and depression effects. These effects are now referred to, in less cognitive language, as positive (PCE) and negative contrast effects, (NCE) respectively. Crespi demonstrated these effects in two separate experiments. To demonstrate the NCE three groups were used, two shifted groups and one unshifted control group. The postshift reward magnitude was 16 units for all groups; preshift reward magnitude was 256, 64, or 16 units. The runway was 6.3 m long and subjects were run at 1 trial per day. Both shifted groups showed a reliable NCE, running slower than the unshifted control group in the postshift phase.

To demonstrate the PCE Crespi used the same runway and three groups were again run. All groups began training on a 16 unit schedule, and then 2 groups were shifted to either a 4 unit or a 1 unit reward schedule after 21 trials. A 3 day intermission was interpolated and then the two shifted groups (16-4 and 16-1) were shifted back to the 16 unit schedule. The control group was not run in this third phase because its performance had become asymptotic and therefore the terminal level was used as the control level. A strong elation or PCE was observed, with both the 16-4-16 group and the 16-1-16 group running faster than the asymptotic level of the control group.

<u>Negative Contrast Effects.</u>

The NCE has been repeatedly demonstrated (eg. Crespi, 1942; DiLollo & Beez, 1966; and see Dunham, 1968), with the size of the

NCE being an increasing function of the discrepancy between preshift and postshift reward magnitude, if postshift reward magnitude is held constant (DiLollo & Beez, 1966). Mikulka, Lehr & Pavlik (1967) showed that the NCE is eliminated following partial reward training at a reward magnitude for pretraining where the NCE is found with continuous reward. However, McHose & Peters (1975) demonstrated that the NCE is found if partial reward was used, provided that the shift in reward magnitude was large enough. Incentive averaging theory (McHose & Moore, 1976), which provides a quantitative definition of "large enough", will be elaborated later in this paper.

Positive Contrast Effect.

The PCE was viewed at one time not to be a replicable phenomenon (see Dunham, 1968). However, most of the early attempts to replicate Crespi's elation effect failed to maintain continuity with his procedures (see Dunham, 1968). Crespi (1942) used a very long (6.3 m) runway and pretrained the subjects with large reward (L) before small reward (S) training. After the S training the subjects were shifted back to the L schedule and the PCE was observed. The NCE requires neither the pretraining nor the long runway (see Dunham, 1968). Recently, it has been shown that the PCE can be reliably reproduced, without the pretraining with large reward and in a much shorter runway, if reward is delayed in the goalbox (Lehr, 1974; Mellgren, 1971, 1972; Mellgren, Seybert, Wrather & Dyck, 1973; Shanab & Biller, 1972; Shanab & Cavallaro, 1975).

It has been suggested that the reason delayed reward training

yields a PCE is that, under immediate reward, the subjects in the large reward control group are responding so quickly that it is virtually impossible for the shifted subjects to run faster than the control group. In other words, the PCE is difficult to obtain under immediate reward due to ceiling effects on running speed. Since delayed reward reduces running speed and hence the ceiling problem, positive contrast is observed under these conditions.

Partial Reinforcement Extinction Effect.

A schedule of reward in which all running trials are followed by reward (R) is termed a continuous (C) schedule of reward. A schedule in which subjects are provided with a mixture of nonreward (N) and R trials is labelled a partial reward (P) schedule. Subjects trained on a P schedule have been found to be more resistant to extinction than subjects trained on a C schedule, an effect which has been labelled the partial reinforcement extinction effect (PREE). The PREE is a very robust effect, however a number of parameters in addition to the mere presence of nonrewarded trials have been shown to affect the size of the PREE.

Reward Magnitude.

In general, increasing the reward magnitude increases the size of the PREE (Gonzalez, Roberts & Bitterman, 1966; Hulse, 1958; Padilla, 1967; Roberts, 1969; Wagner, 1961). This results from an interaction between reward magnitude and schedule (see Sperling, 1965 a, b). That is, resistance to extinction and reward magnitude are inversely related with C training and either

positively related (Hulse, 1958; Wagner, 1961) or not related (Brooks & Dufort, 1967; Roberts, 1969) with P training. In other words, the effect of the reward magnitude variable on the PREE might act primarily on the C controls and not on the P subjects.

Percentage of Reward.

Weinstock (1954, 1958) has shown that there is an inverse relationship between percentage of reward and resistance to extinction. Thus as reward percentage increases resistance to extinction decreases.

Number of Trials.

In general it has been found that increasing the number of training trials will increase the PREE (Bacon, 1962; Brooks & Dufort, 1967; Hill & Spear, 1963; Lewis & Cotton, 1959, Wagner, 1961; Wilson, 1964), but the PREE is still found if very few trials of acquisition are given (Amsel, Hug & Surridge, 1968; Bowen & McCain, 1967; Capaldi & Deutsch, 1967; Capaldi, Lanier & Godbout, 1968; Capaldi & Walters, 1970; McCain & Brown, 1967; Padilla, 1967).

Reward Magnitude and Number of Acquisition Trials.

It has been found that reward magnitude interacts with number of training trials on the PREE. With limited training reward magnitude is positively related to resistance to extinction while with extended training the relationship is reversed (Campbell, Crumbaugh, Rhodes & Knouse, 1971; Capaldi & Capaldi, 1970; Capaldi & Freese, 1974; Hulse, 1958; McCain, 1970; Wagner, 1961).

Patterns of Reward and Nonreward.

The effects of the pattern of reward (R) and nonreward (N) trials interacts with the effect of the number of trials. After limited training, a schedule with more N trials followed by R trials (N-R transitions) will yield greater resistance to extinction than a schedule with equal reward percentage and magnitude but with fewer N-R transitions. Extended training yields greater resistance to extinction from a group trained on a schedule with more consecutive N trials (N length) before an R trial than for a group trained on a schedule with fewer consecutive N trials before an R trial (Capaldi, 1966, 1967). Leonard (1969) presents data which show that the magnitude of reward on a trial which preceeds an N trial is inversely related to resistance to extinction. That is, a group trained with the pattern large reward, nonreward, small reward (LNS) is less resistant to extinction than a group trained with the pattern SNS. The effect of patterns of R and N trials forms the basis of Capaldi's (1967) sequential theory of the PREE.

Effect of Initial N Trials.

It has been shown that a block of N trials before R trials will increase resistance to extinction (Robbins, Chait & Weinstock, 1968; Spear & Spitzner, 1967; Spear, Hill & O'Sullivan, 1965) relative to a C only control group. The effect is called the initial nonreward effect (INE) and is usually smaller than the PREE (Robbins, 1968). Furthermore it has been shown that the number of N trials prior to C does not affect resistance to extinction while as the number of N trials prior to P is

increased, resistance to extinction is increased (Mellgren, Seybert & Dyck, 1978).

Theoretical Interpretations of the Phenomena

Because of the similarities of the experimental paradigms used to investigate contrast and differential resistance to extinction, theorists have attempted to provide a unified interpretation that encompasses both phenomena.

Two theories which have been presented to account for both contrast and differential resistance to extinction are Capaldi's (1974, 1975, Note 1) reward level theory and McHose & Moore's (1976) incentive averaging theory.

Reward Level Theory.

Capaldi divides instrumental learning phenomena into three classes of interest:

     1) providing a reward magnitude or percentage greater than expected, such as a shift from small to large reward,

     2) providing reward magnitude or percentage less than expected, and

     3) providing reward which is both less than and greater than expected, such as partial reinforcement or discrimination learning. The fourth possible class, where expected reward magnitude is the same as obtained reward, is said to be uninteresting because it is assumed that no conditioning takes place.

According to the reinforcement level principle, the growth of habit and of conditioned inhibition depend upon the discrepancy between expected reward and obtained reward. Expected reward is

a construct which is hypothesized to represent the cumulative effects of the subject's reinforcement history. Expected reward is positively related to reward magnitude and percentage and becomes increasingly accurate as the number of trials increases. As the number of trials increases, expectancy also becomes increasingly more stable or resistant to change.

Habit represents the acquired tendency of a stimulus to elicit a response. Increments in habit growth will occur as obtained reward exceeds expected reward and the increments will be larger the more obtained reward exceeds expected reward. If expected reward exceeds obtained reward inhibition increments proportionately to the magnitude of the difference. Importantly both habit and inhibition are conditioned to available stimuli, which include reward stimuli such as the memory of reward [S(R)] and the memory of nonreward [S(N)] as well as apparatus and background cues. Running speed is a negatively accelerated increasing function of effective habit strength (EH) which is defined as habit minus inhibition. Let us now consider how conditioning is affected in the three classes of instrumental learning phenomena outlined above.

1) Obtained reward exceeds expected reward.

If obtained reward exceeds expected reward, performance is predicted to be increased in both postshift and in subsequent extinction. If expectancy is small and stable, then an increase in reward magnitude will result in an increase in habit strength relative to a control group trained under large reward only. Because running speed is an increasing function of habit

strength, this increase in habit strength is predicted to yield a PCE.

The PCE is predicted because the stable expectancy of small reward provides a large number of trials in which expected reward is exceeded by obtained reward, which yields large increments in habit growth and therefore faster responding. This theory also accounts for the fact that the PCE is more reliably obtained under delayed reward than under immediate reward. It is postulated that the asymptote of habit growth is determined by the magnitude of reward and that inhibition will grow during the delay interval in amounts determined by two factors, the magnitude of expected reward and secondly by the duration of the delay interval. Therefore, delayed reward will result in less EH than immediate reward because while habit will be the same in delayed and immediate reward, inhibition is assumed to be greater under delayed reward. Since running speed is assumed to be a negatively accelerated increasing function of EH, increments in EH will produce larger changes in running at lower levels of EH. According to reward level theory then the PCE is more likely to occur under delayed reward due to ceiling effects.

It also follows from the theory that animals shifted from smaller to larger rewards should show greater resistance to extinction than nonshifted subjects, if the appropriate number of trials are run in pre and postshift acquisition. Because the upshift yields habit strength in excess of a nonshifted control group the shifted group will be more resistant to extinction. If too many trials are run in postshift, the shifted group will no

longer have the excess habit and will not show increased resistance to extinction. There are two other reasons why the theory predicts that an upshifted group should be more resistant to extinction than the unshifted control. If the upshifted group has a smaller expectancy of reward at the start of extinction then it should accumulate less inhibition than an unshifted control group over the extinction trials, resulting in greater resistance to extinction. Also, if trials in extinction are massed and expected reward is lower in the shifted group, nonreward is assumed to be less frustrative for the shifted group, again leading to greater resistance to extinction. This treatment of the effects of upshifted reward is also consistent with the INE (Spear et al., 1965; Spear & Spitzner, 1967).

2) Expected reward exceeds obtained reward.

Let us now consider the second class of instrumental learning phenomena, the case where expected reward exceeds obtained reward. If expected reward exceeds obtained reward, inhibition will grow in amounts determined by the discrepency between expected and obtained reward. Also, a frustrative trace (memory) will contribute to the decrement in performance if the intertrial interval (ITI) is short.

If a downshifted group is compared to a group maintained on the lower magnitude schedule, the theory predicts both a NCE and reduced resistance to extinction if there is sufficient difference between expected and obtained reward. DiLollo & Beez (1966) and Peters & McHose (1974) have shown that, all other things equal, the more preshift reward exceeds postshift reward,

the greater the NCE. Also, ITI is a factor in the NCE, with massed trials producing a larger NCE than spaced trials (Capaldi, 1972).

Capaldi & Ziff (1966) introduce another variable by involving sequential variables in the NCE. Two groups were rewarded on the schedules LLN or LNL where L signifies a reward of 20 pellets. The groups were switched in Phase 2 to a continuous 2 pellet reward schedule. The group LNL showed less NCE than group LLN. This result is explained by the sequential model by assuming that the response was conditioned to the memory of nonreward (S[N]) in group LNL but not in group LLN. Because the small reward is similar to nonreward, the postshift cues elicit the response more strongly in group LNL than in LLN, leading to the decreased NCE.

Most of the data reported by Capaldi to support the theory on downshift effects on resistance to extinction come from down- shifts in reward percentage ie. C to P rather than shifts in reward magnitude. According to the reward level theory, expec- tancy of reward is higher under continuous reward than under partial reward, if reward magnitude is equal. A CP group would then start postshift with a higher expectancy than a P control. equal. Then, over many postshift partially rewarded trials, the CP group will accumulate more inhibition on N trials and less habit strength on R trials than the P controls. Therefore, effective habit strength will be less for the CP group than for either a P or a PP control. CP training will thus reduce resistance to extinction, if reward magnitude in C is equal to or larger than reward magnitude in P. A number of researchers have

reported that CP training leads to less resistance to extinction than P training alone (Capaldi, 1974; Hothersall, 1966; Sutherland, Mackintosh & Wolfe, 1965; Traupmann, Amsel & Wong, 1973). Capaldi (1974) also supports the exception, predicted by reward level theory, that if C reward magnitude is less than P reward magnitude, resistance to extinction is increased.

The preceeding argument implies that a PC group, with no shift in reward magnitude, should be conceptually an upshift group and according to the rationale developed above should exhibit increased resistance to extinction relative to a CP condition. In a recent study by Dyck, Dresel & Suthons (1978) this prediction was not consistently supported. In that study, three levels of reward magnitude shift (Up, Non, and Downshift) were crossed with four schedule orders (CC, CP, PC, PP). The results were that the schedule order CP (ie. C in Phase 1 and P in Phase 2 of acquisition) led to greater resistance to extinction than the order PC, under conditions where reward magnitude was shifted either up or down. While the upshift finding was consistent with reward level theory, the downshift finding was not. Specifically, the downshifted CP group should have been the least resistant to extinction of the downshifted groups. Instead, the CP group was very resistant to extinction.

On the basis of these results Dyck et al. proposed that, after a downshift, the instrumental response is first unconditioned (that is, loses strength) and then is reconditioned to situational cues. This reconditioning of the instrumental response would account for both the dissipation of the NCE and

the increased resistance to extinction observed. It was suggested that, following a downshift, expected reward drops to a level below that of obtained reward and after that, conditioning will again occur. Further, it is suggested that the cues to which the instrumental response is reconditioned are schedule generated cues such as S[R] and S[N] as specified by Capaldi (1967).

If the post shift reward schedule is c, then the only reward stimulus available will be S[R], the memory of reward. If, following the initial reward reduction trials, the instrumental response is reconditioned only to S[R], decreased resistance to extinction is predicted. However, if the instrumental response is reconditioned to S[N], which would occur under a P schedule, as specified by Capaldi's (1967) sequential theory, increased resistance to extinction is predicted. This modification argues for a recency effect if reward level is downshifted. Clearly then, if the proposed modification is tenable then groups which received a postshift schedule where obtained reward is less than expected reward in the initial trials should be relatively more resistant to extinction than groups which receive the lower reward magnitude schedule in both phases of the experiment. This prediction is consistent with the findings of Dyal & Sytsma (1976) and Theios & McGinnis (1967) in which a CP group was more resistant to extinction than a PC group.

3) Obtained reward exceeds and is exceeded by expected reward.

Partial reinforcement represents the most extensively analyzed case in which obtained reward is always either less than or

greater than expected reward. According to the theory, as P training continues, inhibitory growth on N trials increases, since expected reward increases with extended training. This inhibition growth would also be larger as reward magnitude increased, for the same reason. This inhibitory mechanism then explains why, on a single alternation schedule, discriminative running occurs (Capaldi, 1958; Capaldi & Lynch, 1966; Tyler, Wortz & Bitterman, 1953).

The reinforcement level theory also predicts the interaction between reward magnitude and the number of acquisition trials on the PREE, as found by Campbell et al, 1971, Capaldi & Capaldi, 1970, Capaldi & Freese, 1974, Hulse, 1958, McCain, 1970 and Wagner, 1961.

Capaldi explains the effect of large and small reward on the first trial in Leonard (1969) using the inhibition construct. Leonard reported that a group trained on a schedule LNS (ie. Large reward, Nonreward and then Small reward) was less resistant to extinction than a group trained on a schedule SNS. If expectancy of reward is higher on N trials for the groups with L before N then inhibition will also be greater for those groups, after extended training and therefore the LN groups should be less resistant to extinction than the SN groups. The results that groups SNL and LNL were more resistant to extinction than groups SNS and LNS are explained in sequential terms (Capaldi, 1967).

Incentive Averaging Theory.

McHose & Moore (1976) also present a theory to explain contrast effects and extinction effects. Incentive averaging theory is similar to reward level theory in that reward parameters of delay, magnitude and percentage combine to control instrumental responding. However, where reward level theory deals with reward variables as separate and different from other situational variables, incentive averaging theory uses the same mechanism for conditioning the instrumental response to reward cues and other situational cues. This theory treats changes in reward parameters in the same fashion that changes in other stimuli are treated. The theory states that simple instrumental conditioning can be viewed as the acquisition of an instrumental response to a stimulus compound, one element of which is $s[g]$, an expectancy stimulus as in Spence's (1956) $r[g]-s[g]$. In the theory, $s[g]$ stimuli are assumed to regulate instrumental responding in the same way as do any other stimuli.

Specifically, instrumental appetitive conditioning always involves the conditioning of a response to a stimulus compound, called AK, where A is itself a compound stimulus and K is an expectancy stimulus comparable to $s[g]$. K is classically conditioned by the pairing of apparatus cues and reinforcement. A consists of all other stimuli, lumped together. The intensity of K is determined by the amount and immediacy of the reward and, as the intensity of K increases K becomes more salient relative to A. Therefore, subjects receiving large reward will accrue more habit to K and less to A relative to subjects that receive small

reward. It is also assumed that K stimuli are generally more salient than are A stimuli.

Using these rules, the theory explains contrast effects as follows. Subjects in a large magnitude reward condition acquire habit to A (H[A]) and to K{L} (H[K{L}]) appropriate to large reward; small reward subjects acquire H[A] and H[K{S}]. H[A] for small reward subjects is higher than for large reward subjects because the intensity of K is higher for the large reward subjects. This is because the intensity of K controls the salience of K and, as salience of K increases, the salience of A decreases and vice versa. The salience of a stimulus controls the maximum to habit accrual to that stimulus.

In a positive contrast paradigm a group SL is compared to a group LL where S indicates small reward and L indicates large reward. At the end of preshift training, subjects in group SL have larger H[A] than do subjects in group LL. Eventually, after enough postshift training the two groups will be equal in H[A] and H[K] and performance will be equal. However, before that time H[A] and H[K] will change at different rates for group SL, because K stimuli are more salient than the A stimuli. In other words, H[K] will rise to its appropriate level more quickly than H[A] will drop to its appropriate level. Therefore H[AK], habit accrued to the AK compound, for group SL will be larger than H[AK] for group LL and a PCE will be observed. This explanation predicts that the lower the reward in Phase 1 the greater the PCE, because the lower the reward, the higher is H[A]. This is consistent with empirical findings (Mellgren et al., 1973).

Delay of reward is assumed to affect the intensity of K and that explains the increased PCE with delayed reward. It is also predicted by this theory that a PCE following reductions in delay of reward will be found, for small reward magnitudes. However, this has not yet been conclusively tested (see Shanab, Rouse & Cavallaro, 1973). The theory also predicts that the amount of the PCE will first decrease and then increase as a function of the number of preshift trials. This is consistent with Mellgren (1971).

There are two components to the NCE in this theory. The first is the difference in $H[A]$ leading to depressed responding in postshift (ie. to small reward) for group IS. The reasoning is the same for negative as for positive contrast effects. The second factor is that $H[K\{S\}]$ for subjects in the unshifted conditions is larger than $H[K\{S\}]$ (habit to incentive from small reward cues) for subjects in the shifted group, a 'generalized decrement' source of the NCE.

The size of the NCE should increase as differences in K between pre and postshift increases. This has been confirmed by DiLollo & Beez (1966) and Peters & McHose (1974). McHose & Peters (1975) present a convincing argument, both by direct experimentation and by a post hoc review of the literature, that it is indeed the K differences between schedules that is responsible for the NCE.

McHose & Moore (1976) state "the present theory is directly applicable to performance in experimental extinction, since extinction is merely a special case of the more general negative

contrast paradigm" (p. 305) but go on to say that if rewards and nonrewards are presented in a pattern then the theory is inapplicable until specification of sequential effects becomes possible. Capaldi explains the Leonard (1969) data using memory principles, and it seems that McHose & Moore are sensitive to the need for similar principles in their theory.

The primary hypothesis of the incentive averaging theory is that instrumental behavior is conditioned to stimulus compounds with the most important element of the compound being expectancies or reward-schedule-produced stimuli of the $r(g)-s(g)$ variety as detailed by Spence (1956). The symbol K is used to specify the incentive or expectancy stimulus comparable to $s(g)$ in Spence's (1956) $r(g)-s(g)$ framework. The symbol A stands for all other stimuli. It is assumed that incentive, K, is a function of reward amount (a) received on each trial:

$$K = M(1 - 10^{-.10a})\qquad(1)$$

where M=100.0 and the .10 was assigned empirically from earlier work (McHose & Peters, 1975; Peters & McHose, 1974). When a is varied from trial to trial, as it is in partial reward schedules, the average incentive($^-K^-$) is calculated

$$^-K^- = p(1)K(1) + p(2)K(2) + \ldots p(n)K(n)\qquad(2)$$

As the $^-K^-$ value of the schedule increases, the habit that accrues to the K stimuli increase relative to that which accrues to the A stimuli. Obviously, it possible to construct schedules where reward parameters such as percentage and magnitude differ but where the $^-K^-$ values are equal. For example let us set a = 1

pellet and set the schedule to continuous reward (C). The K value resulting from a 1 pellet reward is 20.56 and if the probability of that reward is 1.0 as it is in a C schedule then -K- = 1.0 X 20.56 =20.56. Now let us set a = 20 pellets and make the schedule a 20% P schedule. The K resulting from a 20 pellet reward equals 99.00 and the K from a 0 pellet reward equals 0.00. Therefore, -K- for the 20 pellet 20% schedule = .20 X 99.00 + .80 X 0.00 = 19.80. The difference between the -K- values of the two schedules is equal to .76. If such equal incentive schedules are constructed the incentive averaging theory makes a number of predictions.

With the -K- values equal, the amount of habit accruing to the K and A elements of each schedule will be equal at all times. Therefore:

     1) The course of acquisition should be identical for all groups,

     2) shifts from one schedule to another of equal -K- value should produce no contrast effects when compared to the nonshifted control group and

     3) extinction performance should be the same for all groups.

The third prediction of no differences in extinction performance is of primary interest. As outlined earlier, Dyck et al. have suggested that a recency effect will be observed if reward magnitude is shifted. Any two different reward schedules which have the same -K- values will necessarily involve differences in both reward magnitude and percentage. Therefore, Dyck et al.'s

proposal could yield different predictions than McHose & Moore's theory. This experiment set up such a situation, using three schedules of reward, a 1 pellet CRF schedule ($^-K^- = 20.56$), a 3 pellet PRF schedule with the probability of reward equal to 0.40 ($^-K^- = 19.95$) and a 20 pellet PRF schedule with the probability of reward equal to 0.20 ($^-K^- = 19.80$). McHose & Peters (1975) present evidence which suggests that a $^-K^-$ difference between schedules of 35 is the minimum needed to produce the NCE. The $^-K^-$ differences of these three schedules, with a maximum of .76, should be entirely negligible.

Let us consider first the CP and PC conditions. Using the three schedules described above, a 1 pellet C schedule (C1), a 3 pellet 40% P schedule (P3) and a 20 pellet 20% P schedule (P20), two CP conditions and two PC conditions can be formed. These are C1P3, C1P20, P3C1, and P20C1. McHose & Moore clearly predict that the CP groups will not differ from the PC groups in resistance to extinction. However, Dyck et al. predict that, for the CP groups, the instrumental response will be conditioned to S[N] in postshift, yielding increased resistance to extinction relative to the PC groups which would be predicted to condition the instrumental response only to S[R] in postshift. Therefore, the two sets of predictions are clearly different. The four groups described above (C1P3, C1P20, P3C1, P20C1) were run to assess the relative accuracy of these two sets of predictions.

Three unshifted groups (C1C1, P3P3, P20P20) were run, for two reasons. One reason was that incentive averaging theory predicts no PREE when these conditions are compared, a surprising predic-

tion considering the robustness of the PREE. Second, the inclusion of the three unshifted groups makes it possible to test the prediction of no contrast effects. The three unshifted groups represent the contrast control groups for all of the shifted groups, with group C1C1 as the control group for the two PC groups, group P3P3 as the control group for group C1P3 and group P20P20 as the control group for group C1P20. Dyck et al.'s hypothesis does not speak to the contrast effect issue, so no counter predictions are stipulated. It should be pointed out here that the terms NCE and PCE become somewhat confusing in this context since the reward schedules represent shifts in both reward magnitude and percentage. That is, if reward magnitude is increased the percentage is decreased and vice versa. Therefore, differences, if any, between shifted groups and the contrast control group will be discussed only in terms of "contrast" and the direction of difference will be specified.

DESIGN AND A PRIORI PREDICTIONS. Three phases were run, two acquisition and one extinction phase. Seven groups were run, 1) C1C1, 2) P3P3, 3)P20P20, 4)C1P3, 5)C1P20, 6) P3C1, and 7)P20C1 (see Table 1).

Insert Table 1 about here

McHose & Moore predict that there will be no performance differences between any groups in any phase. However, in the light of recent empirical and theoretical work (Capaldi, 1974; Dyal & Sytsma, 1976; Dyck et al, 1978) it is predicted that the

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CP groups (groups C1P3 and C1P20) will be more resistant to extinction than the PC groups (groups P3C1 and P20C1). It is further predicted that the CP groups will not differ from the PP groups. Surprisingly, McHose & Moore predict the absence of a partial reinforcement extinction effect under the present conditions. In extinction then, it is predicted that the groups will order themselves as follows: $C1C1 \leq P3C1; P20C1 < C1P3 = P3P3; C1P20 = P20P20$, where the semi-colon indicates no prediction of the presence or absence of group differences. In Phase 2 however, no predictions different from McHose & Moore's predictions of no contrast effects can be specified.

Method

Subjects.

Subjects were 65 male Sprague-Dawley rats from the Holtzman Co. All subjects were approximately 90 days old at the start of the experiment. Three replications were run. Seven groups were formed by assigning 9 subjects randomly to each group, except group C1C1 which had 11 subjects.

Apparatus.

A single Hunter Co. runway was used for the experiment. The runway is constructed with Plexiglas walls, 12.7 cm high, and ceiling, 9.2 cm wide. The floor is made of aluminum bars with centres 1.3 cm apart. Two electronically operated black metal guillotine doors separate the runway into a startbox, 31 cm long, a runway, 135 cm long, and a goalbox, 31 cm long. An opaque

glass food cup was at the end of the goalbox. The rats progress through the runway was measured by a 0.001 sec timer set up to time two consecutive intervals. The first time period (Run) started when the startbox door was opened and ended when a photocell beam, 124.4 cm from the startbox was broken. The second time period (Goal) started when the Run period ended and ended when a second photocell beam, 33 cm from the first and 18.4 cm inside the goalbox, was broken. Run and Goal speeds were obtained by reciprocating the Run and Goal times and Total speed was obtained by reciprocating the sum of the two measures. A Coulbourn Instruments white noise generator and mixer/amplifier were used to introduce white noise into the experimental chamber through a speaker which was located 30 cm from the ceiling and 2.5 m from the runway.

Procedure.

All subjects received ad lib food and water for at least seven days before being put on a 13 g per day food deprivation regimen, which was then continued throughout the experiment. Water was available ad lib in the home cage throughout the experiment. There were 3 phases of the experiment, Phase 1 and Phase 2 being acquisition phases and Phase 3 being the extinction phase.

During acquisition there were three schedules of reward: C1, continuous reward with 1 0.045 g pellet, P3, partial reward with 3 pellets delivered on a random 40% of the trials and P20, partial reward with a 20 pellet reward, delivered on a random 20% of the trials. The P schedules are presented in Table 2.

Three groups received C1 in Phase 1, and two groups received each of the two partial schedules. In Phase 2, one group from each schedule received a second phase of that schedule, giving groups C1C1, P3P3, and P20P20. The two remaining partially rewarded groups were shifted to the C1 schedule, giving groups P3C1 and P20C1. The two remaining C1 groups were shifted to the partial schedules, one group to each schedule, giving groups C1P3 and C1P20 (see Table 1).

Subjects were run in squads of 3 or 4 subjects, with all subjects in one squad receiving trial N before any subject received trial N+1. The intertrial interval was approximately 3 minutes. All subjects received 5 trials per day throughout the experiment. Phases 1 and 2 were 12 days (60 trials) long each and Phase 3, extinction, was 10 days (50 trials). A white masking noise was present throughout the experiment at a level of 63 db measured at the runway.

Results

The data were analyzed as a Groups X Days X Trials repeated measures ANOVA, with Days and Trials as within factors and Groups as the between factor. There were 7 levels of the groups factor, and 5 levels of trials. There were 12 days in each acquisition phase and 10 days in the extinction phase. All post hoc tests were done using Tukey's procedure at an alpha level of .05. Tables 3 to 11 contain the ANOVA tables from the data analyses.

Appendix 1 contains group means and standard deviations for each runway measure on each day.

Insert Tables 3-11 about here

Acquisition.

In the Phase 1 total measure there was a significant Days effect (F=322.97, df= 11, 68, p<.001), indicating acquisition of the running response. The Days X Groups interaction (graphed as Fig. 1) was significant (F= 1.32, df= 66, 638, p <.05), indicating differential rates of acquisition among the groups, but there was no significant Groups effect. In the Day X Group interaction the only significant within day pairwise comparison was that group P3C1 was faster than group P20P20 on Day 6.

Fig. 2 shows the results obtained in Phase 1 when all subjects that received one schedule are considered together, without regard to the second phase reward schedule planned for them. Here it can be seen that P3 yields faster acquisiton than the other two schedules. Trend analysis supports this observation with the two P3 groups accounting for most of the quadratic variability (F =4.82, df =1. ,68, p < .05), indicating that the P3 group's response speed levelled off more than the speeds of the C1 or P20 groups.

The same results were found in the total measure of Phase 2 acquisition, ie. significant Days and Groups X Days effects (F's=8.45, 2.08; df's= 11, 638; 66, 638; p's <.001) and no significant Groups effect. Post hoc analysis of the Day X Group

effect showed that no shifted groups differed from their respec-
tive contrast control group on any day, as predicted by McHose &
Moore, but group C1P20 was slower than group C1P3 on days 21 and
22, contrary to incentive averaging theory's predictions. Trend
analysis of the Phase 2 results sheds some light on the above
finding. The significant Days X Groups linear trend ($F = 8.29$,
$df = 6,58$, $p < .001$) breaks down to indicate that groups C1P3 and
C1C1 ($F's = 45.00$, 55.00, $df = 1,68$, $p < .01$) account for most of
the linear variability. Therefore, groups C1P3 and C1C1 con-
tinued to increase running speed in Phase 2 while group C1P20
levelled off, so that by late Phase 2 C1P3 and C1C1 were running
faster than C1P20. The Phase 2 results are presented in Figs. 3
- 5.

Insert Fig. 1-6 about here

Extinction.

In the extinction phase of the experiment (see Fig. 6) all
main effects and interactions were significant in the Total and
Run measures and all but the Days X Trials X Groups effect were
significant in the Goal measure. Because of this similarity of
results the total measure only will be discussed unless otherwise
specified. The Days effect ($F = 105.88$, $df = 9,522$, $p < .001$)
indicates the extinction of the running response over days and
the Trials effect ($F = 37.25$, $df = 4,232$, $p < .001$) indicates
slower running on successive trials, with trials 1 and 2 being
significantly faster than the other three trials, and trial 3

being faster than trial 5. The Groups and Groups X Days effects were probed using Tukey's post hoc procedure.

Examination of the Group main effect (F = 10.46, df = 6,56, p < .001) revealed that group C1C1 ran slower than all other groups except P3C1. Group P3C1 was slower than groups P3P3 and C1P3 and group C1P20 was slower than group C1P3. In the Goal measure, groups P20P20 and C1P20 were not different from group C1C1.

The breakdown of the Group X Day interaction (F = 3.89, df = 54,522, p < .001) is more complicated. Importantly, on Day 1 of extinction there were no significant differences in the total measure and therefore it is possible to assign any differences among the groups following this day to differential rates of extinction rather than to terminal acquisition differences. Following this finding there are then a number of theoretically important ways to compare the groups on the remaining days of the extinction phase.

1) PREE.

All groups which received partial reinforcement showed a PREE on a number of days except P3C1 which did not differ from C1C1 on any day. On Days 2-10 C1P3 and P3P3 differed from C1C1. On Days 4-7 all groups except P3C1 showed a PREE. Group P20P20 differed from C1C1 on Days 4-10. Group C1P20 differed from C1C1 on days 4-7 and Day 10 only while group P20C1 was only different from C1C1 on days 4-7.

2) Resistance to extinction following a contrast manipulation.

The only shifted group that ever differed from its contrast control group was group P20C1 which ran faster than C1C1 on Days 4-7.

3) Order effects.

Group C1P3 was more resistant to extinction than P3C1 on Days 2-10. However, group C1P20 was not different from P20C1.

4) Further analyses.

Trend analysis showed significant Days X Groups linear and quadratic effects (F's = 3.08; 16.77, df's = 6,58, p's < .02; .001). When these were broken down further it was found that the groups which received C1 in Phase 2 accounted for most of the linear variability and were ranked C1C1 > P3C1 > P20C1 (F's = 105.52, 75.22, 66.16, df = 1,68, p < .01). Second, the groups C1C1 and P3C1 accounted for almost all of the quadratic variability (F's = 86.29, 47.75, df = 1,68, p < .01). Therefore, we can conclude that the CC and PC groups were less resistant to extinction than the CP and PP groups. Also of interest is the comparison between C1P20 and P20C1. Group P20C1 accounted for more than twice as much of the linear variability as did group C1P20 (F's = 66.16, 26.78 df = 1,68, p < .01), indicating that P20C1 was less resistant to extinction than C1P20. A further ANOVA was run, using only groups C1P20 and P20C1. The Days X Groups effect was marginal (F = 1.73, df = 9,144, p < .09) suggesting that C1P20 might be more resistant to extinction than P20C1. This is, of course, tentative and not statistically

reliable.

Post hoc analysis of the Group X Days effect in the Goal measure showed an interesting interaction between the groups which received P20 in Phase 2 (C1P20 and P20P20) and group C1C1. On Day 1 of extinction C1C1 was running faster in the final alley segment than were groups P20P20 or C1P20. On Days 6 and 7 C1C1 was slower than C1P20. C1C1 was slower than P20P20 on Days 5-8. Therefore, in the Goal section the C1C1 group went from significantly faster running to significantly slower running in just a few days, which is a large difference in resistance to extinction, and so contrary to incentive averaging theory predictions.

Discussion

The first point that must be discussed is the meaning of rejection or non-rejection of the hypothesis of no differences among groups, the statistical null hypothesis. The difficulty in interpretation of the statistical analyses lies in the fact that, as sample size increases, the likelihood of rejection of the null hypothesis increases. This raises problems for theory evaluation because one is forced to consider the difference between statistical and scientific significance.

In relation to this experiment, if only a few subjects had been used in each condition it is conceivable that no differences would have been statistically significant, while if hundreds of subjects had been used in each condition then more contrasts might have been statistically significant. In other words, the less powerful the experiment was, the more likely it would have been to support the incentive averaging theory, while a very

powerful experiment could have capitalized on very small discrepencies and favoured rejection of the theory.

Therefore, the criteria for scientific rejection must include factors other than statistically significant differences. The magnitude of the differences, and the prediction or explanation of those differences by other theories must also be considered. Therefore, small differences among groups will not necessarily mean rejection of the theory but large differences, or differences predictable from other theories, will be considered as evidence contrary to the theory.

Within this framework then, the acquisition results of this experiment generally were consistent with predictions of incentive averaging theory. Specifically, the finding of no differences among the contrast comparison groups is exactly as predicted, even though large shifts in reward magnitude and percentage were involved. However, the findings of acquisition differences as evidenced by the significant Days X Groups effects in both Phases 1 and 2 were contrary to prediction and must be further examined. Examination of Fig. 1 reveals that the two groups that received P3 (P3C1 and P3P3) were responding more quickly at the end of Phase 1 than were the other groups.

In Phase 2 post hoc analysis revealed that group C1P3 was faster than group C1P20 on days 21 and 22. In the light of the above discussion about the criteria for rejection of the theory (ie. large differences or small differences explainable by another theory) let us consider Capladi's (1975,Note 1) reward level theory.

It can be shown that the present acquisition results are consistent with reward level theory if the schedule P3 supports a higher expected reward level than the schedule C1 which in turn supports a higher expected reward level than P20. However, computations based on the equations in Capaldi (1975, Note 1) did not yield this ordering of the schedules for expected reward level.

The fact that no contrast effects were observed yields a great deal of support to incentive averaging theory. This experiment was powerful enough to result in small differences being statistically significant, yet no shifted group ever differed from its contrast control group in Phase 2. Even if reward level theory would also predict these results, which it explicitly does not, incentive averaging theory is more parsimonious and therefore would be preferred. McHose & Peters (1975) give further evidence of the theory's usefulness in predicting contrast effects. It seems likely that minor parameter modifications to either theory would result in a better fit with the present acquisition data. It seems most likely that the few acquisition differences observed do not meet the criteria for scientific importance and thus do not provide serious problems for incentive averaging theory.

The extinction results fail to support incentive averaging theory. The theory predicted no differences among the groups and a number of large differences were found. A strong PREE was found for all groups except P3C1, which never differed from the C1C1 control group.

If the acquisition results are used to generate ad hoc -K-values the schedule P3 would have a higher -K- value than C1 and C1 would have a slightly higher -K- value than P20. In this case the finding that P3C1 was less resistant to extinction than C1P3 can be explained. However, the P3P3 group should have been less resistant to extinction than C1C1 if this was the case, but a strong PREE was found. The question then arises: Are the observed results explicable by another theory?

Reward level theory can explain much of the extinction data if the expected reward levels deduced from the acquisition data are used. The deduced reward levels ordered the schedules such that schedule P3 supported a higher expected reward level than schedule C1 which supported a higher level than schedule P20. In reward level theory running speed is assumed to be a negatively accelerated increasing function of effective habit where effective habit is defined as habit minus inhibition. Habit increments if expected reward is less than obtained reward and inhibition increments if expected reward is greater than obtained reward.

In reward level theory terms then, the group C1P3 would be an upshifted group and P3C1 would be a downshifted group. Therefore, C1P3 would be predicted to be more resistant to extinction than P3C1. This was in fact the observed result. However, this view would label P20C1 as an upshifted group which would be expected to be more resistant to extinction than C1P20. While C1P20 and P20C1 were never reliably different, the direction of differences observed was contrary to that predicted by reward

level theory. That is C1P20 was slightly (nonsignificantly) more resistant to extinction than P20C1.

However, it must be remembered that the shifts in expected reward level, which have been deduced post hoc to be present in this experiment must also necessarily be small in magnitude, because no contrast effects were observed. This could account for the nondifferential performance of C1P20 and P20C1. It would be expected, by reward level theory, that the C1 and P20 schedules would be quite close in expected reward level supported, based on the Phase 1 results (see Fig. 2). If C1 and P20 are quite close then no shift effects would be observed.

Basically, incentive averaging theory founders on the rock of the PREE. The PP groups were both reliably different from the CC control group, contrary to prediction. While some of the acquisition results suggest that the P3 schedule has a higher -K- value than the C1 and P20 schedules, this should have lead to faster extinction for group P3P3, which it did not.

Reward level theory would seem to be vulnerable in the same way. If the C1 and P20 schedules are close in expected reward levels supported, they should have been similar in extinction performance. However, if a more fine-grained analysis is used, these discrepancies can be resolved. Reward level theory can break down the reward stimuli to which habit and inhibition are conditioned further than incentive averaging theory does. Because both S(N) and S(R) stimuli accrue both habit and inhibition, the theory fares better in predicting extinction performance. Subjects which have habit accrued to S(N) will be

predicted to show greater resistance to extinction than subjects without habit accrued to S(N) because S(N) is the only reward stimulus available during extinction. In this way, reward level-sequential theory, by increasing the exactness with which stimuli are specified, is able to account for the PREE obtained in the present experiment. Furthermore, by deducing that P3 is greater than C1 in expected reward level, the finding that P3C1 was less resistant to extinction than C1P3 also follows.

Unfortunately, the relative importance of sequential and reward level variables is yet to be specified. Earlier it was argued that P20C1 would be predicted to be more resistant to extinction than C1P20. This was predicted because P20C1 is an upshifted group in expected reward level and C1P20 is a down-shifted group. It can nonetheless be argued that, because expected reward level is established by the end of Phase 1 and is quite stable after 60 trials, P in Phase 2 would result in greater habit accruing to S(N) than P in Phase 1. This line of reasoning would predict that C1P20 would be more resistant to extinction than P20C1. The theory does not specify whether the molar or the molecular analysis is the more appropriate.

In summary, incentive averaging theory as presented by McHose & Moore (1976) seems to provide a parsimonious explanation of contrast effects and acquisition performance. However, the extension of this theory to extinction performance is unsupported. It is interesting to speculate that the error made by McHose & Moore (1976) lies in the statement that "extinction is merely a special case of the general negative contrast paradigm"

(p. 305). In other words, possibly extinction is not a special case of a downshift in reward, but is rather something altogether different and extinction performance is controlled by stimuli which are, at least to some extent, different from the stimuli which control acquisition responding. Further experimentation is of course needed to determine how the stimuli which control responding in the alleyway during acquisition and extinction can best be specified.

TABLE 1

PHASE 2

PHASE 1	C1	P3	P20
C1	C1C1 $n=11$	C1P3 $n=9$	C1P20 $n=9$
P3	P3C1 $n=9$	P3P3 $n=9$	not run
P20	P20C1 $n=9$	not run	P20P20 $n=9$

TABLE 2

DAY	SCHEDULE	
	20% 20 PELLET	40% 3 PELLET
1	RNRNN	NRNRN
2	NNRNN	NNRNR
3	NRRNN	NRNRN
4	NNRNN	NNNNR
5	NNNNN	RNNRN
6	NNNRN	RRNNN
7	NRNNN	NNNRR
8	NNRNN	RRNNR
9	NNNNN	NRNRN
10	RNNNN	RRNNN
11	NNRNN	NRNRN
12	NNNNR	NNRNR

TABLE 3

SOURCE	SS	DF	MS	F	PROB
GROUPS	5.724	6	0.954	1.05	0.404
ERROR	52.820	58	0.911		
DAYS	144.779	11	13.162	322.97	0.000
DAY X GROUP	3.563	66	0.053	1.32	0.050
ERROR	26.000	638	0.041		
TRIALS	0.715	4	0.179	10.78	0.000
TRIAL X GROUP	0.692	24	0.029	1.85	0.106
ERROR	3.848	232	0.017		
DAYS X TRIAL	2.655	44	0.060	4.16	0.000
DAYS X TRIAL X GROUPS	4.694	264	0.018	1.23	0.01
ERROR	37.018	2552	0.015		

ANOVA TABLE FOR PHASE 1 TOTAL MEASURE

TABLE 4

SOURCE	SS	DF	MS	F	PROB
GROUPS	7.675	6	1.279	1.43	0.220
ERROR	51.978	58	0.896		
DAYS	1.584	11	0.144	8.45	0.000
DAYS X GROUP	2.341	66	0.035	2.08	0.000
ERROR	10.868	638	0.017		
TRIALS	0.910	4	0.227	13.07	0.000
TRIAL X GROUP	0.558	24	0.023	1.34	0.142
ERROR	4.036	232	0.017		
DAY X TRIAL	0.536	44	0.012	1.12	0.275
DAY X TRIAL X GROUP	2.723	264	0.010	0.95	0.712
ERROR	27.778	2552	0.011		

ANOVA TABLE FOR PHASE 2 TOTAL MEASURE

TABLE 5

SOURCE	SS	DF	MS	F	PROB
GROUPS	60.624	6	10.104	10.46	0.000
ERROR	56.052	58	0.966		
DAYS	49.520	9	5.502	105.88	0.000
DAYS X GROUPS	10.913	54	0.202	3.89	0.000
ERROR	27.125	522	0.051		
TRIALS	6.543	4	1.636	37.25	0.000
TRIALS X GROUPS	5.506	24	0.229	5.22	0.000
ERROR	10.187	232	0.044		
DAYS X TRIALS	2.376	36	0.066	2.17	0.000
DAYS X TRIALS X GROUPS	8.120	216	0.038	1.24	0.014
ERROR	63.481	2088	0.030		

ANOVA TABLE FOR EXTINCTION TOTAL MEASURE

TABLE 6

SOURCE	SS	DF	MS	F	PROB
GROUPS	16.430	6	2.738	1.58	0.170
ERROR	100.698	58	1.736		
DAYS	267.667	11	24.333	289.56	0.000
DAYS X GROUPS	7.610	66	0.115	1.37	0.032
ERROR	53.615	638	0.084		
TRIALS	0.554	4	0.139	4.29	0.002
TRIALS X GROUPS	1.496	24	0.062	1.93	0.007
ERROR	7.503	232	0.032		
DAYS X TRIALS	4.931	44	0.112	3.63	0.000
DAYS X TRIALS X GROUPS	9.203	264	0.035	1.13	0.084
ERROR	78.766	2552	0.031		

ANOVA TABLE FOR PHASE 1 RUN MEASURE

TABLE 7

SOURCE	SS	DF	MS	F	PROB
GROUPS	15.110	6	2.518	1.29	0.277
ERROR	113.335	58	1.954		
DAYS	6.178	11	0.562	16.36	0.000
DAYS X GROUPS	5.016	66	0.076	2.21	0.000
ERROR	21.901	638	0.034		
TRIALS	0.826	4	0.206	7.37	0.000
TRIALS X GROUPS	1.066	24	0.044	1.59	0.045
ERROR	6.500	232	0.028		
DAYS X TRIALS	1.172	44	0.027	1.38	0.050
DAYS X TRIALS X GROUPS	4.769	264	0.018	0.94	0.758
ERROR	49.297	2552	0.019		

ANOVA TABLE FOR PHASE 2 RUN MEASURE

TABLE 8

SOURCE	SS	DF	MS	F	PROB
GROUPS	111.406	6	18.568	9.55	0.000
ERROR	112.750	58	1.944		
DAYS	88.399	9	9.822	96.42	0.000
DAYS X GROUPS	16.711	54	0.309	3.04	0.000
ERROR	53.177	522	0.102		
TRIALS	12.950	4	3.238	35.31	0.000
TRIALS X GROUPS	8.732	24	0.364	3.97	0.000
ERROR	21.271	232	0.092		
DAYS X TRIALS	4.522	36	0.126	2.02	0.000
DAYS X TRIALS X GROUPS	15.837	216	0.073	1.18	0.045
ERROR	129.821	2088	0.062		

ANOVA TABLE FOR EXTINCTION RUN MEASURE

TABLE 9

SOURCE	SS	DF	MS	F	PROB
GROUPS	179.789	6	29.965	2.45	0.036
ERROR	710.819	58	12.256		
DAYS	1904.080	11	173.098	331.09	0.000
DAYS X GROUPS	71.977	66	1.091	2.09	0.000
ERROR	333.555	638	0.523		
TRIALS	48.899	4	12.225	51.18	0.000
TRIALS X GROUPS	4.265	24	0.178	0.74	0.803
ERROR	55.410	232	0.239		
DAYS X TRIALS	42.228	44	0.960	5.66	0.000
DAYS X TRIALS X GROUPS	54.529	264	0.207	1.22	0.013
ERROR	432.777	2552	0.170		

ANOVA TABLE FOR PHASE 1 GOAL MEASURE

TABLE 10

SOURCE	SS	DF	MS	F	PROB
GROUPS	459.836	6	76.639	7.11	0.000
ERROR	625.487	58	10.784		
DAYS	6.366	11	0.579	1.70	0.070
DAYS X GROUPS	49.241	66	0.746	2.19	0.000
ERROR	217.752	638	0.341		
TRIALS	35.775	4	8.944	21.59	0.000
TRIALS X GROUPS	10.839	24	0.452	1.09	0.356
ERROR	96.088	232	0.414		
DAYS X TRIALS	6.182	44	0.141	0.75	0.890
DAYS X TRIALS X GROUPS	53.188	264	0.201	1.07	0.218
ERROR	480.221	2552	0.188		

ANOVA TABLE FOR PHASE 2 GOAL MEASURE

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TABLE 11

SOURCE	SS	DF	MS	F	PROB
GROUPS	516.539	6	86.090	8.04	0.000
ERROR	621.284	58	10.712		
DAYS	376.149	9	41.794	68.51	0.000
DAYS X GROUPS	197.692	54	3.661	6.00	0.000
ERROR	318.426	522	0.610		
TRIALS	34.063	4	8.516	16.58	0.000
TRIALS X GROUPS	50.887	24	2.120	4.13	0.000
ERROR	119.186	232	0.514		
DAYS X TRIALS	20.215	36	0.562	1.46	0.039
DAYS X TRIALS X GROUPS	91.747	216	0.425	1.10	0.154
ERROR	803.202	2088	0.385		

ANOVA TABLE FOR EXTINCTION GOAL MEASURE

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MEANS AND S.D. FOR START SECTION BY GROUPS AND DAYS
ACQUISITION RESULTS

DAY		C1C1	P20P20	P3P3	C1P20	C1P3	P20C1	P3C1
1	MEAN	0.16	0.16	0.18	0.21	0.20	0.17	0.16
	S.D.	0.04	0.04	0.05	0.07	0.06	0.04	0.03
2	MEAN	0.20	0.29	0.25	0.23	0.28	0.31	0.23
	S.D.	0.06	0.12	0.08	0.09	0.12	0.14	0.07
3	MEAN	0.30	0.44	0.47	0.38	0.52	0.52	0.49
	S.D.	0.15	0.26	0.28	0.22	0.39	0.34	0.29
4	MEAN	0.45	0.55	0.58	0.52	0.55	0.62	0.57
	S.D.	0.28	0.39	0.43	0.37	0.45	0.46	0.44
5	MEAN	0.50	0.60	0.65	0.57	0.51	0.68	0.68
	S.D.	0.33	0.45	0.55	0.43	0.36	0.57	0.54
6	MEAN	0.59	0.63	0.78	0.63	0.71	0.73	0.85
	S.D.	0.42	0.49	0.70	0.49	0.61	0.64	0.77
7	MEAN	0.65	0.83	0.77	0.72	0.72	0.84	0.85
	S.D.	0.51	0.77	0.72	0.63	0.64	0.83	0.82
8	MEAN	0.70	0.90	0.99	0.74	0.83	0.89	0.98
	S.D.	0.60	0.87	1.08	0.67	0.81	0.88	1.02
9	MEAN	0.73	0.89	1.08	0.82	0.85	0.95	1.02
	S.D.	0.59	0.87	1.19	0.74	0.87	0.95	1.08
10	MEAN	0.84	0.93	1.06	0.81	0.85	1.01	1.08
	S.D.	0.77	0.94	1.20	0.74	0.83	1.10	1.22
11	MEAN	0.82	0.98	1.03	0.84	0.90	0.98	1.06
	S.D.	0.76	1.00	1.14	0.77	0.89	1.03	1.17
12	MEAN	0.90	0.98	1.05	0.88	0.93	1.05	1.05
	S.D.	0.86	1.00	1.17	0.83	0.96	1.18	1.18
13	MEAN	0.88	1.04	1.15	0.95	1.00	1.12	1.06
	S.D.	0.86	1.11	1.37	0.95	1.06	1.34	1.18
14	MEAN	0.95	1.02	1.10	0.99	1.03	1.13	1.07
	S.D.	1.00	1.08	1.27	1.01	1.12	1.33	1.19
15	MEAN	0.92	1.06	1.13	1.06	1.12	1.13	1.10
	S.D.	0.96	1.18	1.33	1.18	1.31	1.35	1.27
16	MEAN	0.97	1.07	1.15	1.03	1.13	1.12	1.07
	S.D.	1.05	1.18	1.39	1.11	1.34	1.36	1.18
17	MEAN	1.02	1.08	1.17	1.03	1.15	1.11	1.09
	S.D.	1.09	1.21	1.43	1.09	1.41	1.29	1.24
18	MEAN	0.99	1.10	1.15	1.06	1.24	1.16	1.10
	S.D.	1.09	1.25	1.41	1.16	1.59	1.42	1.25
19	MEAN	1.04	1.07	1.17	1.07	1.18	1.05	1.04
	S.D.	1.20	1.19	1.43	1.19	1.50	1.27	1.17
20	MEAN	1.06	1.10	1.24	1.06	1.23	1.15	1.13
	S.D.	1.21	1.25	1.61	1.17	1.59	1.43	1.31
21	MEAN	1.10	1.09	1.23	1.02	1.27	1.16	1.13
	S.D.	1.27	1.24	1.57	1.09	1.70	1.44	1.33
22	MEAN	1.08	1.08	1.22	1.06	1.29	1.18	1.11
	S.D.	1.25	1.22	1.57	1.17	1.71	1.48	1.29
23	MEAN	1.08	1.12	1.20	1.03	1.27	1.12	1.07
	S.D.	1.23	1.30	1.51	1.12	1.65	1.33	1.20
24	MEAN	1.07	1.12	1.21	1.10	1.32	1.12	1.09
	S.D.	1.21	1.31	1.53	1.25	1.77	1.41	1.24

MEANS AND S.D. FOR START SECTION BY GROUPS AND DAYS
       EXTINCTION RESULTS

DAY		C1C1	P20P20	P3P3	C1P20	C1P3	P20C1	P3C1
25	MEAN	1.05	1.10	1.24	1.05	1.29	1.11	1.09
	S.D.	1.19	1.26	1.58	1.17	1.71	1.35	1.26
26	MEAN	0.85	1.10	1.24	0.99	1.27	1.06	0.89
	S.D.	0.89	1.25	1.59	1.06	1.70	1.23	0.89
27	MEAN	0.73	1.04	1.19	1.01	1.28	1.02	0.78
	S.D.	0.73	1.13	1.47	1.08	1.67	1.17	0.79
28	MEAN	0.54	1.01	1.15	0.97	1.19	0.90	0.63
	S.D.	0.44	1.08	1.39	0.98	1.51	0.96	0.57
29	MEAN	0.41	0.96	1.03	0.92	1.19	0.85	0.44
	S.D.	0.28	1.01	1.18	0.91	1.49	0.90	0.38
30	MEAN	0.42	0.92	0.87	0.83	1.04	0.83	0.42
	S.D.	0.29	0.94	0.90	0.80	1.29	0.87	0.31
31	MEAN	0.40	0.90	0.82	0.87	1.04	0.79	0.45
	S.D.	0.27	0.92	0.80	0.88	1.25	0.82	0.33
32	MEAN	0.35	0.80	0.84	0.63	0.94	0.70	0.48
	S.D.	0.21	0.77	0.89	0.57	1.06	0.72	0.36
33	MEAN	0.45	0.76	0.70	0.80	0.86	0.68	0.41
	S.D.	0.31	0.70	0.65	0.77	0.96	0.67	0.29
34	MEAN	0.34	0.73	0.73	0.73	0.86	0.62	0.53
	S.D.	0.23	0.69	0.68	0.67	0.91	0.52	0.40

MEANS AND S.D. FOR GOAL SECTION BY GROUPS AND DAYS
ACQUISITION RESULTS

DAY		C1C1	P20P20	P3P3	C1P20	C1P3	P20C1	P3C1
1	MEAN	0.37	0.48	0.42	0.50	0.47	0.44	0.54
	S.D.	0.22	0.34	0.29	0.37	0.30	0.31	0.51
2	MEAN	0.62	0.62	0.63	0.98	0.82	0.65	0.70
	S.D.	0.64	0.68	0.64	1.20	0.90	0.69	0.75
3	MEAN	1.25	1.03	1.22	1.63	1.51	1.24	1.50
	S.D.	2.11	1.52	1.96	3.05	2.85	1.95	2.74
4	MEAN	1.73	1.44	1.59	1.94	1.90	1.52	2.09
	S.D.	3.64	2.56	3.48	4.38	4.36	2.64	4.89
5	MEAN	1.88	1.40	1.85	2.16	2.10	1.73	2.05
	S.D.	4.15	2.60	4.20	5.16	5.09	3.48	4.86
6	MEAN	2.10	1.37	2.30	2.51	2.37	2.00	2.55
	S.D.	5.15	2.47	6.11	6.76	6.20	4.82	6.83
7	MEAN	2.12	1.61	2.18	2.32	2.53	1.82	2.47
	S.D.	5.29	3.13	5.17	5.97	7.08	3.96	6.43
8	MEAN	2.57	1.99	2.39	2.46	2.73	1.74	2.50
	S.D.	7.17	4.17	6.24	6.46	8.10	3.83	6.79
9	MEAN	2.56	2.10	2.54	2.60	2.76	2.02	2.65
	S.D.	7.18	4.99	6.78	7.09	8.02	4.69	7.32
10	MEAN	2.51	2.23	2.66	2.49	2.85	2.14	2.80
	S.D.	7.51	5.38	7.41	6.82	8.65	5.14	8.20
11	MEAN	2.77	2.15	2.60	2.68	2.95	2.21	2.77
	S.D.	8.23	4.88	7.10	7.64	9.18	5.43	8.09
12	MEAN	2.94	2.31	2.49	2.84	2.96	2.21	2.93
	S.D.	9.34	5.66	6.75	8.42	9.40	5.37	9.06
13	MEAN	2.93	2.17	2.75	2.66	3.01	2.42	2.84
	S.D.	9.63	5.19	7.96	7.69	9.59	6.53	8.78
14	MEAN	3.15	2.28	2.76	2.82	3.17	2.68	2.98
	S.D.	10.97	5.59	8.24	8.51	10.69	7.86	9.29
15	MEAN	2.96	2.25	2.61	2.56	3.06	2.57	2.91
	S.D.	9.39	5.35	7.35	7.19	9.67	7.04	8.93
16	MEAN	3.19	2.20	2.66	2.42	3.02	2.55	2.98
	S.D.	10.71	5.17	7.47	6.44	9.43	6.97	9.33
17	MEAN	3.19	2.25	2.63	2.27	2.95	2.58	3.01
	S.D.	10.82	5.50	7.33	5.56	9.19	7.28	9.63
18	MEAN	3.11	2.24	2.58	2.15	2.99	2.59	2.96
	S.D.	10.38	5.47	7.07	5.05	9.54	7.14	9.14
19	MEAN	3.23	2.22	2.71	2.33	3.06	2.56	3.02
	S.D.	10.78	5.17	7.92	5.81	9.83	7.03	9.57
20	MEAN	3.30	2.18	2.69	2.24	3.11	2.55	2.96
	S.D.	11.25	5.00	7.84	5.39	10.02	7.03	9.15
21	MEAN	3.29	2.21	2.70	2.09	3.05	2.69	2.89
	S.D.	11.30	5.25	7.84	4.82	9.76	7.58	8.79
22	MEAN	3.20	2.20	2.60	2.13	2.98	2.83	3.02
	S.D.	10.99	5.09	7.16	5.12	9.34	8.45	9.56
23	MEAN	3.30	2.23	2.53	2.06	3.01	2.75	3.06
	S.D.	11.20	5.20	6.80	4.59	9.53	7.97	9.70
24	MEAN	3.33	2.15	2.49	2.16	3.12	2.82	3.04
	S.D.	11.47	5.07	6.71	5.04	10.00	8.62	9.62

MEANS AND S.D. FOR GOAL SECTION BY GROUPS AND DAYS
EXTINCTION RESULTS

DAY		C1C1	P20P20	P3P3	C1P20	C1P3	P20C1	P3C1
25	MEAN	3.14	2.14	2.64	2.21	3.08	2.82	2.94
	S.D.	10.34	4.79	7.43	5.37	9.92	8.37	9.14
26	MEAN	2.51	2.22	2.72	2.06	3.13	2.66	2.68
	S.D.	7.59	5.15	7.72	4.79	10.14	7.68	7.84
27	MEAN	1.89	2.10	2.46	2.08	2.94	2.61	2.56
	S.D.	5.12	4.63	6.39	4.72	9.12	7.49	7.13
28	MEAN	1.38	2.06	2.62	1.97	2.91	2.28	2.26
	S.D.	3.05	4.54	7.24	4.36	8.87	5.90	5.67
29	MEAN	1.09	2.11	2.39	1.90	2.87	2.11	1.96
	S.D.	2.17	4.82	6.02	4.11	8.62	5.40	4.65
30	MEAN	0.90	2.00	2.25	1.77	2.67	1.98	1.99
	S.D.	1.87	4.26	5.55	3.76	7.80	4.75	4.74
31	MEAN	0.68	1.97	2.39	1.76	2.80	2.09	1.96
	S.D.	1.09	4.29	6.13	3.73	8.73	5.69	4.81
32	MEAN	0.78	1.81	2.29	1.56	2.59	1.70	1.68
	S.D.	1.50	3.94	5.73	3.18	7.31	4.16	4.30
33	MEAN	0.99	1.82	1.93	1.65	2.44	1.72	1.51
	S.D.	2.03	3.93	4.43	3.54	6.81	4.11	3.40
34	MEAN	0.90	1.73	2.05	1.69	2.31	1.43	1.58
	S.D.	1.69	3.65	4.63	3.60	6.37	3.02	3.77

MEANS AND S.D. FOR TOTAL RUNWAY BY GROUPS AND DAYS
      ACQUISITION RESULTS

DAY		C1C1	P20P20	P3P3	C1P20	C1P3	P20C1	P3C1
1	MEAN	0.10	0.10	0.10	0.13	0.12	0.10	0.10
	S.D.	0.07	0.02	0.02	0.03	0.02	0.02	0.01
2	MEAN	0.13	0.17	0.15	0.18	0.19	0.18	0.15
	S.D.	0.03	0.05	0.03	0.04	0.05	0.05	0.03
3	MEAN	0.22	0.27	0.31	0.29	0.36	0.33	0.35
	S.D.	0.08	0.10	0.13	0.12	0.19	0.14	0.15
4	MEAN	0.34	0.37	0.40	0.39	0.41	0.42	0.43
	S.D.	0.16	0.18	0.22	0.2C	0.24	0.21	0.24
5	MEAN	0.38	0.40	0.47	0.44	0.40	0.47	0.50
	S.D.	0.18	0.20	0.28	0.25	0.21	0.28	0.29
6	MEAN	0.44	0.40	0.57	0.49	0.53	0.52	0.64
	S.D.	0.24	0.21	0.38	0.28	0.34	0.32	0.43
7	MEAN	0.47	0.51	0.55	0.52	0.55	0.56	0.62
	S.D.	0.27	0.3C	0.35	0.32	0.36	0.37	0.43
8	MEAN	0.53	0.61	0.69	0.55	0.63	0.56	0.69
	S.D.	0.34	0.39	0.52	0.36	0.45	0.37	0.51
9	MEAN	0.55	0.61	0.75	0.61	0.64	0.63	0.73
	S.D.	0.34	0.42	0.58	0.41	0.47	0.43	0.55
10	MEAN	0.59	0.65	0.75	0.59	0.64	0.67	0.78
	S.D.	0.40	0.45	0.60	0.39	0.46	0.49	0.63
11	MEAN	0.62	0.67	0.73	0.63	0.68	0.67	0.76
	S.D.	0.43	0.46	0.56	0.43	0.50	0.48	0.60
12	MEAN	0.67	0.68	0.72	0.66	0.69	0.70	0.77
	S.D.	0.48	0.48	0.56	0.46	0.53	0.52	0.62
13	MEAN	0.66	0.69	0.80	0.69	0.74	0.75	0.77
	S.D.	0.48	0.50	0.66	0.50	0.58	0.60	0.62
14	MEAN	0.71	0.70	0.77	0.73	0.76	0.78	0.78
	S.D.	0.56	0.50	0.63	0.55	0.61	0.64	0.64
15	MEAN	0.69	0.72	0.77	0.74	0.81	0.78	0.80
	S.D.	0.52	0.54	0.63	0.58	0.69	0.64	0.66
16	MEAN	0.73	0.71	0.80	0.72	0.82	0.77	0.78
	S.D.	0.59	0.53	0.67	0.54	0.69	0.64	0.64
17	MEAN	0.76	0.72	0.80	0.69	0.82	0.75	0.80
	S.D.	0.61	0.54	0.67	0.50	0.71	0.61	0.66
18	MEAN	0.73	0.73	0.78	0.69	0.86	0.79	0.80
	S.D.	0.60	0.55	0.66	0.51	0.77	0.66	0.66
19	MEAN	0.78	0.72	0.81	0.73	0.84	0.73	0.77
	S.D.	0.66	0.53	0.69	0.55	0.75	0.60	0.63
20	MEAN	0.79	0.73	0.84	0.72	0.87	0.79	0.81
	S.D.	0.67	0.55	0.74	0.54	0.79	0.67	0.68
21	MEAN	0.81	0.72	0.83	0.67	0.89	0.80	0.81
	S.D.	0.69	0.55	0.73	0.48	0.83	0.68	0.67
22	MEAN	0.79	0.72	0.82	0.69	0.89	0.82	0.81
	S.D.	0.66	0.54	0.71	0.51	0.82	0.72	0.68
23	MEAN	0.81	0.74	0.81	0.68	0.88	0.78	0.79
	S.D.	0.68	0.57	0.68	0.48	0.79	0.65	0.65
24	MEAN	0.80	0.72	0.81	0.72	0.92	0.78	0.79
	S.D.	0.68	0.55	0.69	0.54	0.86	0.69	0.66

MEANS AND S.D. FOR TOTAL RUNWAY BY GROUPS AND DAYS
EXTINCTION RESULTS

DAY		C1C1	P20P20	P3P3	C1P20	C1P3	P20C1	P3C1
25	MEAN	0.78	0.72	0.83	0.70	0.90	0.79	0.79
	S.D.	0.64	0.54	0.72	0.53	0.84	0.68	0.66
26	MEAN	0.59	0.72	0.84	0.65	0.90	0.74	0.64
	S.D.	0.46	0.55	0.74	0.47	0.84	0.60	0.47
27	MEAN	0.46	0.69	0.80	0.66	0.88	0.70	0.58
	S.D.	0.33	0.50	0.66	0.48	0.80	0.56	0.42
28	MEAN	0.33	0.67	0.79	0.62	0.84	0.60	0.46
	S.D.	0.19	0.47	0.66	0.43	0.74	0.44	0.29
29	MEAN	0.22	0.65	0.71	0.59	0.83	0.55	0.33
	S.D.	0.10	0.46	0.55	0.39	0.73	0.39	0.20
30	MEAN	0.19	0.62	0.61	0.53	0.73	0.54	0.32
	S.D.	0.09	0.42	0.44	0.34	0.63	0.39	0.17
31	MEAN	0.18	0.60	0.59	0.55	0.74	0.51	0.34
	S.D.	0.07	0.41	0.40	0.37	0.63	0.36	0.19
32	MEAN	0.18	0.53	0.59	0.42	0.67	0.42	0.34
	S.D.	0.07	0.34	0.43	0.26	0.53	0.28	0.19
33	MEAN	0.24	0.51	0.47	0.47	0.60	0.41	0.27
	S.D.	0.12	0.32	0.29	0.30	0.46	0.27	0.14
34	MEAN	0.21	0.48	0.50	0.46	0.61	0.37	0.34
	S.D.	0.10	0.31	0.31	0.28	0.46	0.21	0.19

PHASE I TOTAL

Legend:
- CI CI — (filled square)
- P20 CI — (open square, dashed)
- P3 CI — (filled diamond)
- P20 P20 — (open triangle, dashed)
- C1 P20 — (filled triangle)
- P3 P3 — (open circle, dashed)
- C1 P3 — (filled circle)

Y-axis: SPEED I/LATENCY (1.0, .9, .8, .7, .6, .5, .4, .3, .2, .1, 0)

X-axis: DAYS (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12)

C_1 in PHASE 2

C_1 C_1

P_{20} C_1

P_3 C_1

SPEED

1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0

11 12 13 14 15 16 17 18 19 20 21 22 23 24

Preshift   Postshift (Total)

P_3 in PHASE 2

$P_3 P_3$ ○——○
$C_1 P_3$ ●——●

SPEED

1.1 1.0 .9 .8 .7 .6 .5 .4 .3 .2 .1 0

Preshift Postshift (Total)

11 12 13 14 15 16 17 18 19 20 21 22 23 24
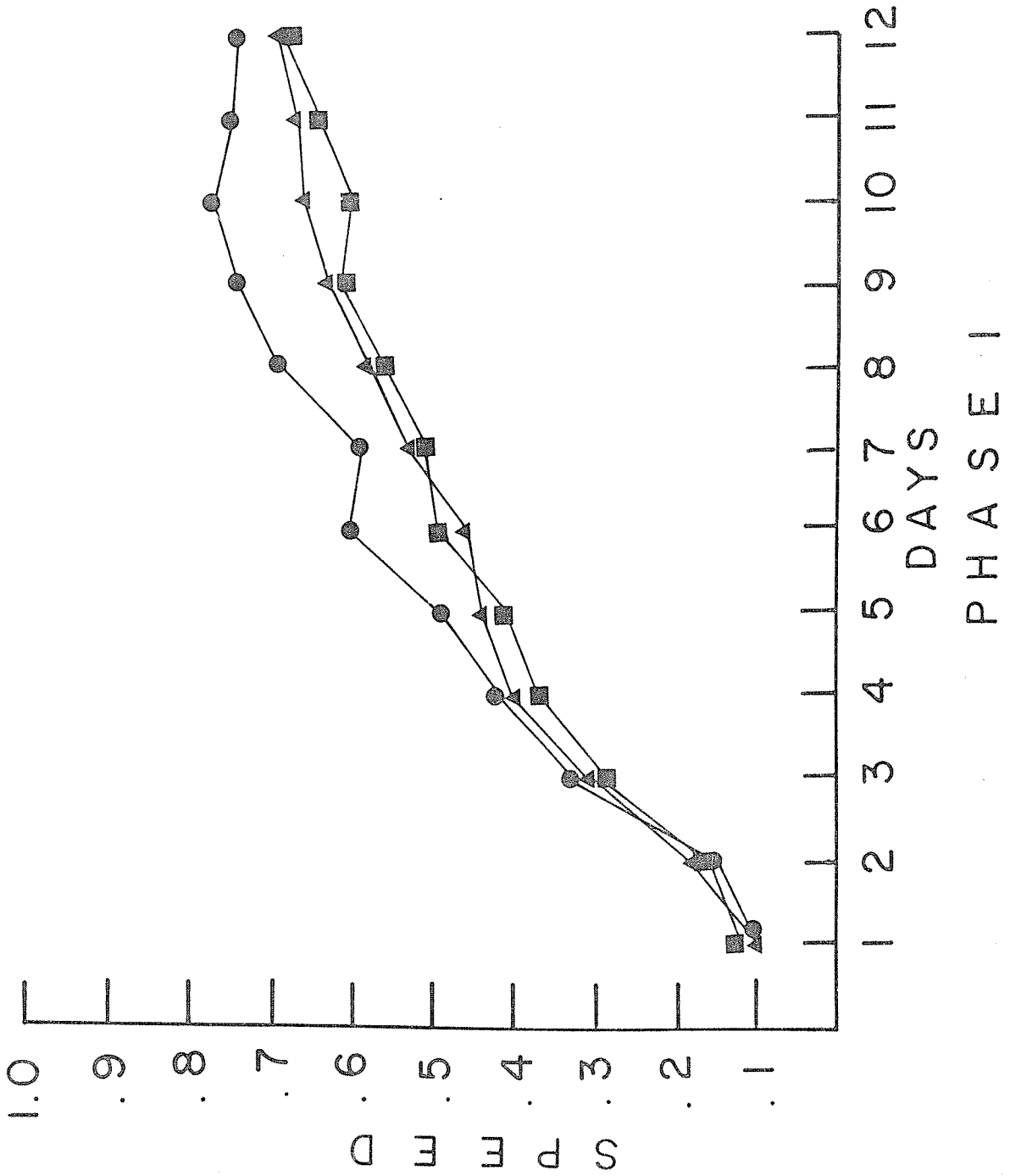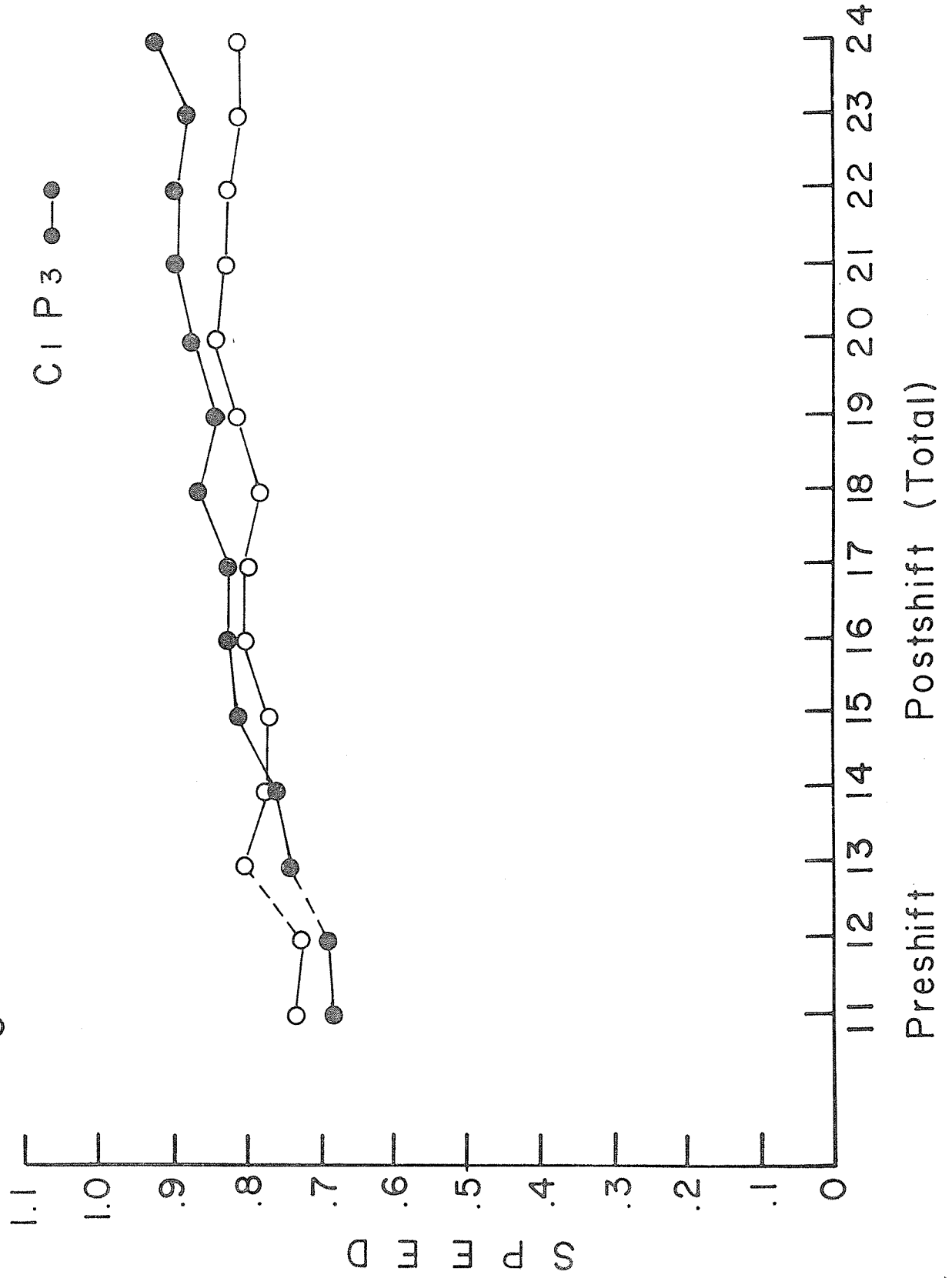
P_{20}in PHASE 2

P_{20} P_{20} △—△

C_1 P_{20} ▲—▲

SPEED

1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0

11 12 13 14 15 16 17 18 19 20 21 22 23 24

Preshift   Postshift (Total)