THE EFFECTS OF DIFFERENTIAL GOALBOX REWARD AND REWARD SHIFTS ON THE FRUSTRATION EFFECT

by

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Introduction

When rats are trained with immediate reward in the first goalbox of a double alleyway and shifted to partial reward, the result is faster second alley speed following nonreward than following reward. This phenomenon has been termed the "frustration effect" (FE) and is interpreted as reflecting the motivational properties of frustrative nonreward (Amsel, 1958; Amsel and Roussel, 1952; Wagner, 1959). Subsequent studies (Peckham and Amsel, 1964, 1967) have shown that the magnitude of the FE is contingent upon the reward magnitude received in the first goalbox. Theoretically, it is contended that the greater the reward-expectancy, the greater will be the ensuing frustration on nonrewarded trials of a partial reinforcement schedule.

One class of experiments (Karabenick, 1969; Daly, 1968; Barrett, Peyser, and McHose, 1965; McHose and Ludvigson, 1965) has extended the notion of frustration in the double alleyway by attempting to demonstrate that reduction of reward magnitude to a nonzero level would result in a finding comparable to the traditional FE. In these studies evidence for the frustrative effects of reward reduction would be indicated by faster second alley speeds following reward reduction as compared to nonshifted control groups, and by second alley speeds following reduction as compared to groups receiving first goalbox reward magnitudes equal to the reduced levels throughout the experiment.

Using a partial within-subjects design, McHose and Ludvigson (1965) trained two groups of rats to run in a double alleyway with either 10 or 2 pellets in the first goalbox. To test the effects of incomplete reward reduction the 10 pellet group was shifted to 10, 2, and zero pellets in the first goalbox on a within-subjects basis. The group which was trained with 2 pellets was shifted to 2 pellets and zero pellets in the first goalbox on a within-subjects basis. The results indicated that the shift from 10 pellets to 2 pellets resulted in faster second alley speeds than when 10 pellets were available. No differences were noted between the 10-2 pellet condition and the 2-2 pellet control condition.

Daly (1968) has suggested that the failure of McHose and Ludvigson to obtain a significant difference between the 10-2 condition and the 2-2 condition could have been due to a confounding because of the use of a partial within-subjects design. Furthermore, Daly mentions that no care was taken to assess the possible interactive or contrast effects between the different reward magnitudes in the first and second goalboxes. In the McHose and Ludvigson study, the shift to zero pellets was the only condition in which rats experienced a first goalbox reward magnitude lower than the one experienced in the second goalbox. It is entirely possible that a contrast process could also be operating in their study.

In order to examine the above contention, Daly (1968) ran a double alleyway experiment in which four acquisition groups of rats separately received first goalbox reward magnitudes of 15, 6, 1, or zero pellets. Each group was then divided into subgroups and shifted to a lower reward magnitude (15-6, 15-1, 15-0, 6-1, 6-0) or was maintained on the original

first goalbox reward magnitude (15-15, 6-6, 1-1, 0-0). The second goalbox reward magnitude was 6 pellets throughout the study. Daly found that during acquisition, second alley speeds were inversely related to first goalbox reward magnitude, i.e., the greater the first goalbox reward magnitude the slower the second alley speeds. As a consequence, Daly suggested that the second alley acquisition data may be conceptualized as demonstrating the operational similarity between the differential conditioning situation (Bower, 1961) and the double alleyway. To this end, preshift or postshift experience with differing reward magnitudes in the first goalbox and second goalbox is assumed by Daly to result in second alley performance which is dictated by contrasts between the two goalbox values. Daly also found that with the exception of a significant change in second alley shift performance which was comparable for the 15 shifted to 1 pellet and the 15 shifted to zero pellet groups, the facilitative effects of incomplete reduction failed to occur.

In an attempt to evaluate the effects of second goalbox reward magnitudes on incomplete reduction, Karabenick (1969) factorially manipulated reward magnitudes in the first and second goalboxes of a double alleyway during acquisition. Each of four groups received either 1 or 15 pellets in Goalbox 1 and either 1 or 15 pellets in Goalbox 2. A shift phase followed during which half of each preshift group was shifted to the opposite reward magnitude in the first goalbox with the second goalbox reward magnitude remaining at the preshift level.

During acquisition Karabenick found that when groups received large second goalbox rewards an inverse relationship was obtained between second alley speeds and first goalbox reward magnitudes. This finding

is similar to the acquisition results obtained by Daly (1968). Karabenick also found that the second alley speeds were unaffected by first goalbox reward magnitude when groups received small second goalbox rewards. During the postshift phase, Karabenick found that reduction in first goalbox reward led to faster second alley speeds than nonshifted controls while increments in first goalbox reward led to slower second alley speeds than nonshifted controls. The second alley speeds exhibited by the groups which received an increase in first goalbox reward were not significantly slower than groups maintained on the higher level throughout the experiment. Similarly, the second alley speeds exhibited by groups which received a reduction in first goalbox reward were not significantly faster than groups maintained on the reduced level throughout the experiment. These data indicate that incomplete reduction of reward does not lead to an effect which is comparable to the FE. In addition, it was evident that second goalbox reward magnitude was a powerful determinant of second alley speeds and may serve to moderate the effect of first goalbox reward magnitude.

The basic assumption which is implied in the above mentioned studies (Karabenick, 1969; Daly 1968; McHose and Ludvigson, 1965) is that the processes which underlie the operation of incomplete reward reduction are comparable to the processes which underlie the operation of reduction to zero reward. Unfortunately, the use of between groups designs and also the failure to simultaneously incorporate both reward reduction and partial reinforcement in Goalbox 1 in the same study preclude a direct assessment of this proposition. A major purpose of the present study was to allow such an examination by shifting the reward magnitude on

rewarded trials of a 50% partial reinforcement schedule in Goalbox 1 of a double alleyway. The concern was whether the magnitude of the FE would vary as a function of goalbox reward shifts.

A second purpose of the present study was to determine the extent to which the FE would be affected by the contrast between the reward magnitude experienced on rewarded trials in Goalbox 1 and the reward magnitude experienced in Goalbox 2. While it has been reported (Krippner, Endsley, and Tacker, 1967) that the reward magnitude experienced in Goalbox 2 does not affect the magnitude of the FE, the present study seeks to replicate further this finding and to determine whether the effect of Goalbox 2 reward magnitude on the FE is dependent upon the magnitude of reward experienced in Goalbox 1. Hence, throughout the present study all rats received 50% partial reinforcement in Goalbox 1 and continuous reward in Goalbox 2 of a double alleyway. During preshift, four groups received either 4 or 12 pellets in Goalbox 1 on rewarded trials and either 4 or 12 pellets in Goalbox 2. After 105 trials, half of the rats in each preshift group were shifted to the opposite reward magnitude on the rewarded trials of the partial reinforcement schedule in Goalbox 1. During the 48 postshift trials the groups received the same Goalbox 2 reward magnitude as experienced during preshift trials.

Method

Subjects

The subjects were 103 female hooded rats obtained from the laboratory colony maintained by the Department of Psychology at Virginia Polytechnic Institute and State University. The rats were between 68 and 75 days old at the beginning of the experiment, and were individually housed throughout the experiment.

Apparatus

The apparatus was an L-shaped double alleyway which was 7.6 cm wide and 12.7 cm high throughout. The first startbox and Alley 1 were 25.4 and 91.4 cm in length, respectively. Goalbox 1, which also served as the Alley 2 startbox, was L shaped and was 33.0 cm long with the short arm of the L being 22.9 cm long. Alley 2 and Goalbox 2 were 182.9 and 35.6 cm in length, respectively. Goalbox 2 was L shaped and was 27.9 cm in length at the short arm of the L. Guillotine doors separated the first startbox from Alley 1, Alley 1 from Alley 2, and Alley 2 from Goalbox 2.

The entire apparatus was covered with .32 cm clear Plexiglas and was constructed from 1.9 cm thick plywood. The first startbox, Alley 1, Goalbox 1, and the guillotine doors in Alley 1 and Goalbox 1 were painted flat black. Alley 2, Goalbox 2, and the guillotine doors in Alley 2 and Goalbox 2 were painted flat white. The floor of Alley 1 and Goalbox 1 was covered with a black rubber mat. The entire apparatus was illuminated by 7 W bulbs suspended 129.5 cm above the top of the alleyway. Food pellet dishes were located 13.9 cm from the guillotine door of the

Goalbox 1 opening into Alley 2 and against the endwall of Goalbox 2. Each dish was 2.5 cm in diameter and 0.9 cm deep.

Start times for Alley 1 were measured from the opening of the first startbox door to the interruption of a photobeam 6.0 cm distant. Running times for Alley 1 were measured from the interruption of the first photobeam to the interruption of a second photobeam 91.4 cm distant. Start times for Alley 2 were measured from the opening of the Goalbox 1 door leading into Alley 2 until the interruption of a photobeam 6.0 cm distant. Running times for Alley 2 were measured from the interruption of the latter photobeam until the interruption of a second photobeam 182.3 cm distant.

Procedure

Over the first 36 days prior to the first preshift trials the rats were handled for approximately 4 min daily. During Days 1-10 rats were allowed access to food and water ad lib in the home cages. On Day 11 rats were placed on a 23 h food deprivation schedule. From Days 16-20 all rats were given access to 45 mg Noyes food pellets scattered in a neutral holding cage. On Day 21 rats were allowed to explore the entire apparatus with pellets available in Goalbox 1 and Goalbox 2. On Day 22 rats were allowed to explore Alley 2 and Goalbox 2 with pellets available in Goalbox 2. On Day 23 rats were allowed to explore the entire apparatus with pellets available in both goalboxes. During this training all guillotine doors were raised and lowered as they would be during the course of the experiment and the photo-electric system was operating continuously. For the next thirteen days all rats received continuous

reinforcement in Goalbox 1 and Goalbox 2 according to the reward magnitude to be encountered during the preshift phase of the experiment. On Days 24-26 rats were given one trial per day; on Days 27-33 two trials per day; on Days 34-36 three trials per day. On preshift Day 1 and throughout the remainder of the experiment rats received three trials per day with an intertrial interval of approximately 30-40 sec.

A trial was initiated with the placing of a rat into the first startbox. As soon as the rat faced the Alley 1 guillotine door, the door was raised to allow the rat to traverse Alley 1. Upon entering Goalbox 1 the guillotine doors were lowered to prevent retracing. During rewarded trials the rat was allowed 20 sec access to the number of food pellets appropriate to its reward condition. On nonrewarded trials the rat was given 20 sec of confinement. After 20 seconds had elapsed and upon facing the guillotine door leading to Alley 2 the door was raised and the rat was allowed to traverse Alley 2. Upon entering Goalbox 2 the guillotine door was closed behind the rat. All rats were allowed 20 sec to consume the Goalbox 2 reward and generally all rats had consumed all of the reward within 20 sec. After the 20 sec in Goalbox 2 had elapsed the rat was placed in a holding cage for an interval of 30-40 sec.

Experimental Design

The rats were randomly assigned to four preshift groups and received either 4 or 12 pellets in Goalbox 1 and either 4 or 12 pellets in Goalbox 2. The four groups were designated 4:4 (n=25), 4:12 (n=26), 12:4 (n=26), and 12:12 (n=26) where the first number represents the Goalbox 1 reward

magnitude and the second number represents the Goalbox 2 reward magnitude.

During preshift and postshift all rats received 50% partial reinforcement in Goalbox 1 and continuous reinforcement in Goalbox 2. The daily sequence of reward (R) and nonreward (N) trials in Goalbox 1 was as follows: NRN, RNR, NNR, RRN, NRR, and RNN. This pattern was repeated throughout the entire experiment. Preshift consisted of 105 such trials.

Postshift consisted of 48 trials with 50% partial reinforcement in Goalbox 1 and with half of the rats in each group shifted to the magnitude opposite that previously received in Goalbox 1. The other half of the rats in each group remained on the same reward magnitude as encountered during preshift. The groups were designated 4-4:4 (n=12), 4-12:4 (n=13), 4-4:12 (n=13), 4-12:12 (n=13), 12-12:4 (n-13), 12-4:12 (n=13), 12-12:12 (n=13), where the first number represents the preshift Goalbox 1 reward magnitude, the second number represents the postshift Goalbox 1 reward magnitude, and the third number represents the Goalbox 2 reward, which remained constant from preshift to postshift.

Results

Four measures of performance were recorded: start and running latencies for Alley 1; and start and running latencies for Alley 2. These latencies were converted to speed scores (cm/sec) for every trial and all analyses were performed using these converted scores. Mean Alley 1 start and running speeds for Trial Block 1 were formed by averaging over the first nine trials for each subject while all subsequent Trial Blocks were averaged over twelve trials per Trial Block for each subject. Mean Alley 2 start and running speeds per Trial Block per subject were formed as follows: five nonreward and four reward trials were separately averaged for Trial Block 1; on all subsequent Trial Blocks six nonreward and six reward trials were averaged separately. The Trial Type Condition variable contained in the analyses of Alley 2 speeds refers to the comparison of mean speeds over rewarded trials *vs* mean speeds over nonreward trials.

Preshift

Alley 1 start and running speeds. Figure 1 shows the mean Alley 1 start and running speeds as a function of trial blocks. It is apparent from Figure 1 that Goalbox 2 reward magnitude had an inverse relationship to Alley 1 start and running speeds. A 2 x 2 x 9 analysis of variance (Goalbox 1 Reward Magnitude x Goalbox 2 Reward Magnitude x Trial Blocks) was performed on mean Alley 1 start and running speeds; the summaries are presented in Tables 1 and 2, respectively.[1] The results of these analyses indicated that groups which received 4 pellets in Goalbox 2 showed faster Alley 1 start speeds ($p < .05$) and running speeds ($p < .001$)

Figure 1. Mean alley 1 start and running speeds as a function of goalbox 1 preshift reward magnitude and goalbox 2 reward magnitude over preshift trial blocks 1-9.

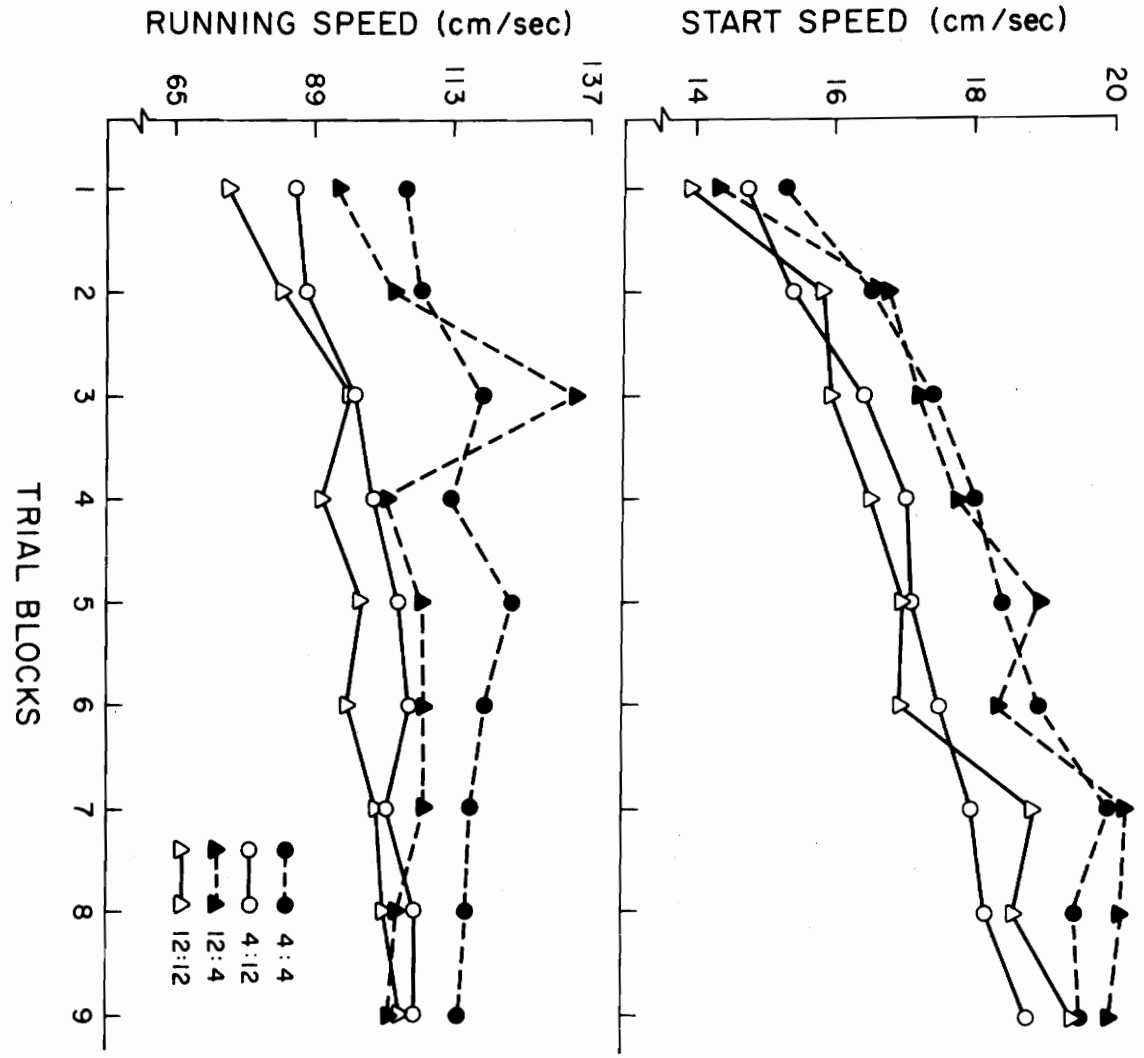

START SPEED (cm/sec)
20
18
16
14
RUNNING SPEED (cm/sec)
137
113
89
65
1
2
3
4
5
6
7
8
9
TRIAL BLOCKS
4:4
4:12
12:4
12:12

Table 1

Summary of Analysis of Variance Performed on Mean Alley 1 Start Speeds Over Preshift Trial Blocks 1-9

Source of Variance	SS	df	MS	F
Goalbox 1 Reward Magnitude (GB1)	.37	1	.37	.005
Goalbox 2 Reward Magnitude (GB2)	335.64	1	335.64	4.97*
GB1 X GB2	.68	1	.68	.01
Ss/GB1 GB2	6673.24	99	67.41	
Trial Blocks (B)	2332.82	8	291.60	34.41****
B X GB1	75.27	8	9.41	1.11
B X GB2	46.31	8	5.79	.68
B X GB1 X GB2	15.41	8	1.93	.23
B X Ss/GB1 GB2	6711.52	792	8.47	

*$p < .05$

****$p < .001$

Table 2

Summary of Analysis of Variance Performed on Mean Alley 1 Running Speeds Over Preshift Trial Blocks 1-9

Source of Variance	SS	df	MS	F
Goalbox 1 Reward Magnitude (GB1)	9224.25	1	9224.25	2.38
Goalbox 2 Reward Magnitude (GB2)	46909.96	1	46909.96	12.10****
GB1 X GB2	358.32	1	358.32	.09
Ss/GB1 GB2	383846.08	99	3877.23	
Trial Blocks (B)	40948.02	8	5118.50	5.40****
B X GB1	7744.21	8	968.03	1.02
B X GB2	14525.42	8	1815.68	1.92*
B X GB1 X GB2	3815.58	8	476.95	.50
B X Ss/GB1 GB2	750243.31	792	947.28	

*$p < .05$

****$p < .001$

than did groups which received 12 pellets in Goalbox 2. The Trial Block effect was also statistically significant for start speeds ($p < .001$) and for running speeds ($p < .001$). All other main effects and interactions were not significant ($ps > .05$).

Alley 2 start speeds. Figure 2 presents the mean Alley 2 start and running speeds as a function of trial blocks. From the start speed portion of Figure 2 it can be seen that (1) start speeds were faster on trials following nonreward than on trials following reward and (2) start speeds were generally faster for rats receiving 4 pellets in either Goalbox 1 or Goalbox 2 than for rats receiving 12 pellets in either Goalbox 1 or Goalbox 2.

A 2 x 2 x 2 x 9 factorial analysis of variance (Goalbox 1 Reward Magnitude x Goalbox 2 Reward Magnitude x Trial Type Condition x Trial Blocks) was perfromed on the mean Alley 2 start speeds over Trial Blocks 1 through 9. The results of this analysis are presented in Table 3.

From Table 3 it may be seen that the Trial Type Condition x Goalbox 1 Reward Magnitude interaction reached statistical significance ($p < .05$). Analyses of this interaction, presented in Table 4, revealed that the Frustration Effect (i.e., faster Alley 2 speeds on nonreward as compared to reward trials) was significant for groups which received either 4 or 12 pellets in Goalbox 1 ($ps < .05$). Also, groups which received 4 pellets in Goalbox 1 had significantly faster Alley 2 start speeds than groups which received 12 pellets in Goalbox 1 on both rewarded and nonrewarded trials ($ps < .05$). Thus, the size of the FE was greater for the 12 pellet group.

Figure 2. Mean alley 2 reward trial and nonreward trial start and running speeds as a function of goalbox 1 preshift reward magnitude and goalbox 2 reward magnitude over preshift trial blocks 1-9.

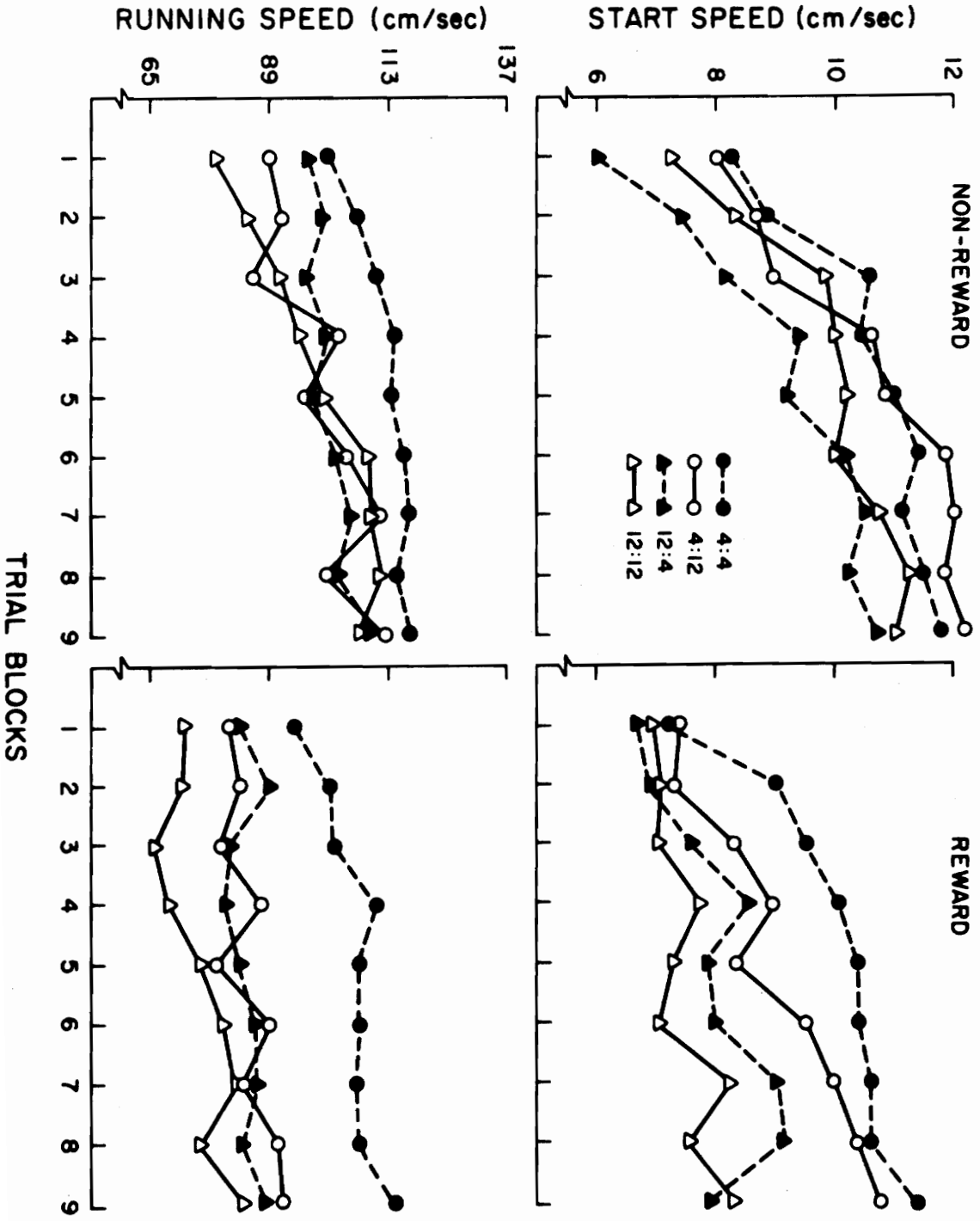

START SPEED (cm/sec)
RUNNING SPEED (cm/sec)
NON-REWARD
REWARD
4:4
4:12
12:4
12:12
TRIAL BLOCKS

Table 3

Summary of Analysis of Variance Performed on Mean Alley 2 Start Speeds Over Preshift Trial Blocks 1-9

Source of Variance	SS	df	MS	F
Goalbox 1 Reward Magnitude (GB1)	1009.82	1	1009.82	7.57**
Goalbox 2 Reward Magnitude (GB2)	17.79	1	17.79	.13
GB1 X GB2	46.33	1	46.33	.35
Ss/GB1 GB2	13214.02	99	133.47	
Trial Type Condition (TT)	1027.28	1	1027.28	74.03****
TT X GB1	78.83	1	78.83	5.68*
TT X GB2	162.62	1	162.62	11.72***
TT X GB1 X GB2	2.30	1	2.30	.17
TT X Ss/GB1 GB2	1373.87	99	13.88	
Trial Blocks (B)	2277.48	8	284.68	33.92****
B X GB1	58.39	8	7.30	.87
B X GB2	32.91	8	4.11	.49
B X GB1 X GB2	70.52	8	8.82	1.05
B X Ss/GB1 GB2	6647.47	792	8.39	
TT X B	146.68	8	18.33	4.15****
TT X B X GB1	55.39	8	6.92	1.57
TT X B X GB2	21.90	8	2.74	.62
TT X B X GB1 X GB2	58.40	8	7.30	1.65
TT X B X Ss/GB1 GB2	3499.49	792	4.42	

*$p < .05$

**$p < .01$

***$p < .005$

****$p < .001$

Table 4

Tests of Differences in Mean Alley 2 Start Speeds for Assessment of the Goalbox 1 Reward Magnitude (4 vs 12 Pellets) x Trial Type Condition (Nonreward vs Reward) Interaction

Condition				
Goalbox 1 Reward Magnitude	4	12	4	12
Trial Type Condition	N	N	R	R
Ordered Means	10.62	9.56	9.54	7.67

Range		2	3	4
Duncan's Multiple Range Statistic		2.800	2.947	3.045
Test Statistic		.48	.51	.52

Difference Table

	12-(R)	4-(R)	12-(N)	4-(N)
12-(R)	-	1.87*	1.89*	2.95*
4-(R)		-	.01	1.07*
12-(N)			-	1.06*

*$p < .05$

Note: $MS_{Error}=MS_{TT \times Ss/GB1\ GB2}=13.88$; $n=468$.

From Table 3, it is evident that the Trial Type Condition x Goalbox 2 Reward Magnitude interaction was significant ($p < .005$). The assessment of this interaction, presented in Table 5, revealed that the Frustration Effect (FE) was significant for groups which received 4 pellets in Goalbox 2 as well as for groups which received 12 pellets in Goalbox 2 ($ps < .005$). Groups which received 4 pellets in Goalbox 2 showed significantly faster Alley 2 start speeds following reward in Goalbox 1 than rats which received 12 pellets in Goalbox 2 ($p < .005$). Following nonreward in Goalbox 1, groups which received either 4 or 12 pellets in Goalbox 2 did not differ in Alley 2 start speeds ($p > .005$).

It may be seen from Table 3 that the Trial Type Condition x Trial Block interaction was significant ($p < .001$). From the analyses presented in Table 6 it may be noted that with the exception of the first two trial blocks a significant FE was exhibited on all trial blocks ($ps < .001$).

Alley 2 running speeds. Mean Alley 2 running speeds as a function of trial blocks are depicted in the bottom portion of Figure 2. Examination of Figure 2 reveals that on nonrewarded trials groups which received 4 pellets in Goalbox 1 ran faster than groups which received 12 pellets in Goalbox 1. Similarly, on Goalbox 1 rewarded trials groups which received 4 pellets in Goalbox 2 ran faster than groups which received 12 pellets in Goalbox 2. During the later trial blocks all groups exhibited an FE. A 2 x 2 x 2 x 9 (Goalbox 1 Reward Magnitude x Goalbox 2 Reward Magnitude x Trial Type Condition x Trial Blocks) factorial analysis of variance was performed on mean Alley 2 running speeds over Trial Blocks 1-9.

Table 5

Tests of Differences in Mean Alley 2 Start Speeds for Assessment of the Goalbox 2 Reward Magnitude (4 vs 12 Pellets) x Trial Type Condition (Nonreward vs Reward) Interaction

Condition				
Goalbox 2 Reward Magnitude	12	4	4	12
Trial Type Condition	N	N	R	R
Ordered Means	10.29	9.89	8.99	8.22

Range		2	3	4
Duncan's Multiple Range Statistic		4.045	4.201	4.308
Test Statistic		.70	.72	.74

Difference Table

	12-(R)	4-(R)	4-(N)	12-(N)
12-(R)	-	.78*	1.68*	2.07*
4-(R)		-	.89*	1.29*
4-(N)			-	.39

*$p < .005$

Note: $MS_{Error}=MS_{TT \times Ss/GB1\ GB2}=13.88$; $n=468$.

Table 6

Tests of Differences in Mean Alley 2 Start Speeds for Assessment of the Trial Type Condition (Nonreward vs Reward) x Trial Block Interaction

Condition									
Trial Type Condition	N	N	N	N	N	N	R	R	R
Trial Block	9	8	7	6	5	4	9	7	8
Ordered Means	11.54	11.28	11.13	11.06	10.40	10.15	9.64	9.53	9.49
Trial Type Condition	N	R	R	R	N	R	R	N	R
Trial Block	3	4	6	5	2	3	2	1	1
Ordered Means	9.41	8.92	8.74	8.49	8.35	8.15	7.51	7.41	6.99
Range	2	3	4	5	6	7	8	9	10
Duncan's Multiple Range Statistic	4.654	4.798	4.898	4.974	5.034	5.085	5.128	5.166	5.199
Test Statistic	.96	.99	1.01	1.02	1.04	1.05	1.06	1.06	1.07

Table 6 (continued)

Range	11	12	13	14	15	16	17	18
Duncan's Multiple Range Statistic	5.299	5.256	5.280	5.303	5.324	5.343	5.361	5.378
Test Statistic	1.08	1.08	1.09	1.09	1.10	1.10	1.10	1.11

Difference Table

	1-(R)	1-(N)	2-(R)	3-(R)	2-(N)	5-(R)	6-(R)	4-(R)	3-(N)
1-(R)	-	.42	.52	1.16*	1.36*	1.50*	1.75*	1.93*	2.42*
1-(N)		-	.09	.74	.93	1.07*	1.33*	1.50*	2.00*
2-(R)			-	.65	.84	.98	1.24*	1.41*	1.91*
3-(R)				-	.19	.33	.59	.76	1.26*
2-(N)					-	.14	.40	.57	1.07*
5-(R)						-	.26	.43	.93
6-(R)							-	.17	.67
4-(R)								-	.50

Table 6 (continued)

	8-(R)	7-(R)	9-(R)	4-(N)	5-(N)	6-(N)	7-(N)	8-(N)	9-(N)
1-(R)	2.50*	2.54*	2.65*	3.16*	3.40*	4.07*	4.20*	4.29*	4.55*
1-(N)	2.08*	2.12*	2.23*	2.74*	2.99*	3.65*	3.78*	3.86*	4.13*
2-(R)	1.98*	2.03*	2.14*	2.65*	2.89*	3.56*	3.69*	3.77*	4.03*
3-(R)	1.34*	1.38*	1.49*	2.00*	2.24*	2.91*	3.04*	3.12*	3.39*
2-(N)	1.14*	1.18*	1.30*	1.80*	2.05*	2.72*	2.84*	2.93*	3.19*
5-(R)	1.00*	1.05*	1.16*	1.67*	1.91*	2.58*	2.71*	2.79*	3.05*
6-(R)	.74	.79	.90	1.41*	1.65*	2.32*	2.45*	2.53*	2.79*
4-(R)	.58	.62	.73	1.24*	1.48*	2.15*	2.28*	2.36*	2.62*
3-(N)	.08	.12	.23	.74	.98	1.65*	1.78*	1.86*	2.13*

Table 6 (continued)

	8-(R)	7-(R)	9-(R)	4-(N)	5-(N)	6-(N)	7-(N)	8-(N)	9-(N)
8-(R)	-	.04	.15	.66	.91*	1.57*	1.70*	1.78*	2.05*
7-(R)		-	.11	.62	.87	1.53*	1.66*	1.74*	2.01*
9-(R)			-	.51	.75	1.42*	1.55*	1.63*	1.89*
4-(N)				-	.25	.91	1.04*	1.12*	1.39*
5-(N)					-	.67	.79	.88	1.14*
6-(N)						-	.13	.21	.48
7-(N)							-	.08	.34
8-(N)								-	.26

*$p < .001$

Note: $MS_{Error}=MS_{TT \times Ss/GB1\ GB2}=4.4186$; $n=104$.

The results of this analysis are presented in Table 7 and indicate that the Trial Type Condition x Trial Blocks x Goalbox 1 Reward Magnitude interaction was statistically reliable ($p < .05$). Table 8 presents the simple effects analyses of this interaction, from which it may be seen that the Goalbox 1 Reward Magnitude x Trial Type Condition interaction was significant on six of the nine trial blocks ($ps < .05$). Since the major interest of this study was focused on terminal performance, further simple effect tests were performed on Trial Blocks 8 and 9 and are summarized in Table 9. Over Trial Blocks 8 and 9, the FE was significant for groups receiving 4 pellets in Goalbox 1 and for groups receiving 12 pellets in Goalbox 1 ($ps < .05$). Moreover, on Trial Block 8 a significantly greater FE was found for groups receiving 12 pellets than for groups receiving 4 pellets in Goalbox 1 ($p < .05$). The 12 pellet groups showed significantly slower running speeds than the 4 pellet group on reward trials ($p < .05$). There were no differences in running speeds as a function of Goalbox 1 Reward Magnitude on nonreward trials ($p > .05$). On Trial Block 9 the 12 pellet group ran significantly slower than the 4 pellet group following reward and nonreward in Goalbox 1 ($p < .05$).

From Table 7 it is apparent that the results of the analysis of variance indicated a significant Goalbox 2 Reward Magnitude x Trial Type Condition interaction ($p < .001$). The simple effects analyses of this interaction, presented in Table 10, indicated that the FE was statistically significant for groups which received either 12 or 4 pellets in Goalbox 2 ($ps < .001$). Furthermore, the 4 pellet Goalbox 2 groups ran significantly faster than the 12 pellet Goalbox 2 groups following reward or nonreward in Goalbox 1 ($ps < .001$). It is clear from Figure 2 that

Table 7

Summary of Analysis of Variance Performed on Mean Alley 2 Running Speeds Over Preshift Trial Blocks 1-9

Source of Variance	SS	df	MS	F
Goalbox 1 Reward Magnitude (GB1)	53425.43	1	53425.43	6.26*
Goalbox 2 Reward Magnitude (GB2)	63827.93	1	63827.93	7.48**
GB1 X GB2	12115.63	1	12115.63	1.42
Ss/GB1 GB2	844505.03	99	8530.35	
Trial Type Condition (TT)	117636.49	1	117636.49	269.39****
TT X GB1	15034.46	1	15034.46	34.43****
TT X GB2	6714.97	1	6714.97	15.38****
TT X GB1 X GB2	96.38	1	96.38	.22
TT X Ss/GB1 GB2	43231.33	99	436.68	
Trial Blocks (B)	46704.45	8	5838.06	12.41****
B X GB1	3714.06	8	464.26	.99
B X GB2	5265.39	8	658.17	1.40
B X GB1 X GB2	5242.67	8	655.33	1.39
B X Ss/GB1 GB2	372507.19	792	470.34	
TT X B	6746.76	8	843.35	5.07****
TT X B X GB1	3490.54	8	436.32	2.62*
TT X B X GB2	2236.34	8	279.54	1.68
TT X B X GB1 X GB2	2010.44	8	251.31	1.51
TT X B X Ss/GB1 GB2	131710.21	792	166.30	

*$p < .05$

**$p < .01$

****$p < .001$

Table 8

Simple Effects Analyses of Variance Performed on Mean Alley 2 Running Speeds for Assessment of the Goalbox 1 Reward Magnitude x Trial Type Condition x Trial Blocks Interaction

Source of Variance	df	MS	F
Goalbox 1 Reward Magnitude x Trial Type Condition (GB1 x TT) at Trial Block 1	1	249.48	1.50
GB1 x TT at Trial Block 2	1	923.46	5.55*
GB1 x TT at Trial Block 3	1	2651.37	15.94*
GB1 x TT at Trial Block 4	1	3261.38	19.61*
GB1 x TT at Trial Block 5	1	550.03	3.31
GB1 x TT at Trial Block 6	1	2008.00	12.07*
GB1 x TT at Trial Block 7	1	416.92	2.51
GB1 x TT at Trial Block 8	1	6607.15	39.73*
GB1 x TT at Trial Block 9	1	1857.21	11.17*
TT x Trial Block x Ss/GB1 GB2	792	166.30	

*$p < .05$

Table 9

Tests of Differences in Mean Alley 2 Running Speeds for Assessment of the Goalbox 1 Reward Magnitude (4 vs 12 Pellets) x Trial Type Condition Interaction at Trial Blocks 8 and 9

Range		2	3	4
Duncan's Multiple Range Statistic		2.829	2.976	3.073
Test Statistic		5.06	5.32	5.50
Condition Trial Block 8				
Goalbox 1 Reward Magnitude	12	4	4	12
Trial Type Condition	N	N	R	R
Ordered Means	107.93	106.52	99.62	78.49
Difference Table Trial Block 8				
	12-(R)	4-(R)	4-(N)	12-(N)
12-(R)	-	21.13*	28.03*	29.44*
4-(R)		-	6.90*	8.31*
4-(N)			-	1.42
Condition Trial Block 9				
Goalbox 1 Reward Magnitude	4	12	4	12
Trial Type Condition	N	N	R	R
Ordered Means	115.81	110.38	102.83	85.45
Difference Table Trial Block 9				
	12-(R)	4-(R)	12-(N)	4-(N)
12-(R)	-	17.38*	24.93*	30.35*
4-(N)		-	7.55*	12.98*
12-(N)			-	5.43*

*$p < .05$

Note: $MS_{Error}=MS_{TT \times B \times Ss/GB1\ GB2}=166.30$; $n=52$.

Table 10

Tests of Differences in Mean Alley 2 Running Speeds for Assessment of the Goalbox 2 Reward Magnitude (4 vs 12 Pellets) x Trial Type Condition (Nonreward vs Reward) Interaction

Condition				
Goalbox 2 Reward Magnitude	4	12	4	12
Trial Type Condition	N	N	R	R
Ordered Means	107.41	99.52	95.35	79.88

Range		2	3	4
Duncan's Multiple Range Statistic		4.771	4.924	5.029
Test Statistic		4.61	4.76	4.86

Difference Table

	12-(R)	4-(R)	12-(N)	4-(N)
12-(R)	-	15.47*	19.64*	27.53*
4-(R)		-	4.18	12.06*
12-(N)			-	7.89*

*$p < .001$

Note: $MS_{Error}=MS_{TT \times Ss/GB1\ GB2}=436.68$; $n=468$.

the interaction was due to a greater FE for the 12 pellet group than for the 4 pellet group.

Postshift

Alley 1 start and running speeds. The mean Alley 1 start and running speeds over preshift Trial Block 9 and postshift Trial Blocks 10 through 13 are presented in Figure 3. From the top portion of Figure 3, which contains the mean Alley 1 start speeds, it may be noted that there is a consistent change over trial blocks but that there is little systematic change among groups. It may also be noted from the lower portion of Figure 3, which contains the mean Alley 1 running speeds, that groups which received 4 pellets in Goalbox 1 during preshift ran faster than groups which received 12 pellets in Goalbox 1 during preshift.

A 2 x 2 x 2 x 5 (Goalbox 1 Preshift Reward Magnitude x Goalbox 1 Postshift Reward Magnitude x Goalbox 2 Reward Magnitude x Trial Blocks) factorial analysis of variance was computed separately for Alley 1 start and running speeds over preshift Trial Block 9 and postshift Trial Blocks 10 through 13. The results of these analyses are presented in Table 11 for start speeds and Table 12 for running speeds.

From Table 11 it may be seen that the Trial Blocks variable was statistically reliable ($p < .001$). For running speeds, Table 12 shows that the Trial Block variable was significant at the .01 level and that the groups which received 4 pellets in Goalbox 1 during preshift ran significantly faster than groups which received 12 pellets in Goalbox 1 during preshift ($p < .05$).

Alley 2 start speeds. The mean Alley 2 start speeds over Trial Block 9 and postshift Trial Blocks 10 through 13 are presented in

Figure 3. Mean alley 1 start and running speeds as a function of goalbox 1 preshift reward magnitude, goalbox 1 postshift reward magnitude, and goalbox 2 reward magnitude over preshift trial block 9 and postshift trial blocks 10-13.

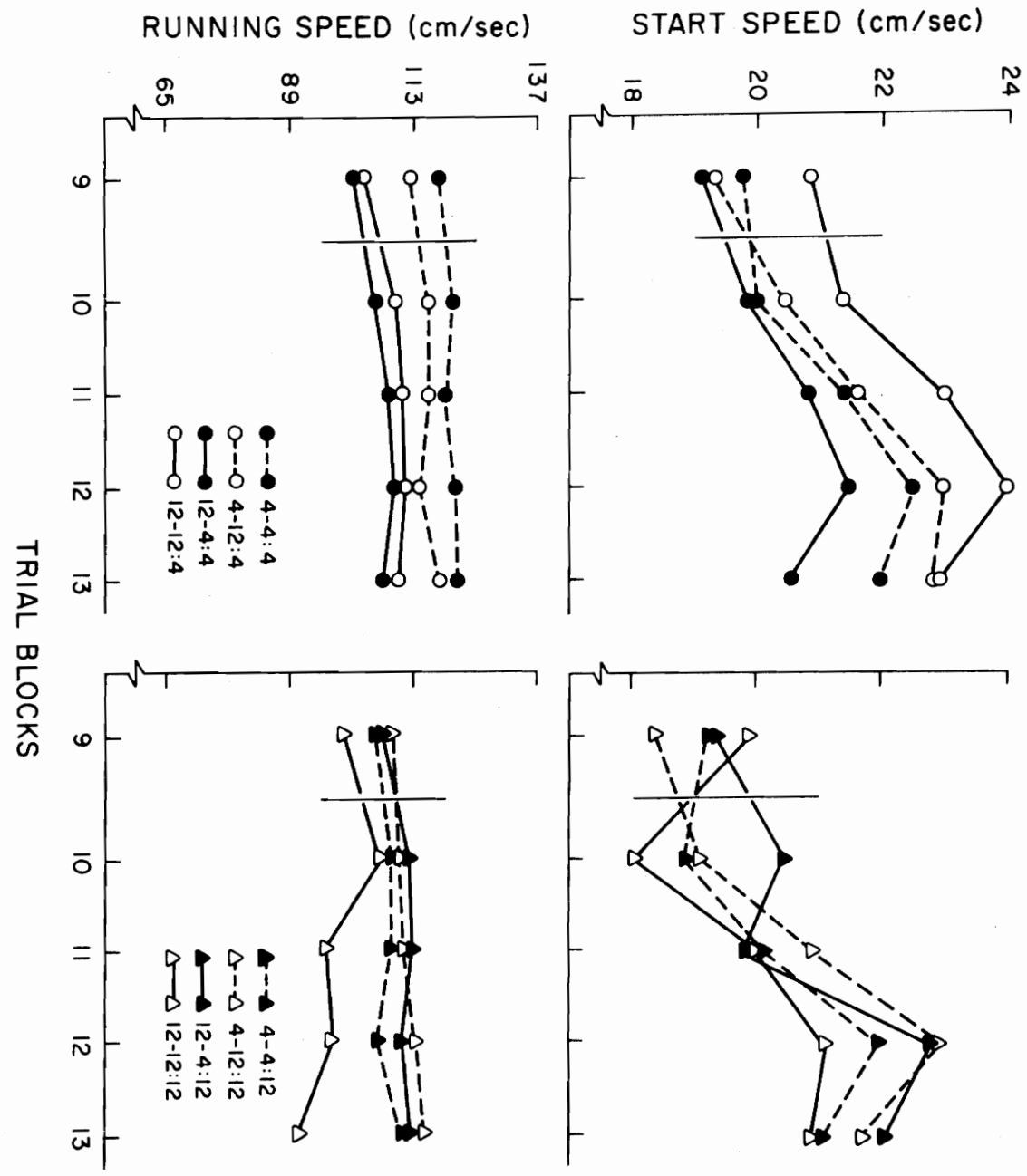

START SPEED (cm/sec)
RUNNING SPEED (cm/sec)
TRIAL BLOCKS
4-4:4
4-12:4
12-4:4
12-12:4
4-4:12
4-12:12
12-4:12
12-12:12

Table 11

Summary of Analysis of Variance Performed on Mean Alley 1 Start Speeds Over Preshift Trial Block 9 and Postshift Trial Blocks 10-13

Source of Variance	SS	df	MS	F
Goalbox 1 Preshift Reward Magnitude (GB1)	.31	1	.31	.01
Goalbox 2 Reward Magnitude (GB2)	119.90	1	119.90	2.40
GB1 X GB2	.42	1	.42	.01
Goalbox 1 Postshift Reward Magnitude (PGB1)	23.31	1	23.31	.47
GB1 X PGB1	4.27	1	4.27	.09
GB2 X PGB1	78.86	1	78.86	1.58
GB1 X GB2 X PGB1	73.50	1	73.50	1.47
Ss/GB1 GB2 PGB1	4741.55	95	49.91	
Trial Blocks (B)	716.50	4	179.12	34.06****
B X GB1	17.60	4	4.40	.84
B X GB2	25.43	4	6.36	1.21
B X GB1 X GB2	11.33	4	2.83	.54
B X PGB1	17.80	4	4.45	.85
B X GB1 X PGB1	23.33	4	5.83	1.11
B X GB2 X PGB1	12.53	4	3.13	.59
B X GB1 X GB2 X PGB1	13.47	4	3.37	.64
B X Ss/GB1 GB2 PGB1	1998.34	380	5.26	

****$p < .001$

Table 12

Summary of Analysis of Variance Performed on Mean Alley 1 Running Speeds Over Preshift Trial Block 9 and Postshift Trial Blocks 10-13

Source of Variance	SS	df	MS	F
Goalbox 1 Preshift Reward Magnitude (GB1)	7880.21	1	7880.21	5.64*
Goalbox 2 Reward Reward Magnitude (GB2)	3577.88	1	3577.88	2.56
GB1 X GB2	885.68	1	885.68	.63
Goalbox 1 Postshift Reward Magnitude (PGB1)	980.43	1	980.43	.70
GB1 X PGB1	903.04	1	903.04	.65
GB1 X PGB2	555.18	1	555.18	.40
GB1 X GB2 X PGB1	4624.60	1	4624.60	3.31
Ss/GB1 GB2 PGB1	132853.91	95	1398.46	
Trial Blocks (B)	1515.36	4	378.84	3.34**
B X GB1	524.71	4	131.18	1.16
B X GB2	334.61	4	83.65	.74
B X GB1 X GB2	668.83	4	167.21	1.48
B X PGB1	187.18	4	46.80	.41
B X GB1 X PGB1	398.53	4	99.63	.88
B X GB2 X PGB1	431.32	4	107.83	.95
B X GB1 X GB2 X PGB1	294.56	4	73.64	.66
B X Ss/GB1 GB2 PGB1	43030.49	380	113.24	

*$p < .05$

**$p < .01$

Figure 4, from which it may be seen that (1) all groups showed an FE and (2) that groups which received 4 pellets in Goalbox 1 during preshift had faster start speeds than groups which received 12 pellets in Goalbox 1 during preshift.

A 2 x 2 x 2 x 2 x 5 (Goalbox 1 Preshift Reward Magnitude x Goalbox 1 Postshift Reward Magnitude x Goalbox 2 Reward Magnitude x Trial Type Condition x Trial Blocks) factorial analysis of variance was performed over preshift Trial Block 9 and postshift Trial Blocks 10 through 13.[2] The results of this analysis are presented in Table 13 and show two effects were significant at the $p < .001$ level. These effects were the Trial Type Condition and Goalbox 1 Preshift Reward Magnitude x Trial Blocks interaction.

Table 14 presents the simple effects analyses of the Goalbox 1 Preshift Reward Magnitude x Trial Blocks interaction. From Table 13 and Figure 4 it is evident that the groups which received 4 pellets in Goalbox 1 during preshift continued to run faster than the 12 pellet groups on preshift Trial Block 9 and postshift Trial Block 10 ($ps < .001$). No differences were found on Trial Blocks 11, 12 and 13 as a function of Goalbox 1 Preshift Reward Magnitude ($ps > .001$). All effects involving Goalbox 1 Postshift Reward Magnitude failed to be statistically reliable ($ps < .001$).

Alley 2 running speeds. The mean Alley 2 running speeds are shown in Figure 5, from which it may be seen that the FE was present for all groups and that on rewarded trials the effects of Goalbox 2 Reward Magnitude and Goalbox 1 Postshift Reward Magnitude were most pronounced.

Figure 4. Mean alley 2 reward trial and nonreward trial start speeds as a function of goalbox 1 preshift reward magnitude, goalbox 1 postshift reward magnitude, and goalbox 2 reward magnitude over preshift trial block 9 and postshift trial blocks 10-13.

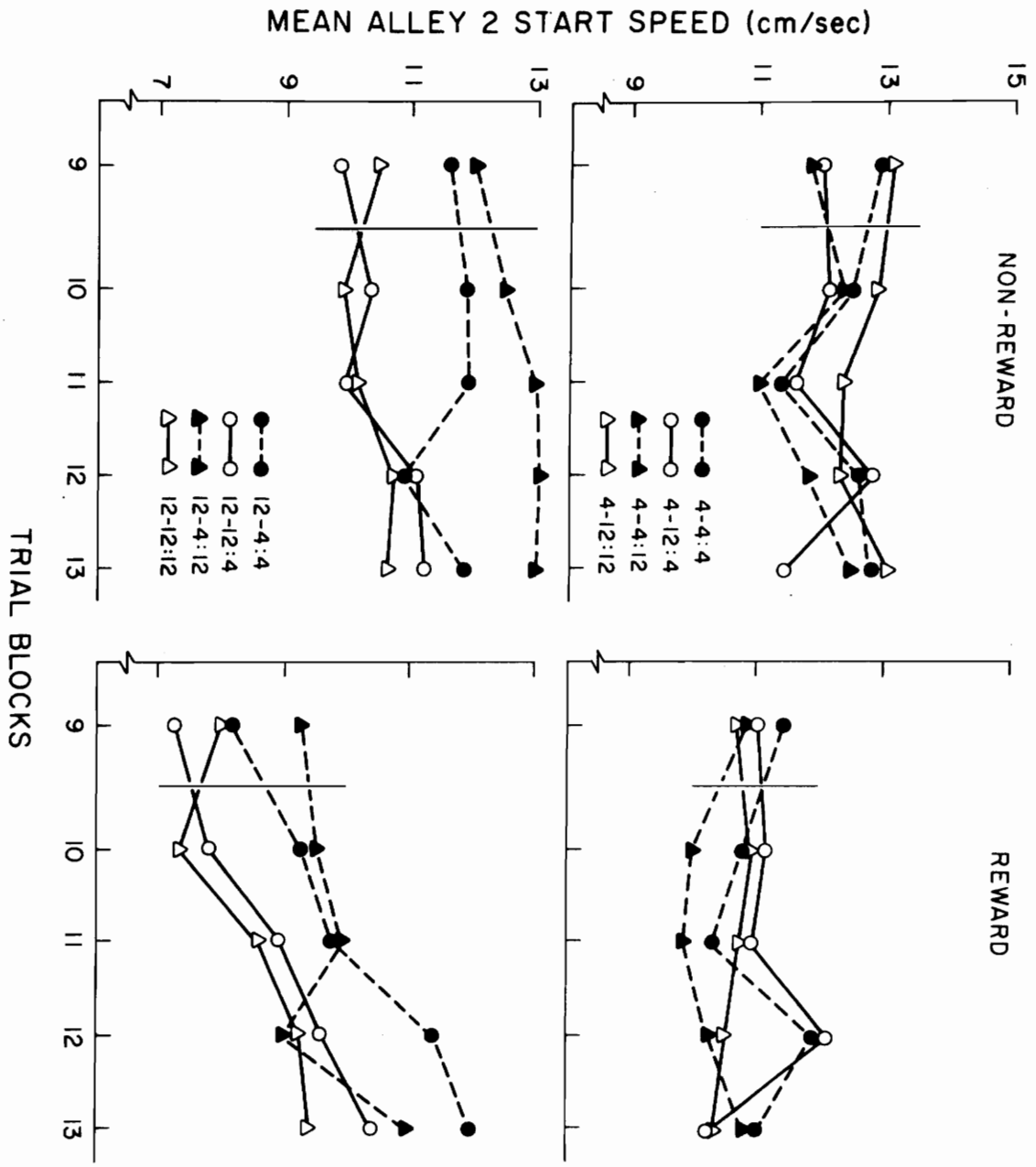

MEAN ALLEY 2 START SPEED (cm/sec)
NON-REWARD
REWARD
TRIAL BLOCKS
4-4:4
4-12:4
4-4:12
4-12:12
12-4:4
12-12:4
12-4:12
12-12:12

Table 13

Summary of Analysis of Variance Performed on Mean Alley 2 Start Speeds Over Preshift Trial Block 9 and Postshift Trial Blocks 10-13

Source of Variance	SS	df	MS	F
Goalbox 1 Preshift Reward Magnitude (GB1)	406.49	1	406.49	3.89
Goalbox 2 Reward Magnitude (GB2)	.46	1	.46	.004
GB1 X GB2	6.49	1	6.49	.06
Goalbox 1 Postshift Reward Magnitude (PGB1)	111.39	1	111.39	1.07
GB1 X PGB1	192.49	1	192.49	1.84
GB2 X PGB1	.48	1	.48	.005
GB1 X GB2 X PGB1	42.60	1	42.60	.41
Ss/GB1 GB2 PGB1	9926.52	95	104.49	
Trial Type Condition (TT)	700.07	1	700.07	33.32****
TT X GB1	28.33	1	28.33	1.35
TT X GB2	67.26	1	67.26	3.20
TT X GB1 X GB2	.003	1	.003	0.00
TT X PGB1	1.20	1	1.20	.06
TT X GB1 X PGB1	.68	1	.68	.03
TT X GB2 X PGB1	.09	1	.09	.004
TT X GB1 X GB2 X PGB1	31.39	1	31.39	1.49
TT X Ss/GB1 GB2 PGB1	1996.19	95	21.01	
Trial Blocks (B)	120.60	4	30.15	4.63****
B X GB1	124.60	4	31.15	4.78****
B X GB2	22.32	4	5.58	.86
B X GB1 X GB2	22.42	4	5.61	.86
B X PGB1	10.00	4	2.50	.38

Table 13 (continued)

Source of Variance	SS	df	MS	F
B X GB1 X PGB1	19.82	4	4.96	.76
B X GB2 X PGB1	10.94	4	2.73	.42
B X GB1 X GB2 X PGB1	4.56	4	1.14	.18
B X Ss/GB1 GB2 PGB1	2473.77	380	6.51	
TT X B	24.05	4	6.01	1.28
TT X B X GB1	47.57	4	11.89	2.54
TT X B X GB2	13.88	4	3.47	.74
TT X B X GB1 X GB2	16.66	4	4.17	.89
TT X B X PGB1	3.59	4	.90	.19
TT X B X GB1 X PGB1	4.95	4	1.24	.26
TT X B X GB2 X PGB1	46.38	4	11.59	2.47
TT X B X GB1 X GB2 X PGB1	9.57	4	2.39	.51
TT X B X Ss/GB1 GB2 PGB1	1781.30	380	4.69	

****$p < .001$

Table 14

Test of Differences in Mean Alley 2 Start Speeds for Assessment of the Goalbox 1 Reward Magnitude (4 vs 12 Pellets) x Trial Block Interaction

Condition										
Goalbox 1 Reward Magnitude	4	4	4	4	12	4	12	12	12	12
Trial Block	12	9	10	13	13	11	12	11	10	9
Ordered Means	11.84	11.71	11.66	11.57	11.24	11.06	10.77	10.28	9.82	9.48

Range	2	3	4	5	6	7	8	9	10
Duncan's Multiple Range Statistic	4.654	4.798	4.898	4.974	5.034	5.085	5.128	5.166	5.199
Test Statistic	1.16	1.20	1.23	1.24	1.26	1.27	1.28	1.29	1.30

Table 14 (continued)

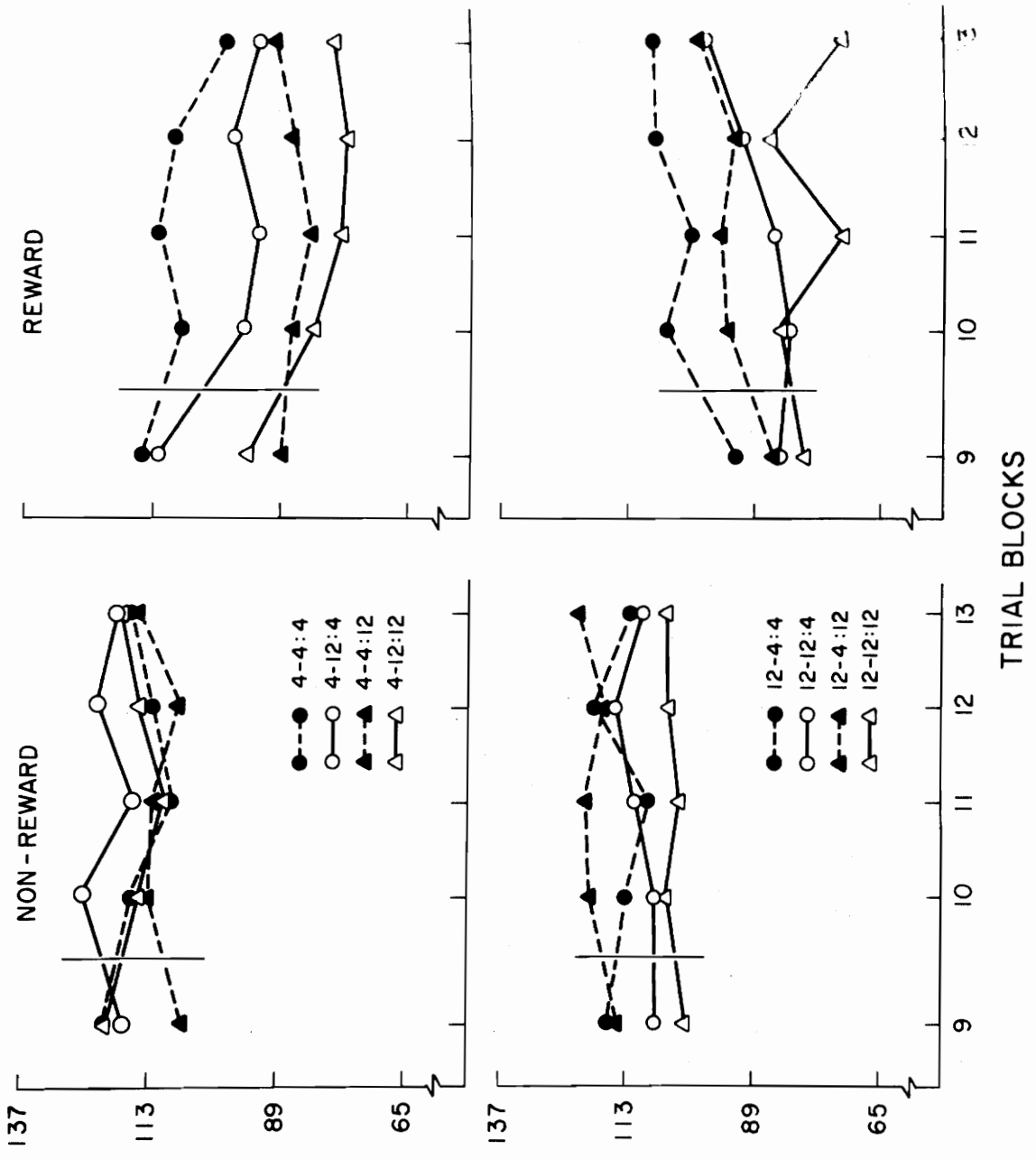
Difference Table

	12-(9)	12-(10)	12-(11)	12-(12)	4-(11)	12-(13)	4-(13)	4-(10)	4-(9)	4-(12)
12-(9)	-	.33	.80	1.29*	1.58*	1.76*	2.09*	2.18*	2.23*	2.36*
12-(10)		-	.46	.95	1.24*	1.42*	1.75*	1.84*	1.89*	2.02*
12-(11)			-	.48	.78	.96	1.29*	1.38*	1.42*	1.56*
12-(12)				-	.30	.47	.80	.89	.94	1.07
4-(11)					-	.18	.51	.60	.64	.78
12-(13)						-	.33	.42	.47	.60
4-(13)							-	.09	.13	.27
4-(10)								-	.05	.18
4-(9)									-	.13

*$p < .001$

Note: $MS_{Error}=MS_{B \times Ss/GB1\ GB2\ PGB1}=6.51$; $n=104$.

Figure 5. Mean alley 2 reward trial and nonreward trial running speeds as a function of goalbox 1 preshift reward magnitude, goalbox 1 postshift reward magnitude, and goalbox 2 reward magnitude over preshift trial block 9 and postshift trial block 10-13.


NON-REWARD
REWARD
4-4:4
4-12:4
4-4:12
4-12:12
12-4:4
12-12:4
12-4:12
12-12:12
137
113
89
65
9
10
11
12
13
1
2
3
MEAN ALLEY 2 RUNNING SPEED (cm/sec)
TRIAL BLOCKS

A 2 x 2 x 2 x 2 x 5 (Goalbox 1 Preshift Reward Magnitude x Goalbox 1 Postshift Reward Magnitude x Goalbox 2 Reward Magnitude x Trial Type Condition x Trial Blocks) factorial analysis of variance was performed over preshift Trial Block 9 and postshift Trial Blocks 10 through 13.[2] The results of this analysis are shown in Table 15 from which the following significant effects may be noted: Goalbox 2 Reward Magnitude x Trial Type Condition ($p < .001$); Goalbox 1 Postshift Reward Magnitude x Trial Type Condition ($p < .001$); and Goalbox 1 Preshift Reward Magnitude x Trial Type Condition x Trial Blocks ($p < .001$).

The assessment of the Goalbox 2 Reward Magnitude x Trial Type Condition interaction is given in Table 16 from which it may be seen that groups which received 4 or 12 pellets in Goalbox 2 showed significant FE's ($ps < .001$). The significant interaction was apparently due to faster Alley 2 speeds on reward trials exhibited by the 4 pellet groups as compared to the 12 pellet groups ($p < .001$). No significant differences as a function of Goalbox 2 Reward Magnitude were obtained in nonreward trials ($p > .001$).

The Goalbox 1 Postshift Reward Magnitude x Trial Type Condition interaction was assessed by the simple effects analyses presented in Table 17, from which it may be seen that (1) significant FE's were obtained for groups which received 4 or 12 pellets in Goalbox 1 during postshift ($p < .001$) and (2) on reward trials the groups receiving 4 pellets in Goalbox 1 during postshift ran faster than the associated groups receiving 12 pellets ($p < .001$). No differences were obtained as a function of Goalbox 1 Postshift Reward Magnitude on nonrewarded trials ($p > .001$).

Table 15

Summary of Analysis of Variance Performed on Mean Alley 2 Running Speeds Over Preshift Trial Block 9 and Postshift Trial Blocks 10-13

Source of Variance	SS	df	MS	F
Goalbox 1 Preshift Reward Magnitude (GB1)	2936.74	1	2936.74	.78
Goalbox 2 Reward Magnitude (GB2)	18613.44	1	18613.44	4.95
GB1 X GB2	3332.30	1	3332.30	.89
Goalbox 1 Postshift Reward Magnitude (PGB1)	12532.05	1	12532.05	3.34
GB1 X PGB1	6699.66	1	6699.66	1.78
GB2 X PGB1	155.36	1	155.36	.04
GB1 X GB2 X PGB1	851.26	1	851.26	.23
Ss/GB1 GB2 PGB1	356936.74	95	3757.23	
Trial Type Condition (TT)	118095.12	1	118095.12	294.13****
TT X GB1	4.04	1	4.04	.01
TT X GB2	8695.95	1	8695.95	21.66****
TT X GB1 X GB2	680.74	1	680.74	1.70
TT X PGB1	4893.83	1	4893.83	12.19****
TT X GB1 X PGB1	675.38	1	675.38	1.68
TT X GB2 X PGB1	1541.09	1	1541.09	3.84
TT X GB1 X GB2 X PGB1	218.49	1	218.49	.54
TT X Ss/GB1 GB2 PGB1	38143.09	95	401.51	
Trial Blocks (B)	1339.55	4	334.89	1.49
B X GB1	4765.42	4	1191.35	5.30
B X GB2	1095.06	4	273.77	1.22
B X GB1 X GB2	1292.85	4	323.21	1.44
B X PGB1	2165.27	4	541.32	2.41

Table 15 (continued)

Source of Variance	SS	df	MS	F
B X GB1 X PGB1	194.06	4	48.51	.22
B X GB2 X PGB1	1442.69	4	360.67	1.61
B X GB1 X GB2 X PGB1	1099.89	4	274.97	1.22
B X Ss/GB1 GB2 PGB1	85344.62	380	224.59	
TT X B	486.66	4	121.67	.75
TT X B X GB1	3016.93	4	754.23	4.66****
TT X B X GB2	495.86	4	123.96	.77
TT X B X GB1 X GB2	859.54	4	214.89	1.33
TT X B X PGB1	1566.82	4	391.70	2.42
TT X B X GB1 X PGB1	461.69	4	115.42	.71
TT X B X GB2 X PGB1	978.93	4	244.73	1.51
TT X B X GB1 X GB2 X PGB1	339.55	4	84.88	.52
TT X B X Ss/GB1 GB2 PGB1	61554.34	380	161.98	

****$p < .001$

Table 16

Test of Differences in Mean Alley 2 Running Speeds for Assessment of the Goalbox 2 Reward Magntiude (4 vs 12 Pellets) x Trial Type Condition (Nonreward vs Reward) Interaction

Condition				
Goalbox 2 Reward Magnitude	4	12	4	12
Trial Type Condition	N	N	R	R
Ordered Means	115.10	112.42	99.57	85.30

Range		2	3	4
Duncan's Multiple Range Statistic		4.894	5.055	5.166
Test Statistic		6.08	6.28	6.42

Difference Table

	12-(R)	4-(R)	12-(N)	4-(N)
12-(R)	-	14.27*	27.12*	29.80*
4-(R)		-	12.85*	15.53*
12-(N)			-	2.68

*$p < .001$

Note: $MS_{Error}=MS_{TT \times Ss/GB1\ GB2\ PGB1}=401.51$; $n=260$.

Table 17

Test of Differences in Mean Alley 2 Running Speeds for Assessment of the Goalbox 1 Postshift Reward Magnitude (4 vs 12 Pellets) x Trial Type Condition (Nonreward vs Reward) Interaction

Condition				
Goalbox 1 Postshift Reward Magnitude	4	12	4	12
Trial Type Condition	N	N	R	R
Ordered Means	115.07	112.46	98.09	86.81

Range		2	3	4
Duncan's Multiple Range Statistic		4.984	5.055	5.166
Test Statistic		6.08	6.28	6.42

Difference Table

	12-(R)	4-(R)	12-(N)	4-(N)
12-(R)	-	11.28*	25.65*	28.25*
4-(R)		-	14.37*	16.97*
12-(N)			-	2.60

*$p < .001$

Note: $MS_{Error}=MS_{TT \times Ss/GB1\ GB2\ PGB1}=401.51$; $n=260$.

Finally, the simple effects analysis of the Goalbox 1 Preshift Reward Magnitude x Trial Type Condition x Trial Blocks interaction is presented in Table 18. As can be seen from Table 18, this interaction was produced by a Goalbox 1 Preshift Reward Magnitude x Trial Type Condition interaction which was significant on Trial Block 9 ($p < .001$) and which was not significant on Trial Blocks 10 through 13 ($p > .001$). It may be seen from the previously mentioned Table 9 that while both groups showed significant FE's on Trial Block 9 the significant interaction was due to faster Alley 2 running exhibited by the 4 pellet group than the 12 pellet group following reward and nonreward in Goalbox 1.

Table 18 also presents the analysis of the effects of Goalbox 1 Preshift Reward Magnitude and Trial Type Condition (i.e., FE) on Trial Blocks 10, 11, 12, 13. It is clear that while the Goalbox 1 Preshift Reward Magnitude failed to produce reliable differences on any of these Trial Blocks ($ps > .001$) the FE's were highly significant at each of the four Trial Blocks ($ps < .001$).

Table 18

Simple Effects Analyses Performed on Mean Alley 2 Running Speeds for Assessment of the Goalbox 1 Preshift Reward Magnitude x Trial Type Condition x Trial Block Interaction

Source of Variance	df	MS	F
Goalbox 1 Preshift Reward Magnitude x Trial Type Condition (GB1 x TT) at Trial Block	1	1857.21	11.47*
GB1 x TT at Trial Block 10	1	169.47	1.05
GB1 x TT at Trial Block 11	1	13.04	.08
GB1 x TT at Trial Block 12	1	61.37	.38
GB1 x TT at Trial Block 13	1	919.84	5.68
TT x B x Ss/GB1 GB2 PGB1	380	161.98	
GB1 at Trial Block 10	1	659.92	2.94
GB1 at Trial Block 11	1	184.65	.82
GB1 at Trial Block 12	1	50.89	.23
GB1 at Trial Block 13	1	46.39	.21
B x Ss/GB1 GB2 PGB1	380	224.59	
Trial Type Condition (TT) at Trial Block 10	1	25485.13	157.34*
TT at Trial Block 11	1	24822.33	153.24*
TT at Trial Block 12	1	22343.62	137.94
TT at Trial Block 13	1	27230.63	168.11
TT x B X Ss/GB1 GB2 PGB1	380	161.98	

*$p < .001$

Discussion

A summary of results is contained in Table 19 and describes the significant effects in both Alley 1 and Alley 2 for both the preshift and postshift experimental phases.

Alley 1

Preshift. During preshift groups which received 4 pellets in Goalbox 2 showed faster start and running speeds than groups which received 12 pellets in Goalbox 2. While several studies have examined the effects of magnitude of reward in Goalbox 1 of a double alleyway (McHose & Gavelik, 1969; Peckham & Amsel, 1967; Krippner, Endsley, & Tacker, 1967a; McHose & Ludvigson, 1965), the emphasis has been placed on the Alley 2 findings. From the present data it appears that within the double alleyway the magnitude of reward variable operates in a manner which is opposite to that reported when reward magnitude and partial reinforcement are manipulated in a single alleyway (Wagner, 1961).

Without prior findings, it remains to interpret the above findings within a theoretical framework. McHose (1970) and Daly (1968) have offered an empirically oriented description which would seem to merit consideration. Within this description, the double alleyway is conceptualized as representing a differential conditioning paradigm. The contrasting reward values in Goalbox 1 and Goalbox 2 dictate the nature of performance to be expected in Alley 1 and Alley 2. If reward is larger in one alleyway rather than the other then the speeds approaching the larger reward should be faster than if both magnitudes were large.

Table 19

Summary of Alley 1 and Alley 2 Results

Phase	Measure	Effect	Result
			Alley 1
Preshift	Start and Running Speeds	GB2	GB2=4 faster than GB2=12
Postshift	Start Speeds	B	No other effects were significant
	Running Speeds	GB1	GB1 faster than GB1=12
			Alley 2
Preshift	Start Speeds	GB1 x TT	Nonreward Trials: GB1=4 faster than GB1=12 Reward Trials: GB1-4 faster than GB1=12 FE for GB1=12 greater than FE for GB1=4
	Running Speeds	GB1 x TT at Trial Block 9	Nonreward Trials: GB1=4 equal to GB1=12 Reward Trials: GB1=4 faster than GB1=12 FE for GB1=12 greater than FE for GB1=4
	Start Speeds	GB2 x TT	Nonreward Trials: GB2=4 equal to GB2=12 Reward Trials: GB2=4 faster than GB2=12 FE for GB2=12 greater than FE for GB2=4
Preshift	Running Speeds	GB2 x TT	Nonreward Trials: GB2=4 faster than GB2=12 Reward Trials: GB2=4 faster than GB2=12 FE for GB2=12 greater than FE for GB2=4

Table 19 (continued)

Phase	Measure	Effect	Result
Postshift	Start Speeds	GB1 x TT at Trial Blocks 9, 10	Nonreward Trials: GB1=4 faster than GB1=12 Reward Trials: GB1=4 faster than GB1=12 FE for GB1=12 greater than FE for GB1=4
		GB1 x TT at Trial Blocks 11, 12, 13	No effect of GB1
	Running Speeds	GB1 x TT at Trial Block 9	Nonreward Trials: GB1=4 equal to GB1=12 Reward Trials: GB1=4 faster than GB1=12 FE for GB1=12 greater than FE for GB1=4
		GB1 x TT at Trial Blocks 10, 11, 12, 13	No effect of GB1
		PGB1 x TT	Nonrewarded Trials: PGB1=4 equal to PGBL=12 Reward Trials: PGBL=4 faster than PGB1=12 FE for PGB1=12 greater than FE for PGB1=4
		GB2 x TT	Nonreward Trials: GB2=4 equal to GB2=12 Reward Trials: GB2=4 faster than GB2=12 FE for GB2=12 greater than FE for GB2=4

Conversely, speeds approaching the smaller of two rewards should be slower than if both magnitudes were small. In a sense, the former would be equivalent to a "positive contrast" and the latter to a "negative contrast."

Examination of Figure 1 and Table 19 reveals that during preshift groups 4:4 and 12:4 exhibited faster speeds than groups 4:12 and 12:12. According to the above notion, groups 12:4 and 4:12 experience a positive and negative contrast, respectively, in Goalbox 1. The major finding which remains to be interpreted, however, is the faster speeds of group 4:4 and the slower speeds of group 12:12. While the author is reluctant to posit a dual process explanation, it is possible that for the 12:12 group the larger reward magnitude in Goalbox 1 yields greater interference with performance due to the greater amount of fractional frustration ($\underline{r_f}$) in Alley 1 or greater partial reinforcement frustration in Goalbox 1 than would be experienced by the 4:4 group. While the interfering effects of $\underline{r_f}$ would also be expected to occur for groups 4:12 and 12:4, the present data indicate that the contrast process is the more potent effect.

Postshift. The postshift data indicate that the running speed measure was affected solely by the preshift levels of reward. Examination of Figure 3 and Table 19 reveals that group 4-4:4 ran faster than group 12-4:4 and that group 4-12:4 ran faster than group 12-12:4. According to the above notion, it may be hypothesized that the 12-4:4 group experienced a negative contrast as a function of the reduction of reward in Goalbox 1. Similarly, the reward increase in Goalbox 1 for the 4-12:4 group would be interpreted as a positive contrast. With

respect to those groups which experienced 12 pellets in Goalbox 2, it is apparent that a shift from 4 to 12 pellets in Goalbox 1 (group 4-12:12) resulted in faster speeds than those maintained on 12 pellets (group 12-12:12) and thus they experienced a positive contrast. Shift from 12 to 4 pellets (group 12-4:12) did not appear to result in a negative contrast but rather resulted in a level comparable to the 4-4:12 group. The latter finding would seem to indicate that with large reward, the negative contrast experienced by reduction in Goalbox 1 reward is equivalent to the negative contrast experienced when Goalbox 1 reward is always smaller than Goalbox 2 reward. The absence of Goalbox 2 effects during postshift suggests that contrasts which are induced by shifts in Goalbox 1 reward magnitude take precedence over effects which may result from contrasts between the reward magnitudes of Goalbox 1 and Goalbox 2.

Alley 2

Preshift. One purpose of the present study was to determine the extent to which the FE would be affected by the reward magnitudes encountered in Goalbox 1 and Goalbox 2. The preshift Alley 2 data indicated that the 4 pellet Goalbox 1 Reward Magnitude groups' start speeds were faster than those of the 12 pellet Goalbox 1 Reward Magnitude groups on trials following either reward or nonreward. The 4 pellet Goalbox 1 Reward Magnitude groups ran faster than the 12 pellet Goalbox 1 Reward Magnitude groups on rewarded trials and did not differ from the 12 pellet Goalbox 1 Reward Magnitude groups on nonrewarded trials. Thus, the start and running speed FE's were larger for the groups which

received 12 pellets in Goalbox 1 than for the groups which received 4 pellets in Goalbox 1. Amsel (1962, 1958) has hypothesized that the magnitude of the FE is determined by the amount of primary frustration (R_F). R_F is hypothesized to be directly related to the strength of the anticipatory goal response (r_g). The strength of r_g is in turn directly related to the magnitude of reward encountered in Goalbox 1 on rewarded trials. Thus, the size of the FE should be directly related to the magnitude of reward encountered in Goalbox 1 on rewarded trials. The present results support Amsel's hypotheses.

Scull (1973) states that if Amsel's frustration theory is to be supported then groups which receive large Goalbox 1 reward should show faster Alley 2 speeds on nonreward trials than groups which receive small Goalbox 1 reward. According to this interpretation the present preshift start and running speed results do not support Amsel's theory. However, if large Goalbox 1 reward groups run slower than small reward groups on rewarded trials, they may show a greater increase in running speeds following nonreward, and yet be equal to the absolute level of nonreward running speeds exhibited by the small reward groups. Clearly the effects of nonreward are greater for the large reward groups and hence one should conclude that their FE's are greater. This latter interpretation of the size of FE's will be used throughout this paper.

The finding of an inverse relationship between Alley 2 speeds and Goalbox 1 Reward Magnitude on rewarded trials has been reported by investigators using within-subjects designs (McHose & Gavelik, 1969; McHose & Ludvigson, 1965; Peckham & Amsel, 1964) and a between-subjects design (McHose & Gavelik, 1969). Krippner et al. (1967a) failed to find

any effects of Goalbox 1 reward magnitude on reward trial Alley 2 speeds. The relationship between first goalbox reward magnitude and nonreward trial Alley 2 speeds has been reported as being direct (Peckham & Amsel, 1967; Krippner, et al., 1967a) or nonexistent (McHose & Gavelik, 1969; McHose and Ludvigson, 1965). An inverse relationship between Alley 2 speeds and Goalbox 1 reward magnitude has been reported by Daly (1968) and Karabenick (1969). These latter investigations used between groups designs and presented rats with continuous reinforcement in Goalbox 1.

The results of the present study indicate that Alley 2 running speeds are inversely related to Goalbox 2 Reward Magnitude on trials following either reward or nonreward in Goalbox 1. Alley 2 start speeds are inversely related to Goalbox 2 Reward Magnitude on trials following reward in Goalbox 1 and are unaffected on trials following nonreward in Goalbox 1. These results indicate that for Alley 2 start and running speeds the size of the FE is directly related to Goalbox 2 Reward Magnitude. Krippner, Endsley and Tacker (1967b) obtained an inverse relationship between Alley 2 start speeds and concluded that the size of the FE was unrelated to Goalbox 2 reward magnitude. As the number of studies which have attempted to relate Goalbox 2 reward magnitude and the size of the FE is small, further research is needed to resolve the different findings of the present study and those of Krippner, et al. (1967b).

Amsel's frustration theory (1962, 1958) makes no reference to the effects of second goalbox reward magnitude on the size of the FE. Daly (1968) has suggested that the reward magnitudes experienced in the two goalboxes generalize. Thus, large Goalbox 2 reward would yield larger

perceived Goalbox 1 reward magnitudes than would small Goalbox 2 reward magnitudes. If it is assumed that the size of the FE is directly related to the perceived reward magnitude experienced in Goalbox 1 then the present results are accounted for. The major shortcoming of Daly's explanation is that the mechanism for goalbox reward magnitude generalization is unspecified. Since the alleyways and goalboxes were different (black with rubber floor vs white with natural wood grain floor) intergoalbox generalization was, if any, felt to be limited.

The results of the present study indicated an inverse relationship between Alley 2 speeds and Goalbox 1 and Goalbox 2 reward levels for trials following reward in Goalbox 1. Extending the notions suggested for the Alley 1 data, rats which received large rewards in Goalbox 1 were reluctant to leave that goalbox because of its high secondary reinforcement value. Rats which received small rewards in Goalbox 1 had less secondary reinforcement associated with Goalbox 1 and hence were less reluctant to run in Alley 2. If it is assumed that r_g interferes with ongoing running behavior then the effects of Goalbox 2 Reward Magnitude on Alley 2 speeds following Goalbox 1 reward may be accounted for. The higher the Goalbox 2 reward magnitude the larger the r_g, and hence the greater the interference with Alley 2 speeds. Clearly, further research is needed to assess the utility and generality of the above explanations.

Postshift. The second major interest of the present study was to assess the effects of Goalbox 1 reward magnitude shift on the magnitude of the FE. The basic premise underlying the present study is that if incomplete reduction of Goalbox 1 reward is in itself frustrating then this frustration would combine with the frustration generated by nonreward

and yield a greater FE. Thus, if incomplete reduction of Goalbox 1 reward is inherently frustrating, the 12-4:4 and 12-4:12 groups should show greater FEs' than the 4-4:4 and 4-4:12 control groups, respectively. Such results would be indicated by a significant Goalbox 1 Preshift Reward Magnitude x Goalbox 1 Postshift Reward Magnitude x Trial Type Condition interaction.

The results of the present study indicate that the effect of Goalbox 1 Preshift Reward Magnitude on Alley 2 speeds decreases over the postshift phase of the experiment. Goalbox 1 Postshift Reward Magnitude and Goalbox 2 Reward Magnitude showed an inverse relationship to Alley 2 reward trial running speeds and did not significantly affect nonrewarded trial running speeds. During postshift, significant running speed FEs' were found for groups which received either 4 or 12 pellets in Goalbox 1 during postshift, and also for groups which received either 4 or 12 pellets in Goalbox 2. The Goalbox 1 Preshift Reward Magnitude x Goalbox 1 Postshift Reward Magnitude interaction and all other interactions involving these factors were found to be not significant by analyses of Alley 2 start and running speeds. These latter results indicate that the shift of reward in Goalbox 1 did not result in performance levels that were reliably faster or slower than control groups maintained on the reduced level of Goalbox 1 reward magnitude throughout the experiment.

These results are similar to the results reported by McHose and Ludvigson (1965) and Barrett, Peyser, and McHose (1965). These investigators, using partial within-subjects designs, found that incomplete reduction of Goalbox 1 reward resulted in faster Alley 2 speeds. However,

these speeds were not faster than the speeds of control groups maintained on the reduced level. In addition, McHose and Ludvigson (1965) report that the FE was larger for large rather than small Goalbox 1 reward magnitude. The conclusion of both studies was that incomplete reduction of reward in Goalbox 1 did not result in faster Alley 2 speeds than those of groups maintained on the reduced level.

As previously mentioned, Daly (1968) has criticized studies using within-subject incomplete reward reduction in terms of possible contamination by carryover effects. Daly performed an experiment during which groups of rats received continuous reward in Goalbox 1. Experimental groups experienced Goalbox 1 reward reduction after an acquisition phase. Alley 2 speeds for the reduced reward groups were not found to be faster than those groups maintained on the reduced magnitudes throughout the experiment. Daly reported that the group shifted from 15 pellets to 1 pellet ran as fast as the 1 pellet control group and faster than a group maintained on zero pellets in the first goalbox throughout the experiment. On this basis Daly concluded that large reward reduction to nonzero levels is frustrating.

Karabenick (1969) found that incomplete reduction of Goalbox 1 reward resulted in Alley 2 speeds that were faster than those of non-reduced controls, but were not faster than those of control groups maintained on the reduced reward level throughout the experiment. Karabenick also found that while increases in Goalbox 1 reward magnitude led to decreases in Alley 2 speeds relative to nonshifted controls, these speeds were not slower than those of controls maintained on the increased level of reward throughout the experiment. These results are similar to

the reward trial postshift results of the present study. Finally, similar to the reward trial results of the present experiment, Karabenick found that second Goalbox 2 reward magnitude and second alley speeds were inversely related.

In summary, incomplete reduction of Goalbox 1 reward neither affects the size of the FE through frustration greater than that of control groups, as indicated by the results of this study, McHose and Ludvigson (1965), and Barrett, Peyser, and McHose (1965), nor is it inherently frustrating (Karabenick, 1969; Daly, 1968). Thus, it would appear that complete reduction of reward is a qualitatively different event than incomplete reduction of reward. As indicated previously, the effects of reward shift on the FE appear to be mediated strictly by the level of reward magnitude, rather than by any frustrative properties of shift. This is indicated by the lack of interactions involving preshift and postshift Goalbox 1 reward level effects.

Finally, it should be noted that during the postshift phase of the present study the reward level encountered in the second goalbox had the same effects as reported during the preshift phase. Alley 2 running speeds varied inversely with the reward level encountered in the second goalbox on rewarded trials, and the larger reward magnitude resulted in a larger FE than the smaller reward magnitude. The consistency of this effect argues well that contrasts between the first and second goalbox do affect Alley 2 speeds.

Summary

During preshift, Alley 1 start and running speeds were inversely related to Goalbox 2 reward magntiude. These results were interpreted

as being due to contrasts between Goalbox 1 and Goalbox 2 reward magnitudes. Alley 1 running speeds were inversely related to preshift Goalbox 1 reward magnitude during postshift. These results were accounted for by examining the possible effects of contrasts in Goalbox 1 due to the shifting of reward magnitudes.

The preshift Alley 2 results indicated that the size of the FE was directly related to Goalbox 1 and Goalbox 2 reward magnitude. While the Goalbox 1 effect is in accord with Amsel's frustration theory, the Goalbox 2 effect is interpreted within a response competition and secondary reinforcement context. During postshift the size of the FE was directly related to the magnitude of reward received in Goalbox 1 during postshift and in Goalbox 2. In general, the data suggest that incomplete reward reduction does not constitute a frustrative event.

Footnotes

[1]To achieve equal cell frequencies, the missing data of one subject that refused to run in the alleyway was replaced with the mean of the available data from the corresponding treatment combination. The degrees of freedom for all analyses of variance were reduced accordingly.

[2]Main effects and interactions were deemed significant if they were at the $p < .001$ significance level, this following the suggestion of Brownlee (1965, pp. 510-511) on controlling alpha error for analyses of variance with over 20 sources of variance.

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THE EFFECTS OF DIFFERENTIAL GOALBOX REWARD AND REWARD SHIFTS ON THE FRUSTRATION EFFECT

by

James Charles Gutmann

(ABSTRACT)

To determine whether incomplete reward reduction and reward increment would influence the "frustration effect" (FE) in double alleyway, rats were given 153 trials with 50% partial reward in Goalbox 1 with 4 or 12 pellets in Goalbox 1 and 4 or 12 pellets in Goalbox 2. On trials 106-153, the postshift phase, half of the rats in each group were shifted to a reward magnitude opposite to that previously received in Goalbox 1. During preshift, Alley 1 start and running speeds were inversely related to Goalbox 2 reward magnitude. The size of the FE was directly related to Goalbox 1 and Goalbox 2 reward magnitude. During postshift, Alley 1 running speeds were inversely related to preshift Goalbox 1 reward magnitude. The size of the FE was directly related to Goalbox 1 and Goalbox 2 reward magnitude. The results were discussed in terms of Amsel's theory of frustration.