RECENCY AND SUMMATION EFFECTS OF NONREWARD IN CHILDREN

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ABSTRACT

RECENCY AND SUMMATION EFFECTS OF NONREWARD IN CHILDREN

By

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This study was designed to investigate the effects of recency and summation of frustrative nonreward on children's performance. Kindergarten children performed a lever pulling task on a three-lever apparatus. Session I consisted of 100% reinforcement; Sessions II and III consisted of three partial reinforcement patterns presented in random orders.

Analyses of latency and movement times at the third lever confirmed the recency hypothesis; i.e., when a single nonreward was administered in two different patterns a greater FE occurred after the more immediate nonreward than after a nonreward that was separated from the time of measurement by a rewarded response. The data analyses also supported the notion of the summation properties of nonreward since two successive nonrewards yielded a greater FE than a single nonreward. Theoretical discussion focused on a new concept of reward expectancy.

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N. H. D.

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RECENCY AND SUMMATION EFFECTS OF NONREWARD IN CHILDREN

Considerable research has been generated by Amsel's (1958) interpretation of the 'frustrative nonreward effect'. By 'frustration' Amsel refers to the "active properties of non-reward following reward [Amsel, 1962, p. 306]." Amsel (1958, 1962) used a criterion response (running in the second length of a double runway) that was spatially different from the non-reinforced instrumental response (running in the first length). Amsel suggested that subsequent to the development of reward expectancy nonreward leads to frustration, an aversive emotion which increases the response that immediately follows the unrewarded response.

Study of the frustration effect (FE) in children was begun by Penney, whose findings are in accord with those of Amsel in that "nonreinforcement of a response at one lever (R_1) increases the speed of a subsequent response at a second lever (R_2), where both R_1 and R_2 have been reinforced by the same reward [Penney, 1960, p. 214]." Penney (1960) reports that the increment in speed of R_2 is a function of the number of continuous reinforcements the child received prior to the introduction of nonreinforcement. Nevertheless, as Ryan and Watson (1968) have suggested, Penney's results may show only an <u>apparent</u> frustration effect that is attributable to slower speeds following nonrewarded trials.

In their recent review of the frustrative nonreward literature, Ryan and Watson (1968) point out that the use of massed trials (short intertrial intervals) characterizes many unsuccessful attempts to obtain the FE. Using spaced trials (long intertrial intervals) to counteract the carry-over of frustration from one trial to another, Ryan (1965) found that smaller R_2 response latencies in the 50% reinforcement group, as compared with the 100% group, did support an FE interpretation. The 50% group also had smaller response latencies than the 100% group on rewarded trials--a phenomenon which Ryan interprets as a "ceiling effect or perseveration of frustration from nonrewarded to rewarded trials [Ryan and Watson, 1968, p. 114]."

A study of size of interresponse intervals (IRI, i.e., time between R_1 and R_2) reveals that transient nature of the FE (Watson and Ryan, 1966). For an IRI greater than 5 seconds, R_2 movement speed was not at all determined by R_1 reward conditions.

Thus, this series of studies strongly suggests a frustration effect with children; yet the theory of nonreward may be further specified by looking at the possible effect of the patterning of nonreward on the size of the FE. A look at the frequency and recency aspects of that patterning might determine whether these are at all related to the FE. Will nonreward of two spatially separate responses have a greater frustration effect on a third response than nonreward at just one of them? What effect will nonreward of a response have on a later response when the two are separated in time and space by a rewarded response? The first of these questions deals with the summation of nonreward.

There is to date no study reported in the child literature directed to this question. Nevertheless, Bower (1962), employing a three-alley apparatus--an extension of Amsel's two-alley runway--found with rats as Ss that experience with two nonrewards led to faster running times than did experience with one nonreward. There have been no attempts to replicate Bower's demonstration of a summation effect nor to extrapolate to the interpretation of frustration effects in children. The first purpose of the present study is, therefore, to attempt to test Bower's finding in a different operant setting--a three-lever analogue of the three-alley runway--with children as Ss. The second purpose of the study is to determine whether there is an effect due to recency of nonreward.

METHOD

Subjects. Subjects were 50 children from the Elliott School Kindergarten, Holt, Michigan. A total of 20 children were discarded due to absence on one of the three consecutive days of testing (5 children were lost in this manner), and due to apparatus malfunction (failure of relays to stop timing devices). Consequently, the final sample in the study consisted of 30 kindergarten children (Mean age = 5.8 yr, sd = .36 yr.). There were 15 boys and 15 girls.

Apparatus. The apparatus was a child-sized metallic gray desk--a right-angled box with adjustable legs attached. As indicated in Fig. 1, three levers (R_1, R_2, R_3) were mounted on the 22 x 30 in. sloping front. Also mounted on the sloping front surface of the desk were three corresponding green stimulus arrows (S_1, S_2, S_3) and a metal goal cup. A smaller separate console housed a power switch, a relay switch for lever selection, and two clocks (one latency, one movement), as well as two amplifiers and a power supply.

Insert Figure 1 about here

The three levers were moved in the order R_1-R_2-R_3. R_1 was pushed to the left along a 16 in. horizontal track; R_2 began slightly below the end of the R_1 track and was pulled down the sloping surface toward S along an 11 in. vertical track; and R_3 began at the endpoint of the R_2 excursion and pulled toward the right along an 8 in. horizontal track.

Procedure. The E manipulated the incidence of nonreward at R_1 and/or at R_2 and measured the effect of these manipulations on S's response at R_3. The manipulations of nonreward yielded three nonreward-reward conditions which were randomly administered to each S. A trial-sequence was represented by any one of the following conditions:

Condition NR-R-R Nonreward at R_1 followed by reward at R_2 and R_3.

Condition R-NR-R Reward at R_1 followed by nonreward at R_2 and reward at R_3.

Condition NR-NR-R Nonreward at R_1 and R_2 and reward at R_3.

A lever pull was initiated by a start switch, which in turn illuminated a stimulus light and activated an electronic timer. The stimulus lights served to direct the child's attention to the appropriate lever and to signal the beginning of a lever pull. As soon as a lever was moved, a photoelectric cell stopped the first timer and started the second. The first timer recorded latency (time between stimulus onset and initial movement of the lever) while the second timer recorded movement time (duration of the lever pull. After a lever was moved through its entire excursion, a marble was delivered manually from behind the hand shield via a transparent tube located at the left side of the desk. After each marble was deposited in the goal cup, **S** retrieved the marble and dropped it into a vertical plastic tube mounted on a plastic ledge. The IRI was maintained at 5 seconds since Watson and Ryan (1966) report that with longer intervals there is no relation between events at two successive levers. The ITI was two minutes so as to minimize possible carryover effects from one trial-sequence to another, while not prolonging the session unnecessarily. During the two-minutes ITIs, **S**s were read short picture stories. The story reading was to provide a relatively uniform intertrial interval activity for all **S**s which could be easily interrupted when resuming the lever pull task.

The experimental design consisted of one day of training under continuous reinforcement, followed by two days of the

test procedure during which the three reward-nonreward conditions were introduced. The situation was introduced to the child as a game and story time. Each **S** was shown an array of small toys and asked to select the one he would like to win. The child placed the toy on the ledge at the top of the marble rackup tube and was told that he might keep the toy he had chosen if he could completely fill the marble tube with marbles (capacity = 20 marbles). Then the child was told that he could "win" marbles by moving a lever from one end of its track completely to the other end. The signal light was pointed out and the child was instructed to move the lever "as soon as the light goes on". In addition, he was instructed to move the levers in the proper sequence: first the top lever, then the side lever, and finally the bottom lever, and then begin anew with the top lever. **S** placed his hand on the front edge of the desk after each manipulation of a lever.

Simultaneous with the instructions, each child completed two practice runs (i.e., performed all procedural steps for two lever pulls--R_1 and R_2). The remainder of the training session consisted of 6 trial-sequences (R_1-R_2-R_3) for eighteen marbles---which when combined with the two marbles gained in practice enabled **S** to win the toy.

On the following two days, the trial-sequences randomly comprised all three reward-nonreward conditions, yielding a total of 12 trial-sequences and enabling **S** to acquire twenty marbles. With the exception of the introduction of nonrewarded trials all other procedural details in the training phase were retained in the test phase.

Table 1 indicates the reinforcement schedule used for all Ss during both days of testing with nonreward. The schedule was established by starting the day with the R-NR pattern in order to reestablish the reward expectancy from the previous day on the first lever pull. The introduction of nonreward then followed according to the predetermined random schedules.

Insert Table 1 about here

The experiment was carried out in a small room near the children's kindergarten room. One E gave directions to the child, returned levers to their original positions, timed intertrial and interresponse intervals, and read the two-minute stories. A second E manipulated the start switch, channel selector and timing devices on the console (removed from the child's line of vision), and recorded latency and movement times.

Data Analysis. Four separate analyses of variance (Lindquist Model $A_{days} \times B_{reinforcement\ pattern} \times C_{subjects}$) were performed--one each for latency to R_2, latency to R_3, movement to R_2, and movement to R_3. After the main effects were tested in the main analysis of variance, the experimenter looked at the nonreinforcement phase in terms of planned comparisons for the

R_3 latency and R_3 movement times. The comparisons were made between the R-NR and the NR-R orders and between the NR-NR order and the remaining two.

RESULTS

Table 2 summarizes the entire study in terms of total response times (or the time to respond, summing across all trials on a given day and across all Ss). The reader should bear in mind that the nonreward condition at R_2 is actually comprised of two of the reinforcement patterns. Therefore, the NR-R and the NR-NR columns should be collapsed into one condition, nonreward at R_1, since Ss did not experience the different consequences at R_2 until after response measures for the second lever had been taken. For example, for Latency to R_2 on Day 1, the nonreward condition response time of 112.45 sec. (the average of 112.84 and 112.06) was compared with the reward condition time of 119.69 sec.

Insert Table 2 about here

Before analyzing for the summation and recency effects, it was deemed necessary to demonstrate the fundamental FE described in the nonreward literature. The results of the study satisfy this requirement since children's performance at the second lever was characterized by shorter latency and movement times following nonrewarded trials than following rewarded trials. This conforms with other studies that have demonstrated the FE in children, using latency measures (Ryan, 1965; Watson & Ryan, 1966; Lobb, Moffitt, & Gamlin, 1966) and movement speeds (Penney, 1960; Watson & Ryan, 1966).

Latency to R_2.— The analysis performed on latency to R_2, summarized in Table 3, yielded a significant order effect. This indicates a shorter latency following trials that are not rewarded at R_1 than is the case when R_1 is rewarded. This is the frustration effect of nonreward.

Insert Table 3 about here

It is apparent as shown in Fig. 2 that, although not statistically significant ($F = 1.22$), the difference between the R_1 reward condition (R-NR) and the nonreward conditions (NR-R/NR-NR) is even greater on Day 2 than on Day 1.

Insert Figure 2 about here

Movement to R_2.— Measures of R_2 movement time reflect very nearly the same pattern as those of latency. As shown in Table 4, theorder effect was again significant, indicating

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Insert Table 4 about here

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that movement response time was faster after nonrewarded trials than after those that were rewarded, and confirming the fundamental frustration effect found in Latency to R_2. It is interesting to note that latency times for the reward condition (R-NR) were considerably longer on Day 2 than on Day 1 (see Fig. 2). On the other hand, movement times were considerably shorter on Day 2 than on Day 1 (see Fig. 3).

Insert Figure 3 about here

Latency to R_3.— Table 5 summarizes the analysis of variance on R_3 latency. There was a significant main effect due to days reflecting a decrease in latency with the additional day of testing. The main effect of order was also significant

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Insert Table 5 about here

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and, interestingly enough, latency to R_3 decreased in the order of NR-R > R-NR > NR-NR (see Table 2). This was the order expected given that recency effects are operating in the second condition and both recency and summation effects are found in the third condition.

A planned comparison of the NR-R and the R-NR conditions indicated a significant difference between them [F (1,58)= 6.47, $p < .05$]. This is evidence for the recency effect of nonreward, since the R-NR condition had a greater effect on quickening *S*'s response at R_3 than did the NR-R condition. The two conditions employed differed procedurally only in the order of the nonreward; they were equivalent as to the numbers of rewards, nonrewards, and transitions between the two--important considerations in view of the work of Capaldi on sequential effects (Capaldi, 1966; Capaldi, 1967). Any systematic differences between the conditions should, therefore, have been due to the spacing of the nonreward. One implication of the greater frustration effects under the R-NR condition may be that with the more recent incidence of nonreward, its frustrating effects on subsequent responses had less chance to dissipate with time than those of the earlier nonreward--or less chance to be cancelled out by the effects of a subsequent reward.

A planned comparison between NR-NR and the remaining two conditions also revealed a significant difference [F (1,58)=12.50, $p < .01$]. The NR-NR order showed a significantly greater frustration effect than either of the remaining orders. This suggests that subsequent effects of successive nonreward may be said to be cumulative, supporting the summation hypothesis of the study.

Movement to R_3.— As shown in Table 6, the only significant effect was that due to order indicating, as with Movement to R_2, that response was faster after nonreward trials than after

Insert Table 6 about here

reward trials. A planned comparison between the R-NR and NR-R conditions did not yield a significant recency effect for movement times [F (1,58)= 6.50, $p < .025$].

DISCUSSION

The present study was designed to investigate the effects of recency and summation of nonreward with children. The results demonstrated that both recency and summation of nonreward influenced children's performance. The study suggests that the frustration effect depends not only on the incidence of nonreward, the variable most previous investigations of the FE have considered, but also on the patterning of nonreward. It is the nonreward patterning that prompts the recency and summation contentions.

The evidence gained in the present study supporting both recency and summation effects in frustrative nonreward strengthens the conclusion advanced by Ryan, Strawbridge, and Watters (1969); for conditions receiving the same number of rewards but arranged in different configurations, the reward expectancies may be very dissimilar. Ryan et. al. (1969) have suggested that a new concept of reward expectancy may be necessary if Amsel's frustration theory is to be useful for accounting for children's behavior in partial reward situations. In their experiment different groups of children were given from one to four N-lengths (N-length referring to the number of consecutive nonrewards). The study was to determine what effect these different N-lengths would have on the partial reinforcement acquisition effect (PRAE). In addition to the four N-length groups, a random 50% group and a 100% reward group were also included in the study. Significantly faster speeds were obtained in the 3 N-length and 4 N-length groups as well as in the random 50% group, when compared to the 100% control group. Performance of the 1 N-length and 2 N-length groups was not significantly different from the performance of the control group.

On the basis of these results, Ryan et. al. suggest that the expectancy for reward, and hence the FE, can be modified by ***S***'s learning the nonreward pattern. Differences among the reward groups were seen as a function of the extent to which ***S***s could learn the sequence of rewards and nonrewards and thereby reduce their expectancy for reward on nonrewarded trials. Since the patterns of single and double alternations are more likely to be learned by this age group (kindergarten and first grade) than those of triple and quadruple alternations, the FE of nonreward would be expected to be less for the first two patterns.

Since the data on recency and summation effects in the present study are not inconsistent with Ryan's notion of expectancy, some methodological procedures can be considered for inspecting that kind of reward expectancy. One problem that has plagued investigators of children's performance in frustrative nonreward situations is that they can at best only indirectly infer the child's expectancy for reward. One way to assess expectancy for reward would be to *ask* the child after responding at lever 1 or lever 2, to predict the reward condition at the next lever. Success at prediction would support the Ryan notion above.

We are currently investigating this question.

A second way to deal experimentally with reward expectancies would be to determine the effects of learning on FE. In the present study, all reward-nonreward sequences were randomly presented to each child and could not, therefore, be reliably anticipated or learned. On the other hand, if Ryan et. al.'s contention that learning can modify the FE is correct, one would expect studies designed to directly investigate learning influences to show such a modification. Another experiment currently underway is attempting to measure the extent to which learning reward and nonreward patterning affects the recency and summation aspects of frustrative nonreward.

Interestingly enough, the results of the research show considerable variation in R_3 response times across reinforcement orders, even though the reward expectancy for R_3 can be assumed to be equal under all reward-nonreward conditions in the sense that a response at that lever was always rewarded--regardless of the nonreward pattern. Some children verbalized an awareness that they always received a marble at R_3, yet this realization did not seem to produce any systematic change in their R_3 responses. The variability among the three conditions in response time at the third lever is perhaps supportative of a "motivational" interpretation of the effects of nonreward in this study rather than an "associative" one (Pederson, 1967). A more cognitive interpretation of reward expectancy would predict an equal response at the third lever for all orders.

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TABLE 1

SCHEDULE OF REWARD AND NONREWARD
FOR TWO DAYS OF TESTING

TRIAL	PATTERN OF REINFORCEMENT	
1	Reward-Nonreward-Reward	(R-NR-R)
2	Nonreward-Reward-Reward	(NR-R-R)
3	Reward-Nonreward-Reward	(R-NR-R)
4	Nonreward-Nonreward-Reward	(NR-NR-R)
5	Nonreward-Reward-Reward	(NR-R-R)
6	Nonreward-Nonreward-Reward	(NR-NR-R)
7	Reward-Nonreward-Reward	(R-NR-R)
8	Nonreward-Nonreward-Reward	(NR-NR-R)
9	Nonreward-Reward-Reward	(NR-R-R)
10	Reward-Nonreward-Reward	(R-NR-R)
11	Nonreward-Reward-Reward	(NR-R-R)
12	Nonreward-Nonreward-Reward	(NR-NR-R)

TABLE 2

SUMMARY OF DATA FOR ALL STATISTICAL ANALYSES:

Total Latency and Movement Times Are Expressed as Seconds. Data Were Summed Across Ss and Trials for a Given Day.

	LATENCY R_2			LATENCY R_3			MOVEMENT R_2			MOVEMENT R_3		
	NR-R	R-NR	NR-NR	NR-R	R-NR	NR-NR	NR-R	R-NR	NR-NR	NR-R	R-NR	NR-NR
DAY 1	112.84	119.69	112.06	95.07	89.11	81.83	61.54	70.39	61.15	53.89	60.22	51.13
DAY 2	110.06	126.22	109.63	89.80	84.59	84.01	59.96	64.41	65.03	56.71	53.04	53.92
TOTAL	222.90	245.91	221.69	184.87	173.70	165.84	121.50	134.80	126.18	110.60	113.26	105.05

TABLE 3

SUMMARY OF THE ANALYSIS OF VARIANCE ON LATENCY TO R_2

Source	SS	df	MS	F	p
Between-Ss	57.85	29			
Subjects (S)					
Within-Ss					
DAys (A)	0.02	1	0.01	0.07	NS
A x S	4.13	29	0.14		
Orders (B)	1.57	2	0.78	15.60	.001
B x S	2.87	58	0.05		
A x B	0.22	2	0.11	1.22	NS
A x Bx S	5.76	58	0.09		
within cells	52.85	540			
Total	125.27	719			

TABLE 4

SUMMARY OF THE ANALYSIS OF VARIANCE ON MOVEMENT TO R_2

Source	SS	df	MS	F	p
Between-Ss	18.06	29			
Subjects (S)	18.06	29			
Within-Ss					
Days (A)	0.02	1	0.02	0.11	NS
A x S	5.01	29	0.17		
Orders (B)	0.37	2	0.185	3.70	$<.05$
B x S	2.86	58	0.05		
A x B	0.19	2	0.085	1.70	NS
A x B x S	3.06	58	0.05		
within cells	23.10	540			
Total	52.67	719			

TABLE 5

SUMMARY OF THE ANALYSIS OF VARIANCE ON LATENCY TO R_3

Source	SS	df	MS	F	*p*
Between-*S*s	31.42	29			
Subjects (S)	31.42	29			
Within-*S*s					
DAys (A)	0.08	1	0.08	5.3	<.05
A x S	0.44	29	0.015		
Orders (B)	0.76	2	0.38	9.5	<.01
B x S	2.35	58	0.04		
A x B	0.15	2	0.08	0.53	NS
A x B x S	9.17	58	0.15		
within cells	32.96	540			
Total	77.33	719			

TABLE 6

SUMMARY OF THE ANALYSIS OF VARIANCE ON MOVEMENT TO R_3

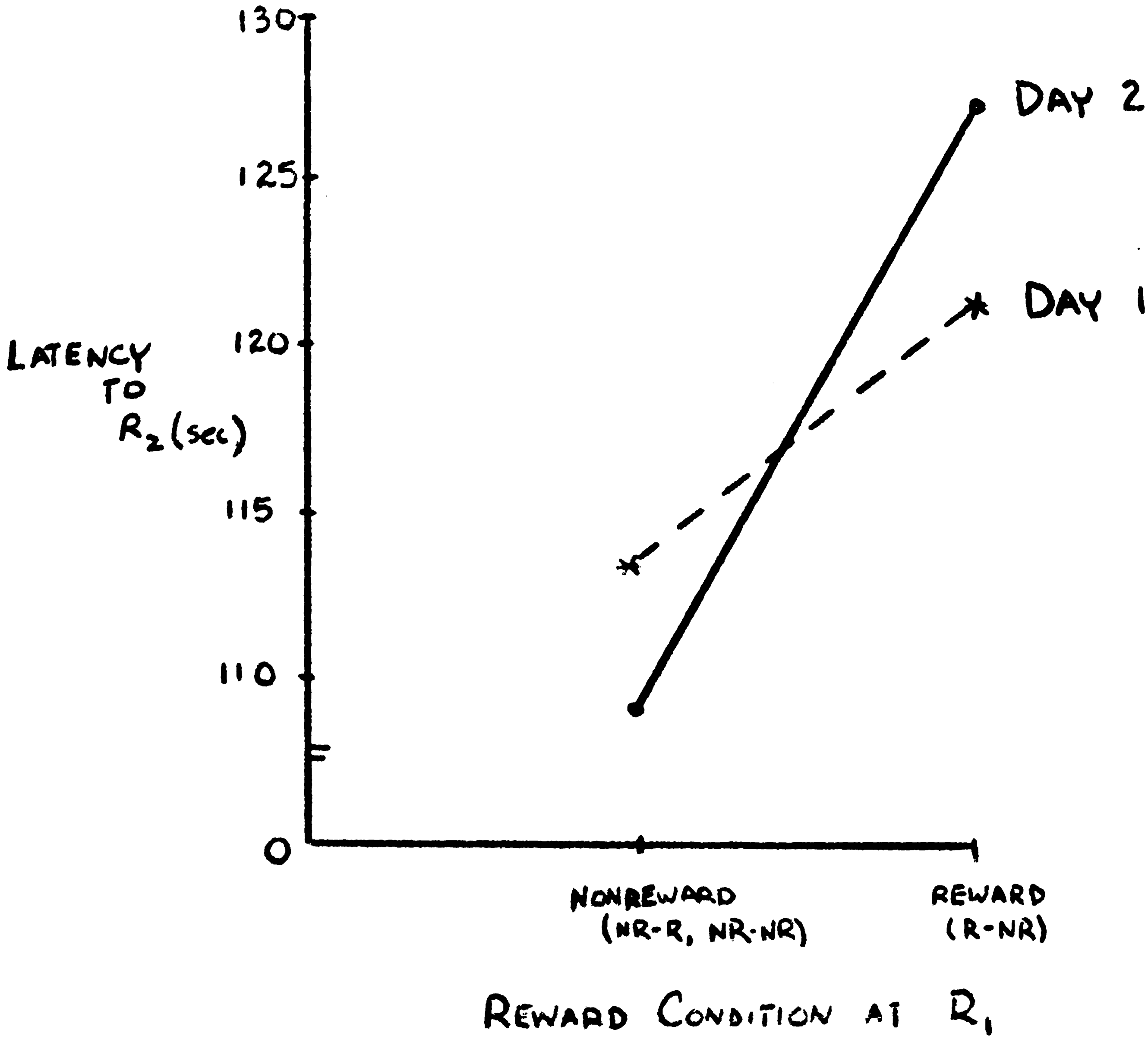
Source	SS	df	MS	F	*p*
Between-*S*s	21.62	29			
Subjects (S)	21.62	29			
Within-*S*s					
Days (A)	0.01	1	0.01	0.06	NS
A x S	4.34	29	0.15		
Orders (B)	0.15	2	0.08	4.00	.05
B x S	1.29	58	0.02		
A x B	0.27	2	0.135	2.25	NS
A x B x S	3.50	58	0.06		
within cells	17.82	540			
Total	49.00	719			

FIGURE CAPTIONS

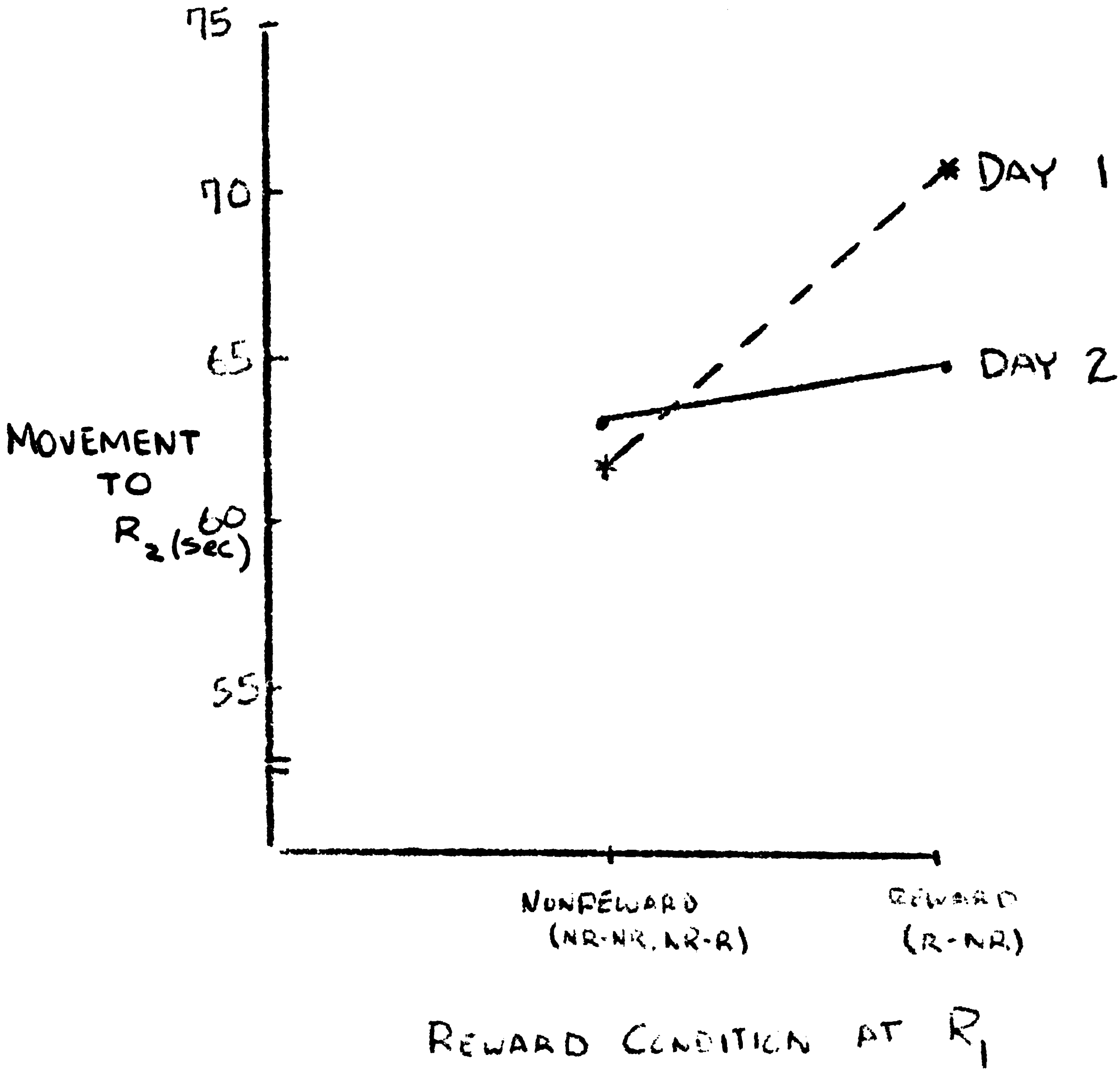
Figure 1. Schematic Representation of the apparatus

Figure 2. Latency to R_2 as a function of reward condition at R_1 (Data are summed across all *S*s and all trials)

Figure 3. Movement to R_2 as a function of reward condition at R_1 (Data are summed across all *S*s and all trials)



130
125
120
115
110
0
LATENCY TO R_2 (sec)
DAY 2
DAY 1
NONREWARD (NR-R, NR-NR)
REWARD (R-NR)
REWARD CONDITION AT R_1


75
70
65
60
55
MOVEMENT
TO
R2 (sec)
DAY 1
DAY 2
NONREWARD
(NR-NR, NR-R)
REWARD
(R-NR)
REWARD CONDITION AT R1