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THE BEHAVIORAL EFFECTS OF PARTIAL
REINFORCEMENT AS A FUNCTION OF THE
STIMULUS SIMILARITY OF THE INTERTRIAL INTERVAL

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THE BEHAVIORAL EFFECTS OF PARTIAL REINFORCEMENT AS A FUNCTION
OF THE STIMULUS SIMILARITY OF THE INTERTRIAL INTERVAL

BY

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CHAPTER I

INTRODUCTION

Although both Pavlov (1927) and Skinner (1938) had published articles dealing with the effects of less than 100% reinforcement upon acquisition and extinction, it was not until the Humphrey's investigation (1939) that partial reinforcement became an enigma for learning theorists. Hull's theory came under the sharpest criticism because with a decrease in the number of reinforcements in acquisition there was not a corresponding decrease in habit strength as measured by resistance to extinction. Despite such criticism, Hull did not deem it necessary to consider the problem of partial reinforcement in his Principles of Behavior (1943). Humphreys, on the other hand, proposed an expectancy principle as an alternative theory. In his theory, conditioned responses are the consequence of the Ss expectation that reinforcement will appear. After reinforcement on every trial during acquisition, the extinction responses dissipate because the sudden shift from uniform reinforcement to uniform nonreinforcement makes it easy to change to an expectation

of uniform nonreinforcement. In extinction after partial reinforcement, however, the S continues to expect that reinforcement will be periodic as it was during acquisition, thus extinction is prolonged by his expectation that reinforcement will be re-introduced.

The experimentation by Humphreys appeared contradictory to the Hullian approach to learning. It was not until 10 years later that an "answer" to the partial reinforcement challenge was forthcoming from the Hullian camp. Virginia Sheffield (1949), a student of Hull's, based her explanation upon differences in generalization decrement for the partially reinforced and consistently reinforced groups. In her hypothesis, extinction involves different cues from those used in acquisition. Omission of reinforcement alters the stimulus situation and makes extinction a case of transfer of training in which a certain amount of generalized decrement is to be expected because of the change in cues. When dealing with consistently reinforced Ss, the occurrence of reinforcement on a given trial produces effects which provide characteristic stimuli at the start of the following trial. These aftereffects, for example, could be the taste of food or possibly food particles still in the mouth. With the onset of extinction, the stimulus pattern is changed abruptly not only by the absence of the aftereffects of reinforcement but also by the presence of whatever new stimulation results from the absence of reinforcement.

When training with partial reinforcement is given, on the other hand, the S is exposed to cues which are normally present only during extinction. These cues are the after-effects of nonreinforced trials. The aftereffects could be the lack of gustatory traces or the absence of food particles in the mouth. On reinforced acquisition trials that follow nonreinforced trials, with these nonreinforcement cues as part of the current stimulus pattern, reinforcement is re-introduced and the S therefore learns to perform the response in the presence of these nonreinforcement cues. Sheffield points out that since the response has been conditioned during acquisition to the cues characteristic of extinction, one would expect less generalized decrement due to the change in the total stimulus pattern when reinforcement is withdrawn completely than is found after acquisition with reinforcement on every trial. Thus, the initiation of extinction trials produces a relatively large change in the conditioned stimulus pattern when it follows training with reinforcement on every trial but much less change when it follows acquisition with partial reinforcement. In other words, there is more of a difference in the afferent patterns between continuous reinforcement and extinction than between partial reinforcement and extinction.

Since Sheffield postulated that these aftereffects dissipate with the passage of time, the testing of the aftereffects hypothesis consisted of controlling some of the

aftereffects of reinforcement and nonreinforcement by the spacing of trials. The assumption was that if animal 3s were used with trials widely spaced, most of the aftereffects of reinforcement or nonreinforcement would have dissipated by the start of the next trial, making the conditioned stimulus pattern much the same whether reinforcement had or had not been received on the previous trial. Sheffield, therefore, postulated that there would be no difference between the partially and continuously reinforced groups when trials were distributed. With massed trials, however, the aftereffects would not dissipate since the aftereffects of nonreinforcement of the previous trial could be conditioned to the running responses on a reinforced trial. Massing of training trials, Sheffield contended, should give the maximum advantage to the partial reinforcement group in resisting extinction as compared with reinforcement on every trial, whereas the spacing of trials should diminish or destroy this advantage. Sheffield's experimentation added credence to this theory. With the intertrial interval being 15 minutes, she found no difference between the partially reinforced and continuously reinforced groups in resistance to extinction as measured by median response times. However with massed training, i.e., 15 second intertrial interval, the partially reinforced 3s were significantly more resistant to extinction. An integral part of Sheffield's theorizing was the postulate that aftereffects dissipate with time. It was this segment of her theory which

was experimentally questioned by later theorists.

Weinstock (1954), in an experiment designed to test the Hull-Sheffield hypothesis, examined acquisition and extinction curves of a runway response with an intertrial interval of 24 hours. Four groups received 100, 80, 50 and 30 percent reinforcement during a 75 day acquisition series. Then all groups received a 20 day extinction series. There were no significant group differences in latency or running time as far as acquisition was concerned. During extinction, however, group differences in running times were significant beyond the .01 level, with an inverse relationship existing between the percentage of reinforcement and resistance to extinction.

In view of the large intertrial interval, the extinction results can not be handled by the Hull-Sheffield hypothesis. Weinstock, therefore, postulated a modified contiguity theory to account for the partial reinforcement effect. According to this theory, in extinction the S makes other or competing responses resulting in a decrement in response strength of the original response. Competing responses which the S makes to an empty goal box may also occur on a nonreinforced trial. During the course of a series of nonreinforced trials, these competing responses are found to have no functional relationship to reinforcement and therefore "habituate" or drop out of the S's response repertoire. Thus the partially reinforced animals, which have had some number of nonreinforced trials

during acquisition, will, in extinction, have their competing responses to an empty goal box habituated to a relatively lower level of response strength as compared with the continuously reinforced animals. Having habituated, the competing responses will occur with a low frequency and there will be little decrement in the strength of the original response due to the presentation of a nonreinforced trial. The lowest percentage reinforcement group will have had the greatest number of nonreinforced exposures during acquisition and the highest percentage group will have had the smallest number of nonreinforced exposures. Accordingly, one would expect the greatest amount of habituation of competing responses to have occurred in the group having the smallest percentage of reinforcement or the largest number of nonreinforced exposures. On the other hand, the continuously reinforced group will not have had any nonreinforced trials. This group will have had no chance to habituate its competing responses and, as a result, will show the greatest decrement in the strength of the original response during extinction. Weinstock, therefore, predicted an inverse relationship between percentage of reinforcement and resistance to extinction, i.e., the higher the percentage, the lower the resistance to extinction. It was not coincidental that his results substantiated his claim.

This experiment questioned seriously the Hull-Sheffield hypothesis. It is to be noted, however, that the objections

are not directed against the existence of the aftereffects but are contrary to the temporal properties assigned to them by this particular hypothesis. Thus, Weinstock's experiment was not critical to the notion of aftereffects.

E. J. Capaldi subscribes to the aftereffects approach in accounting for the partial reinforcement effect. He does not, however, adopt the Hull-Sheffield concept of dissipation. Capaldi and his associates attempted to determine the temporal characteristics of the aftereffects of reinforcement and non-reinforcement. Capaldi and Stanley (1963), employing single alternating partial reinforcement under several conditions of trial spacing, that is, 15 seconds, 2 minutes, 10 minutes and 20 minutes, observed that all Ss eventually ran relatively slower on nonreinforced trials and relatively faster on the reinforced trials. These results imply that aftereffects remain functional for at least 20 minutes and question the view that dissipating occurs as a mere function of time as is held by the Hull-Sheffield hypothesis. The complexity of these aftereffects is further illustrated by Capaldi, Hart and Stanley (1963), who have indicated that aftereffects are subject to interference. They have presented evidence which indicates that by placing the S in a baited goal box for a relatively brief period during the intertrial interval, the aftereffects of nonreinforcement are replaced by the aftereffects of reinforcement. In effect the stimulus

complex for these SS was the same as for the SS under continuous reinforcement schedule, that is, there was always the after-effects of reinforcement. Thus, Capaldi's studies indicate that under appropriate conditions, an aftereffect which would have remained functional for at least 20 minutes (Capaldi and Stanley, 1963), can be interfered with within as brief a period as 30 seconds (Capaldi et al. 1963). Capaldi et al. (1963) hypothesized that the extent of interference is probably related to the stimulus similarity which exists between the original reinforcement situation and the interfering situation. With this hypothesis, results, such as those supplied by Weinstock (1954), can be interpreted in terms of aftereffect theory by Capaldi, the theory having been modified by the above-mentioned temporal assumptions. When trials are separated by 24 hours, the receipt of the maintenance diet, occurring as it does following the daily trial, would serve to interfere with the aftereffects of nonreinforcement. However, Capaldi states that since the maintenance diet is administered in the presence of stimuli, i.e., the home cage, quite unlike those provided by the goal box in which reinforcement and nonreinforcement occur, very little basis exists for interference.

The Weinstock experiment served the purpose of questioning the soundness of the aftereffects hypothesis as posited by Hull and Sheffield. Capaldi and his associates, however,

by modifying the aftereffects theory, have avoided the snares in the original postulation of the hypothesis. Thus the Weinstock experiment, which was critical to the Hull-Sheffield hypothesis, does not occupy such a position concerning Capaldi's modified aftereffects theory. In fact, Capaldi has theoretically accounted for the results of the Weinstock experiment. The use of Capaldi's interference hypothesis, in accounting for the partial reinforcement effect however, remains in the realm of theory, for it has not been empirically tested.

The present experiment was designed to determine the efficacy of Capaldi's interference hypothesis in accounting for the partial reinforcement effect with large intertrial intervals. The interference hypothesis was tested by varying the degree of stimulus similarity between the original reinforcement situation, the goal box, and the interfering situation, the intertrial interval. Groups, having their intertrial interval in the home cage, which is essentially the same procedure as the Weinstock experiment, experienced the least amount of stimulus similarity. The highest possible degree of similarity between the original reinforcing situation and the interfering situation could be attained by having them exactly alike, thus, another group had their intertrial interval in the goal box.

Capaldi would predict better performance on the part of

the group having their intertrial interval in the home cage due to the absence of interfering stimuli. A logical extension of Weinstock's theory, however, would seem to call for the opposite results. Ss with their intertrial interval in the goal box would have a chance for competing responses to be habituated, whereas those Ss with their intertrial interval in the home cage would not be exposed to such a possibility.

CHAPTER II

EXPERIMENT I - METHOD

Subjects. The Ss were 20 male Holtzman strain rats, purchased from the Holtzman Company, Madison, Wisconsin. The Ss were about 60 days old at the beginning of the experiment. (c.f. Table I)

Apparatus. The apparatus was a straight-alley runway which is a total of 72 inches long, 5 inches wide, enclosed by sides 8 inches high, constructed entirely of wood and painted a mid-gray throughout. A microswitch, mechanically operated by the Ss weight upon a hinged floor section was located 12 inches from the proximal end of the alley and was so constructed that upon being depressed a standard electric timer was automatically started. A similar microswitch and hinged floor section were also located 60 inches from the start box door, served to close the circuit, thus stopping the electric timer. Two inches beyond the hinged floor section was a sheet metal door, painted mid-gray which can be lowered so as to restrict the S to the goal region. The

TABLE 1

NUMBER OF Ss EMPLOYED IN EXPERIMENT I

LOCATION OF INTERTRIAL INTERVAL

		HOME CAGE	GOAL BOX
% OF REINFORCEMENT	100%	5	5
	50%	5	5

end of the runway terminates in a 5 inch wide x 3 inch long "elbow" bend in which food could be placed. Ten identical elbows were employed, 5 elbows for the reinforced trials and 5 for the nonreinforced trials. The elbow arrangement prevented the S from determining whether the goal box contained any food until it had passed over the hinged floor section. The entire runway and all goal boxes were covered by hinged hardware cloth.

Procedure. On each of the initial ten days of the experiment, the Ss were deprived of food for 23 hours, handled in groups of 6 for approximately one hour and returned to their home cage. Each S was individually housed, where it was allowed to eat Purina Laboratory Chow for one hour. On days 11 and 12 each S was allowed to individually explore the runway for 5 minutes, no food being available and the door in the goal box region being open.

The Ss were randomly assigned to four groups, that is, two groups of 10 Ss each received 100% reinforcement with one of these groups having their intertrial interval in the home cage and the other group having their interval period in the goal box. The remaining two groups of 10 Ss each received 50% reinforcement with one group having their intertrial interval in the home cage and the other in the goal box. The randomization of reinforcement for both of the partially reinforced groups was defined by randomly employing three Gellerman (1933) orders.

Because of scheduling difficulties, the running period proper was divided into 3 segments. All Ss were fed one hour per day at approximately 20 minutes after the last trial of the day. Thus at the beginning of the daily trials all Ss had been deprived of food for at least 20 hours. Throughout phases of the experiment, the Ss were allowed a maximum of 60 seconds to traverse the runway.

CHAPTER III

EXPERIMENT I - RESULTS

In an attempt to impose stability of the dependent response measurement, the running times for each S for the eight trials per day were averaged. These mean running scores were then averaged over blocks of days. The blocks of days were determined in deference to the Capaldi and Stanley experiment (1963) which utilized blocks of 1-5 days, 6-13 days, 14-18 days and 19-23 days. The mean scores were then transformed logarithmically using the formula:

$$x'_{ijk} = \log (x_{ijk} + 1)$$

to insure that the distribution of scores approximated the normal curve.

As can be seen in Figure 1, on the first block of days, days 1-5, the Continuously Reinforced Ss regardless of the location of the intertrial interval performed appreciably faster in running the length of the maze. On the second block of days there was a sharp decrease in mean log running time i.e., faster running for all groups. The third block

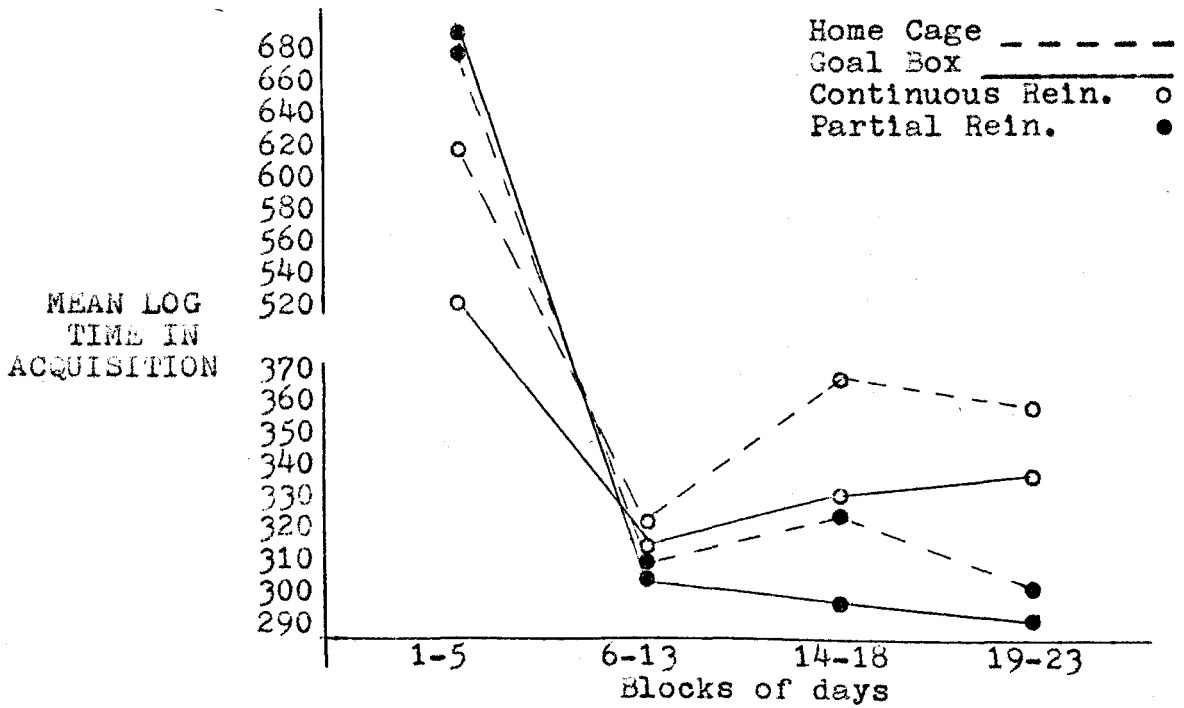


Fig. 1 Mean log running times in acquisition for all groups over blocks of days in Experiment I.

of days was characterized by an increase in running times for both groups having continuous reinforcement, the group having their intertrial interval in the home cage being the slowest of the two groups having continuous reinforcement while the group having partial reinforcement in the goal box had the faster running times. On the final block of days the differences between the partial and continuously reinforced groups became more pronounced. The continuously reinforced - home cage Ss remained the slowest group, with the continuously reinforced group next. The partially reinforced Ss with their intertrial interval in the home cage was next to the fastest in terms of running times while the partially reinforced - goal box Ss were the best performing group.

A 2 (location of intertrial interval) x 2 (continuous or partial reinforcement) x 4 (blocks of days) multifactor analysis of variance was used to determine the existence of any significant differences between treatments. (c.f. Table 2) The main effects of the repeated factor, blocks of days, ($F_{3,48} = 122.18$) was found to be statistically significant ($F_{.95} = 2.84$). It was for this reason that a single factor analysis of variance was built into the statistical design to test the treatment differences within the last block of days.

TABLE 2
ANALYSIS OF VARIANCE - EXPERIMENT I

Source	d.f.	M.S.	F
Between <u>Ss</u>	19		
A (location)	1	9593	2.35
B (reinforcement)	1	873	.21
AB	1	3590	.88
Within <u>Ss</u>	60		
C (blocks of days)	3	489458	122.18*
AC	3	1296	.32
BC	3	22449	5.60*
ABC	3	2837	.71
C x <u>Ss</u> w/n groups	48	4006	

$F_{.95}(3, 48) = 2.84$

TABLE 3

SINGLE FACTOR ANALYSIS OF VARIANCE OF FINAL BLOCK OF
DAYS IN EXPERIMENT I

Source	SS	d.f.	MS	F.
SS treat	7863	3	2621	18.86*
SS w/n treat	2224	16	139	
SS total	<u>10087</u>	<u>19</u>		

$$F_{.95}(3, 16) = 3.24$$

TABLE 4

DUNCAN q' TEST FOR DIFFERENCES BETWEEN ORDERED MEANS FOR
THE LAST BLOCK OF DAYS IN EXPERIMENT I

Group	GP	HP	HC	GC
Ordered Means	296	306	334	334
$q'_{.95}(k, 16)$		300	315	323
$s_x q'_{.95}(k, 16)$		15.60	16.38	16.80
GP		10.00	38.00*	48.00*
HP			28.00*	38.00*
HC				10.00

Following the significant over-all F, in the single factor analysis of variance (c.f. Table 3) a Duncan q' statistic was used to probe the nature of the differences between treatment means.

As can be seen in Table 4 both of the partially reinforced groups i.e., GP (Goal Box-Partial) and HP (Home Cage-Partial) differed significantly in log running times from the two continuously reinforced groups HC (Home Cage-Continuous) and GC (Goal Box-Continuous).

CHAPTER IV

EXPERIMENT II - METHOD

Subjects. The Ss were 24 male Holtzman strain rats, purchased from the Holtzman Company, Madison, Wisconsin. The Ss were about 60 days old at the beginning of the experiment. (c.f. Table 5)

Apparatus. The same apparatus was employed in Experiment II as was used in Experiment I.

Procedure. Despite the attempts to impose stability of the dependent response measurement in Experiment I the range of mean log running times for the first block of days was from 537 to 686. It was therefore decided to alter the pre-training procedure in Experiment II. As in Experiment I, on each of the initial ten days of the experiment, the Ss were deprived of food for 23 hours, handled in groups of 6 for approximately one hour and returned to their home cage. On days 11 and 12, however, each S was allowed to individually explore the runway for 10 minutes, no food being available and the door in the goal box region being open. Thus the Ss in Experiment II were allowed twice as much exploration time as were the Ss in Experiment I.

TABLE 5

NUMBER OF Ss EMPLOYED IN EXPERIMENT II

LOCATION OF INTERTRIAL INTERVAL

	HOME CAGE	GOAL BOX
100%	6	6
50%	6	6

In Experiment I the running period proper was divided into three segments due to scheduling difficulties. In Experiment II the above mentioned difficulties did not present themselves hence a single factor analysis of variance was utilized to determine the existence of any significant differences in running time as a function of the segment of the experiment. Since the F_{Obs} (6.76) did not exceed the critical value $F_{.95}(2,17)$ (19.4), no differences were assumed to be a function of the time of day in which the Ss were tested. Therefore the running period proper in Experiment II was divided into two segments in which all four groups i.e., Home Cage-Continuous, Home Cage-Partial, Goal Box-Continuous and Goal Box-Partial, were equally represented by three Ss.

CHAPTER V

EXPERIMENT II - RESULTS

The increase in the amount of pre-training proved efficacious in restricting the range of the Ss mean log running times in Experiment II.

As can be seen in Figure 2, on the first block of days the Ss in Experiment II reacted in the same manner as those in Experiment I i.e., the continuously reinforced Ss regardless of the location of the intertrial interval performed the task of running the length of the alley appreciably faster. The sharp decrease in mean log running times for all groups for the second block of days was again noted. The third block of days was again characterized by an increase in the running times for both of the continuously reinforced groups. Thus far the results of Experiment II are identical to the results of the first experiment. It is at this point that the similarity ceases. In Experiment I (c.f. fig. 1) both of the continuously reinforced groups had slower running times in the third block of days than the partially reinforced Ss. The group having their intertrial interval in the home cage

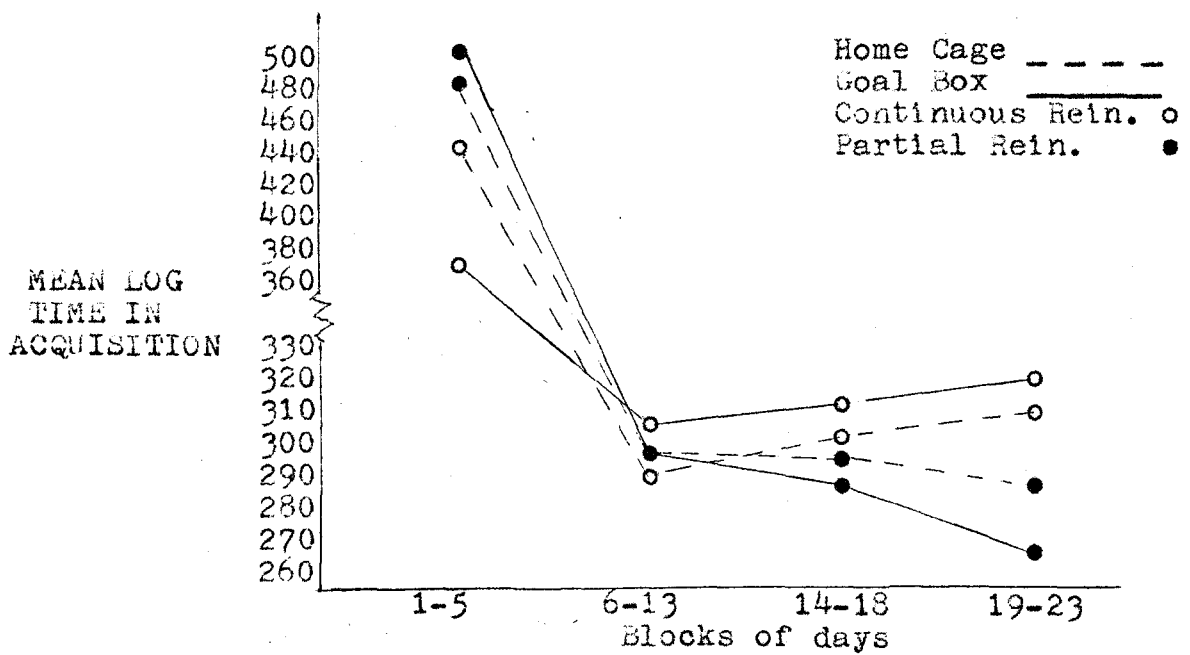


Fig. 2 Mean log running times in acquisition for all groups over blocks of days in Experiment II.

was found to be the slowest of the two groups in traversing the runway. In Experiment II both continuously reinforced groups likewise had higher running times in the third block of days. However, in this experiment, the Ss having their intertrial interval in the goal box had the highest times for running the length of the alley. Since there weren't any differences between the groups that were continuously reinforced there seems to be no relationship between location of the intertrial interval and performance for the Ss that are continuously reinforced. On the other hand, such a relationship seems to exist for the partially reinforced Ss for in both experiments the goal box- partial group was the fastest. On the final block of days the differences between the partially and continuously reinforced Ss became more conspicuous. The continuously reinforced-goal box Ss remained the slowest group, with continuously reinforced-home cage group next. The partially reinforced Ss with their intertrial interval in the home cage was next to the fastest in terms of running times while the partially reinforced-goal box S had the best times in traversing the alley.

The statistical analysis of the data in Experiment II was essentially the same as that described in Chapter III, save for the differences in the number of Ss and hence differences in the degrees of freedom in the second experiment.

TABLE 6
ANALYSIS OF VARIANCE - EXPERIMENT II

Source	d.f.	MS	F
Between <u>Ss</u>	23		
A (location)	1	1176	.454
B (reinforcement)	1	1395	.538
AB	1	8246	3.185
S w/n groups	20	2589	
Within <u>Ss</u>	72		
C (blocks of days)	3	130096	89.29*
AC	3	34157	23.44*
BC	3	51358	35.25*
ABC	3	2130	1.46
C x <u>Ss</u> w/n groups	60	1457	

$F_{.95} (3,60) = 2.76$

TABLE 7

SINGLE FACTOR ANALYSIS OF VARIANCE OF FINAL BLOCK OF
DAYS IN EXPERIMENT II

Source	SS	d.f.	MS	F.
SS treat	9389	3	3130	14.22*
SS w/n treat	4409	20		
SS total	<u>13798</u>	<u>23</u>		

$$F_{.95} (3, 20) = 2.92$$

TABLE 8

DUNCAN q' TEST FOR DIFFERENCES BETWEEN ORDERED MEANS FOR
THE LAST BLOCK OF DAYS IN EXPERIMENT II

Group	GP	HP	HC	GC
Ordered Means	266	283	305	318
$q'_{.95}(k, 20)$		2.95	3.10	3.18
$s_x q'_{.95}(k, 20)$		17.84	18.75	19.23
GP		17.00	39.00*	52.00*
HP			22.00*	35.00*
HC				13.00

A 2 x 2 x 4 multifactor analysis of variance was utilized in determining the existence of any significant differences between treatments. The main effects of the repeated factor, blocks of days, ($F_{3,60} = 89.29$) was found to differ significantly ($F_{.95} = 2.76$) from the other partitions of the total variation. The last block of days was, therefore, investigated through the use of a single factor analysis. The statistically significant F for treatment effects necessitated the employment of a Duncan q' statistic to probe the nature of the differences between the treatment means.

The results of Experiment II correspond exactly to the data presented in Table 4 concerning Experiment I, i.e. both of the partially reinforced groups, GP (Goal Box-Partial) and HP (Home Cage-Partial) differed significantly in mean log running times from the two continuously reinforced groups, HC (Home Cage-Continuous) and GC (Goal Box-Continuous).

CHAPTER VI

DISCUSSION

The raison d'etre of this experiment was not the demonstration of the existence of the partial reinforcement effect. Although the two experimental groups (partial reinforcement) differed significantly from the control groups (continuous reinforcement), there were not any significant differences between the two control groups. Thus, this lack of significant results limits the amount of conclusive statements that can be made regarding the theories in question. There are, however inferences that can be made.

Although the Weinstock experiment was not critical to Capaldi's modified aftereffects theory, it remained unaccountable by Capaldi until he posited his interference hypothesis. (Capaldi et al 1963) In accordance with this theory, Capaldi predicted that SS that experienced the least amount of stimulus similarity between the original reinforcement situation and the interfering situation, the intertrial

interval, would excel in performance. This prediction was not upheld.

Weinstock, however, had not made a prediction on the outcome of such an experiment. It was inferred in the present study that Weinstock's theory would predict opposite results. For this reason one can neither accept nor reject any segment of his theory on the strength of this experiment. Nevertheless there is a tendency to lean toward Weinstock's interpretation of the results since the two experimental groups in Experiment I missed being significantly different in Weinstock's favor by a margin of three one hundredths of a second and in Experiment II by a margin of five one thousandths of a second.

The burden of presenting evidence to account for the observed results lies squarely upon the shoulders of Capaldi. The experimental methodology that was utilized was essentially that designated by Capaldi and the apparatus was basically the same as that used in the Capaldi and Stanley experiment (1963), as was the pretraining procedure. The use of mean log running time was another factor consistent with Capaldi's previous research. It would appear that everything was done to maximize the possibility of obtaining results consistent with Capaldi's modified aftereffects theory and yet it seems that the theory can't account for the data.

On the other hand, Weinstock's theory was being

questioned and tested by an experiment completely foreign to the previous research done by himself and other theorists dedicated to extending and/or embellishing the theories promulgated by Estes and other proponents of the statistical approach to learning theory.

Weinstock's habituation theory, states that the partially reinforced animals, will, in extinction have their competing responses to an empty goal box habituated to a relatively lower level of response strength as compared with the continuously reinforced Ss. This theory was of the ad hoc variety or at least limited only to experiments utilizing resistance to extinction as a measure of learning. It was for this reason that the author had to deal with a "logical extension" of Weinstock's theory in order to pit these seemingly opposing theories against each other.

There are, however, adherents of statistical approach to learning theory who have not limited themselves quite as much as Weinstock, and who can give a reasonable accounting of the observed data. Estes and Burke (1953) describe the stimulus situation as a set of elements, each of which is conditioned to exactly one response at a given trial in an all or none basis. During learning, if a certain response A_1 is reinforced, a cue may switch and become newly conditioned to A_1 . The probability of such a change is the rate of learning parameter θ .

In 1959 Estes accounted the partial reinforcement effect in terms of a contiguity-interference interpretation. In such a theory the function of nonreinforcement is to establish a situation in which competing responses have a high probability. When elements, connected with the correct response, are present with competing responses - then these elements are connected with the competing response. The competing response gains connections at the expense of the previously correct response. In a partial reinforcement acquisition series, however, the competing responses which were conditioned early in training will re-appear. The response produced stimuli following nonreward are conditioned to reward on the following reinforced trial. Therefore, in extinction there are these response produced stimuli resulting from nonreward which are conditioned to the correct response. At this point it may be noticed that Estes' postulations are not dissimilar to Sheffield's aftereffects theory. Estes' conclusion is that the initiation of extinction trials produces a relatively large change in the conditioned stimulus pattern when it follows 100% reinforcement in acquisition but much less change when it follows acquisition with partial reinforcement.

This interpretation of Estes could be considered similar to prior aftereffects theorizing but it is definitely not a trace theory, for the response produced stimuli are not

directly dependent upon prior nonreinforcement. In Estes' scheme of things anything that is not a correct response is a competing response.

Since competing responses do not dissipate with time he can account for the "carry over effect" in an experiment utilizing distributed practice which was the stumbling block to the Hull-Sheffield aftereffects theory.

Restle (1955) carries the statistical approach to learning one step further and considers every individual cue as either "relevant" or "irrelevant". According to Restle, in a learning situation, the S learns to relate his response correctly to the relevant cues through a process of conditioning. At the same time, his response becomes independent of the irrelevant cues through a process entitled adaptation. On each trial a constant proportion, θ , of unconditioned relevant cues becomes conditioned. Restle postulates that a conditioned relevant cue affects performance in that it contributes to a correct response, whereas an unconditioned relevant cue contributes equally to both correct and incorrect responses. Adaptation is a complementary process to conditioning, for similarly Restle postulates that on each trial, a constant proportion, θ , of unadapted irrelevant cues becomes adapted. If a cue is thought of as a "possible solution" to a problem, then an adapted cue is a possible solution that the S rejects or ignores. In

a theory of this type, an adapted cue is non-functional in the sense that it contributes to neither a correct nor an incorrect response.

It is to be noted that the same constant proportion θ appears in dealing with conditioning and adaptation. Thus Restle assumes:

$$\theta = \frac{r}{r + 1}$$

where r is the number of relevant cues in the problem and 1 is the number of irrelevant cues.

With Restle's definition of the rate of learning parameter, θ , as a premise it could be concluded that the Ss having their intertrial interval in the home cage would possess the lower value of θ since they would experience all the cues associated with the home cage in addition to the cues of the goal box and their own proprioceptive cues which the Ss in the goal box group would similarly be exposed. Thus the ratio of relevant to irrelevant cues, θ , the rate of learning parameter for those Ss in the home cage group would be lower than those Ss having their intertrial interval in the goal box.

It needs to be re-emphasized that one can neither accept nor reject any segment of the theories presented above, including Capaldi's modified aftereffects theory on the strength of this experiment. A definitive experiment has yet to be presented. This experiment could be considered

to serve as a beginning in experimentation, enabling one to determine alterations in the experimental procedure which could serve to eliminate the masking of treatment differences, and pave the way for a much needed critical experiment in this area.

Among the recommended procedural changes is the elimination of the use of hinged floor sections. The hinged floor sections did not guarantee that equal distances were covered by all Ss. The microswitches were triggered by the S's weight upon the floor sections. However, there was no way of controlling where the S was when it stepped on this part of the alley, e.g., S #1 could have triggered the microswitch by stepping on the proximal end of the floor section with his foreleg, while S #2 could have triggered the microswitch by stepping on the distal end of the floor section with his hindleg. This difficulty can be alleviated through the use of "photo-beams" which would always be sensitized by the S's foreleg.

The location of the guillotine door, used in restricting the S to the goal box region of the alley also served as a source of error. The door was located only six inches from the distal end of the goal box, hence, after each trial the door in being lowered, usually was lowered on the S rather than behind it. The purpose of the door was to prevent the S from escaping. In this experiment, however,

the door served as a cue to escape from the goal box.

The third improvement in the procedure concerns the amount of pre-training. In a future experiment the time allotted the S to explore the runway prior to the beginning of the acquisition series should be increased to fifteen minutes.

The fourth and final suggestion necessary in determining the relative effectiveness of the opposing theories in accounting for the partial reinforcement effect with large intertrial intervals is that in addition to the undertaking of an experiment with the above mentioned procedural alterations a subsequent experiment should be engaged in using essentially the same procedure as that used in the Weinstock experiment. The location of the intertrial interval should be manipulated in the same matter as in this experiment. The efficacy of the opposing theories can only be inferred from this experiment of differences between these theories would not be inferential but empirically determined.

CHAPTER VII

SUMMARY

Weinstock's experimentation dealing with the partial reinforcement effect with large intertrial intervals has been theoretically accounted for by Capaldi's modified aftereffects theory, although not empirically observed. The present study was undertaken to determine the efficacy of Capaldi's interference hypothesis in accounting for Weinstock's data.

The testing of the interference hypothesis consisted in controlling the amount of stimulus similarity between the reinforcement situation, the goal box and the interfering situation, the home cage. In Experiment I the Ss were randomly assigned to four groups, i.e. two groups of 10 Ss each received 100% reinforcement with one of the groups having their intertrial interval in the home cage and the other group having their intertrial period in the goal box. The remaining two groups of 10 Ss each received 50% reinforcement with one group having their intertrial interval in the home cage and the other in the goal box. Experiment II

served as a replication of Experiment I but differed in that a larger number of Ss were used and the amount of pre-training was altered slightly.

The two experimental groups (partial reinforcement) differed significantly from the control groups (continuous reinforcement). The partial reinforcement with large inter-trial intervals in acquisition was therefore observed. There were not, however, any significant differences between the two partially reinforced groups. This lack of significant results limited the amount of conclusive statements that can be made regarding the theories in question.

The prediction by Capaldi that the partially reinforced Ss, receiving their intertrial interval in the home cage would excel in performance was not upheld. Capaldi cannot account for the observed results. Adherents to the statistical approach to learning theory, however, seem to be able to give a reasonable accounting of the data.

Three procedural changes deemed necessary to eliminate the masking of treatment differences were suggested. They were:

1. The elimination of the use of hinged floor sections in favor of utilizing photo-electric cells.
2. Extending the length of the goal box to alleviate the problem of lowering the restraining door on the S rather than behind it.

3. Extending the time allotted to each S to explore the runway prior to the initiation of the acquisition trials.

In addition to the undertaking of an experiment with the above mentioned procedural changes, a subsequent experiment was also called for before a definitive experiment can be said to have been presented in this area of learning theory.

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VITA

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