AN EXPERIMENTAL INVESTIGATION OF THE COMPARATIVE EFFECT OF MASSED AND SPACED PRE-REST PRACTICE UPON BOTH MASSED AND SPACED POST-REST PERFORMANCE ON THE PURSUIT ROTOR TASK

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by

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INTRODUCTION

The area of motor learning has occupied the attention of psychologists for approximately the last fifty years. Since the time of Bryan and Harter, around the turn of the present century, the interest in the acquisition of motor skills has progressively increased. From a mass of experimental investigation, certain phenomena have been noted: (1) The advantage of spaced practice over massed practice, a phenomenon which has been known for many years; (2) Reminiscence, or the gain in performance over rest without additional practice, which seems to be related to the advantage of distributed practice over continuous practice; and (3) The relatively rapid increase in performance scores, early in performance after a rest, as compared with initial learning. The latter phenomenon has no universal name, but has been called initial spurt, regaining set, warm-up, etc., by various investigators. Also in post-rest performance, after the initial spurt, there is sometimes found a period of decline before the original rate of improvement found in pre-rest practice again manifests itself.

Any comprehensive theory of motor learning should then be able to handle all the characteristics of motor performance curves noted above, specifying the exact conditions for their occurrence. The adequacy of a motor learning theory will depend upon how inclusive and how predictive the theory is. It may be noted here, that most of the characteristics already listed, seem to have some relationship to some type of rest period involved in the experimental situation. Therefore, it is not surprising, that the variables proposed by various theorists have attempted to explain motor performance curves in terms of factors either operating in the rest periods, or factors operating in the practice periods which disappear or dissipate in the rest periods; or by a combination of these two possibilities. In the next section, some of the more important and pertinent theories of motor learning will be evaluated.

HISTORICAL BACKGROUND

Early theories of why distributed practice is better than massed practice in motor learning and why reminiscence occurs have been reviewed by McGeoch (14). One possible explanation is the presence of rehearsal during the rest periods. That is, during rest periods or inter-trial intervals, the subject engages in implicit practice trials which add appreciably to the number of explicit practice trials. Such a state of affairs could explain both reminiscence and the superiority of spaced practice, except that it seems unlikely that rehearsal is an important factor in motor learning situations in which verbal cues are relatively unimportant even though it is feasible to assume that the factor of rehearsal may be present in many verbal learning situations. Another possible explanation is in terms of the concept of fatigue. Fatigue, however, when defined as the accumulation of waste products within the organism, cannot be considered as a basic factor in motor learning because the superiority of distributed practice operates for very short periods of practice.

Two other theories which should be mentioned emphasize the concepts of refractory phase and perseveration, both of which have an implied physiological origin. According to the refractory phase theory, after a response has been made, there is a certain period or phase before the response can be repeated. Therefore, in massed practice, repeating the response continuously would meet the resistance of the refractory phase.

Unless several additional assumptions are made, however, the concept has limited utility. Perseveration theory assumes that after overt practice has stopped, the neural activity engendered would continue on for some time. This perseveration presumably has a consolidation effect which leads to more efficient learning in distributed practice; consolidation would also account for reminiscence. The concept rests on flimsy physiological evidence and has not been operationally conceptualized.

Motivation may decline with continuous work and may be higher after a rest. This could explain the superiority of distributed practice and reminiscence. Then how does one explain the changes in motivation which presumably occur? The concept poses as many problems as it explains.

Of the more modern theories, the first to be considered is the stimulus-maturation hypothesis. Although not directly stated by him as a stimulus-maturation hypothesis, Snoddy (15, 16) has formulated his explanation of learning derived primarily from his extensive experimental work on mirror star tracing in terms of primary and secondary growth. Primary growth appears early in learning and is the permanent type of learning which is fairly stable. Primary growth is defined in terms of the cumulative mean of the performance curve. Secondary growth or maturation comes late in learning and is dependent, in part, upon the amount of primary growth present at that time and inversely related to the amount of inter-trial rest. On the other hand, primary growth is a function of the number of repetitions and proportional to the length of the inter-trial rest. There is an interaction between primary and secondary growth called interference which, depending upon the amount of previous practice, will produce plateaus in the learning curve. Snoddy's formulation seems to be able to account for the various learning phenomena mentioned previously. However, because of the qualitative, non-operational definitions of the variables, the variables are not quantifiable, i.e. the system is not profitable for prediction in its present form.

A test of the stimulus-maturation hypothesis was made by Dore' and Hilgard (5) who analyzed Snoddy's mirror tracing experiments and their own studies with the pursuit rotor. They concluded that the stimulus-maturation hypothesis need not be envoked to explain the difference between distributed and massed practice since this phenomenon can be explained as adequately in terms of commonly accepted concepts. Dore' and Hilgard offer to explain motor learning in terms of improvement with practice and non-improvement (loss) with non-practice and with two work factors, loss within practice sessions and improvement with rest. As is the case with Snoddy's concepts, the proposed variables of Dore' and Hilgard are only useful in separating and labeling some of the phenomena found in motor learning and are not sufficiently developed to allow quantitative prediction. A similar proposal by Bell (3) accounts for the course of improvement found in practice with the two variables of interference and warmup. Interference is considered to be the greatest in early trials and gradually diminishes with additional practice.

Warmup, on the other hand, increases with practice until a constant value is reached. Both warmup and interference are operationally defined. However, Bell's formulation is useful primarily in its conception of warmup but incomplete with reference to many of the characteristics found in motor learning.

Melton (13) believes that pursuit rotor learning can be explained in terms of interaction of work decrement and recovery from work, and of learning and forgetting factors. Since no attempt is made to interpret the phenomena beyond a programmatic stage, the system is largely untestable.

Hull's (6) proposal of motor learning is essentially like that of Dore' and Hilgard, Bell, and Melton. Hull has the concept of reactive inhibition (I_R), a negative drive state, which implies that the making of a response sets up a tendency to not repeat that response. This is considered to be a type of temporary work decrement which dissipates with the passage of time. Hull's other major concept which refers to motor learning is conditioned inhibition ($_SI_R$), a learned resting response which reduces the drive of reactive inhibition. Conditioned inhibition is postulated to be a habit and, as such, does not dissipate over short rest periods. Therefore, remeniscence is due to the dissipation of reactive inhibition with rest. Any permanent difference in performance found to exist between massed and distributed practice is due to the greater amounts of conditioned inhibition generated under massed practice. With respect to this concept, Kimble (8) has shown that the likelihood of the operation of conditioned inhibition depends upon the attainment of a critical value of reactive inhibition and that conditioned inhibition probably will not develop if the inter-trial rest periods are more than a few seconds in length. Hull does not attempt to explain the initial sharp rise in post-rest performance or the course of performance subsequent to the initial rise.

Ammons (1, 2) has developed what is probably the most complete and comprehensive miniature system of pursuit rotor learning. The variables are: (1) A temporary work decrement similar to Hull's reactive inhibition; (2) A permanent work decrement similar to Hull's conditioned inhibition; and (3) A warmup decrement which is the inverse of Bell's warmup variable. From his critical analysis of the proposed factors, Ammons has made ten assumptions from each of which he has derived several propositions which are capable of being experimentally verified.

The last two theories conclude the theoretical discussion of motor learning and constitute the systematic framework of the present investigation. However, because of the greater generality of Hull's system, the terminology of Hull will be employed rather than that of Ammons.

STATEMENT OF THE PROBLEM

The present study is an attempt to identify and measure the three intervening variables which have been postulated to account for rotory pursuit phenomena, namely, conditioned inhibition, reactive inhibition, and warmup decrement, or set. In order to accomplish these ends: (1) We investigated the comparative effect of massed and spaced pre-rest practice upon both massed and spaced post-rest performance on the pursuit rotor task, (2) the 30 second trials used in the distributed[1] practice were fractionated into three 10 second measuring units.

The definite hypotheses with reference to these manipulations which, obtained at the inception of the study, are as follows:

Because reactive inhibition develops with practice and is postulated to dissipate as an increasing function of the length of inter-trial interval, we predict: (1) The pre-rest performance for the distributed practice will be superior to that of the massed practice. (2) After an equal amount of rest, there will be more reminiscence in the massed practice groups than in the distributed practice groups.

Because of the depressing effect of reactive inhibition and of its more permanent accompaniment of conditioned inhibition under massed conditions, we predict: (3) After the distribution of practice conditions have had a chance to operate in post-rest performance, the groups will be ranked in perform-

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[1]In the present experiment the terms "distributed" and "spaced" are used interchangeably.

ance from high to low in the following order, (a) spaced-spaced, (b) massed-spaced, (c) spaced-massed, and (d) massed-massed.

Because of the possible extinction of conditioned inhibition in changing from massed to spaced practice and the development of conditioned inhibition in changing from spaced to massed practice, we predict: (4) With continued practice, the differences between groups practicing under identical conditions will become smaller and the differences between groups practicing under unlike conditions will become larger.

Because of the variable of set or warmup decrement, we predict: (5) On the first post-rest 30 second trial the performance on the third 10 second unit will be higher than on the first 10 second unit; whereas the opposite relationship should be true in the pre-rest 30 second trials.

Although no specific predictions could be formulated ahead of time, it will be seen that, the 10 second unit of measurement within a 30 second trial of distributed practice made possible a great deal of information about the intervening variables of conditioned inhibition and reactive inhibition.

EXPERIMENTAL PROCEDURE

A. <u>Subjects</u>. A total of sixty-five undergraduate college students recruited from the sections in introductory psychology at Michigan State College were used as subjects. About 60% of the subjects were men, however, the number of men and women in each group is approximately the same. Three S's records were rejected because of recording difficulties; two S's records were omitted in order to match the experimental groups more closely on the first 30 second trial. Therefore, the data of the present study is based on 60 S_s, fifteen in each of the four groups. The first 30 S_s were assigned randomly to one of the four groups. The last 30 S_s were placed in one of the groups on the basis of their performance in the first 30 seconds of practice in order to match the groups more closely. This was done without interrupting the recording of the S_s performance.

B. <u>Apparatus</u>. The apparatus consisted of a Koerth-type circular pursuit rotor, two Standard Electric timers which measured to the nearest .01 second S's time on target, a hinged stylus, a Variac to maintain a constant speed for the rotor, a stop-watch, and a double throw-four pole electric switch which simultaneously stopped one clock and started the other clock. The pursuit rotor unit, electric timers, Variac, and switch were mounted on a wooden base. The rotor table was a black, wooden, shellacked disk, 27.1 cm. in diameter, and the brass circular target was 1.9 cm. in diameter set flush with the larger disk and 8.1 cm. from the center of the larger disk to the center of target. The pursuit rotor was designed to turn counter-clockwise in a horizontal position at sixty r.p.m. This direction was deemed to be a more difficult and a more fatiguing task as compared with the usual clockwise motion of the rotor. As such, this modification should lead to a lower performance level and enable a better study of reminiscence and other inhibitory effects. The hinged stylus prevented undue pressure being extertеd on the target by the subject. All experimental work was done in a quiet room with only the experimenter and the subject present.

C. Experimental Design. The basic time unit used to measure all S's performance was a 10 second interval. A longer time interval trial could be calculated from the basic 10 second units. Accurate recording for every 10 seconds of practice was accomplished by manually throwing the four pole-double throw switch with a swift rapid thrust at the end of each 10 second period as measured by the stop-watch. E then recorded the reading on the stopped electric timer, reset it to zero and placed his hand on the handle of the switch in readiness for the next throwing of the switch. E had sufficient time to carry out all the operations in the 10 second period.

The stop-watch was also used to measure and indicate the 30 second trials and 30 seconds of rest in the distributed practice groups and to measure the over-all time for practice and rest sessions.

The measurement of pursuit rotor performance by means of 10 second measuring units within 30 second performance trials in the distributed practice groups is a new technique and was introduced with the hope that it would enable (1) an identification of progressive changes in set or warmup decrement and (2) a charting of the development and decline of inhibition in a detailed fashion.

In the pre-rest practice session all 60 subjects worked for six minutes. The massed group (N-30) worked continuously for six minutes while the distributed group (N-30) alternated between 30 seconds practice and 30 seconds rest until six minutes of practice had been completed. After six minutes of pre-rest practice, both groups had five minutes rest.[2] The post-rest practice session was eight minutes long. As in pre-rest practice, there were two conditions of practice, massed and distributed. However, there was an important difference. Only one-half or 15 S_s of the pre-rest distributed group continued in the same distributed condition in post-rest practice session while the other 15 S_s switched from the pre-rest condition of distributed practice to one of massed practice in the post-rest session of eight minutes.

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[2]The five minute rest period was used as one to provide maximum reminiscence from pre-rest to post-rest performance because of the results from pursuit rotor studies by Kimble and Horenstein (12) and Ammons (2) and because preliminary work carried out by Experimenter with the same apparatus and procedure as used in the present study also indicated that somewhat greater reminiscence occurred with a five minute rest than with a longer or shorter interval.

Similarly, 15 Ss of the pre-rest massed condition continued under the massed condition of practice in the post-rest period while the other 15 Ss were switched to the same distributed practice as other distributed groups had for the eight minutes post-rest session. When both pre-rest and post-rest practice sessions are considered together, there are four groups as follow: distributed-distributed (D-D), distributed-massed (D-M), massed-distributed (M-D), and massed-massed (M-M).

D. Instructions to Subjects. Each subject was first instructed by Experimenter on the following points: To do his best in attempting to keep the stylus on the rotating target as much of the time as possible; to hold the stylus with a relaxed grip; to assume a relaxed posture; and to use a relaxed rotory movement in attempting to follow the target. The operation of the pursuit rotor was then demonstrated by Experimenter while at the same time repeating the instructions that had been given previously. The Ss were told not to start except when told to start, to stop immediately when told to stop and to pick up the stylus, but to make no attempt to follow the target when a "ready" signal was given. After the first stop in the distributed pre-rest practice groups, S was informed that he would alternately work and rest. This was also done before the start of post-rest practice to prevent continued practice after the signal "stop" had been given. When told to stop, S put the stylus down on the table top during the inter-trial interval and, in the case of distributed groups, S stood quietly in front of the rotor.

During the five minute rest for all groups, S_s were permitted to sit down and converse or read. If a S violated any of the instructions during the practice periods, he was corrected immediately. This happened relatively infrequently and did not consume more than a few seconds at any one time for any one subject.

RESULTS AND DISCUSSION

As can be seen from Figure 1 and Table I, the pre-rest performance for the distributed practice is superior to that of the massed practice. The differences in pre-rest performance between M-M and M-D groups and between D-D and M-D groups, however, are not significant (Table I). Hypothesis one is, therefore, confirmed.

The comparison of the last 30 second pre-rest trial with the first 30 second post-rest trial may be made in Figure 1, and the statistical analysis of reminiscence is presented in Table II. All four groups show a highly significant amount of reminiscence. Differences are not significant between M-M and M-D, and between D-D and D-M. As predicted, however, the difference in reminiscence scores between the massed groups and the distributed groups is significant at the 10% level of confidence in favor of the massed groups (See Table III).[3]

Also when a 10 second unit is used as shown in Figure 2, all four groups show a highly significant amount of reminiscence (See Table IV). With this measure differences between M-M and M-D and between D-D and D-M are not significant. But the difference between the massed and distributed groups is now slightly in favor of the distributed groups rather than the massed groups, but the difference as seen in Table V in no way approaches significance.

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[3]If the reminiscence scores had been reckoned from the extrapolated values of the trial after the last trial of pre-rest practice, this difference would probably have been significant at a higher level of confidence.

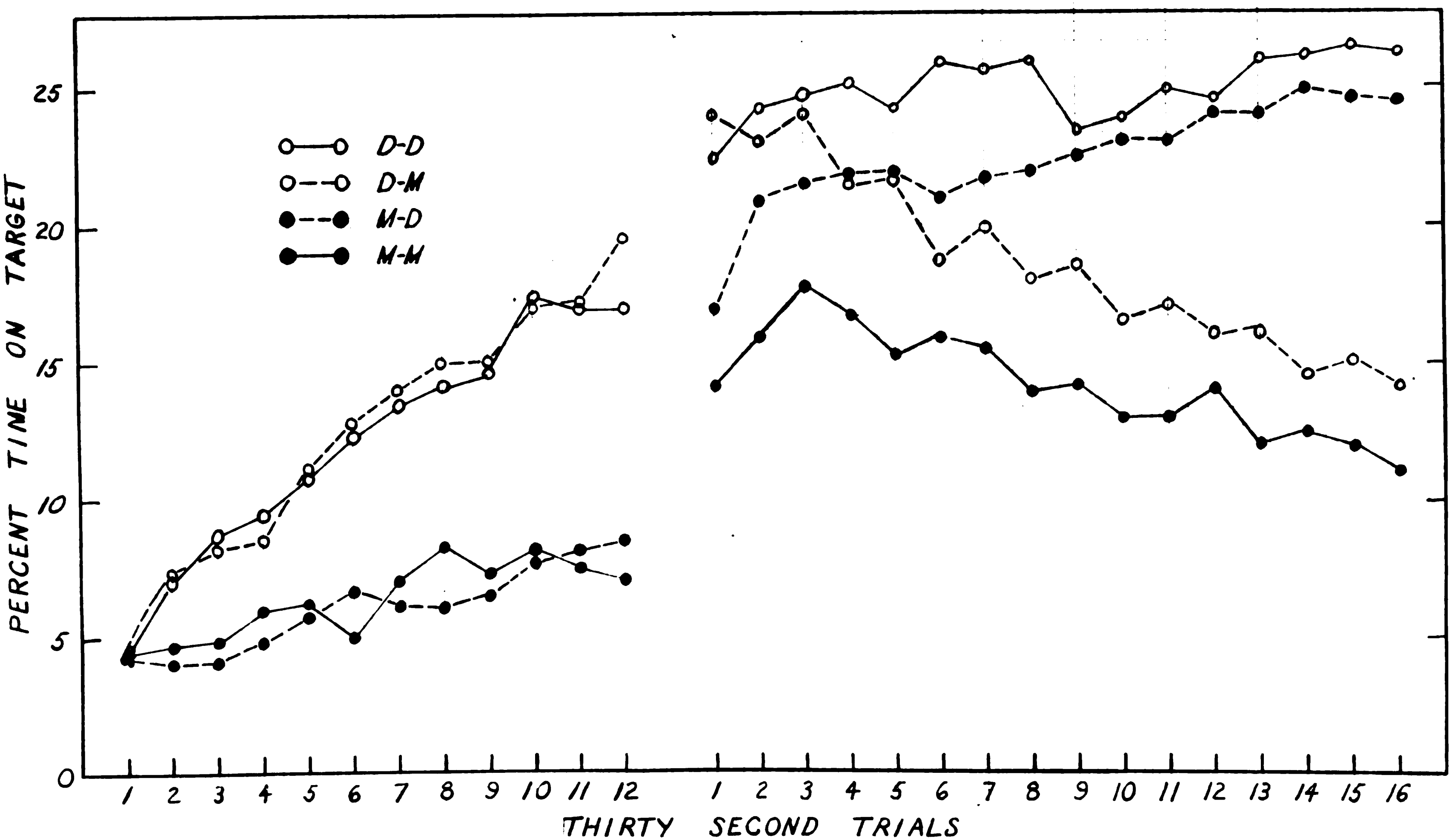

Figure 1 - Performance curves for all four groups for both pre-rest practice (trials #1-12) and post-rest practice (trials #1-16) based **on the means of thirty second trials.**

TABLE I.

AVERAGE TOTAL PRE-REST PERFORMANCE SCORES IN SECONDS

Groups	M-M	M-D	D-M	D-D	M-M&M-D	D-M&D-D
Mean	22.974	21.539	45.031	43.667	22.257	44.349
Standard error of the mean	5.788	3.676	6.434	5.399	3.219	4.219
Difference	1.435		1.365		22.093	
Standard error of the diff.	6.857		8.400		5.236	
t	0.2092		0.1625		4.219	
P	> .50		> .50		< .01	

TABLE II.

MEAN REMINISCENCE SCORES FOR ALL GROUPS AFTER FIVE MINUTE REST BASED ON 30 SECOND TRIALS IN .01 SECONDS

Groups	M-M	M-D	D-M	D-D	M-M&M-D	D-M&D-D
Mean	206.93	251.20	134.27	175.00	229.07	154.64
Standard error of the mean	39.10	46.41	45.23	33.76	30.09	27.97
t	5.292	5.413	2.969	5.184	7.622	5.535
P	$<.01$	$<.01$	$<.02$	$<.01$	$<.01$	$<.01$

TABLE III.

COMPARISON OF REMINISCENCE MEASURES BETWEEN GROUPS FOR 30 SECOND TRIALS AFTER FIVE MINUTE REST IN .01 SECONDS

Groups	M-M	M-D	D-M	D-D	M-M&M-D	D-M&D-D
Mean	206.93	251.20	134.27	175.00	229.07	154.64
Standard error of the mean	39.10	46.41	45.23	33.76	30.09	27.97
Difference	44.27		40.73		74.43	
Standard error of the diff.	60.69		56.39		41.08	
t	0.729		0.722		1.812	
P	.48		.48		.08	

This finding is only a seeming contradiction. In the first place, the measurement of reminiscence with 30 second trials is lowered in distributed practice by not taking into account the high value of trial #34 compared to the decline of performance in the last two pre-rest 10 second trials (Figure 2, trials #34, #35 and #36). The last three 10 second tirals, when averaged (See Figure 1, trial 12), are higher than trial #36 alone, thereby increasing the advantage of the massed reminiscence scores over the distributed. On the other hand, reminiscence measures based on 10 second trials give maximal reminiscence values to the distributed practice groups and show that the reminiscence scores for both distributed and massed practice are almost equal. This difference in measuring techniques would account for the seemingly opposite results obtained in the present experiment.

Examination of Figure 1 shows that after two minutes of practice, the post-rest performance level of the four groups ranges from high to low in the predicted order (hypothesis three): (a) D-D, (b) M-D, (c) D-M, (d) M-M. Also, as predicted, the curves for D-D and M-D and also for M-M and D-M converge with continued practice. The differences between D-D and M-D and also between M-M and D-M on the last minute of practice are not significant, while these differences are extremely large in the early part of post-rest practice. The difference between the post-rest distributed and the post-rest massed groups which is continuously increasing, is highly significant at the last minute of post-rest practice as shown in Table VI. Thus hypothesis four is confirmed. Ammons (2) has shown a similar trend in terms of a decline in performance during post-rest massed practice. It should be pointed out, however, that although the differences between the two groups working under similar practice conditions are not statistically significant at the end of post-rest practice, there has been a consistent difference throughout the eight minutes of post-rest practice. Longer post-rest practice, of course, might bring about a complete equalization of performance.

From Figure 2 it can be seen that the performance for all groups on the third 10 second period of the first post-rest 30 second trial is higher than on the first 10 second period. The statistical analysis of these results is presented in Table VII. The difference between the first and third 10 second periods on the first 30 second post-rest trial is significant at the 2% level of confidence. Futhermore, this difference is opposite to that found in the pre-rest practice trials and the last six minutes of post-rest practice where set is assumed to be well established. This result is in full agreement with our predictions in hypothesis five. This initial post-rest increase presumably due to the regaining of set was studied by Ammons (2), and the "hump phenomenon" or the characteristic shape of the post-rest curve found by Ammons (2) and predicted by Ammons (1) in his theoretical analysis is found in the present experiment in the massed-massed group and both post-rest distributed groups (See Figure 1).

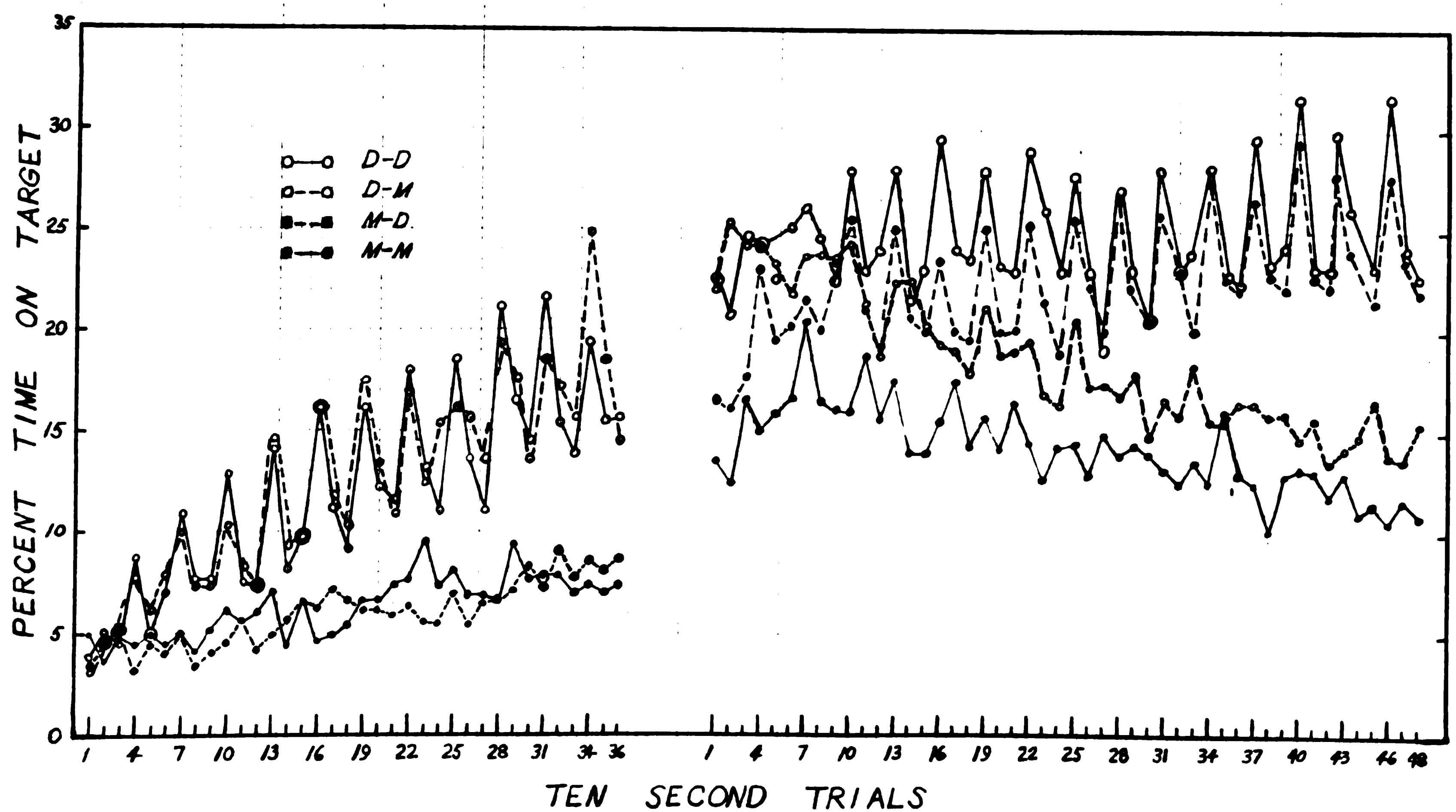

Figure 2 - Performance curves for all four groups for both pre-rest practice (trials #1-36) and post-rest practice (trials #1-48) based on the means of ten second trials.

TABLE IV.

MEAN REMINISCENCE SCORES FOR ALL GROUPS
AFTER FIVE MINUTE REST BASED
ON 10 SECOND TRIALS IN
.01 SECONDS

Groups	M-M	M-D	D-M	D-D	M-M&M-D	D-M&D-D
Mean	54.47	78.27	80.87	67.80	66.37	74.33
Standard error of the mean	17.44	20.56	20.48	21.66	13.42	10.09
t	3.118	3.814	3.944	3.122	4.945	7.368
P	<.01	<.01	<.01	<.01	<.01	<.01

TABLE V.

COMPARISON OF REMINISCENCE MEASURES BETWEEN GROUPS FOR 10 SECONDS AFTER FIVE MINUTE REST IN .01 SECONDS

Groups	M-M	M-D	D-M	D-D	M-M&M-D	D-M&D-D
Means	54.47	78.27	80.87	67.80	66.37	74.33
Standard error of the mean	17.44	20.56	20.48	21.66	13.42	10.09
Difference	23.80		13.07		7.96	
Standard error of the diff.	28.78		29.83		16.79	
t	0.826		0.438		0.474	
P	.41		>.50		>.50	

TABLE VI.

SIGNIFICANCE OF DIFFERENCES BETWEEN GROUPS FOR THE LAST MINUTE OF POST-REST PRACTICE IN .01 SECONDS

Groups	M-M	D-M	M-D	D-D	M-M&D-M	M-D&D-D
Means	689.33	884.00	1466.73	1577.00	786.67	1521.87
Standard error of the mean	124.76	104.83	142.78	103.21	82.04	86.93
Difference	194.67		110.27		735.20	
Standard error of the diff.	162.91		175.88		119.48	
t	1.195		0.627		6.162	
P	.22		$>.50$		$<.01$	

TABLE VII.

COMPARISON OF THE DIFFERENCE BETWEEN THE FIRST POST-REST 10 SECOND TRIAL AND THE THIRD POST-REST 10 SECOND TRIAL FOR ALL GROUPS IN .01 SECONDS

Post-Rest Trials	3rd	1st
Mean	208.53	186.41
Difference	22.12	
Standard error of the mean	8.94	
t	2.474	
P	.02	

At this point we can say that the findings are in essential agreement with the theoretical analyses of motor learning made by Hull (6) and Ammons (1) and are in accord with the empirical findings of Ammons (2), Bell (3), Buxton (4), Kientzle (7), Kimble (11), Kimble and Horenstein (12), and Melton (13).

Several interesting analyses are possible with the 10 second unit of measurement. For one thing, it seems that reactive inhibition (I_R) builds up in a single 30 second work period. For both distributed groups show a significant amount of reminiscence with 30 seconds rest after the first 30 seconds pre-rest practice trial as indicated by the increase in performance between the third and fourth 10 second trials. On the other hand, the massed groups which had no rest show a definite decrement at this point (See Table VIII). As can be seen from Table IX, the difference between the massed groups and the distributed groups in terms of score change is highly significant while the differences between M-M and M-D, and also between D-M and D-D are insignificant.

Another important finding from the 10 second analysis is that the amount of reminiscence displayed in the distributed groups between pre-rest 10 second trials #33 and #34 which were separated by a 30 second rest does not differ significantly from the amount of reminiscence found between the 36th pre-rest trial and the first 10 second post-rest trial which were separated by a five minute rest (See Table X). The reminiscence measure between trials #33 and #34 was selected for comparison with the five minute reminiscence measure since

TABLE VIII.

COMPARISON OF THE PERFORMANCE CHANGES BETWEEN THE THIRD AND FOURTH 10 SECOND TRIALS OF PRE-REST PRACTICE IN .01 SECONDS

Groups	M-M	M-D	D-M	D-D	M-M&M-D	D-M&D-D
Mean	-8.00	-19.60	31.67	44.47	-13.80	38.06
Standard error of the mean	4.49	6.73	9.69	9.99	4.13	6.94
t	-1.78	-2.91	3.27	4.45	-3.34	5.48
P	.10	.02	<.01	<.01	<.01	<.01

TABLE IX.

COMPARISON OF THE DIFFERENCE BETWEEN THE THIRD TO THE FOURTH 10 SECOND TRIAL DIFFERENCES FOR ALL GROUPS IN .01 SECONDS

Groups	M-M	M-D	D-M	D-D	M-M&M-D	D-M&D-D
Mean	-8.00	-19.60	31.67	44.47	-13.80	38.06
Standard error of the mean	4.49	6.73	9.69	9.99	4.13	6.94
Difference	11.60		12.80		51.86	
Standard error of the diff.	8.11		13.93		8.09	
t	1.431		0.919		6.402	
P	.17		.36		$< .01$	

TABLE X.

COMPARISON OF REMINISCENCE SCORES FOR THE DISTRIBUTED GROUPS FOR A 30 SECOND REST (PRE-REST TRIALS #33-34) AS AGAINST REMINISENCE SCORES FOR A FIVE MINUTE REST (TRIALS #36-1) AS BASED ON 10 SECOND TRIALS IN .01 SECONDS

Groups	D - D		D - M		D-D & D-M	
Reminiscence Points	36-1	33-34	36-1	33-34	36-1	33-34
Mean	67.80	55.00	74.17	91.87	70.99	73.44
Difference	12.80		-17.70		-2.45	
Standard error of the diff.	25.42		23.70		35.44	
t	0.5664		-0.7467		-0.0694	
P	.50		.46		>.50	

Note: A negative difference is in favor of the 30 second rest period.

this point most closely resembled the five minute reminiscence measure in performance level. In other words, reactive inhibition under distributed practice conditions seems to dissipate almost completely in 30 seconds, assuming that no marked decrement due to loss of set occurs during the five minute rest period.

There is evidence, however, that the factor of set is not a significant factor. When reminiscence is measured after five minutes rest for both distributed and massed groups, the loss in performance due to loss in set for both groups should be approximately the same; particularly if only the massed groups' reminiscence is measured on the basis of 30 second trials. By this procedure, one may counteract any possible learning to regain set on each trial in the distributed group by allowing the massed group greater time to regain set before calculation of the reminiscence score. Comparing the five minute reminiscence score for 10 second intervals in the distributed groups and the five minute reminiscence score divided by three obtained for 30 second trials with the massed groups, we find that they are almost exactly equal (0.74 seconds and 0.76 seconds, respectively).

In other words, with the factor of set fairly well controlled, there is just as much reminiscence shown in the distributed group as in the massed group, and our conclusion is the same: after reactive inhibition approaches the maximal value possible under distributed practice conditions, it builds up to the maximal value in approximately 30 seconds and then with 30 seconds rest shows complete or almost complete dissipation. There is indirect evidence from Kimble (10) of the rapid dissipation of reactive inhibition. In his analysis of related motor skill data, Kimble has shown that no conditioned inhibition can develop unless the massing of practice is complete. Since the development of conditioned inhibition is dependent upon a critical value of reactive inhibition being attained and no conditioned inhibition builds up with 30 second work and 5 second inter-trial rest, the conclusion is that considerable reactive inhibition dissipates in less than 5 seconds. We might further conclude that the maximal value of reactive inhibition possible under well distributed conditions is approximately equal to the maximal value possible under completely massed conditions.

In fact, the maximal value of reactive inhibition seems to be reached in approximately 30 seconds of work. This assumption is about the only one that can be made in light of all the reminiscence data considered together. The curve in Figure 3 which shows the increase in reminiscence scores and the final leveling off to a maximal reminiscence value during pre-rest trials for the distributed group cannot be legitimately considered a curve of the development of reactive inhibition, for the reminiscence data indicate that I_R builds up to a maximal value in approximately 30 seconds and is also most completely dissipated in the same period of time. Rather, this curve seems to be more legitimately a description of the progressive increase in the ceiling to which performance can rise after each inter-trial rest period.

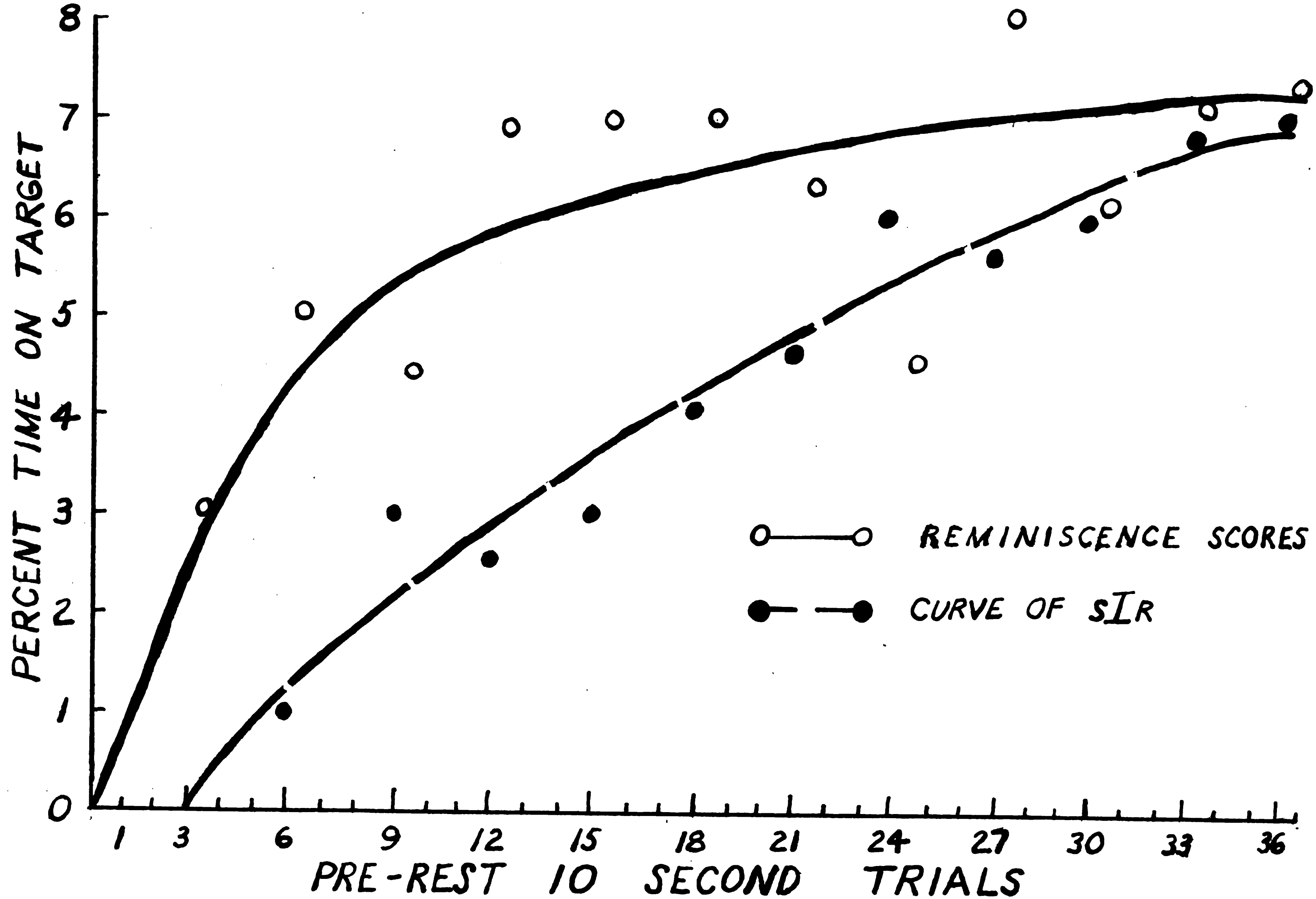

Figure 3 - Curve of pre-rest reminiscence scores and theoretical curve of $_{S}I_{R}$.

The fact that Ammons (2) obtained data which indicated maximal reminiscence is reached after seven to eight minutes of pre-rest practice can be explained by the fact that his groups were not equated for initial habit strength so that Ammons' curve of reactive inhibition may not actually represent a curve of the development of reactive inhibition but rather the ceiling to which reminiscence values may rise as determined by the amount of habit strength present at that period of practice where reminiscence scores were calculated. In accord with our results Kimble (10) has shown that the amount of reminiscence (which is assumed to a valid indicator of reactive inhibition) for groups working under massed conditions and with 5 second inter-trial rest is the same. Since these are different conditions, the conclusion is that there is a limiting value which is reached by both groups to which reactive inhibition can rise.

The curve showing the increase in reminiscence scores during pre-rest distributed practice is derived in the following manner. We assume that most, if not all reactive inhibition dissipates during a 30 second rest period (See Table X), therefore, in the distributed groups, score changes over the 30 second inter-trial rest were considered to be valid reminiscence scores or valid measures of the amount of reactive inhibition built up in the previous 30 second practice trial. Essentially Figure 3 was derived from Figure 2. The reminiscence curve was obtained by plotting each of the average reminiscence scores for the distributed groups during pre-rest practice. These reminiscence scores are computed by subtracting the average value on the last 10 second trial of a 30 second trial from the average value of the first 10 second trial of the succeeding 30 second trial. A curve is then fitted by sight through these points.

The developmental curve of conditioned inhibition in pre-rest practice is presented in Figure 3. The points upon which the curve is based were derived from Figure 2 by taking the successive differences between every third trial of the distributed groups starting with trial #6 and the corresponding trial for the massed groups. Then, a free-hand curve was fitted to these points. The conditioned inhibition curve when extrapolated to zero fell at the second 30 second trial. The principle assumption made in this derivation is that reactive inhibition at the end of the third 10 second trial in the spaced groups is approximately equal to the reactive inhibition at the same point of practice in the pre-rest massed groups (Compare Table V with Table X).

If, at the start of post-rest practice, the amount of I_R present in M-M and D-M is considered equal, then the reciprocal of the differences between these two groups throughout post-rest practice should show the rate of development of conditioned inhibition (See Figure 1). A plotting of these successive differences is given in Figure 4 and a curve was fitted visually through these points. Both Figures 3 and 4 show the development of $_SI_R$ or conditioned inhibition, and though Figure 3 is derived from pre-rest data based on 10 second trials and Figure 4 is derived from post-rest data based on 30 second trials, the two conditioned inhibition curves show a remarkable similarity in general shape and take the form of the postulated exponential function for the growth of a habit.

The same assumption underlies the derivation of Figures 5 and 6 from Figures 1 and 2, respectively. That is, the amount of reactive inhibition present at the beginning of post-rest practice for groups M-D and D-D is the same and the differences between the two groups during post-rest practice is due to the presence of conditioned inhibition. Figure 5 which is derived from the successive differences between M-D and D-D by 30 second trials presumably shows the general form of the extinction of ${}_{S}I_{R}$. The curve is a decay function similar to curves found for the extinction of other habits. Figure 6 which is derived from 10 second trials shows better than Figure 5 the cylic nature of the extinction process. Here it is indicated that each more or less complete extinction of ${}_{S}I_{R}$ is followed rapidly by spontaneous recovery.

One other datum of interest may be noted. As can be seen from examination of Figure 1, the performance of the D-M group in post-rest practice has a regularity of rise and fall which is closely paralleled to the distributed work-rest pattern established in the pre-rest practice session. This would seem to indicate that the conditioned inhibition which develops in post-rest D-M group is regulated by the practice conditions already established.

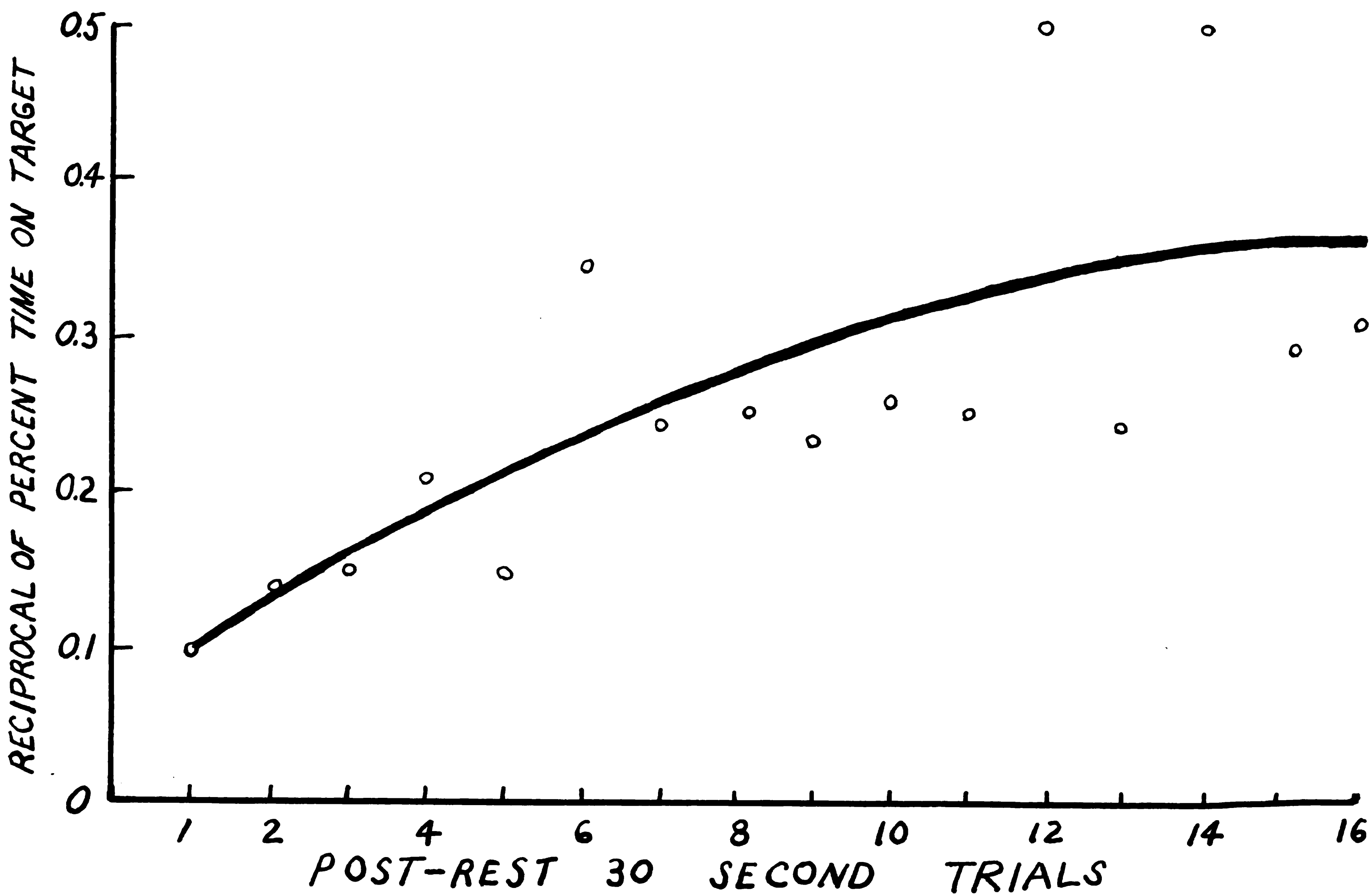

Figure 4 - Theoretical curve of development of $_{S}I_{R}$ in post-rest practice.

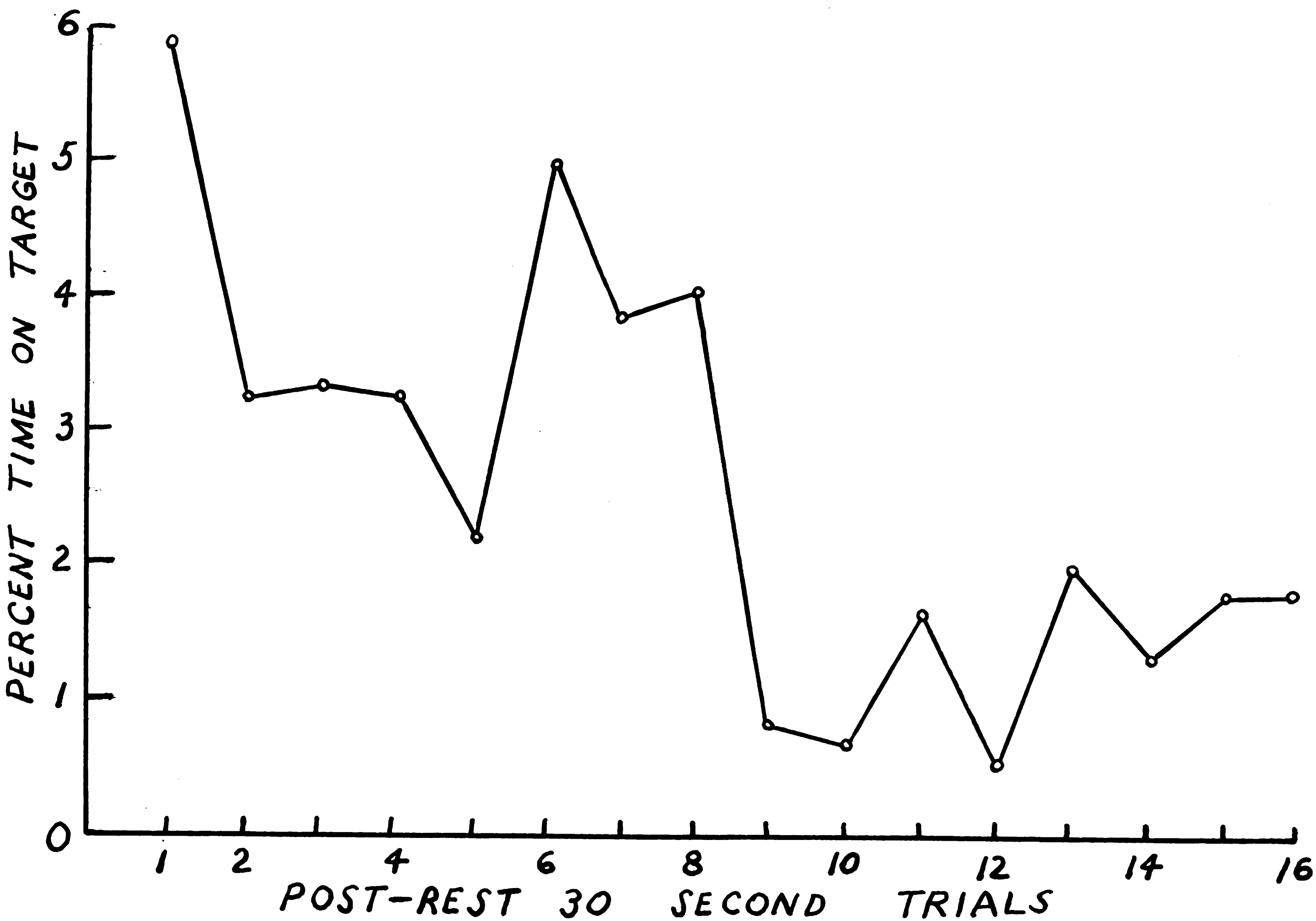

Figure 5 - Theoretical extinction curve of ${}_{S}I_{R}$ based on 30 second trials.

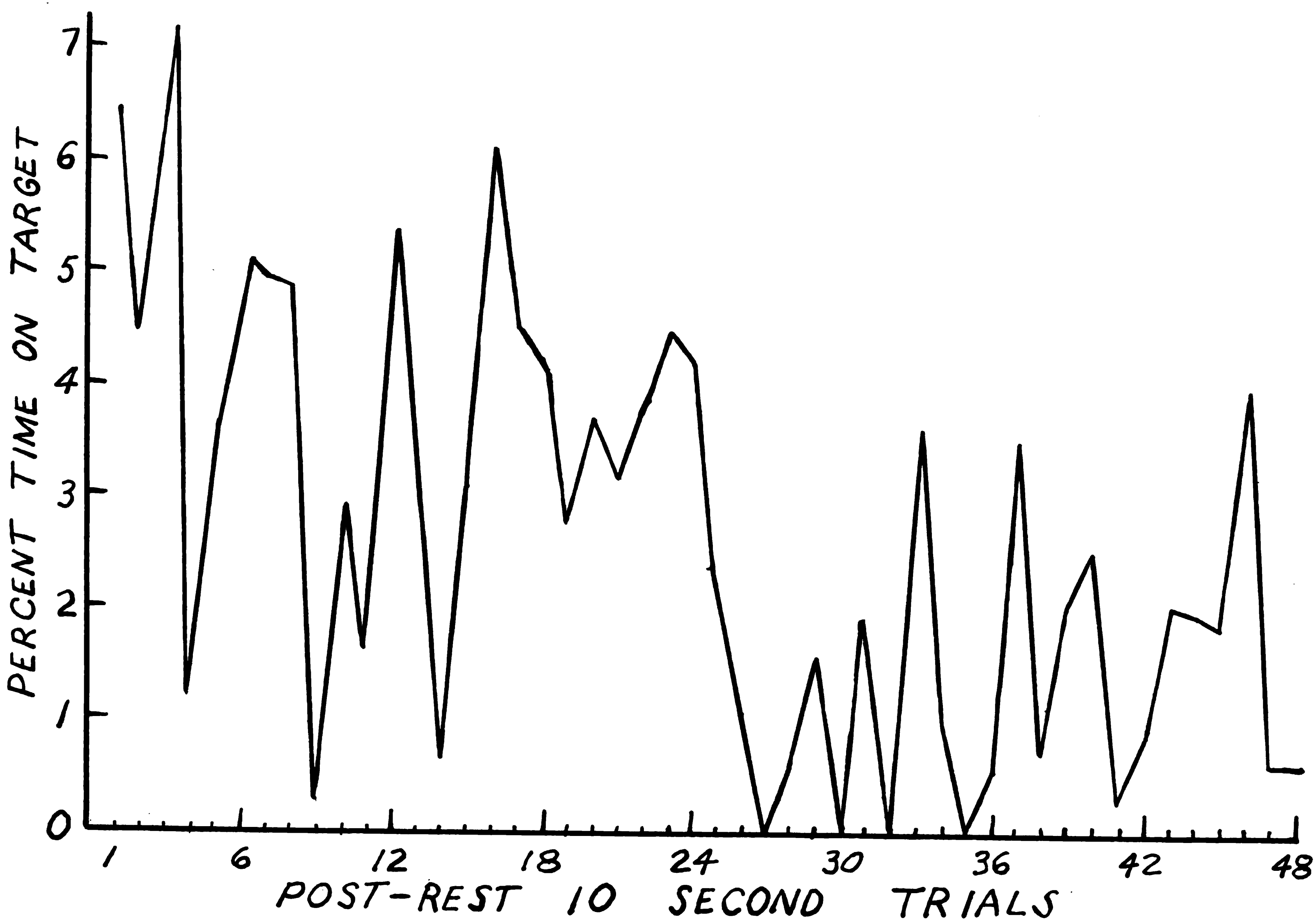

Figure 6 - Theoretical extinction curve of ${}_{S}I_{R}$ based on 10 second trials.

Since many of these findings aforementioned have not been previously reported and since the present study was not designed to study them in an exhaustive manner, our conclusions are considered tentative and a great deal of further research is deemed necessary.

SUMMARY AND CONCLUSIONS

Four groups of 15 subjects each worked on the pursuit rotor task under one of the following pre-rest, post-rest conditions: (a) massed-massed, (b) massed-distributed, (c) distributed-massed, and (d) distributed-distributed.

Pre-rest practice was six minutes long, the rest was five minutes and post-rest practice was eight minutes. Massed conditions were continuous practice, while distributed practice conditions were alternately 30 seconds work and 30 seconds rest. The pursuit meter rotated in a counter-clockwise direction at a speed of sixty revolutions per minute.

The main experimental technique was the measurement of performance at 10 second intervals within a 30 second trial for the distributed practice groups. From this technique results were obtained relating to conditioned inhibition and reactive inhibition.

Five implications of the constructs of reactive inhibition, conditioned inhibition, and set are tested and confirmed. They are: (1) The pre-rest performance for the distributed practice is superior to that of the massed practice groups; (2) After an equal amount of rest, there is more reminiscence in the massed practice groups than in the distributed practice groups; (3) After a few minutes of post-rest practice, the groups will be ranked in performance from high to low in the following order: (a) spaced-spaced, (b) massed-spaced, (c) spaced-massed, and (d) massed-massed; (4) With continued post-rest practice the differences between groups practicing

under identical conditions become smaller and the differences between groups practicing under unlike conditions become larger; (5) On the first post-rest 30 second trial the performance on the third 10 second unit is higher than on the first 10 second unit, whereas the opposite relationship is true in the pre-rest 30 second trials and in post-rest practice after set has been regained.

Several other relationships are also indicated: (1) Considerable reactive inhibition develops with the initial 30 seconds of work; (2) This reactive inhibition, however, is almost if not completely, dissipated in a 30 second rest period; (3) Conditioned inhibition undergoes experimental extinction when practice conditions are changed from massed to distributed; (4) When a 10 second measure is employed for measuring reminiscence over a five minute rest, there is no difference between distributed groups and massed groups.

In addition, theoretical curves plotting the course of development of conditioned inhibition in both pre-rest and post-rest practice are derived. Curves of the extinction of conditioned inhibition in post-rest practice are also presented. These latter conclusions and analyses are considered tentative.

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