THE EFFECT OF MASSING AND DISTRIBUTION OF PRACTICE ON ROTARY PURSUIT TEST SCORES

by

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A report of cooperative research of the Department of Psychology, Army Air Forces School of Aviation Medicine, Randolph Field, Texas, and the Department of Psychology, State University of Iowa, Iowa City, Iowa, conducted by means of equipment and procedures provided by the Army Air Forces School of Aviation Medicine and a grant-in-aid from the National Research Council Committee on Selection and Training of Aircraft Pilots, from funds provided by the Civil Aeronautics Administration.

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Committee on Selection and Training of Aircraft Pilots

Executive Subcommittee

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LETTER OF TRANSMITTAL

NATIONAL RESEARCH COUNCIL

2101 Constitution Avenue, Washington, D. C.
Division of Anthropology and Psychology

Committee on Selection and Training of Aircraft Pilots

March 27, 1945

Dr. Dean R. Brimhall
Director of Research
Civil Aeronautics Administration
Washington 25, D. C.

Dear Dr. Brimhall:

Attached is a report entitled The Effect of Massing and Distribution of Practice on Rotary Pursuit Test Scores, by Kenneth W. Spence, Claude E. Buxton, and Arthur W. Melton. This report is submitted by the Committee on Selection and Training of Aircraft Pilots with the recommendation that it be included in the series of technical reports issued by the Division of Research, Civil Aeronautics Administration.

The report is one of a series to be devoted to extensive research on psychomotor tests conducted at the State University of Iowa through the cooperation of the Committee on Selection and Training of Aircraft Pilots and the staff of the AAF School of Aviation Medicine. As indicated in the Editorial Foreword, while the Committee on Selection and Training of Aircraft Pilots has made but a minor contribution to this study in the form of funds to facilitate the statistical treatment of results, it is included in the series of Committee reports, with the consent of the Air Surgeon, AAF, in the interest of presenting a complete picture of research at the State University of Iowa on psychomotor tests employed in the selection and classification of pilots.

Cordially yours,

Morris S. Viteles

Morris S. Viteles, Chairman
Committee on Selection and
Training of Aircraft Pilots
National Research Council

MSV:rm

EDITORIAL FOREWORD

In 1943, the Committee on Selection and Training of Aircraft Pilots with the cooperation of the Army Air Forces and the U. S. Navy, undertook further investigation of the reliability and relative validity of certain of the psychomotor tests which were being currently employed in the selection of applicants for flight training. These studies were undertaken with the view of determining (1) the effects of extending the time limits (or increasing the number of trials) on the reliability and validity of these instruments; (2) the effects of certain other modifications in the procedures of administration on the reliability and validity; and (3) the intercorrelationships of these psychomotor tests and certain psychomotor and paper-and-pencil tests which are at present being employed in selection batteries at the present time. The over-all goal is, of course, the construction of a selection test battery of greater validity than those already in use.

Prior to the initiation of the program sponsored by the Committee on Selection and Training of Aircraft Pilots the State University of Iowa was already cooperating with the Army Air Forces in an experimental analysis of certain psychomotor tests used in the Aviation Psychology Program of the Army Air Forces. One report of these investigations has appeared as Report No. 29, Division of Research, Civil Aeronautics Administration, April, 1944. The present report describes a second study to grow out of this earlier program. While the Committee on Selection and Training of Aircraft Pilots has made but a minor contribution to this study in the form of funds to facilitate the statistical treatment of results, it is included in this series of Committee reports in the interest of presenting a complete picture of research at the State University of Iowa on psychomotor tests employed in the selection and classification of pilots.

CONTENTS

SUMMARY

Determination of the optimal administrative procedures for the School of Aviation Medicine Rotary Pursuit Test was undertaken at the State University of Iowa as part of a research program on psychomotor tests for selection purposes in aviation. Data obtained on this test were analyzed to answer the following specific questions: (1) the effects of various combinations of length of work period and rest period on the level of performance, (2) the reliability of scores, (3) the intercorrelations among learning segments, and (4) the nature of the learning curve in the task situation.

Two S.A.M. Rotary Pursuit Tests and stylis, provided by the Department of Psychology, School of Aviation Medicine, Randolph Field, Texas, were set up to duplicate as closely as possible the testing conditions employed in the Army Air Forces. All work periods, rest periods, and warning signals were presented automatically, while the time the stylus was in contact with the target on each trial was recorded on a Standard Electric Time Clock.

Three different samples of subjects, none of whom had had previous experience with the test, were employed in the investigation. One sample consisted of 240 women students, another of 121 civilian male students, and a third of 200 Army students with the ages of the civilian subjects ranging from 17 to 32 years and the ages of the Army subjects ranging from 18 to 25 years.

In each of the three samples of subjects four different conditions of practice and rest were employed. In Condition A the subject worked continuously for 8 minutes (recorded as 24 trials of 20 seconds each), in Condition B the subject was tested for 25 seconds with rest intervals of 5 seconds between trials (16 trials), in Condition C the subject worked for 20 seconds with rest intervals of 10 seconds between trials (16 trials), and in Condition D the subject was tested for 30 seconds with rest intervals of 20 seconds interpolated between trials (16 trials).

Preliminary analysis of the data showed that it was undesirable to combine the findings of the men and women subjects. Correlation coefficients were secured between odd and even trials for each of the three samples under the four practice conditions, while intercorrelations between trial segments, total score and gain for the four conditions were obtained only for the two male groups. A general summary of the findings of this study is as follows:

1. When the curves of learning in terms of per cent of time on the target for each of the three samples of subjects under the various conditions were compared it was apparent that Condition D (representing distributed practice) resulted in a higher level of skill and a more rapid rate of learning per amount of practice than any of the other three relatively marked, work conditions.

2. When subjects of the Army group were tested under Condition C, allowed to rest 24 hours, and tested again under Condition D, their average score on the final trial of Condition C was considerably lower than that on the initial trial on Condition D, with their scores rapidly improving as Condition D trials continued. The Pearson r between the two conditions appeared low enough to warrant the separate determination of the validity coefficients of the test scores obtained under Condition D with flight criterion measures. Evidence seemed to suggest that test scores secured under Condition D were not weighted as heavily with the work decrement factor resulting from massed practice as were those under the other three conditions.

3. The reliability coefficients between odd and even trials for each of the three samples under the four conditions were above .90. The reliability coefficients were higher under the conditions of massed practice, probably because the scores were based on greater total amounts of practice. From an analysis of data of the two samples of men, it was found that the reliability coefficients increased consistently under all conditions when based on larger and larger segments of practice.

4. In the Army group the correlations between segments of the learning curve varied from .84 to .96 between adjoining, and from .69 to .82 between initial and final segments. When the correlation coefficients between segment scores and total scores were obtained for the same group it was discovered that the r's were higher for the middle segments of the practice period than for the initial and final segments. Pearson r's between gain scores and segment scores tended to increase from zero at the initial stage of practice to between .60 to .70 at the final stages of practice.

THE EFFECT OF MASSING AND DISTRIBUTION OF PRACTICE ON ROTARY PURSUIT TEST SCORES

INTRODUCTION

A major problem in the use of psychomotor tests for selection purposes is the determination of the optimum conditions of work and rest. Little or nothing is known about the effect of variation of the number of trials and the length of the practice and rest periods on the level of performance, the reliability and validity of scores representing different stages of the learning process and the extent to which different learning segments are related.

The present experiment was undertaken at the initiation of the Department of Psychology, AAF School of Aviation Medicine, as one of a series of investigations directed at studying various administrative procedures for psychomotor classification tests developed and produced by the School of Aviation Medicine. The purpose of the present study was to ascertain the effect of varying the degree of massing and distribution of practice on performance on the S.A.M. Rotary Pursuit Test during the standard 15 minute overall testing period employed in the Army Air Forces selection and classification program.

The results, particularly if one of the experimental conditions yielded a learning rate appreciably greater than that which occurs under the present standard AAF conditions, were to be used by the School of Aviation Medicine in a study in collaboration with one of the research units of the Army Air Forces Training Command as a guide to ascertaining whether this condition favorable to learning showed a higher validity with success in learning to fly. Specifically, then, the present investigation was concerned with the effects of various combinations of length of work and rest periods on (1) the rate and level of performance, (2) the reliability of scores, and (3) the intercorrelation among scores based on different learning segments.

APPARATUS

Two Rotary Pursuit Tests[1] and styli, provided by the Department of Psychology, Research Section, School of Aviation Medicine, Randolph Field, Texas, were set up according to instructions so as to duplicate as closely as possible the standard testing conditions employed in the Army Air Forces tests. A control unit specially constructed for the project by the Department of Psychology, School of Aviation Medicine, permitted the automatic presentation

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[1]This apparatus is an adaptation of the well-known Koerth Pursuit Apparatus. It has been improved by means of the addition of automatic recording of performance and the provision for the simultaneous testing of subjects in small groups. For further information on the S.A.M. Rotary Pursuit Test, see: A.A.F. School of Aviation Medicine. The S.A.M. Rotary Pursuit Test for the classification of aviation cadets. Project No. 125, Report No. 1, 1 March 1943. Also Staffs PRU No. 2 and Department of Psychology, School of Aviation Medicine. Research program on psychomotor tests in the Army Air Forces. Psychol. Bull., 1944, 41, pp. 314-315; and Melton, A. W. The selection of pilots by means of psychomotor tests. J. Aviat. Med., 1944, 15, pp. 118-119.

of all work and rest periods, and all warning signals. Measurement of the time the stylus was in contact with the target on each trial was made by means of a Standard Electric Time Clock, Model S, with readings in thousandths of a minute. Four clocks in all were used, since in one of the experimental conditions (A, continuous work) two clocks were required for each apparatus. In this condition the two clocks were switched into the circuit alternately and automatically by the control unit. Individual data sheets were provided for recording the scores (see Appendix A).

SUBJECTS

The experiment involved three different samples of students at the State University of Iowa: 240 women students, 120 civilian male students, and 200 Army students. The ages of the civilian subjects ranged from 17-32 years, the Army students from 18-25 with the large majority falling within the age range of 18-22. The data for the three samples have been treated separately. None of the subjects had any previous experience with this test.

EXPERIMENTAL PROCEDURE

Four different conditions of distribution of practice and rest were employed in each of the three samples of subjects. One sub-group of subjects in each sample was run under one of the four practice conditions. The conditions were as follows:[2]

A. Continuous work for 8 minutes (recorded as 24 trials of 20 seconds each)

B. Work 25 seconds - Rest 5 seconds (16 trials)

C. Work 20 seconds - Rest 10 seconds (16 trials)

D. Work 10 seconds - Rest 20 seconds (16 trials)

Within each sample the subjects were run in a counterbalanced order until near the end of the experiment when it was necessary to complete those groups which were short because of records which had been found invalid (incorrect readings of the clock, etc.). Graduate students in psychology acted as experimenters. Each was carefully instructed in the procedure of the experiment and the use of the control unit, and was given considerable practice in reading the clocks prior to the experiment. The apparatus was set up in a quiet room. Two subjects were tested at a time, the experimenter giving the following instructions[3] and demonstrations:

1. "This is a test of your ability to follow a moving target. This black disc (point) will rotate in a clockwise direction." (Examiner traces motion with finger.) "Your task is to keep the point of this stylus (point) in contact

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[2]The subjects in Conditions B and D of the Army sample were run a total of 24 instead of 16 trials.

[3]These are standard AAF classification test instructions.

with the round brass target (point) while the disc is turning. Your score is the amount of time the stylus is on the target."

2. "The stylus is to be held lightly in your preferred hand in this manner." (Examiner demonstrates correct manner of holding stylus.) "Hold the back of the hand up, with all four fingers and the thumb grasping the handle. Hold the cord in your other hand." (Examiner follows moving target with stylus.) "Follow the target like this, trying to stay in contact with it for as great a time as possible. You will do best if you develop a smooth, free-swinging motion of your arm and shoulder, like this." (Examiner demonstrates.)

3. "You will notice that the stylus is made so that you cannot easily put pressure on its point. Do not attempt to put pressure on the point by turning the handle up like this (examiner demonstrates), by tilting the stylus like this (examiner demonstrates), or by putting your finger on the metal rod like this (examiner demonstrates). Now pick up your styluses and place them on the target." (Each man's grip on his stylus is examined and corrected, if necessary, by the test administrator who repeats appropriate parts of the instructions.)

4. "You will be given a series of tests and rests. When the disc starts, put the stylus on the target and try to keep it there. Your score does not begin to count until the first bell rings. When the second bell rings, lift the stylus off the target and keep it off until the disc starts again. Are there any questions?"

5. "Remember, your score is the amount of time that the stylus is actually in contact with the target. Ready....."

RESULTS

The presentation of results has been divided into four parts: (1) distributions, means, and standard deviations of total and segmental scores; (2) learning data; (3) reliability measures; (4) intercorrelations between various trial segments, total scores and gains.

Preliminary analysis of the data revealed sufficient differences between the men and women subjects, both as regards level of performance and the effects of the experimental conditions, to make it seem undesirable to combine their data. For this same reason analysis of the reliability measures and segmental intercorrelations were computed only for the men's groups. The latter were obtained for each of the male groups in order to provide information as to the consistency of these statistics in samples of this size.

Distributions, Means and Standard Deviations of Total and Segmental Scores. Table 1 presents the frequency distributions for the twelve different groups of subjects. Tables 2 and 3 show the means and standard deviations of the distributions of the learning scores under the four different practice con-

FREQUENCY DISTRIBUTIONS OF (CUMULATIVE) SCORES

Minutes (Thousandths)	Army Men Groups				Civilian Men Groups			Women Groups			
	A	B	C	D	B	C	D	A	B	C	D
1-200	3	2	2	3	1	3	3	5	7	7	10
201-400	8	6	6	8	0	0	5	10	8	12	21
401-600	9	6	5	12	5	4	11	10	15	15	18
601-800	0	5	6	5	6	2	6	8	7	0	3
801-1000	0	4	10	8	2	1	3	7	8	6	3
1001-1200	3	4	5	3	3	4	1	3	5	4	0
1201-1400	5	1	5	1	2	4	1	3	1	5	0
1401-1600	2	4	3	0	2	1	0	3	2	2	0
1601-1800	1	5	2	0	2	2	0	3	1	0	0
1801-2000	3	4	5	0	3	2	1	3	3	1	0
2001-2200	3	3	0	0	2	3	0	1	1	0	0
2201-2400	3	1	0	0	1	0	0	2	0	0	0
2401-2600	0	2	0	0	1	0	0	2	0	0	0
2601-2800	1	2	0	0	0	0	0	0	0	0	0
2801-3000	3	1	1	0	0	0	0	0	0	0	0
3001-3200	2	0	0	0	0	0	0	0	0	0	0
3201-3400	0	0	0	0	0	0	0	0	0	0	0
3401-3600	2	0	0	0							
3601-3800	1	0	0	0							
	50	50	50	50	30	30	30	60	60	60	60

ditions for the Army men and civilian male students.[4] The means of the learning scores for the women groups are given in Table 4.

Comparisons of the values in these tables indicate that under comparable working conditions the women subjects perform more poorly than men at all stages of practice. The data for the two samples of men are more or less similar although the scores of the Army group which worked under Condition A are consistently more variable than those for the comparable civilian group.[5]

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[4]For comparison with the other two samples, the total scores, mean, and standard deviations of the Army men are based on the first 16 trials of Conditions B and D. (See footnote 2.)

[5]No attempt has been made to ascertain the statistical significance of the difference between comparable scores for the three groups. Calculation for some of the larger differences between the two male samples indicated that the only differences that approach significance (beyond the 5% level of confidence) are those between some of the variability measures (σ dis) for the A groups. The mean performance scores of the men are significantly superior to comparable measures obtained for the women. The 't' ratios for the total scores were all significant beyond the 1% level.

TABLE 4

MEANS IN MINUTES OF VARIOUS SEGMENTS OF LEARNING SCORES
(WOMEN)

Trial Segment	Group A* Mean	Group B Mean	Group C Mean	Group D Mean
1-4	.082	.125	.112	.057
5-8	.113	.171	.148	.080
9-12	.153	.210	.176	.120
13-16	.184	.245	.216	.148
17-20	.181	---	---	---
21-24	.194	---	---	---
1-8	---	.296	.260	.137
9-16	---	.456	.392	.268
1-12	.340	---	---	---
13-24	.559	---	---	---
1-16	.530	.752	.652	.405
1-24	.904	---	---	---

*N for each group = 60

Learning Data. Curves of learning[6] in terms of the per cent of time on the target, for each of the three samples of subjects, are presented in Figures 5, 6, and 7. The numerical data on which these graphs are based are presented in Appendix B. These graphs permit a comparison of the level of skill attained after various amounts of practice under the four conditions of work and rest. It is readily apparent from an examination of these graphs that Condition D in which the subjects worked 20 seconds and rested 20 seconds resulted in a more rapid rate of learning per amount of practice, and a higher level of skill than any of the other three, relatively massed, work conditions. There are no consistent differences among the latter, although there is a tendency for the scores under Condition B to be somewhat below those for the other conditions in the men's groups. The results for the two larger samples, the women and Army men, present a more or less similar picture. The more variable results in Figure 7 are probably not unrelated to the smaller number of subjects in each of the groups in the sample of civilian men subjects.

These results indicate that Condition C under which the Rotary Pursuit Test has been given in the Army Air Forces battery of psychomotor tests is a highly massed condition. In fact, there is little or no difference in the rate of progress under this condition and the rate under continuous work (Condition A).

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[6] Note that the learning curves of the Army men for Conditions B and D are based on 24 trials.

MEANS AND STANDARD DEVIATIONS (IN MINUTES) OF
VARIOUS SEGMENTS OF LEARNING SCORES (NAVY MEN)

Trial Segments	Group A* Mean	Group A* Sdis.	Group B Mean	Group B Sdis.	Group C Mean	Group C Sdis.	Group D Mean	Group D Sdis.
1-4	.189	.160	.225	.169	.173	.130	.105	.060
5-8	.144	.168	.159	.207	.242	.170	.132	.069
9-12	.077	.172	.152	.226	.177	.147	.164	.073
13-16	.107	.191	.128	.215	.122	.160	.216	.088
17-20	.127	.196	---	---	---	---	---	---
21-24	.130	.173	---	---	---	---	---	---
1-8	---	---	.345	.366	.415	.297	.237	.226
9-16	---	---	.289	.414	.290	.298	.380	.255
1-12	.710	.458	---	---	---	---	---	---
13-24	.968	.538	---	---	---	---	---	---
1-16	---	---	1.066	.766	1.004	.579	.617	.267
1-24	1.674	.973	---	---	---	---	---	---

*N for each group = 50

TABLE 3

MEANS AND STANDARD DEVIATIONS (IN MINUTES) OF
VARIOUS SEGMENTS OF LEARNING SCORES (CIVILIAN MEN)

Trial Segments	Group A* Mean	Group A* Sdis.	Group B Mean	Group B Sdis.	Group C Mean	Group C Sdis.	Group D Mean	Group D Sdis.
1-4	.194	.140	.216	.164	.215	.121	.103	.071
5-8	.251	.153	.279	.172	.284	.137	.134	.091
9-12	.312	.133	.331	.173	.328	.141	.166	.093
13-16	.320	.103	.358	.171	.376	.155	.191	.096
17-20	.361	.121	---	---	---	---	---	---
21-24	.360	.147	---	---	---	---	---	---
1-8	---	---	.495	.329	.498	.250	.237	.158
9-16	---	---	.689	.334	.704	.288	.356	.186
1-12	.757	.397	---	---	---	---	---	---
13-24	1.041	.348	---	---	---	---	---	---
1-16	---	---	1.184	.638	1.201	.512	.593	.378
1-24	1.799	.669	---	---	---	---	---	---

*N for each group = 30

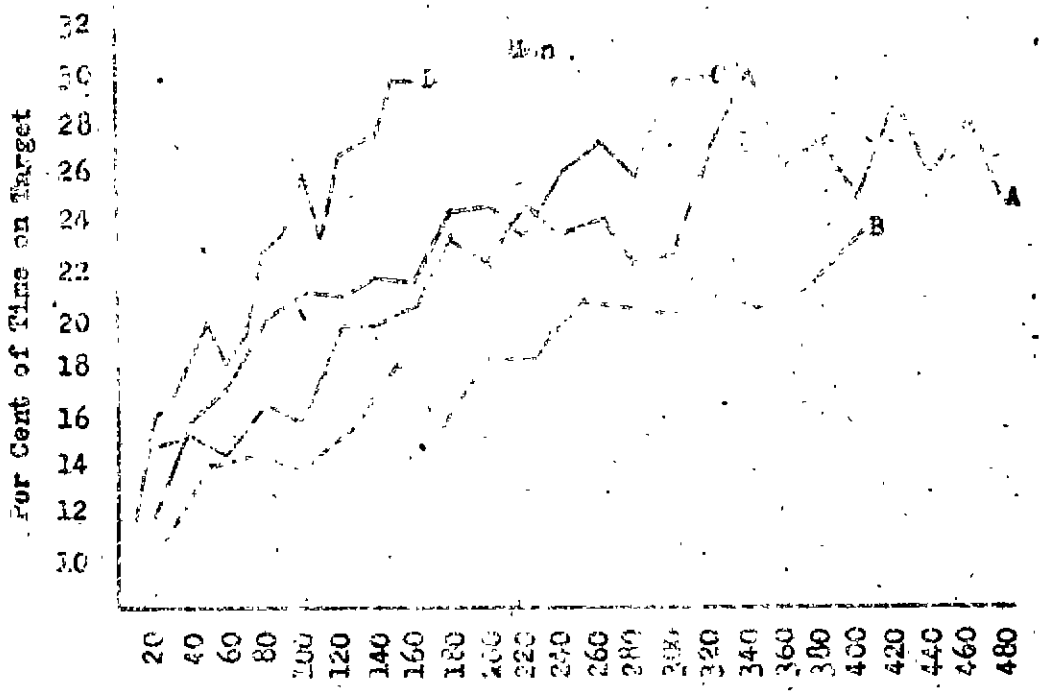

FIGURE II

GRAPH SHOWING PERFORMANCE (PER CENT OF TIME ON TARGET) AS FUNCTION OF AMOUNT OF PRACTICE FOR THE CIVILIAN MEN (N, for each group = 30)

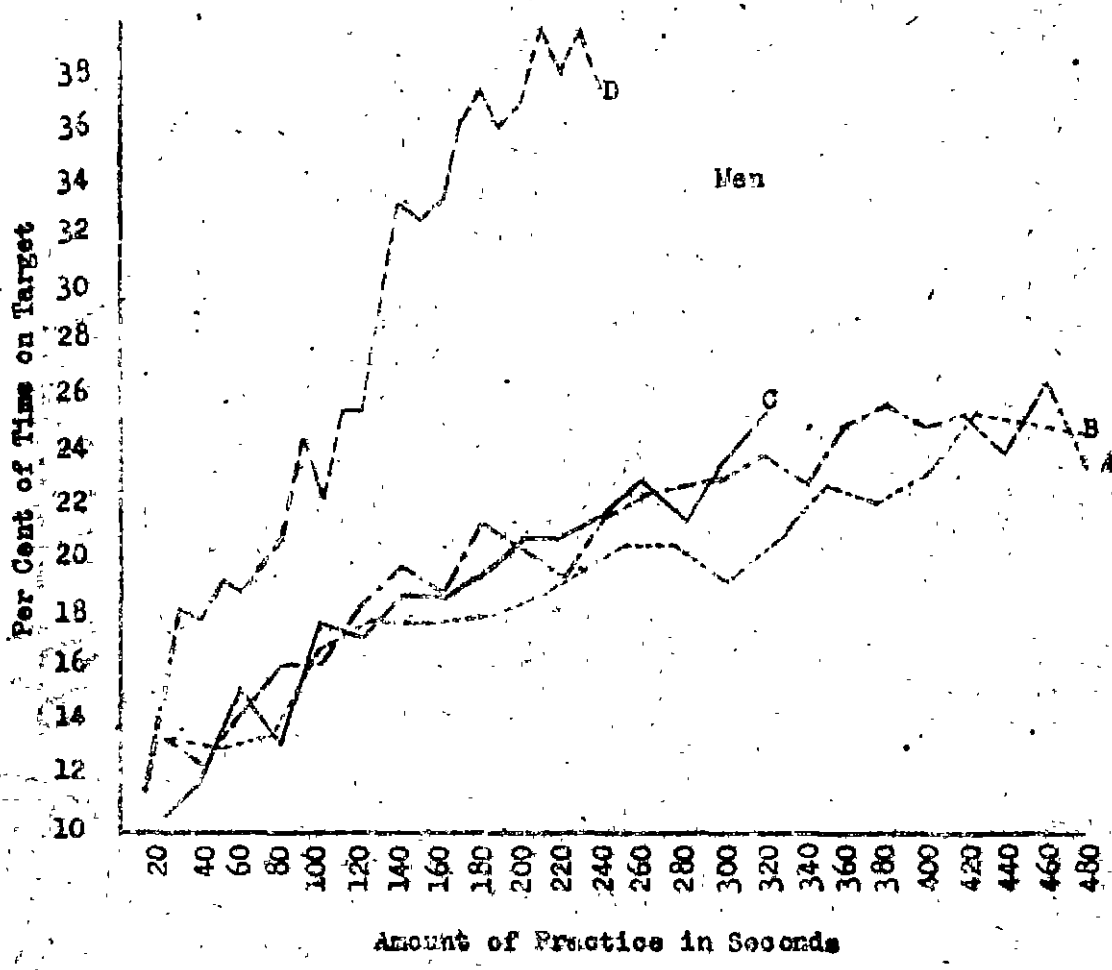

FIGURE I

GRAPH SHOWING PERFORMANCE (PER CENT OF TIME ON TARGET) AS FUNCTION OF AMOUNT OF PRACTICE FOR THE ARMY SUBJECTS (N for each group = 50)

If we think of the performance score (P = % of time on target) on the rotary test as being, other things equal, a joint function of a hypothetical factor, skill, and a further factor, work decrement or inhibition, i.e., [P = f (S, I)], it will be seen that Conditions A, B, and C provide a performance score in which the work decrement factor is prominent whereas in Condition D this factor is, relatively at least, minimized.

An indication of the level of performance attained by subjects that had practiced under a relatively massed Condition (C) when this work inhibition has presumably been reduced by a lengthy rest period is shown in Figure IV. This graph presents the performance curves for Groups C and D of the Army men and further results 24 hours later for the original Group C when run under Condition D. The level of performance on the first few trials on the second day, it will be observed, is considerably above the level of performance attained at the end of the first day. Presumably the difference between these levels represents the extent to which the performance score for Condition C at the end of the first day is depressed by this work inhibition factor.

The question as to which of these two conditions of practice, massed or distributed, provides the more valid score so far as predicting success in learning to fly cannot, of course, be answered by the results of the present investigation. Some indication of the extent to which the two different measures, that in which work inhibition is relatively great and that in which it is minimized, are related can be obtained by correlating the scores for members of Group C obtained on the first day with their scores on the second day. That is, such a coefficient might be thought of as indicating the extent to which test scores heavily weighted by work inhibition would correlate with test scores in which work inhibition would not be so great because of recovery during the 24-hour interval. The product-moment correlation between the total cumulative score for the first day and the first four trials of day 2 for Group C of the Army sample was .68. This value compares with correlations in the neighborhood of .90 found between adjoining four trial segments on the same day, e.g., Trials 8-12 vs. 13-16 in day 1. While indicating that the two measures are fairly highly correlated, it is sufficiently low to warrant separate determination of the validity coefficient of test scores obtained under distributed practice (Condition D) with flight criterion measures.

Reliability of Measures. Correlation coefficients between the odd and even trials for all three samples under the several practice conditions are shown in Table 5. It will be seen that these values are consistently high, ranging for the two men's samples from .95 to .98 and from .91 to .97 in the sample of women subjects. It will be observed that the correlations in the case of the men's groups show a consistent trend, tending to be higher the greater the massing of practice. The data for the women show a similar trend with the exception that the correlations for Conditions B and C are reversed in size.

This tendency for the reliability coefficients to increase under the massed conditions may, on the other hand, be related to the fact that the scores for the massed conditions are based on greater total amounts of practice. Thus Condition A scores are based upon 480 seconds of work, Condition B scores on 400 seconds, Condition C scores on 320 seconds, and Condition D on only 160 seconds of practice.

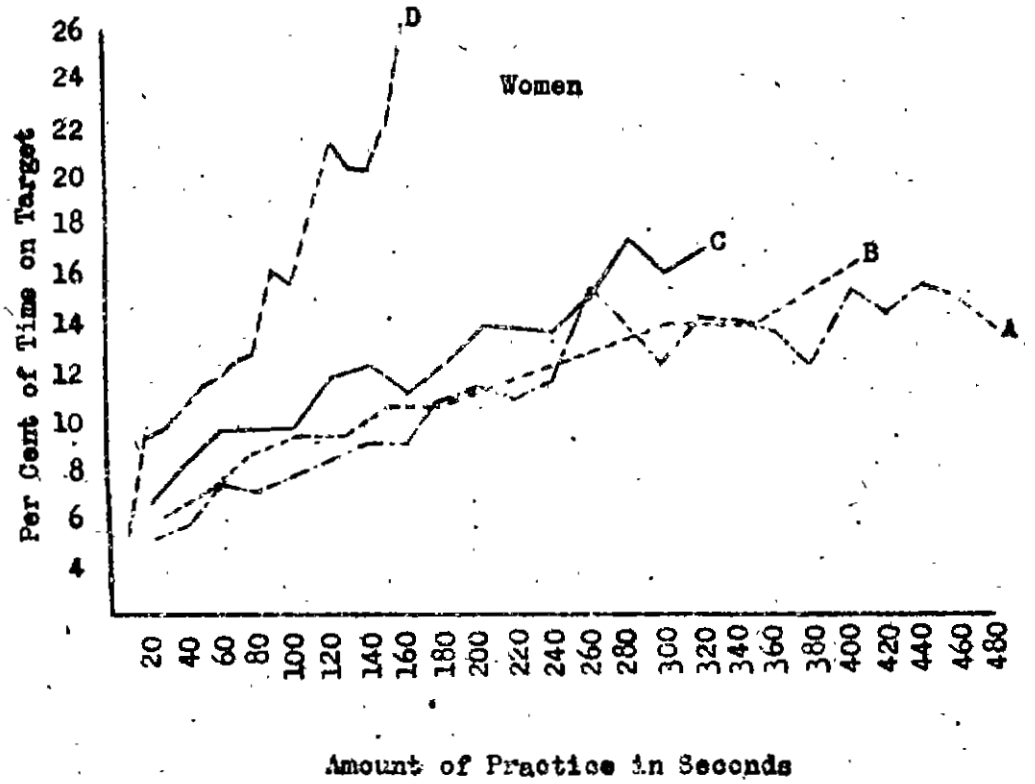

FIGURE III

GRAPH SHOWING PERFORMANCE (PER CENT OF TIME ON TARGET) AS FUNCTION OF AMOUNT OF PRACTICE FOR THE WOMEN (N for each group = 60)

Table 5

[illegible] Reliability Coefficients*

Condition	Army Men ([illegible])	Civilian Men (30)	Women (60)
A	.98	.97	.97
B	.98	.96	.95
C	.97	.96	.96
D	.95	.95	.91

*All of the [illegible] coefficients are based on the first 16 trials for Conditions B, C, and D. That is, the sum of scores on Trials 1, 3, 5, 7, 9, 11, 13, and 15 were correlated with those on trials 2, 4, 6, 8, 10, 12, 14 and 16. In the case of Condition A the scores correlated were based on odd and even trials for the 24 trials of [illegible] seconds each.

Table 6 lends further support to this interpretation. It presents the reliability coefficients for successively longer segments of practice beginning with the first four trials and adding successively four trial increments. It will be seen that the coefficients increase consistently in the two samples and for all conditions as they are based on larger and larger segments of practice. Figure V, in which the reliability coefficients for the different work conditions in the Army sample are plotted as a function of the amount of practice in terms of seconds, shows clearly that these reliability coefficients increase to an asymptotic value as the length of the practice period is increased.

These results indicate that test scores based on only eight trials, particularly in the more massed conditions, would provide measures of satisfactory reliability. Under Condition A, in which the subject worked continuously, scores based on only four trials (80 seconds) gave correlations above .92. The question as to whether scores based on such a brief period of practice measure the same thing as scores based on more extended practice must also be taken into consideration. The next section, therefore, provides evidence on the extent to which different segments of learning correlate with each other, with the total score, and also with a measure of gain (final segment of four trials minus initial segment of four trials).

Intercorrelations Between Various Trial Segments, Total Scores and Gains in Performance Level. Intercorrelations between segmental, total, and gain scores for both the Army and civilian groups are presented in the tables in Appendix C. Examination of comparable tables will reveal that essentially similar results were obtained for the two samples. Probably, because of the larger number of cases in the Army sample the correlations for these groups tend to be somewhat more stable than those for the civilian group. For this reason our discussion will be based primarily on the data for the Army sample.

The results in each of the conditions are more or less similar so far as the correlations between practice segments (i.e., four trial segments) are

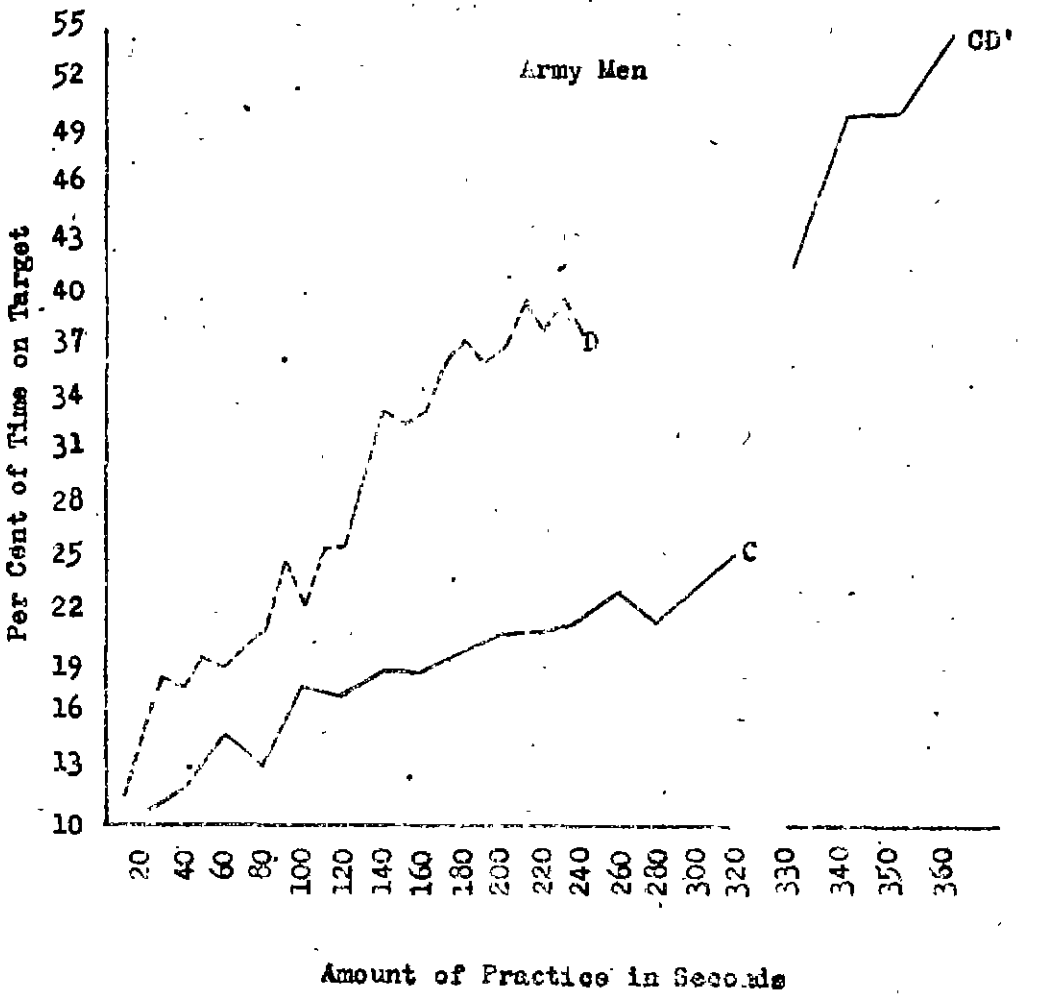

FIGURE IV

GRAPH SHOWING PERFORMANCE (PER CENT OF TIME ON TARGET) AS A FUNCTION OF AMOUNT OF PRACTICE FOR THE ARMY MEN. CONDITIONS C, D, AND D' AFTER INITIAL TRAINING ON CONDITION C.
(N for each group = 50)

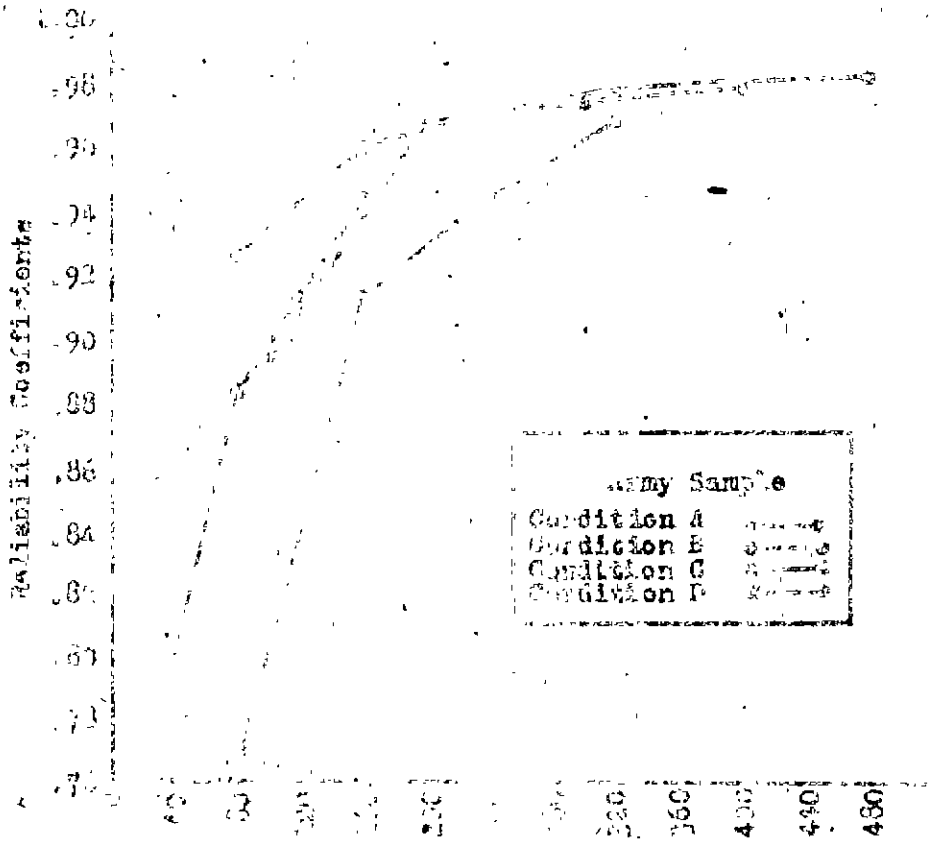

FIGURE 4

ODD-EVEN RELIABILITY COEFFICIENTS AS A FUNCTION OF TIME ALLOWED FOR PRACTICE

TABLE 6

ODD VS. EVEN TRIAL CORRELATION COEFFICIENTS
FOR CUMULATIVE SEGMENTS OF LEARNING TRIALS
(ARMY AND CIVILIAN MEN)

Trial Segments	Conditions A		B		C		D	
	Army	Civ.	Army	Civ.	Army	Civ.	Army	Civ.
1-4	.93	.94	.89	.89	.77	.87	.80	.87
1-8	.96	.96	.97	.91	.91	.90	.88	.94
1-12	.97	.96	.98	.94	.95	.94	.91	.96
1-16	.98	.97	.98	.96	.97	.96	.95	.95
1-24	.98	.97						

concerned. In general, adjoining segments correlate most highly with each other and, with increasing distance between segments, the coefficients decrease. Correlations between adjoining segments in the Army sample range from .84 to .96 while those between the most distant segments, i.e., between initial and final segments vary from .69 to .82. (See Tables 19-22 in Appendix C.)

An interesting relationship between the segment scores and the total cumulative score (all trials) is revealed in Figure VI. This graph shows that the correlation coefficients between the segment scores and total score are greater for the middle segments of the practice period than in the case of the initial and final segments. The four different conditions reveal essentially the same pattern. All segments, it will further be observed, are highly correlated with the total score. The latter is a kind of compromise score depending upon initial performance and amount of gain from practice.

A gain measure has been suggested by some investigators as possibly providing a better indication of rate of learning a complex motor skill than either initial or final status, or the total score. Figure VII reveals some interesting information concerning this measure. It shows that the gain score correlates zero with initial status but that the relationship increases consistently thereafter to a value between .60 and .70. The correlations between the gain measure and total score for the four practice conditions, as shown at the extreme right of the graph, range about half way between the extremes of the coefficients for the smaller segments, i.e., 1-4, 5-8, etc. The difference in the magnitude of the correlations between the gain scores and segment scores is not a little surprising in view of the high correlations found to exist among the latter. These correlations ranged, as stated above, between .69 and .96.

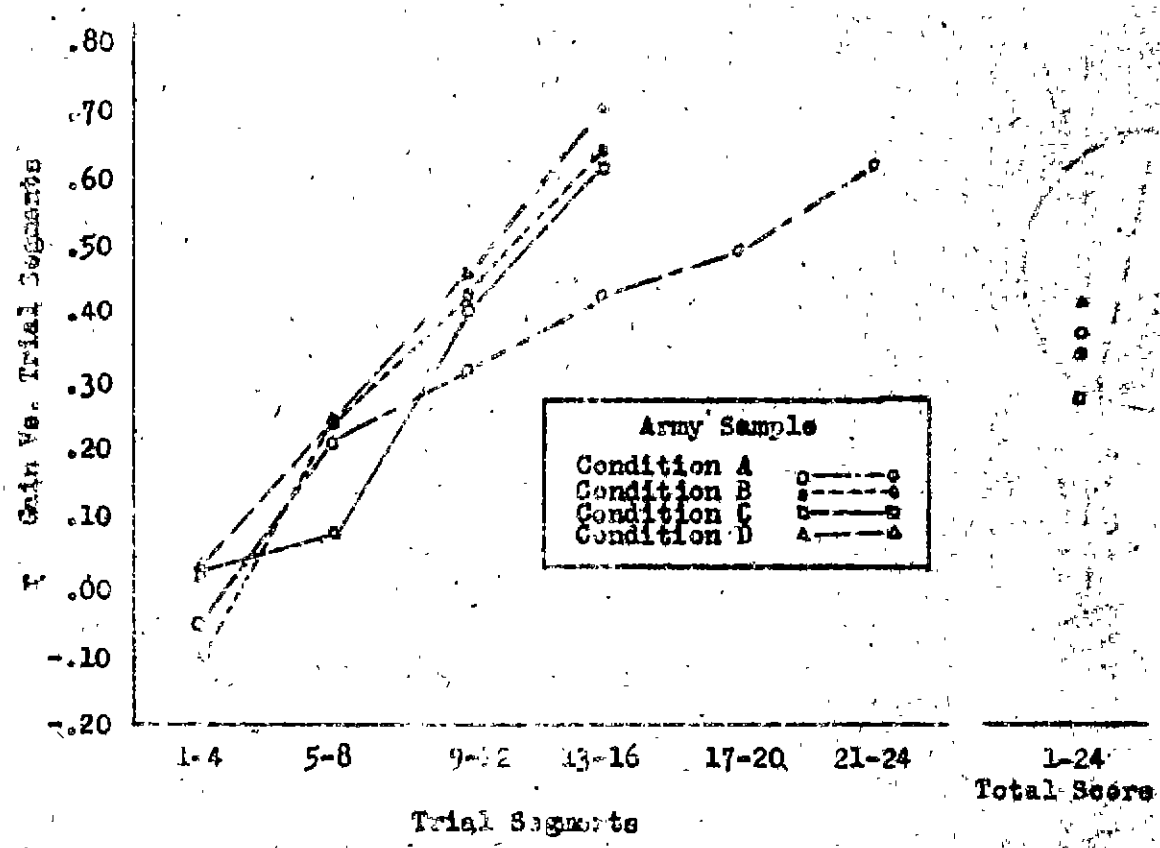

FIGURE VII

CORRELATIONS BETWEEN GAIN AND THE VARIOUS TRIAL SEGMENT SCORES

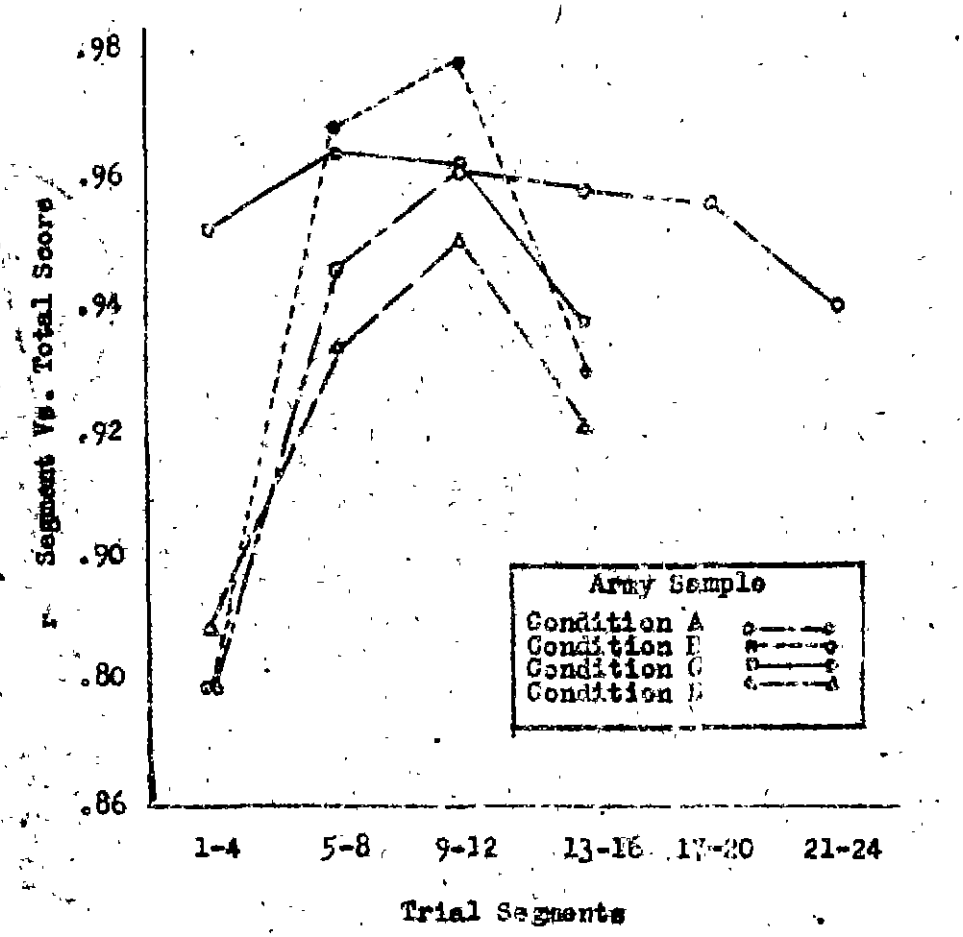

FIGURE VI

CORRELATIONS BETWEEN TRIAL SEGMENTS AND TOTAL SCORES

SUMMARY

Three different samples of subjects, 200 students in the Army Specialized Training Program at the University of Iowa, 120 civilian male students and 240 women students were run in an investigation concerned with the effects of different practice-rest conditions on performance scores obtained with the Rotary Pursuit Test. In each sample one quarter of the subjects practiced under one of four experimental conditions which differed in the distribution and length of work and rest periods. The major findings of the study may be briefly summarized as follows:

1. Performance on the Rotary Pursuit Test was significantly superior in all three samples under the condition (D) in which the work periods were briefest and the rest periods longest.

2. The practice condition (C) employed in the Army Air Force Tests, in which 20 second work periods are interspersed with 10 second rest periods, gave results which differed negligibly from the most highly massed condition (A) of continuous work.

3. Subjects from the Army sample, after working under the Army Air Force Test conditions (C) showed a marked increase in level of performance when tested 24 hours later. Both this finding and that reported above of improvement of performance with distributed practice suggest that work decrement is a prominent factor in the performance score obtained under the standard AAF test condition.

4. Reliability coefficients between odd and even trials for all three samples were above .90. These coefficients increased consistently under all conditions when based on larger and larger segments of practice.

5. In the Army sample adjoining segments of the learning curve showed high correlations, with the correlations decreasing as segments decreased in proximity to each other.

6. In the Army sample the correlations between segment scores and the total cumulative scores were high for all four conditions and highest for the middle segments of the practice period.

7. Correlations between gain scores and segment scores for all four conditions of the Army sample increased from zero at the initial status of practice to between .60 and .70 at the final stage of practice.

APPENDIX A

SAMPLE OF DATA SHEET

APPENDIX A

SAMPLE OF DATA SHEET

University of [illegible] vs. d., S.A.M. Rotary Pursuit Test

Hour____ Date____ Sex____ Age___ Name_____

T____ Time No._____ Arm No._____ Group_____

Driving Exper.: Occasional___ Moderate___ Great deal____

Sports Exper.: Golf___ Golf___ Medal___ Best at_____

Flying Exper.: Dual hours___ Solo hours___ Where____

Comments:_____

S.A.M. tests, dates_____

Sum, odd_____

Sum, even_____

Trial	Cum. Score	Trial Score	Trial	Cum. Score	Trial Score
1.			13.		
2.			14.		
3.			15.		
4.			16.		
5.			17.		
6.			18.		
7.			19.		
8.			20.		
9.			21.		
10.			22.		
11.			23.		
12.			24.		

Remarks:

APPENDIX B

MEAN TIME AND MEAN PER CENT OF TIME ON TARGET (MINUTES) AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUPS A, B, C, D, OF ARMY MEN, CIVILIAN MEN, AND WOMEN

TABLE 8

MEAN ERROR (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND AMOUNT OF PRACTICE FOR GROUP ARMY MEN

Trial	Mean Error (Minutes)	Mean Per Cent Time on Target	Amount of Practice (Sec.)
1	.056	13.4	25
2	.054	12.9	50
3	.057	13.7	75
4	.070	16.8	100
5	.074	17.7	125
6	.074	17.7	150
7	.074	17.7	175
8	.077	18.5	200
9	.082	19.4	225
10	.086	20.6	250
11	.086	20.6	275
12	.081	19.2	300
13	.086	20.6	325
14	.095	22.8	350
15	.092	22.1	375
16	.096	23.0	400
17	.105	25.2	425
18	.104	24.9	450
19	.102	24.5	475
20	.119	28.5	500
21	.107	25.7	525
22	.110	26.4	550
23	.116	27.8	575
24	.108	25.9	600

TABLE 7

MEAN TIME (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP A, ARMY MEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.045	13.5	20
2	.042	12.6	40
3	.048	14.4	60
4	.054	16.2	80
5	.054	16.2	100
6	.061	18.3	120
7	.066	19.8	140
8	.063	18.9	160
9	.072	21.6	180
10	.068	20.4	200
11	.065	19.5	220
12	.072	21.6	240
13	.075	22.5	260
14	.076	22.8	280
15	.077	23.1	300
16	.080	24.0	320
17	.076	22.8	340
18	.083	24.9	360
19	.085	25.5	380
20	.083	24.9	400
21	.084	25.2	420
22	.080	24.0	440
23	.089	26.7	460
24	.078	23.4	480

TABLE 11

MEAN TIME (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP A, CIVILIAN MEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.048	14.4	20
2	.043	12.9	40
3	.048	14.4	60
4	.055	16.5	80
5	.052	15.6	100
6	.065	19.5	120
7	.066	19.8	140
8	.068	20.4	160
9	.078	23.4	180
10	.074	22.2	200
11	.082	24.6	220
12	.073	25.4	240
13	.081	24.3	260
14	.074	22.2	280
15	.075	22.5	300
16	.090	27.0	320
17	.101	30.3	340
18	.087	26.1	360
19	.096	28.8	380
20	.083	24.9	400
21	.097	29.1	420
22	.086	25.8	440
23	.094	28.2	460
24	.083	24.9	480

TABLE 12

MEAN TIME (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP B, CIVILIAN MEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.045	20.8	25
2	.055	13.2	50
3	.059	14.1	75
4	.057	13.7	100
5	.064	15.3	125
6	.075	18.0	150
7	.065	15.6	175
8	.076	18.2	200
9	.076	18.2	225
10	.086	20.6	250
11	.085	20.4	275
12	.084	20.1	300
13	.087	20.9	325
14	.084	20.1	350
15	.090	21.6	375
16	.097	23.3	400

TABLE 9

MEAN TIME (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP C, ARMY MEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.035	10.5	20
2	.040	12.0	40
3	.051	15.3	60
4	.048	14.4	80
5	.059	17.7	100
6	.057	17.1	120
7	.063	18.9	140
8	.062	18.6	160
9	.066	19.8	180
10	.070	21.0	200
11	.070	21.0	220
12	.072	21.6	240
13	.077	23.1	260
14	.072	21.6	280
15	.079	23.7	300
16	.085	25.5	320

TABLE 10

MEAN TIME (MINUTES) ON TARGET, MEAN PERCENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP D, ARMY MEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.019	11.4	10
2	.025	15.0	20
3	.031	18.6	30
4	.030	18.0	40
5	.033	19.8	50
6	.032	19.2	60
7	.033	19.8	70
8	.035	21.0	80
9	.041	24.6	90
10	.037	22.2	100
11	.043	25.7	110
12	.043	25.7	120
13	.050	29.9	130
14	.056	33.5	140
15	.054	32.3	150
16	.056	33.5	160
17	.060	35.9	170
18	.062	37.1	180
19	.060	35.9	190
20	.062	37.1	200
21	.066	39.5	210
22	.063	37.7	220
23	.066	39.5	230
24	.062	37.1	240

MEAN TIME (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP C, CIVILIAN MEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.039	13.7	20
2	.052	15.6	40
3	.057	17.1	60
4	.066	19.8	80
5	.070	21.0	100
6	.070	21.0	120
7	.072	21.6	140
8	.072	21.6	160
9	.081	24.3	180
10	.082	24.6	200
11	.078	23.4	220
12	.087	26.1	240
13	.091	27.3	260
14	.086	25.8	280
15	.099	29.7	300
16	.099	29.7	320

TABLE 14

MEAN TIME (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP D, CIVILIAN MEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.019	11.4	10
2	.026	15.6	20
3	.028	16.8	30
4	.030	18.0	40
5	.033	19.8	50
6	.030	18.0	60
7	.032	19.2	70
8	.038	22.8	80
9	.039	23.4	90
10	.043	25.7	100
11	.039	23.4	110
12	.044	26.3	120
13	.046	27.5	130
14	.046	27.5	140
15	.050	29.9	150
16	.050	29.9	160

TABLE 1

MEAN TIME (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP A, WOMEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.016	4.8	20
2	.019	5.7	40
3	.028	8.4	60
4	.023	6.9	80
5	.026	7.8	100
6	.028	8.4	120
7	.030	9.0	140
8	.030	9.0	160
9	.035	10.5	180
10	.038	11.4	200
11	.036	10.8	220
12	.038	11.4	240
13	.051	15.3	260
14	.047	14.1	280
15	.040	12.0	300
16	.046	13.8	320
17	.046	13.8	340
18	.044	13.2	360
19	.040	12.0	380
20	.050	15.0	400
21	.047	14.1	420
22	.052	15.6	440
23	.050	15.0	460
24	.045	13.5	480

TABLE

MEAN TIME (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP B, WOMEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.024	5.1	25
2	.028	6.7	50
3	.034	8.1	75
4	.038	9.1	100
5	.038	9.1	125
6	.043	10.3	150
7	.044	10.6	175
8	.046	11.0	200
9	.049	11.8	225
10	.051	12.2	250
11	.054	12.9	275
12	.057	13.7	300
13	.058	13.9	325
14	.058	13.9	350
15	.064	15.3	375
16	.068	16.3	400

TABLE 17

MEAN TIME (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP C, WOMEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.021	6.3	20
2	.027	8.1	40
3	.032	9.6	60
4	.032	9.6	80
5	.032	9.6	100
6	.038	11.4	120
7	.041	12.3	140
8	.037	11.1	160
9	.041	12.3	180
10	.046	13.8	200
11	.045	13.5	220
12	.045	13.5	240
13	.050	15.0	260
14	.057	17.1	280
15	.053	15.9	300
16	.056	16.8	320

TABLE 18

MEAN TIME (MINUTES) ON TARGET, MEAN PER CENT OF TIME ON TARGET AND CUMULATIVE AMOUNT OF PRACTICE FOR GROUP D, WOMEN

Trial	Mean (Minutes)	% Time on Target	Amount of Practice (Sec.)
1	.009	5.4	10
2	.015	9.0	20
3	.016	9.6	30
4	.017	10.1	40
5	.019	11.4	50
6	.020	12.0	60
7	.021	12.6	70
8	.021	12.6	80
9	.021	16.1	90
10	.026	15.6	100
11	.031	18.6	110
12	.036	21.5	120
13	.034	20.4	130
14	.034	20.4	140
15	.038	22.8	150
16	.043	25.7	160

APPENDIX D

INTERCORRELATIONS BETWEEN VARIOUS TRIAL ELEMENTS, TOTAL SCORE AND GAIN FOR GROUPS A, B, C, D, OF ARMY MEN AND CIVILIAN MEN

TABLE 19

INTERCORRELATIONS BETWEEN VARIOUS TRIAL SEGMENTS, TOTAL SCORE AND GAIN
GROUP A, ARMY MEN

Score	1	2	3	4	5	6	7	8	9
1. Trials 1-4									
2. Trials 5-8	.88								
3. Trials 9-12	.84	.92							
4. Trials 13-16	.78	.89	.91						
5. Trials 17-20	.78	.85	.89	.91					
6. Trials 21-24	.74	.83	.87	.90	.94				
7. Trials 1-12	.94	.97	.96	.90	.88	.86			
8. Trials 13-24	.79	.88	.92	.95	.98	.97	.91		
9. Trials 1-24	.88	.95	.96	.96	.96	.94	.97	.98	
10. Gain (#6-#1)	-.06	.22	.32	.43	.49	.63	.19	.53	.38

TABLE 20

INTERCORRELATIONS BETWEEN VARIOUS TRIAL SEGMENTS, TOTAL SCORE AND GAIN
GROUP B, ARMY MEN

Score	1	2	3	4	5	6	7
1. Trials 1-4							
2. Trials 5-8	.87						
3. Trials 9-12	.80	.93					
4. Trials 13-16	.69	.84	.93				
5. Trials 1-8	.96	.97	.90	.89			
6. Trials 9-16	.76	.90	.98	.98	.87		
7. Trials 1-16	.88	.97	.98	.93	.96	.97	
8. Gain (#4-#1)	-.11	.24	.43	.65	.09	.55	.35

TABLE 21

INTERCORRELATIONS BETWEEN VARIOUS TRIAL SEGMENTS, TOTAL SCORE AND GAIN GROUP [illegible], ARMY MEN

Score	1	2	3	4	5	6	7
1. Trials 1-4							
2. Trials 5-8	.96						
3. Trials 9-12	.89	.89					
4. Trials 13-16	.82	.83	.91				
5. Trials 1-8	.99	.99	.87	.83			
6. Trials 9-16	.87	.91	.99	.99	.88		
7. Trials 1-16	.95	.96	.96	.94	.97	.95	
8. Gain (#4-#1)	.02	.08	.41	.62	.06	.52	.29

TABLE 22

INTERCORRELATIONS BETWEEN VARIOUS TRIAL SEGMENTS, TOTAL SCORE AND GAIN GROUP D, ARMY MEN

Score	1	2	3	4	5	6	7
1. Trials 1-4							
2. Trials 5-8	.84						
3. Trials 9-12	.77	.87					
4. Trials 13-16	.73	.76	.86				
5. Trials 1-8	.95	.96	.86	.78			
6. Trials 9-16	.77	.84	.96	.97	.85		
7. Trials 1-16	.89	.93	.95	.92	.95	.97	
8. Gain (#4-#1)	.03	.25	.46	.71	.15	.62	.43

TABLE 23

INTERCORRELATIONS BETWEEN VARIOUS TRIAL SEGMENTS, TOTAL SCORE AND GAIN
GROUP A, CIVILIAN MEN

Score	1	2	3	4	5	6	7	8	9
1. Trials 1-4									
2. Trials 5-8	.82								
3. Trials 9-12	.77	.83							
4. Trials 13-16	.55	.63	.78						
5. Trials 17-20	.56	.59	.72	.84					
6. Trials 21-24	.52	.66	.63	.75	.86				
7. Trials 1-12	.93	.95	.92	.70	.67	.65			
8. Trials 13-24	.58	.67	.75	.91	.96	.94	.71		
9. Trials 1-24	.82	.89	.91	.86	.87	.85	.94	.91	
10. Gain (#6-#1)	-.45	-.13	-.10	.24	.34	.53	-.24	.42	.07

TABLE 24

INTERCORRELATIONS BETWEEN VARIOUS TRIAL SEGMENTS, TOTAL SCORE AND GAIN
GROUP B, CIVILIAN MEN

Score	1	2	3	4	5	6	7
1. Trials 1-4							
2. Trials 5-8	.92						
3. Trials 9-12	.86	.84					
4. Trials 13-16	.82	.74	.88				
5. Trials 1-8	.98	.98	.87	.80			
6. Trials 9-16	.86	.80	.96	.97	.85		
7. Trials 1-16	.96	.93	.95	.92	.96	.95	
8. Gain (#4-#1)	-.24	-.23	.09	.37	-.24	.24	.00

TABLE 25

INTERCORRELATIONS BETWEEN VARIOUS TRIAL SEGMENTS, TOTAL SCORE AND GAIN
GROUP C, CIVILIAN MEN

Score	1	2	3	4	5	6	7
1. Trials 1-4							
2. Trials 5-8	.88						
3. Trials 9-12	.66	.82					
4. Trials 13-16	.73	.83	.89				
5. Trials 1-8	.97	.97	.77	.81			
6. Trials 9-16	.72	.85	.96	.98	.81		
7. Trials 1-16	.87	.95	.92	.94	.94	.96	
8. Gain (#4-#1)	-.08	.21	.55	.63	.08	.61	.38

TABLE 26

INTERCORRELATIONS BETWEEN VARIOUS TRIAL SEGMENTS, TOTAL SCORE AND GAIN
GROUP D, CIVILIAN MEN

Score	1	2	3	4	5	6	7
1. Trials 1-4							
2. Trials 5-8	.90						
3. Trials 9-12	.88	.96					
4. Trials 13-16	.89	.94	.93				
5. Trials 1-8	.97	.98	.95	.94			
6. Trials 9-16	.90	.97	.98	.98	.96		
7. Trials 1-16	.94	.98	.98	.97	.99	.99	
8. Gain (#4-#1)	.10	.57	.58	.72	.47	.66	.58