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THE EFFECT OF MASSING AND DISTRIBUTION OF PRACTICE ON THE S.A.M. COMPLEX COORDINATION TEST

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

December 26, 1945

Dr. Dean R. Brimhall
Asst. to Administrator for Research
Civil Aeronautics Administration
Room 5835, Commerce Building
Washington 25, D. C.

Dear Dr. Brimhall:

Attached is a report entitled The Effect of Massing and Distribution of Practice on the S.A.M. Complex Coordination Test, 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 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:pd

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 to 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 interrelationships of these psychomotor tests and certain psychomotor and paper-and-pencil tests which are not being employed in selection batteries at the present time.

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. Three reports of these investigations have appeared in the CAA Division of Research Series as Reports Nos. 29, 44, and 45. The present report describes another study growing 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

This research was undertaken to determine the effects of four practice-rest conditions on performance scores obtained with the School of Aviation Medicine Complex Coordination Test. The investigation was directed at studying (1) the nature of the learning curve in this test situation; (2) the effects of various combinations of length of work period and rest period on the level of performance; (3) the reliability of scores after different lengths of practice; and (4) the intercorrelations between different learning segments, gain scores, and total scores.

The equipment consisted of two School of Aviation Medicine Complex Coordination Tests (AAF adaptations of the Mashburn Serial Action Test) arranged so as to duplicate as closely as possible the conditions employed in the AAF classification centers. In the testing situation the subject was confronted with a panel on which appeared three paired rows of jewel signal lights, one row in each pair containing red jewels and the other, green. The testee manipulated the stick and rudder to match the lighted green jewels in each row with the stimulus pattern made by the red jewel lights in each corresponding row. The patterns of the red lights were presented automatically, and the number of matches made during successive 30 second practice periods were recorded.

Two hundred men, 50 in each of the four different work-rest conditions, served as subjects. All were members of the various Army Specialized Training Programs at the State University of Iowa, and ranged in age from 17 to 39 years. None of the subjects had had previous experience with the test.

Four different combinations of work and rest were employed. Group A practiced continually for 8 minutes; Group B had three work periods of 120 seconds, with rest intervals of 60 seconds; Group C had four practice periods, each 90 seconds in length with interspersed rest periods of 40 seconds; and Group D had six work periods of 60 seconds with alternate rest periods of 20 seconds. Half of the subjects in each group were run on one test unit and half on the other, and the order of running the subjects was counterbalanced among the different practice conditions.

A general summary of the findings of this study is as follows:

1. No obvious differences in learning between the groups appeared until toward the end of the practice period (270 to 360 seconds) when all three distributed practice groups were superior to Group A. A comparison of the four groups of subjects in terms of (1) total score and (2) final status score by means of analysis of variance indicated that the differences between the means of the total score were not significant, while those for the final status score were significant between the one and five per cent levels. When the t test was applied to the differences between Group A and each of the three distributed practice groups

for the final status score, only one of the differences (A versus B) was significant beyond the one per cent level.

2. A comparison of the performances on the Rotary Pursuit Test and the Two-Hand Coordination Test with the performance on the S.A.M. Complex Coordination Test showed that for the two former tests the most distributed practice condition, involving the shortest work period, was the only one providing a significant increase in performance level over the condition of continuous practice. In this investigation instead of the differences between continuous and distributed practice conditions increasing with decrease in length of work period the tendency was for them to become smaller. It should be remembered, however, that for the S.A.M. Complex Coordination Test the rest periods in the distributed groups decreased with decrease in the length of the work periods instead of increasing as in the two earlier studies.

3. Correlation coefficients between scores made on odd and even 30 second work periods for the four experimental conditions varied from .84 to .90. The distribution of work-rest, as in the case of Group B, gave a reliability coefficient of .90 which makes its reliability as satisfactory as the 8-minute test employing continuous practice.

4. A gain score based on the difference between the first and last thirds of the practice period tended to correlate negatively with the first third (-.47 to -.20) and positively with the last third (.17 to .34). The correlations of this gain score with the total score were centered around zero (-.15 to .07).

THE EFFECT OF MASSING AND DISTRIBUTION OF PRACTICE ON THE S.A.M. COMPLEX COORDINATION TEST

INTRODUCTION

This experiment is one of a series of investigations concerned with studying the effects of varying the degree of massing and distribution of practice on performance scores on the various psychomotor tests employed in the Army Air Forces selection and classification program. Two previous investigations, one involving the School of Aviation Medicine Rotary Pursuit Test[1] and the other the School of Aviation Medicine Two-Hand Coordination Test,[2] have shown that the learning rate and level of performance attained at the end of the practice period in the tests varied markedly with the length of the practice and rest periods, and that the level of performance attained under the standard AAF conditions was relatively low, approximating that found under the most massed (continuous) practice condition.

As in the previous experiments, investigation was also directed at studying the nature of the learning curve in this test situation, the reliability of scores after different lengths of practice and the intercorrelations between various types of scores, e.g., those representing different learning segments, gain scores, and total (or cumulative) scores.[3] The determination of the validity of the scores of the practice-rest conditions for predicting success or failure in flight training was not undertaken in this investigation.

APPARATUS

Two School of Aviation Medicine Complex Coordination Tests, Model D, provided by the Department of Psychology, School of Aviation Medicine, were used. The Complex Coordination Test is the AAF adaptation of the Mashburn Serial Action Test.[4] The two units were arranged so as to dupli-

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[1]Spence, K. W. Buxton, C. E., and Melton, A. W. The effect of massing and distribution of practice on rotary pursuit test scores. Washington, D. C.: CAA Division of Research, Report No. 44, March 1945.

[2]Spence, K. W., Buxton, C. E., and Melton, A. W. The effect of massing and distribution of practice on two-hand coordination test scores. Washington, D. C.: CAA Division of Research, Report No. 45, April 1945.

[3]In another project conducted at the State University of Iowa under Committee auspices the authors studied the relationships among certain complex psychomotor performance tests (the Rotary Pursuit Test, the Two-Hand Coordination Test, the Complex Coordination Test, etc.) and paper-and-pencil tests of perceptual motor ability, with an evaluation of these instruments as measures of flight performance. See: Spence, K. W., Buxton, C. E., and Melton, A. W. An appraisal of certain tests of pilot aptitude. (Final report submitted to the NRC Committee on Selection and Training of Aircraft Pilots.)

[4]The names applied to the different versions of this type of psychomotor test may be found in: McFarland, R. A., and Channell, R. C. A revised serial reaction time apparatus for use in appraising flight aptitude. Washington, D. C.: CAA Division of Research, Report No. 34, September 1944, page v.

cate as closely as possible the experimental conditions employed in the AAF classification centers. Figure 1 shows the arrangement of the pair of test units. Each subject is confronted with a panel on which appear three paired rows of jewel signal lights.[5] One row in each pair contains red jewels and the other green jewels. One red jewel in each of the three rows is automatically lighted, thus providing a stimulus pattern which the subject is required to match by lighting the paired green jewel in each row. The subject controls the lighting of the green jewels by moving the rudder and stick; the latter in two dimensions, forward and backward, and left and right. When the stick and rudder are moved into the proper position and the adjoining red and green lights are lit, the test unit automatically flashes on a different combination of three red lights for the subject to match. The subject's score is the number of such 3-way matches in the experimental period. On the units employed this score was recorded automatically on a dial at the rear of the apparatus.

A special timing unit provided for automatic presentation of all combinations of work and rest, including the condition under which practice was continuous. This unit also provided a signal every 30 seconds, thus permitting the recording of scores for this length of period under all four conditions.

SUBJECTS

Two hundred men, fifty in each of the four different work-rest conditions, served as subjects in the experiment. All were members of the various Army Specialized Training Programs at the State University of Iowa. Arrangements were made with the company officer in charge to schedule the men, and although under some pressure to serve as subjects they seemed to be interested in the task for its own sake.

Their ages ranged from 17 to 39, with the median at 21.3. None of the subjects had previous experience with the test.

EXPERIMENTAL PROCEDURE

Four different combinations of work and rest were employed, fifty subjects being run under each condition. As may be seen from Table 1 which summarizes the different work-rest conditions, Group A practiced contin-

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[5]The vertical rows of lights on each side of the panel of the Mashburn Test have not been consistently used in the testing situation. An experimental determination of the effect of these "distraction" lights on the performance of the subjects during the testing procedure is reported in: Nance, R. D., Buxton, C. E., and Spence, K. W. The effect of distraction lights upon performance on the Mashburn serial coordination test. Washington, D. C.: CAA Division of Research, Report No. 29, April 1944.

FIGURE 1

THE SCHOOL OF AVIATION MEDICINE COMPLEX COORDINATION TEST uously for eight minutes. As in the case of all four groups, however, the number of settings completed during each thirty seconds of work was recorded by the experimenter.

TABLE 1

DISTRIBUTION OF PRACTICE-REST CONDITIONS

Group	Practice-Rest Condition	Number Work Periods
A (N = 50)	Continuous practice for 8 minutes (30 second scores)	1
B (N = 50)	Work 120 seconds; Rest 60 seconds	3
C (N = 50)	Work 90 seconds; Rest 40 seconds	4
D (N = 50)	Work 60 seconds; Rest 20 seconds	6

In Group B three work periods of 120 seconds were alternated with rest periods of 60 seconds. Group C had four practice periods, each 90 seconds in length with interspersed rest periods of 40 seconds. Finally, the practice distribution for Group D consisted of 60 seconds of work alternated with 20 seconds of rest. In all these groups, as in the continuous work condition, the number of settings matched at the end of each 30 seconds of work was recorded.

In order to control for any difference between the two complex coordination test units half of the subjects in each group were on one test unit and half on the other. Also, the order of running the subjects was counterbalanced among the different practice conditions.

The subjects, run in pairs, were instructed in the operation of the apparatus by the experimenter and then given a two minute practice period prior to the test trials. The instructions and demonstrations given the subjects are presented in Appendix A. In the case of groups B, C, and D additional instructions were given to the effect that they were to release the controls of the apparatus during the rest period and to remain quiet until the panel lights came on again. The experimenter was a graduate student in psychology who had been carefully instructed in the operation of the control and test units.

RESULTS

Learning Data. Figure 2 and Appendix B provide a comparison of the rate of learning and level of performance attained under the four experimental conditions. These data show the mean number of matches made by each group during successive 30 second practice periods. Inspection of the

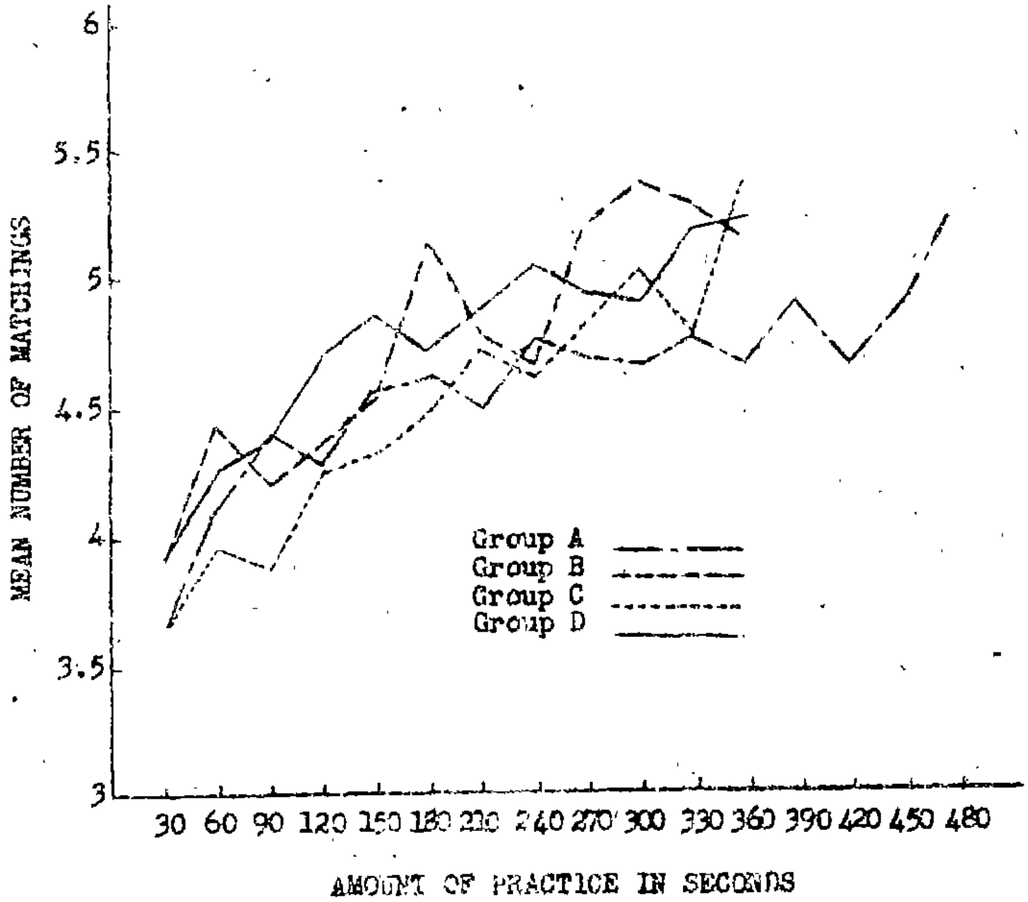

FIGURE 2

THE PRACTICE CURVES UNDER THE
FOUR DIFFERENT EXPERIMENTAL CONDITIONS

curves in Figure 2 reveals no obvious differences in learning between the groups except for the fact that towards the end of the practice period (270 to 360 seconds) all three distributed practice groups were consistently better than the group (A) which practiced continuously. Table 2 presents a further comparison of the four groups of subjects in terms of (1) the total score, and (2) the final status score, i.e., score for period 270 to 360 seconds. A simple analysis of variance into two components gave an F ratio (between variance/within group variance) of 1.60 for the total score and an F of 2.88 for the final status score. Since an F value of 2.65 is, with the appropriate number of degrees of freedom, significant at the five per cent level, we may conclude that the differences between the means for the total score may be explained in terms of chance fluctuations, whereas those for the final status score are significant between the one and five per cent level.

The lower portion of Table 2, which presents the results of the application of the t-test to the differences between the continuous group (A) and each of the three distributed groups for the final status score, shows only one of the differences (A vs. B) to be significant beyond the one per cent level. The difference between Groups A and D just lacked being significant at the five per cent level while that between Groups A and C was not significant at the ten per cent level.

TABLE 2

MEAN TOTAL AND FINAL STATUS SCORES AND SIGNIFICANCE OF DIFFERENCES

Groups (N = 50)	Total Score Mean	Total Score σ_{dis}	Final Status Score Mean	Final Status Score σ_{dis}
A	53.62	10.55	18.76	3.69
B	57.00	12.63	21.00	4.44
C	53.84	8.92	19.98	3.30
D	57.00	10.82	20.24	3.82

$F_{total\ scores} = 1.60$ (F of .01 = 3.88)
$F_{final\ scores} = 2.88$ (F of .05 = 2.65)

EVALUATION OF DIFFERENCES BETWEEN CONTINUOUS (A) AND DISTRIBUTED CONDITIONS (B, C, D) FOR FINAL STATUS SCORE

M_1	M_2	D	t	Confidence Level
A	B	2.24	2.90	< 1%
A	C	1.22	1.58	20% - 10%
A	D	1.48	1.92	10% - 5%

Measured in terms of their standard deviations none of the differences between the final status scores of the distributed and continuous practice groups in the present study with the Complex Coordination Test were as large as comparable score differences obtained between the continuous practice group and the most distributed group in the studies using the Rotary Pursuit[6] and Two-Hand Coordination Tests.[7] Table 3 presents data which provide a comparative picture of the results obtained with the different psychomotor tests.

As may be seen, three different combinations of work and rest in addition to the continuous practice condition were employed in the Rotary Pursuit Test, while in the study with the Two-Hand Coordination apparatus two different distributed work-rest conditions were compared with the continuous practice condition. In the Rotary Pursuit Test performance between 200 and 240 seconds of practice (200 and 250 seconds in the case of Group B) provides the scores that are compared.[8] It will be seen that Group B actually performed less well than the continuous group (A) and that Group C was only slightly, if at all, superior to Group A. The most distributed condition, involving the shortest work period (Group D), was the only one that provided a significant increase in performance level over the continuous practice condition.

In the case of the Two-Hand Coordination Test, the scores compared in Table 3 are for the last 120 seconds of practice (360-480 seconds). It will be seen that the differences between the continuous and distributed conditions again increase with reduction of length of the work period. Turning, finally to the results of the present investigation we see an apparently different trend in the differences. Instead of becoming larger and more significant with decrease in the length of the work period they tend to become smaller. The explanation of the difference is probably to be found in the fact that in the Complex Coordination Test the rest periods in the distributed groups decreased with decrease in the length of the work periods instead of increasing as in the two earlier studies. This difference is also revealed by the different trend in the W/R ratios in the present study. Attention should also be called to the fact that the size of the difference varies fairly consistently (inversely) with this W/R ratio. It is also interesting to note that the smallest W/R ratio in the present experiment was not as small as those that produced the very large, significant differences in the two earlier studies.

Reliability of Measures. Correlation coefficients between scores made on odd and even 30 second work periods for the four different experimental

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[6]Spence, K. W., Buxton, C. E., and Melton, A. W. Op. cit.

[7]Spence, K. W., Buxton, C. E., and Melton, A. W. Op. cit.

[8]Group D had only 240 seconds of practice. There were no significant differences among Groups A, D, and C at any later stages of practice.

TABLE 3

COMPARISON OF EFFECTS OF DISTRIBUTION OF PRACTICE
IN THREE EXPERIMENTS INVOLVING PSYCHOMOTOR TESTS

Group	Work-Rest Conditions	W/R Ratio	Difference	Diff/σ Diff
	ROTARY PURSUIT TEST (ARMY GROUP N = 50)			
A	Continuous; Work 8 min.	∞		----
B	Work 25 sec; Rest 5 sec.	5.0	-.003 min.	-.18
C	Work 20 sec; Rest 10 sec.	2.0	.005 min.	.30
D	Work 10 sec; Rest 20 sec.	.5	.120 min.	6.90
	TWO-HAND COORDINATION TEST (N = 50)			
A	Continuous; Work 8 min.	∞		----
B	Work 60 sec; Rest 15 sec.	4.0	.111 min.	1.89
C	Work 30 sec; Rest 30 sec.	1.0	.316 min.	5.63
	COMPLEX COORDINATION TEST (N = 50)			
A	Continuous; Work 8 min.	∞		----
B	Work 120 sec; Rest 60 sec.	2.0	2.24	2.73
C	Work 90 sec; Rest 40 sec.	2.25	1.22	1.72
D	Work 60 sec; Rest 20 sec.	3.00	1.48	1.95

conditions are presented in Table 4. These values fall between comparable measures obtained on the Rotary Pursuit and Two-Hand Coordination Tests, being lower than those on the former and slightly higher than those on the latter. The differences between the different conditions in the present experiment are not significant.

As in the case of the other two psychomotor tests the reliability of a score is dependent upon the length of the practice period involved. Thus, Figure 3 shows how the odd versus even correlations under each experimental condition increases with the length of the practice period. About the only striking difference between the results shown in this graph and comparable data from the other two psychomotor tests is the fact that the continuous condition (Group A) did not produce the highest reliability for the shortest practice segment as was the case with the Rotary Pursuit and Two-Hand Coordination Tests. In fact, just the opposite result was obtained with the continuous practice group consistently exhibiting the lowest reliability for all three practice lengths.

TABLE 4

RELIABILITY COEFFICIENTS

Groups	Work Periods	Odd vs. Even Coefficients
A	(1-15) vs. (2-16)	.84
B	(1-11) vs. (2-12)	.90
C	(1-11) vs. (2-12)	.86
D	(1-11) vs. (2-12)	.84

So far as reliability and level of performance are concerned, the above results indicate that a five-minute test on the Complex Coordination Test involving a total of four minutes of work and one minute rest, distributed as in the case of Group B, would be just as satisfactory as the present eight-minute test employing continuous practice. Not only was the reliability of this curtailed test slightly higher than the longer one (.90 versus .84), but the level of practice attained was almost as great.

Relationship Between Gain Score and Scores Based on Successive Practice Segments and Total Score. Figure 4 shows how the gain score (determined by subtracting the score on the first 120 seconds of work from the score obtained between 240 and 360 seconds of practice) correlated with successive work periods of 120 seconds and the total score.[9] It will be seen that the correlations with the initial segment were all negative and that they show a consistent shift through zero to positive values by the third segment of practice. The gain measures showed little or no correlation with total scores, the coefficients ranging from -.15 to .07. This picture parallels very closely that obtained with the Two-Hand Coordination Test.

SUMMARY

This study investigated the effects of different practice-rest conditions on scores obtained with the School of Aviation Medicine Complex Co-

[9] Editor's Note. It should be noted that the gain scores are derived from scores on one segment of practice (120 seconds) and scores on later segments of practice (240 seconds and 360 seconds). The gain scores are then correlated with these segment scores. It has been pointed out that these gain scores are not statistically independent of the scores based on successive practice segments, and that it is necessary to use as a measure of rate of learning a score not determined by the initial and terminal points. Such an analysis is at present being made of rate of learning on the S.A.M. Complex Coordination Test.

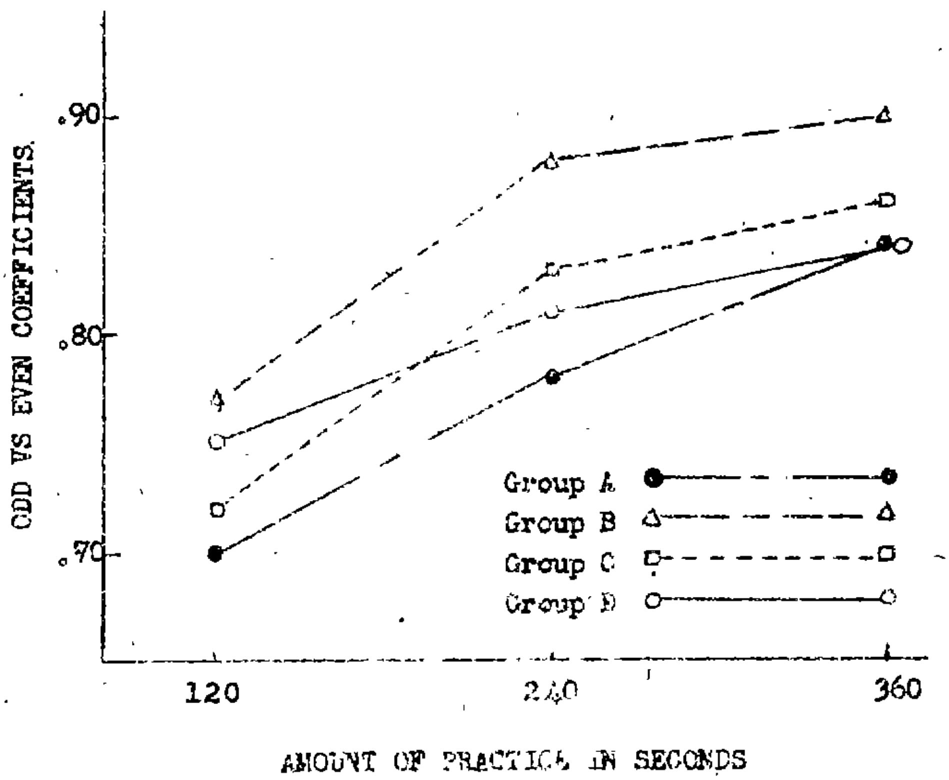

FIGURE 3

ODD VERSUS EVEN CORRELATION COEFFICIENTS
AS A FUNCTION OF THE AMOUNT OF PRACTICE

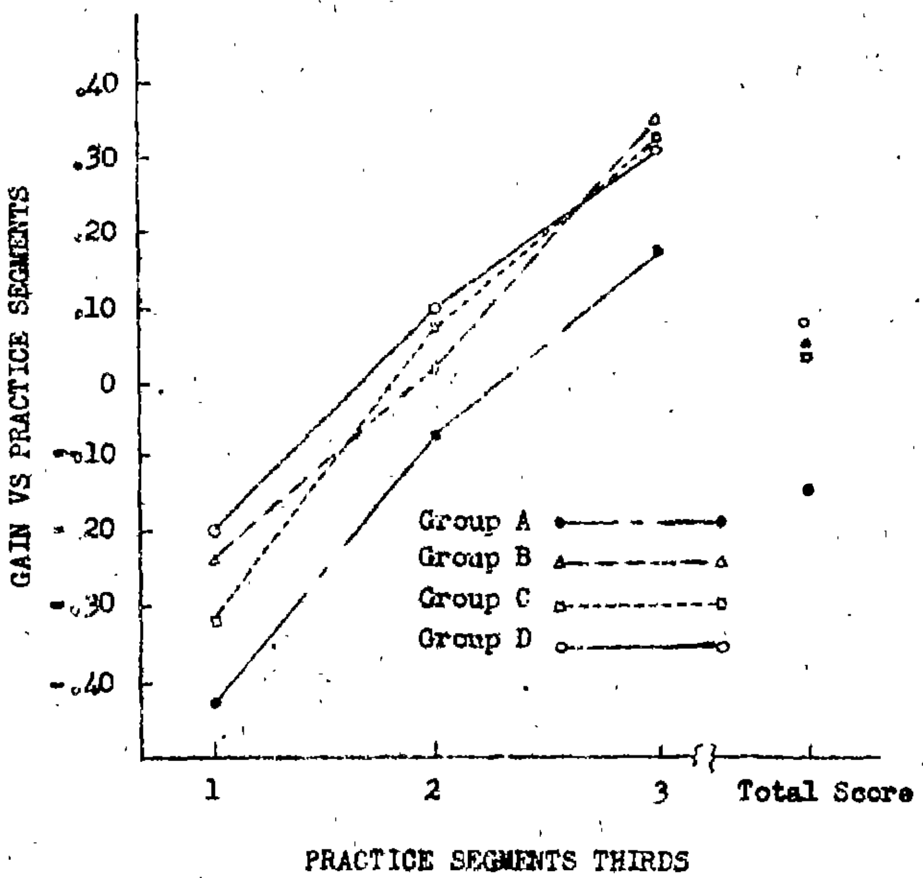

FIGURE 4

CORRELATION BETWEEN GAIN SCORE AND SCORES ON SUCCESSIVE PRACTICE SEGMENTS AND TOTAL SCORES ordination Test. The subjects, 200 students in the Army Specialized Training Program at the State University of Iowa, were divided into four groups, A, B, C, and D, each of which was run under a different combination of work and rest periods. The following statements briefly summarize the main findings of the study:

1. Differences in learning between the four groups were not obvious until towards the end of the practice period when all three of the distributed practice groups were consistently better than Group A. A simple analysis of variance into two components gave an F value of 1.60 for the total score and an F value of 2.88 for the final status score (the score for the period 270 to 360 seconds). The differences between the means for the total score did not approach an acceptable level of significance, whereas those for the final status score were significant between the one and five per cent levels. When the t test was applied to the differences between Group A and each of the distributed practice groups for the final status score, only the difference between Groups A and B was found to be significant beyond the one per cent level.

2. The effect of distributing the practice periods was found to be less marked in the present experiment with the Complex Coordination Test than in the Rotary Pursuit and Two-Hand Coordination Tests. It should be noted, however, that the ratio of the work period to the rest period was not as low in any of the practice conditions used in the present experiment as those used in the experiments with the other psychomotor tests.

3. Reliability coefficients between odd-even work periods for the full test period varied from .84 to .90. Similar coefficients for successively longer practice segments exhibited consistent increases as the length of the practice increased.

4. A gain score based on the difference between the first and last thirds of the practice period tended to correlate negatively with the first third (-.47 to -.20) and positively with the last third (.17 to .34). The correlations of this gain score with the total score were centered around zero (-.15 to .07).

APPENDIX A

DIRECTIONS FOR THE ADMINISTRATION OF THE SCHOOL OF AVIATION MEDICINE COMPLEX COORDINATION TEST

APPENDIX A

DIRECTIONS FOR THE ADMINISTRATION OF THE SCHOOL OF AVIATION MEDICINE COMPLEX COORDINATION TEST[10]

I. "This is a coordination test. (1) Your task will be to line up a green light with each of the three red lights. Moving the stick from side to side (2) moves the top green light. Moving the stick forward and backward (3) moves the middle green light; and moving the rudder bar (4) moves the bottom green light."

II. "Move the stick sideways (5) to match the top green light with the top red light. Get in directly underneath. If it is off to one side

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(1) Before the subject comes into the room the stepping switch bar of the demonstration apparatus should be set at No. 18. The other apparatuses should be at No. 19. The lights should be on before commencing to give instructions. As the subjects come into the test room, ask them to stand on their letters on the floor.

As the examiner begins giving the instructions, he should take a seat in the demonstration apparatus. Since the subjects are partially behind and are on each side of the examiner in this situation, he should make a special effort to speak clearly and to distribute his attention equally among the subjects when he speaks "up" to them.

(2) Move the stick to the extreme right and then to the extreme left and then back to neutral. Move the stick slowly enough so that there is a perceptual discreteness in the illumination of each successive green light. The speed of movement also applies to (3), (4), (5), (7), and (8) below.

(3) Move the stick to the extreme distal position and then to the extreme proximal position and then back to neutral.

(4) Press the right foot forward on the rudder bar as far as possible and then the left foot. Come back to neutral. In carrying out (2), (3), and (4) coordinate the control movements with the appropriate parts of the instructions, e.g., start moving the stick forward while you say, "Moving the stick forward. . .," and then pause until the stick is at the extreme forward position before saying, "and backward."

(5) Match the top pair of lights.

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[10]These are standard AAF classification test instructions.

(6) like this, it will not work. Then hold the stick in position to keep the top lights matched while you move it forward or backward (7) to match the middle lights. Then hold the stick steady while you match the bottom lights with the rudder bar. (8) When you have matched all three lights, a new setting of red lights will appear. (9) Go right ahead and match the new setting of red lights without bothering to come back to neutral." (10)

III. "If a green light goes off altogether, as in the top row at present (11) move the control a little and the light will come on again. (12) If you move any of the controls as far as it will go (13) there will be no green light. You must ease back a bit to find the end green light. (14) Do you have any questions?" (15)

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(6) Demonstrate a radial (diagonal) matching with the top green light. Come back to the correct matching position before proceeding with the next sentence.

(7) Match the middle pair of lights.

(8) Match the bottom pair of lights.

(9) Hold the controls steady after the lights have changed, to give each subject opportunity to notice that the red lights have changed positions.

(10) Match the new top light while maintaining the elevator and rudder bar positions. Pause a moment and then allow all controls to come back to neutral.

(11) Move the control just far enough from neutral to cause the top green lights to go off.

(12) Move the control to the right to bring on one light. Then move it to the left to turn on the adjacent light.

(13) Move the stick to the extreme right.

(14) Ease back enough to allow the end green light to come on.

(15) Turn off the lights. Get up from the chair and face the subjects to answer any questions they may have. Whenever possible, answer questions by repeating appropriate parts of preceding instructions. If any subject asks whether he may match the lights in any but the prescribed order, say, "Match the top light first. Then hold the stick that far over to the side while you match the middle light. Then hold the stick steady while you match the bottom light with the rudder bar."

IV. "Now take seats in the apparatus and put your feet on the rudder bar." (16)

V. "When the test starts, you may use either your right or left hand on the stick, but use only one hand throughout the test. (17) Keep your heels off the floor. (18) Match as many settings of the lights as you can until I tell you to stop. If the red lights ever fail to come on, let me know immediately. We will now have a practice period. Ready. . . Go." (19)

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(16) All seats should be at the middle adjustment. Occasionally, it will be necessary to move a chair backward or forward. The seat position need be moved only for extremely tall or short subjects. This should be done by the operator.

(17) Pause a second, and look at each subject in turn to see that he has only one hand on the stick. Do not permit bracing of one hand with the other.

(18) Pause a second, and look at each subject in turn to see that his heels are off the floor.

(19) Turn on the lights and start the stop watch as you say "Go." Allow two minutes for practice.

Act as a proctor throughout the practice period, dividing your attention between subjects as equally as possible. Correct misunderstandings and answer justifiable questions, repeating appropriate parts of the instructions for this purpose whenever this procedure is suitable. Do not coach any subject unless it becomes apparent, 30 to 40 seconds after practice has begun, that he does not comprehend the method by which matchings are to be accomplished. When coaching is necessary, use this standard procedure.

a. Point to the top light and say, "Move the stick sideways to match this light."

b. When the top light has been matched, point to the middle red light and say, "Now hold the stick that far over to the side while you move it forward or back to match this light."

c. When the top and middle lights have been matched, say, "Now hold the stick steady in that position while you match the bottom one."

d. When the new setting appears, say, "Now match the new setting in the same way as quickly as possible."

VI. "Stop. (20) Put your hands in your lap." In Conditions B, C, and D the following additional instructions were given. "You will be given several trials with short rest periods between each trial. When the lights go on begin work. When the lights go off relax and wait for the next trial. About three seconds before each trial I will say 'Ready.' At the ready signal put your feet on the bar and hand on the stick. When the lights go on start making the matchings."

VII. "We are now ready to begin the test. Your score will be the number of matchings you can make in the time allowed. Work as rapidly as you can. Ready. . . Go." (21)

VIII. "Stop. Put your hands in your lap. That is the end of the test." (22)

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(20) Turn off the lights. Record the practice scores and set the stepping switch bars at No. 40. Do not continue with the instructions until all manipulations have been completed.

(21) Turn on the lights. Record scores at every flash of the 30 second signal. Observe subjects closely for at least one minute to make sure they are adhering to regulations and working at the task.

(22) Check the scores before dismissing the subjects. Note machine number, handedness, and age of each subject.

APPENDIX B

MEAN NUMBER OF MATCHES AND CUMULATIVE AMOUNT OF PRACTICE

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MEAN NUMBER OF MATCHES AND
CUMULATIVE AMOUNT OF PRACTICE

Cum. Sec. Practice	GROUPS A	B	C	D
30	3.64	3.90	3.64	3.92
60	4.10	4.42	3.96	4.26
90	4.40	4.20	3.88	4.38
120	4.28	4.36	4.24	4.70
150	4.56	4.54	4.32	4.86
180	4.62	5.14	4.48	4.72
210	4.50	4.78	4.72	4.88
240	4.76	4.66	4.62	5.04
270	4.68	5.20	4.82	4.94
300	4.66	5.36	5.02	4.90
330	4.76	5.28	4.78	5.18
360	4.66	5.16	5.36	5.22
390	4.90			
420	4.66			
450	4.88			
480	5.22			