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by Lt. Allen

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CHAPTER I - GENERAL.

SECTION I.

INTRODUCTION.

1. PURPOSE OF STUDY.- This study was undertaken to compare a number of tests on the basis of value in predicting code aptitude. In the present study, four code aptitude tests and a number of other tests of various types have been compared by statistical methods in an attempt to select the one most useful in prognosis.

2. SOURCES OF INFORMATION.- Direct references or footnotes have not been given since the greater part of the data was gathered from the files of The Signal School and hence is not available generally. The one exception is in Chapters 3 and 4, where a part of the material was derived from "MENTAL TESTS FOR PROSPECTIVE TELEGRAPHERS" by L. L. Thurstone. The contributions of each of the other works listed in the Bibliography can not be definitely stated. A large number of them are not actually connected with this study but were valuable in suggesting procedures and methods.

3. ACCURACY OF FIGURES.- The figures given throughout this study have been carefully checked and are believed to be highly accurate. There may be some errors, particularly in Chapter 3 and Sections I and II of Chapter 4, due to the copying of correlations done by others rather than computing them directly from the source data but since these data were not available, the correlations had to be accepted and are believed to be correct.

SECTION II.

A REVIEW OF TESTING IN THE SIGNAL CORPS.

4. FIRST SIGNAL CORPS SCHOOL FOR ENLISTED MEN.- The first school for enlisted men of the Signal Corps for the training of specialists was organized at Fort Leavenworth, Kansas, in October, 1913. Previous to the establishment of this school, enlisted men specialists had been procured by enlisting men with previous training or by training them in the organization to which they were assigned. No records of the entrance or graduation requirements are available beyond the order establishing the school which directed that "men with sufficient ability" would be detailed for the courses.

5. WORLD WAR SCHOOLS.- During the World War, the Signal Corps attempted to provide itself with specialists, particularly radio and telegraph operators, by direct enlistment. Just before the war, a number of specialists from the commercial communication companies were enlisted in the reserve and called to active duty upon the declaration of war. The supply of trained men proved inadequate and various schools for the training of operators were established. Some of these were operated in conjunction with various colleges, usually for the training of candidates for commission in the Signal Corps. In connection with the school at Carnegie Institute of Technology (Pittsburgh, Pennsylvania), L. L. Thurstone tested the predictive value of several tests, his findings are considered in detail in Chapters 3 and 4. The school at Fort Leavenworth was maintained and another school for enlisted specialists was opened at Leon Springs, Texas, in 1917. An Army School Center, including a school for Signal Corps Personnel, was organized at Langres, Haut Marne, France, in December, 1917. Following the construction of Camp Meade, Maryland, all Signal Corps Schools were moved to that post. The schools for enlisted personnel were

moved there in September, 1918.

6. WAR TIME REQUIREMENTS. a. In July, 1918, the committee on Education and Special Training of the General Staff was requested by the Signal Corps to provide the personnel listed in Table No. 1. No requirements except the code qualification were given.

SPECIALISTS	NO. PER MONTH	LENGTH OF COURSE	HOURS OF TRAINING	CODE QUALIFICATION
Radio Technician	1600	13 weeks	429 (1)	None noted
Radio Operator	1000	6 weeks	264	20 W.P.K.
Telegraph Operator	50	8 weeks	264	20 W.P.K. in both codes (2).

- (1) Approximately 33 hours of vocational training were given each week.
 (2) International and American Morse Codes.

TABLE NO. 1.

b. In the school at Langres, the time allotted to each course was decidedly longer, as may be seen from Table No. 2. No requirements beyond a graduation test in radio or telegraph theory were given.

7. THE SIGNAL SCHOOL.- a. The Signal School (originally called the Signal Corps School) was established at Fort Monmouth (Camp Alfred Vails until 1925), Oceanport, New Jersey, in 1919. No data relative to the first courses, entrance, or graduation requirements are available. It is presumed that "men with sufficient ability" were available and to be sent to the school as to the former service schools.

SPECIALISTS	HOURS OF TRAINING
Radio Electrician	3000
Radio Operator	960
Telegraph Operator	960

TABLE NO. 2.

b. In 1922 the following entrance requirements were listed:

Radio Electricians: Arithmetic, as covered in a common school test.

General Aptitude Test; to determine general knowledge and intelligence of the candidate.

Mechanical Aptitude Test; to determine familiarity of the candidate with any form of mechanical work.

Receiving Test in the International Morse Code. The candidate should be able to receive at the rate of at least five words per minute, both straight press and code messages.

Radio Operators: The same tests except that candidates are not required to show as great a degree of proficiency in arithmetic, general, or mechanical aptitude as candidates for the electricians course.

Telegraph Operators: Same as for Radio operators.

*Name of test not given.

c. The requirements were changed somewhat in 1923, as follows:

Radio Electrician: Arithmetic as covered in an eighth grade common school course.

Elementary electricity based on the Signal Corps Training Pamphlet No. 1.

A composition of about 200 words on an assigned subject.

Sending and receiving test for radio and telegraph electricians.*

Radio Operators:

Arithmetic to include fractions.

Reading.

Penmanship.

Sending and receiving test for radio and telegraph operators.*

* Requirements not given.

d. In addition, in 1923, and presumably before, all candidates for the radio electricians course were required to be noncommissioned officers of the first three grades or other noncommissioned officers suitable for appointment to the first three grades. This last requirement was changed in 1929 to allow any enlisted man suitable for appointment for the first three grades to take the course.

8. USE OF TESTS AT THE SIGNAL SCHOOL.- a. In 1924, the Otis Self-Administering Test of Mental Ability was given to all candidates and has since been adopted as a standard test in rejecting men obviously unable to pass the requirements in the time allotted for the course. The relation of mental ability tests to code aptitude is considered in Chapter 2.

b. Between 1924 and the present, a large number of tests have been examined in an attempt to discover any test or group of tests which would disclose radio operating ability. Among them were the Army Alpha, the Otis test, the Army Mechanical Aptitude Test Form A, the Ferriter test, the General Information test, the Woody-McCall Arithmetic Test, the Seashore tests, the Thurstone Rhythm test, and both the original and the present forms of the Signal Corps Code Aptitude test. Of these tests, three, the Otis, and the General Electrical Information, and the Signal Corps Code Aptitude, are used at the present time.

SECTION III.

FUNDAMENTALS OF TESTING

9. GENERAL.- To determine the effectiveness of a test, it is necessary to ascertain exactly what is to be measured. In a prognosis test, this is complicated by several factors not encountered in a test of achievement. Among the more prominent of these are the interest of the student, the method and efficiency of the teaching, and the proportion of the student's learning ability which is utilized. It is relatively easy to measure a student's vocabulary but extremely difficult to devise a test to determine how much a certain course of study will increase that vocabulary. The difficulty is far more than proportionately increased as the operation under consideration becomes more complex. For example, a test to measure the expected increase of vocabulary, such as mentioned above, could be devised much more easily than a test which would predict the student's ability to increase his vocabulary and spell all the added words correctly.

10. FUNDAMENTAL NATURE OF CODE RECEPTION.- With this in mind the difficulties in preparing a test to predict success or failure in radio operating may be understood. However, code reception is indispensable to the student radio operator and is also the most difficult part of the course. Accordingly, any test that will predict aptitude in code reception will probably be the best guide to the student's final ability as a radio operator. Therefore, all tests will be considered in relation to the student's ability to learn to receive code groups.

11. CORRELATION.- a. The next consideration is the method of making comparisons. It would be possible to arrange a list of students who were tested before taking a certain course and show opposite their names, their test scores and class standing after the completion of the course; but such a method is cumbersome and unless there is practically no difference in the standing in each case, the relation or lack of it between test scores and class standing is difficult to determine. Moreover, by this method it is impossible to compare two different groups accurately. Statisticians have eliminated this difficulty by devising methods to compute a coefficient or "percentage" of correlation. This correlation, abbreviated as "r", varies from one to minus one (from 1.00 to -1.00). Referring to paragraph 9, if the student who had the highest score in a test given for the purpose of predicting the increase of his vocabulary was the student who learned the most words, the student with the second highest score stood second in the number of words learned, and the other student ranked similarly, the test would have a coefficient of one ($r = 1.00$). Such a coefficient would indicate that the test was perfect for its purpose of determining the relative amount of ability which each student possessed for learning new words under certain conditions. Perfect coefficients are never found, so that in actual practice, if there were a high degree of relationship between the test standing and the number of words learned, the coefficient would be some large fraction of 1.00; for example, r might equal .74. There is also a similar method of expressing inverse relationships. For example, if the best student in a test was the worst in achievement, the second best in the test, the next to the worst in achievement, and the remaining students were ranked in the same way, the coefficient of correlations would be minus one ($r = -1.00$). There are no perfect inverse correlations and, in general, any inverse correlation is apt to be small and unreliable because of

the difficulty of devising a test to measure inability or lack of ability.

b. There are some important points to consider in using a coefficient of correlation to evaluate a test. Since it is impossible to obtain a test to give perfect correlation, such values as are obtainable must be appraised to determine their usefulness in judging a test. Various investigators have set widely divergent standards, some refusing to consider any value below .80 or .90 and others considering values as low as .25 or .30 as significant. Table 3 indicates the significance assigned to the various values of r . in this study.

r .	SIGNIFICATION
Above .75	Extremely close correlation, seldom found in practice, particularly in prognosis tests
.65 to .74	Very good correlation.
.55 to .64	Good correlation.
.45 to .54	Fair correlation.
.40 to .44	Poor correlation.
Below .40	No correlation or chance relationship.

TABLE NO. 3.

c. There are some errors inherent in the mathematical processes used in deriving the coefficients. The size of the group under consideration also affects the reliability of any coefficient derived from the comparison of sets of records for the group. The combined amount of error caused by both of these factors is indicated approximately by the "probable error", abbreviated as P.E. The P.E. is

derived from a formula (which varies somewhat with different methods of computing r .) and is usually quoted with the coefficient. For example, a coefficient of .74 with a probable error of .025 ($r = .74 \pm .025$) since the error may have caused an increase or decrease of the final result to that extent. No coefficient is considered useful unless it is more than four times as large as the probable error (r must be greater than 4 times P.E.).

d. It is sometimes desirable to show the relation between two tests or between a test and achievement with the relation undisturbed by the knowledge or mental ability of the students, that is, to compare them as if they were between a large number of students of equal knowledge or mental ability instead of between groups in which these qualities vary. This can be done by means of a formula which "partials out" or eliminates the undesirable factor and the result is known as a partial correlation. By comparing the partial correlation with the original correlation, the extent to which the eliminated factor influenced the original result is apparent. The probable error is found in the same way as for a correlation and it must be less than one-fourth of the partial correlation for the result to be valid. The value of partial correlations is approximately the same as that of correlations as shown in Table No. 3.

e. Most of the coefficients of correlation in this study were computed by the Otis method (using the Otis Correlation Charts) although some few were derived by the Pearson method.

12. SCORING.- a. Another important factor which must be considered in the method used in marking the test or achievement. Scoring is of two general types, subjective and objective. Subjective scoring is that in which the credit given is dependent upon the judgment of the marker; for instance, a student might be asked to define ten words and be given credit to the extent the scorer considered the student's definitions approximated the correct ones. The trouble

with this type of scoring is that the scorer must have full knowledge of the subject of the test, two different scorers' marks on the same test may vary at different times), and that it is a slow and awkward method of marking. In the objective method, the questions are so phrased that there is only one possible answer to each question and unless the student has that answer, he is given no credit for the question. Such a test can be scored quickly, easily, and accurately by anyone having a set of correct answers and the student will always obtain the same score unless or regardless of who does the scoring.

b. It will be seen that unless the tests and measures of achievement are scored objectively, the possible error in scoring makes any accurate comparison, either between tests and achievements or between different tests, impossible. All tests considered in this study are scored objectively unless otherwise noted. It is fortunate that achievement in receiving the telegraphic code can be both easily measured. If any two operators are equal in other respects, the one capable of receiving the most code groups in a given time is the better operator. The actual method of scoring is to consider an operator capable of receiving code at the speed at which he can receive five letter code groups for two consecutive minutes without error. All students considered in this study, except those reported by L. L. Thurstone, have been rated by this method, so that any operator rated at a particular speed is as capable (in code reception) as any other operator with the same rating. It might be added, that it has been found in practice that an operator's value is usually proportional to his speed in code reception, the better operators being capable of higher speeds.

SECTION IV.

THE GROUPS STUDIED

13. GENERAL.- Records of officers and enlisted men of the Army have been examined in this study, the rank of the group generally being indicated. The age limits are not definitely known but probably are 18 to 40.

14. SELECTION OF GROUPS STUDIED.- The different groups received different amounts of training which may account for some of the variations in the results. Whenever possible, the groups have been arranged so that groups with equal training are compared. No definite figures are available as to the time necessary for proper training and that subject has not been considered at this time because the technique of training is still the subject of experimentation.

15. INTEREST.- The interest of the men was probably high. All of them were volunteers for the courses and expected to advance themselves professionally by taking them.

16. RECORDS OF PROGRESS.- The method of recording code speed progress may be open to criticism. In the Signal School, a student is given credit when he attains the speeds of 5, 8, 12, 15, 18, 20, 22, 24, 26, 28, and 30 words per minute. The lower portion of this scale is irregular but it was adopted because the difference in difficulty is supposed to be equal between any two consecutive speeds with the method of teaching used at the present time.

CHAPTER 2 - TESTS OF MENTAL ABILITY

SECTION I.

THE ARMY ALPHA TEST.

17. GENERAL.- During the war, large scale psychological testing was employed for the first time in determining the fitness of soldiers for various duties. There were no suitable tests of mental ability in existence simple enough to give and score and interpret to enable the examiners to handle the numbers of men to be tested. The psychologists directing the army examinations developed several tests which were designed to measure mental ability and provide reliable standards for comparison.

18. CORRELATION WITH MENTAL ABILITY.- The Army Alpha test was one of several mental ability tests developed and used in this work. It was a written test containing some 212 questions of several types. It correlated very highly with the then existing individual mental ability tests.

19. USE OF THE ARMY ALPHA.- a. In certain batteries of tests, the Army Alpha was used to measure the mental ability of various groups of men classified according to their occupations. There was no group of radio operators but there was one group of telegraph operators and it is believed that the similarity of their occupations renders any conclusions drawn from the figures as valid for one as for the other. These figures are given in Table No. 4 (page 14).

b. In this group it may be seen that there is a very slight difference in the medians (the median is the middle score of the group) between the different classes of operators. In fact, the apprentices have a higher median than the journeymen and one nearly equal to that of the experts. Such a situation would be impossible were operating ability directly dependent upon mental ability.

NO. OF MEN	CLASSIFICATION	MEDIAN
36	Apprentice	89.7
165	Journeyman	83.0
34	Expert	90.5
255	Total	84.8

TABLE NO. 4.

e. The actual distribution of this group by letter grades is given in Table No. 5. This distribution is very nearly normal, having only a slight skew to the right (there are more scores than would be found in an absolutely normal group of equal size). It is not at all different than one which might be found for a number of unrelated occupations. The absence of very low scores is the most significant feature of the distribution.

GRADE	A (high)	B	C+	C	C-	D	D- (low)
Percentage of Total	7.5	20.3	32.1	29.1	10.0	1.2

TABLE NO. 5.

d. Another survey of 21 men, including both telegraph and radio operators, gave a median of 165. The smallness of the group makes this median of extremely doubtful value.

NO OF MEN	CLASSIFICATION	TEST	COMPARED WITH	r.	P.E.
38	Enlisted Men	Army Alpha	Final Code Speed	-.078	↑ -.11
37	Enlisted Men	Army Alpha Part 1.	Final Code Speed	-.01	↑ -.11
37	Enlisted Men	Army Alpha Part 2.	Final Code Speed	-.22	↑ -.10
37	Enlisted Men	Army Alpha Part 2.	Final Code Speed	.23	↑ -.10
37	Enlisted Men	Army Alpha Part 4.	Final Code Speed	.08	↑ -.11
37	Enlisted Men	Army Alpha Part 5.	Final Code Speed	-.03	↑ -.11
37	Enlisted Men	Army Alpha Part 6.	Final Code Speed	-.03	↑ -.11
37	Enlisted Men	Army Alpha Part 7.	Final Code Speed	-.10	↑ -.11
37	Enlisted Men	Army Alpha Part 8.	Final Code Speed	-.06	↑ -.11

TABLE NO. 6.

e. The Army Alpha was used at the Signal School with results given in Table No. 6. It is quite apparent there is no relation between the Alpha score and attained code speed nor are the results obtained by using any part of the test more satisfactory. The highest correlation, $r. = .23$, between Part 3 and the Final Code Speed, is only two times as large as the probable error and hence valueless.

20. CONCLUSIONS.- In view of the results of the two investigations given above, it does not seem probable that the Army Alpha has any value in predicting probable success or failure in operating except that it might be used to eliminate men of extremely low mental ability.

SECTION II.
THE OTIS TEST.

21. DESCRIPTION.- The Otis Self-Administering Tests of Mental Ability are a series of written tests with 75 questions each, designed to measure general mental ability. They have been used at The Signal School for several years principally to eliminate men of such inferior mental ability that their chance of passing the course is slight. It is not a suitable test for prognosis of ability to learn code as may be seen from Table No. 7.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	r.	P.E.
18	Officers	Otis	Final Code Speed	.107	-.154
41	Officers	Otis	Final Code Speed	.20	-.100
31	Officers	Otis	Final Code Speed	.27	-.111
67	Enlisted Men	Otis	Final Code Speed	.19	-.079
82	Enlisted Men	Otis	Final Code Speed	.18	-.071
23	Enlisted Men	Otis	Final Code Speed	.10	-.134

TABLE NO. 7.

22. CORRELATIONS.- There is no relation between the scores on the Otis test and the ability to learn code. Because of the low correlations obtained in the cases above, the Otis test need not be considered further as a code aptitude prognosis test.

SECTION III.

CONCLUSIONS.

23. VALUE OF MENTAL ABILITY TESTS IN PREDICTING CODE APTITUDE.- While not entirely conclusive, all evidence seems to indicate that tests of general mental ability are of little value in predicting ability to learn code reception. Exception for the fact that slightly more than the lowest grade of mental ability seems to be necessary, there is no definite requirement which might be disclosed by such tests. It may be that the very slight difference above the average is no more than is required in any skilled trade. In view of this, a mental ability test is unnecessary except for the elimination of the absolutely unfit candidates. Of the two tests considered, the Otis test is probably the best because of its simpler administration.

CHAPTER 3 - MISCELLANEOUS TESTS.

SECTION I.

SEVERAL TESTS AND RESULTS.

24. THE ARMY MECHANICAL APTITUDE TEST.- As was stated above, a number of tests were examined in an effort to adapt some standard test as a prognosis test. One test used was the Army Mechanical Aptitude Test (Form A), a written test for determining mechanical knowledge and aptitude. Only one comparison with attained code speed is available. For a class of 23 men, the correlation was $r. = .54 \pm .096$. This is a fair correlation, although its value is decidedly lessened by the small number of students taking the test. The Mechanical Aptitude test was studied primarily for the development of a predictive test for certain subcourses in the Radio Electrician's courses. No further data are available concerning the test and it may be that further investigation gave unsatisfactory results.

25. ARITHMETIC TESTS.- An arithmetic test gave a correlation of $r. = .15 \pm .10$ for a class of 40 men. No details are available concerning this test, but considering the requirements for admission to the Signal School, it was undoubtedly one which could be passed by any grammar school graduate. Thurstone also gave an arithmetic test in his study of prognosis tests and found a correlation of $r. = .06 \pm .05$ for a class of 165 drafted men. It is, therefore, concluded that arithmetic tests are of no value in predicting code aptitude.

26. THURSTONE'S STUDY.- a. In addition to the arithmetic test, Thurstone gave a number of standard tests to the students under his direction, the results of which, except for the arithmetic test (mentioned above) and the Thurstone Rhythm Test which will be discussed later, are tabulated in Table No. 8. In

his report, Thurstone states that all except the last two tests, Spelling and Sentence, are of some value in determining students apt to fail, but except for the Opposites tests, the correlations are low and as low as to render them unworthy of consideration. Moreover, since the group studied was not selected at all, it may be that the lowest ranking students were below average in mental ability. The correlation for the Opposites test is not high enough to allow it to be used for prediction.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	r.	P.E.
165	Drafted Men	Opposites	Final Code Speed	.42	-.04
165	Drafted Men	Analogies	Final Code Speed	.29	-.05
165	Drafted Men	Gordon Directions Test	Final Code Speed	.27	-.05
165	Drafted Men	Trabus Completion Test	Final Code Speed	.21	-.05
165	Drafted Men	Spelling	Final Code Speed	.18	-.06
165	Drafted Men	Sentence	Final Code Speed	.09	-.05

TABLE NO. 8.

b. Thurstone compared the years of schooling with the ability to learn telegraphy and found a correlation of $r. = .00 - .08$. He stated that of the tested students, those who left school before finishing grammar school were conspicuously low in telegraphy, which gives color to the theory given above, that a number of men of low intelligence were included in the group, inasmuch as there is usually a fairly high correlation between intelligence and extent of schooling.

27. THE SEASHORE TESTS.- The Seashore Measures of Musical Ability were tested at the Signal School as prognosis tests; no data is available concerning the results. They have been reported as unsatisfactory as aptitude tests.

SECTION II.

THE GENERAL ELECTRICAL INFORMATION TEST.

28. DESCRIPTION.- The General Electrical Information Test is a written test devised at The Signal School, intended to show the extent of a candidate's knowledge of elementary electricity. It is used because the briefness of the courses at The Signal School necessitates that the candidates with the most experience be chosen, their other qualifications being equal. This is particularly important in choosing students for radio operators' courses, for the student who has some knowledge of electrical theory will have a better understanding of the work and will be able to devote more time and attention to attaining speed in code reception.

29. CORRELATIONS.- a. Table No. 9 shows the correlations of the General Electrical Information Test with the final code speed for a number of groups.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	r.	P.E.
18	Officers	G.E.I.	Final Code Speed	.50	$\pm .113$
41	Officers	G.E.I.	Final Code Speed	.43	$\pm .085$
31	Officers	G.E.I.	Final Code Speed	.28	$\pm .109$
67	Enlisted Men	G.E.I.	Final Code Speed	.04	$\pm .080$
32	Enlisted Men	G.E.I.	Final Code Speed	.18	$\pm .071$
23	Enlisted Men	G.E.I.	Final Code Speed	.16	$\pm .136$

TABLE NO. 9.

b. The only correlation which might be considered significant is the one found for the first group of officers. This may be due to chance because of the smallness of the group. It is more probably explained by the fact that this group consists of Signal Corps officers with considerable service in the army and probably more experience in radio and electrical subjects than the average student.

c. The General Electrical Information test does not give any indication of being of any value in predicting operating ability.

SECTION III.

CONCLUSIONS.

30. VALUE OF MISCELLANEOUS TESTS IN PREDICTING CODE APTITUDE.- None of the tests examined in this chapter have proved satisfactory as prognosis tests for determining code aptitude although one of them, the Opposite test, might be of use should no other test be found. It seems that the ability to learn to receive code is a special ability not directly dependent upon mental ability, education, or mechanical ability. This conclusion was reached independently by a number of investigators and some of them designed tests to indicate this ability. These special code aptitude tests will be considered next.

CHAPTER 4 - CODE APTITUDE TESTS.

SECTION I.

THE THURSTONE RHYTHM TEST.

31. DESCRIPTION. - The Thurstone Rhythm test is an auditory test especially designed as an aptitude test. The tester gives, by means of a key and buzzer, a group of dots and dashes, repeating them once, and the students indicate the pattern of transmission by marking vertical lines for dots and horizontal lines for dashes. For example, should the instructor send AC, (dot, dash, dash, dot, dash, dot), the student would write 1--1-1. There are thirty-five groups in the test, arranged in order of difficulty. The final score is the number correct. The test can be given in about fifteen minutes and scored in a reasonable length of time.

32. CORRELATIONS.- a. L. L. Thurstone gave this test to 165 drafted men in November, 1917, together with the tests described in Chapter 3. He obtained a correlation of $r = .48 \pm .06$ between the scores on the test and the final code speed, indicating a fair relationship. In addition, he found that of the fifteen students with the lowest scores on the test, only three attained the average code speed of the group, the other twelve making considerably lower speeds.

b. The Thurstone Rhythm test was used one year at The Signal School and gave the results listed in table No. 10.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	r.	P.E.
11	Officers	Thurstone	Final Code Speed	.59	$\pm .131$
31	Officers	Thurstone	Final Code Speed	.55	$\pm .083$
11	Officers	Thurstone	Final Code Speed	-.15	$\pm .198$
31	Officers	Thurstone	Final Code Speed	.50	$\pm .073$

TABLE No. 10.

e. This test gives a higher correlation with the final code speed than any test so far examined and moreover seems to give it consistently. The high correlation with the Otis test found in the last group is probably the result of chance for there is no correlation in the preceding group. This becomes more evident when a partial correlation is found between the Thurstone test scores and the final code speed with the possible effects of the Otis test eliminated. The partial correlation is $r_{.55}^{\pm .084}$. The small difference (.01) between the original and the partial correlations shows that the test scores do not depend upon mental ability.

33. CONCLUSIONS.- The Thurstone test is reasonably satisfactory for code aptitude prognosis. The ease in administering the test, the objectivity and the short time required to give the test are some of the advantages. Against this must be set the time required in scoring and the need of skilled personnel to give the test (this might be eliminated giving it with the Miphene as the Signal Corps Code Aptitude test is given). No reason is given for the repetition of each group and the effects of such repetitions are open to question.

SECTION II.

THE FERRITER CODE APTITUDE TEST

34. DESCRIPTION.-a. The Ferriter Code Aptitude test was devised by Captain J. P. Ferriter, Signal Corps, U. S. Army, to measure code aptitude. In this test, the conventional Morse symbols for six foreign letters are used. Generally, these are given the same meaning as in the usual transmission save that the student is not required to indicate discritical marks. Each letter is transmitted to the student five times consecutively and the group is repeated several times, the instructor giving the name of the character as each one is transmitted, and the student attempts to learn to recognized the characters in this period.

b. The letters are then transmitted in random order and the student is required to write the characters as they are received. One hundred and fifty characters are transmitted this way. This transmission is repeated twice. The test is scored by counting the number of letters correctly received in one transmission (of one hundred and fifty letters), using the best score of the three. The passing score was set at ninety.

c. There are a number of decided disadvantages to this test. It is difficult to administer and requires a considerable period of time. Moreover, there is an extremely heavy penalty for the inexperienced student; any student who has had even slight training in code reception will do better than an inexperienced man regardless of the relative abilities of the two. It is not at all certain that the proper number of repetitions for learning are given in the first section of the test. It seems highly probably that this test is a better test of immediate memory than of code aptitude.

35. CORRELATIONS. - g. There is not a great deal of data available on the Ferriter test.

In the correlations for the test, the probably errors were calculated by the author of this study.

b. The different portions of the test, that is, the scores of the three parts in the second section correlated quite well, as is to be expected. The correlations are given in Table No. 11.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH:	r.	P.E.
18	Enlisted Men	Part 1	Part 2	.61	±.054
18	Enlisted Men	Part 1	Part 3	.79	±.059
18	Enlisted Men	Part 2	Part 3	.75	±.069
18	Enlisted Men	Part 3	Parts 1 & 2	.79	±.059

TABLE NO. 11

c. The Ferriter test does not correlate well with tests of mental ability which shows that it measures some special ability rather than general mental ability. The correlations are listed in Table No. 12. The high correlations found in the third group is believed to be the result of chance. Even if it is not, it is of little value because of the small number of men in the group.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	r.	P.E.
19	Enlisted men	Ferriter	Army Alpha	.23	± .147
32	Enlisted Men	Ferriter	Otis	.45	± .095
13	Enlisted Men	Ferriter	Otis	.61	± .116
23	Enlisted Men	Ferriter	Otis	-.07	± .138

TABLE NO. 12.

4. Table No. 13 gives the correlations of the Ferriter test with the final code speed.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	r.	P.E.
35	Enlisted Men	Ferriter	Final Code Speed	.48	± .087
30	Enlisted Men	Ferriter	Final Code Speed	.39	± .171
19	Enlisted Men	Ferriter	Class rank in Code Speed.	.59	± .101
11	Enlisted Men	Ferriter	Initial Code Speed	.53	± .145
11	Enlisted Men	Ferriter	Final Code Speed	.71	± .100
23	Enlisted Men	Ferriter	Final Code Speed	.55	± .120

TABLE NO. 13.

g. There is some correlation between the test scores and the attained code speed. The correlation in the first group is fair. The probable errors of the second and sixth groups are too great to allow them to be considered. The third group gives a very good figure but it is open to question because of the smallness of the group and the uncertainty as to the exact method of ranking the class.

f. The fourth and fifth correlations are one group of experienced men. These figures show the test to be of some value for the correlation increases with the learning. However, a partial correlation between the Ferriter test and the final code speed with the initial code speed eliminated gives a correlation of $r = .59 \pm .103$, showing considerable dependence upon experience. To a certain extent, the Ferriter test may be useful in indicating the men most likely to benefit by training, particularly men with experience who wish to take further training. However, the group is so small that the figures must be accepted with due reserve.

g. The sixth correlation is of a group of Signal School students who were given the Signal Corps Code Aptitude test as well as the Ferriter test. The correlation between the Signal Corps Code Aptitude test scores and the final code speed is shown in the Table No. 17.

36. COMPARISON WITH THE THURSTONE RHYTHM TEST.- A comparative study of the Thurstone Rhythm test and the Ferriter Code Aptitude test showed that the Thurstone test was slightly superior for prognostication and considerably simpler in administration.

37. CONCLUSIONS.- The Ferriter Code Aptitude test seems to be of some use in predicting operating ability but it has such inherent disadvantages that it is believed to be practically valueless. More data is required before its prognostic value can be definitely settled. In view of the administrative difficulties, it is believed to be of considerably less value than the Thurstone test.

SECTION III.

THE ORIGINAL SIGNAL CORPS CODE APTITUDE TEST

38. DESCRIPTION. -a. The original (so-called to distinguish it from the present test of the same title) Signal Corps Code Aptitude test was devised at The Signal School in an effort to get a test of more predictive value than any of these heretofore studied. The test is a written one, divided into four parts. The first part consists of the determination of the sameness or difference of thirty pairs of transmitted code groups indicated by underlining a "yes" or "no". The second part consists of copying rapidly spoken single letters and numbers. The third part is the copying of dictated groups of numbers with from four to seven digits. In the fourth part, the student is given an opportunity to learn a code group and then is required to indicate for each of a series of transmitted groups whether or not each individual group is the learned group.

b. This test is rather difficult to administer and its administration requires a considerable period of time. The fourth part is probably open to the same objections as to the Ferriter test although not to such a marked degree in that the student has less to learn at one time. The second and third parts are particularly objectionable. They depend too much upon the examiner, for it is impossible for two persons to read with the same distinctness and volume. In addition, the reading must be completed in a specified time with an allowable variation of only a second or two and it is probable that the examiner's rate of reading would not be constant throughout. This feature makes comparisons between any two groups of doubtful value and makes the objectivity

of the test suspect.

39. CORRELATIONS.- In a class of 11 officers, the test gave a correlation of $r = .32 \pm .182$ and in a class of 31 officers, a correlation of $r = .32 \pm .109$. Both of these figures have probable errors too great to allow them to be considered.

40. CONCLUSIONS.- This test does not seem to have any value. It is evidently of less value than the Ferriter test and less useful than the Thurstone test which gave much higher correlations for the same two groups of officers. (See Table No. 10, page 27.)

SECTION IV

THE SIGNAL CORPS CODE APTITUDE TEST

41. DESCRIPTION. a. The present Signal Corps Code Aptitude test was formed by enlarging the first of the original Signal Corps Code Aptitude test and dropping the other parts. In its present form the test consists of seventy-eight pairs of code groups whose similarity or dissimilarity the student indicates by underlining a "yes" or "no" on the test sheet. The test may be given from an Ediphone record or some other form of automatic transmitter thus eliminating any errors due to mistakes in transmission and inequalities in speed and quality of transmission. Moreover, by preparing a number of records from one master record, the test can be given wherever an Ediphone transmitter is available under the same conditions which obtain at The Signal School.

b. The advantages of this test are its simplicity in administering, as described above; its shortness (the entire test may be given in about twenty minutes); the ease of scoring; and its objectivity. The chief disadvantage is the possibility of the student's guessing the answers.

c. For directions as to the administration of the Signal Corps Code Aptitude test, copy of the test and student's sheet, see Appendices A and B.

42. CORRELATIONS.-a. The Signal Corps Code Aptitude test does not correlate to any extent with mental ability as is shown in Table No. 14. The first, fourth, fifth, and sixth correlations are unacceptable because of the slight difference between them and their probable errors. The second and third are believed to be the result of chance for the reasons given below.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	r.	r _{FE}
19	Officers	S.C.C.A.	Otis	.80	+ -.147
41	Officers	S.C.C.A.	Otis	.49	+ -.079
51	Officers	S.C.C.A.	Otis	.88	+ -.087
66	Enlisted Men	S.C.C.A.	Otis	.94	+ -.080
82	Enlisted Men	S.C.C.A.	Otis	.14	+ -.072
28	Enlisted Men	S.C.C.A.	Otis	.004	+ -.187

TABLE NO. 14.

b. In order to appraise the two high correlations in Table No. 14, the partial correlations between the Aptitude test scores and the code speed with the Otis scores eliminated are found. The partial correlations for all six groups are given in order to verify any findings in the two cases under discussion. These correlations are given in Table No. 15, with the groups arranged in the same order as in Table No. 14.

c. The slight variation between the partial correlations and the original correlations show that the standing in the Otis test has a negligible effect on the score of the Signal Corps Code Aptitude test or on the code speed. It is an additional demonstration of the small importance of mental ability in learning to receive the Morse Code.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	PARTIAL OUT	r	P.E.
18	Officers	S.C.C.A.	Code speed	None	.66	± .087
18	Officers	S.C.C.A.	Code speed	Otis	.66	- .087
41	Officers	S.C.C.A.	Code Speed	None	.54	± .073
41	Officers	S.C.C.A.	Code Speed	Otis	.52	- .076
31	Officers	S.C.C.A.	Code Speed	None	.73	± .054
31	Officers	S.C.C.A.	Code Speed	Otis	.71	- .054
67	Enlisted Men	S.C.C.A.	Code Speed	None	.75	± .053
67	Enlisted Men	S.C.C.A.	Code Speed	Otis	.59	- .053
82	Enlisted Men	S.C.C.A.	Code Speed	None	.75	± .032
82	Enlisted Men	S.C.C.A.	Code Speed	Otis	.74	- .033
23	Enlisted Men	S.C.C.A.	Code Speed	None	.62	± .080
23	Enlisted Men	S.C.C.A.	Code Speed	Otis	.62	- .080

TABLE NO. 15.

d. Table No. 16 is a composite table giving the correlations between the Signal Corps Code Aptitude test and the General Electrical Information test; the correlations between the Signal Corps Code Aptitude test and the final code speed; and the partial correlations between the Signal Corps Code Aptitude test and the final code speed with the General Electrical Information test scores eliminated. (The correlations between the General Electrical Information test and the final code speed are given in Table, No. 9, page 22.)

g. There are no significant correlations between the Signal Corps Code Aptitude test and the General Electrical Information test. The probable errors are too large to allow the highest correlations, the first and sixth groups, to be considered. The reduction caused by partialing is generally slight. The greatest reductions are in the first groups which contain less than one-fourth of the entire number of men and are believed to be the result of chance.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	PARTIAL OUT	r.	P.E.
18	Officers	S.C.C.A.	G.E.I.	None	.43	± .127
18	Officers	S.C.C.A.	Code Speed	None	.66	± .087
18	Officers	S.C.C.A.	Code Speed	G.E.I.	.57	± .140
41	Officers	S.C.C.A.	G.E.I.	None	.37	± .091
41	Officers	S.C.C.A.	Code Speed	None	.54	± .073
41	Officers	S.C.C.A.	Code Speed	G.E.I.	.45	± .083
31	Officers	S.C.C.A.	G.E.I.	None	.26	± .107
31	Officers	S.C.C.A.	Code Speed	None	.73	± .054
31	Officers	S.C.C.A.	Code Speed	G.E.I.	.70	± .061
67	Enlisted Men	S.C.C.A.	G.E.I.	None	.02	± .080
67	Enlisted Men	S.C.C.A.	Code Speed	None	.59	± .053
67	Enlisted Men	S.C.C.A.	Code Speed	G.E.I.	.59	± .053

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	PARTIAL CUT	r	P.E.
82	Enlisted Men	S.C.C.A.	G.E.I.	None	.16	+ -.071
82	Enlisted Men	S.C.C.A.	Code Speed	None	.75	+ -.032
82	Enlisted Men	S.C.C.A.	Code Speed	G.E.I.	.74	+ -.033
23	Enlisted Men	S.C.C.A.	G.E.I.	None	.40	+ -.013
23	Enlisted Men	S.C.C.A.	Code Speed	None	.62	+ -.080
23	Enlisted Men	S.C.C.A.	Code Speed	G.E.I.	.60	+ -.087

TABLE NO. 16.

f. Although the Correlations between the Signal Corps Code Aptitude tests and the final code speed have been given before in connection with other tests, they are given again in Table No. 17, together with two additional groups which were omitted above because of insufficient data. The correlations vary from $r = .46$ to $r = .75$. The lowest of them, the last two groups, are the Radio Operators classes. These classes had less extended training than any other group except the third group. Since the third group had a higher percentage of experienced men, the low correlations obtained for the last two groups may be due to insufficient training.

NO. OF MEN	CLASSIFICATION	TEST	COMPARED WITH	r.	P.E.
18	Officers	S.C.C.A.	Final Code Speed	.66	$\pm .087$
41	Officers	S.C.C.A.	Final Code Speed	.54	$\pm .073$
31	Officers	S.C.C.A.	Final Code Speed	.73	$\pm .054$
67	Enlisted Men	S.C.C.A.	Final Code Speed	.59	$\pm .053$
82	Enlisted Men	S.C.C.A.	Final Code Speed	.75	$\pm .032$
23	Enlisted Men	S.C.C.A.	Final Code Speed	.62	$\pm .080$
41	Enlisted Men	S.C.C.A.	Final Code Speed	.46	$\pm .077$
84	Enlisted Men	S.C.C.A.	Final Code Speed	.48	$\pm .056$

TABLE NO. 17.

43. CONCLUSIONS.- The figures presented above show the value of this test. While some correlations with the final code speeds are not as high as might be desired, the majority are extremely satisfactory and the test is the best for prognosis of code aptitude of any so far studied. In addition to its superior prognostic qualities, the Signal Corps Code Aptitude test is highly objective and it is the easiest to administer and score.

CHAPTER 5 - SUMMARY.

SECTION I.

GENERAL TESTS.

44. VALUE OF GENERAL TESTS.-a. None of the general or special tests considered in the first three chapters of this study gave any results which justified their use as code aptitude prognosis tests. One of the mental ability tests might be used to eliminate those students whose mental ability is so low as to presuppose failure. Probably any standardized mental ability test would do for this purpose. The Otis test is superior to the Army Alpha test because of its greater simplicity; the Otis test has 75 questions and requires no oral directions; the Army Alpha test has 212 questions and requires a number of oral directions.

b. The use of the Opposites test (Chapter 3, page 19) is not recommended unless further investigation should disclose that it is more valuable than this study shown.

c. The General Electrical Information test might be of value if used in conjunction with other tests or as used at The Signal School; to choose the men with the most electrical experience from a group of otherwise equal individuals. Further investigation might show some value in using it with the Signal Corps Code Aptitude test to determine the weight to be given to the code aptitude test score of an experienced man.

SECTION II.
APTITUDE TESTS.

45. VALUE OF APTITUDE TESTS.- a. Table No. 18 gives some of the advantages and disadvantages and the probable relative usefulness of the four aptitude tests considered in Chapter 4.

TEST	ADVANTAGES	DISADVANTAGES	VALUE
Darstone	Good correlation. easy to administer. Quickly administered. Objective scoring.	Not easy to score.	GOOD
Ferriter	Some correlation. Objective scoring.	Hard to administer. Long time required. Hard to score	FAIR
Original S.C.C.A.	Objective scoring.	Poor correlation. Considerable time needed. Hard to administer. Not objective in administration.	POOR
S.C.C.A.	Good correlation. Easy to administer Quickly administered. Objective administration. Objective scoring. Easily scored.	Guessing possible	VERY GOOD

TABLE NO. 18.

b. It will be seen that the Signal Corps Code Aptitude test has the greatest number of advantages and the fewest disadvantages. It is believed to be the most satisfactory test of the group for diagnosing code aptitude.

SECTION III.

CONCLUSIONS.

46. THE NATURE OF CODE APTITUDE.- This study has shown that code aptitude is a special ability and as such cannot be measured by general tests of mental ability nor by test not especially designed for the purpose.

47. NATURE OF A SATISFACTORY TEST FOR DETERMINING CODE APTITUDE.- It has also been shown that a comparatively simple test will measure this ability. The measurements will be sufficiently accurate to permit the selection of students susceptible to training as radio operators.

48. THE VALUE OF THE PRESENT SIGNAL CORPS CODE APTITUDE TEST.- It has also been shown, that of all the tests examined, the Signal Corps Code Aptitude test is the best indicator of relative ability to learn to receive code groups. This test seems capable of being used as a measure of actual ability. It is believed that the Signal Corps Code Aptitude test is the only one available at the present time which is reliable in determining the suitability of the candidate for a course in which learning to receive Morse code is one of the requirements.

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