PSYCHOLOGICAL TRAITS OF SUCCESSFUL PILOTS

RESEARCH FINDINGS OF 1942

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PSYCHOLOGICAL TRAITS OF SUCCESSFUL PILOTS

A Summary of Some of the
More Important Findings From the
Psychological Research Program for
Aviation Cadets During the Year 1942

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PSYCHOLOGICAL TRAITS OF SUCCESSFUL PILOTS

Research Findings of 1942

I. Selection of Aviation Cadets

There are three primary considerations that determine the policies for selecting men for pilot training in the Army Air Forces. These are: (1) the number of trained pilots required, (2) the equipment, the instructors and the time available for training these pilots, and (3) the nation's manpower reserve. The goal, in number of trained pilots, has been set. The amount of equipment that can be used in training, the number of available instructors, and the time schedule, are practical limitations. In order to obtain the desired number of pilots and to make the most economical use of equipment in the short time available, it is imperative that adequate use be made of our present manpower reserve.

If we are to produce in the shortest time a highly effective Air Force, we must make use of the best available techniques in selecting from the manpower pool those men who should go into pilot-training schools. Every man who fails to complete his training course costs the Air Forces hundreds of hours of time, irreplaceable equipment, and thousands of dollars. We cannot afford to waste time and equipment trying to train those who can never hope to succeed. Fortunately, techniques have been developed that can be employed to select from the manpower pool the men who are most likely to succeed in aircrew training. It is with these techniques, by means of which the men who possess the traits that will enable them to become successful members of an aircrew can be identified, that this report is concerned.

Since the careful selection of Aviation Cadets is made doubly important by the present manpower problem, a brief summary of the facts relating to the available supply of first-class pilot material is in order. This will serve as an introduction to the discussion of the traits that are characteristic of good pilots.

During the first ten months of 1942, for every 100 men of Aviation Cadet age taken into the Army, approximately 28 men, either civilians or soldiers, applied for Aviation Cadet training, and approximately 10 men were accepted. Complete figures for the last two months of the year are not yet available.

These data furnish a basis for planning manpower utilization in 1943. The present problem is to select from enlisted ranks, or from the pool of men who are available for induction, the required number of men who have a strong interest in flying and who are first-rate pilot material. The best way to select these men is by a series of successive sortings, by means of which each individual will be assigned where he will be of most value to the Army. The classification procedures for Aviation Cadets are a part of the general manpower

utilization program of the Army. In Figure 1 is illustrated a procedure by means of which the sorting out of the men to be trained as pilots can be accomplished in 1943 in relation to the sorting procedures for other specialties. The general plan outlined here can be applied either in case the Preliminary Test of Aviation Cadet Aptitude is given to applicants of suitable ages before they are inducted, or in the case that it is given to men who volunteer after they are inducted.

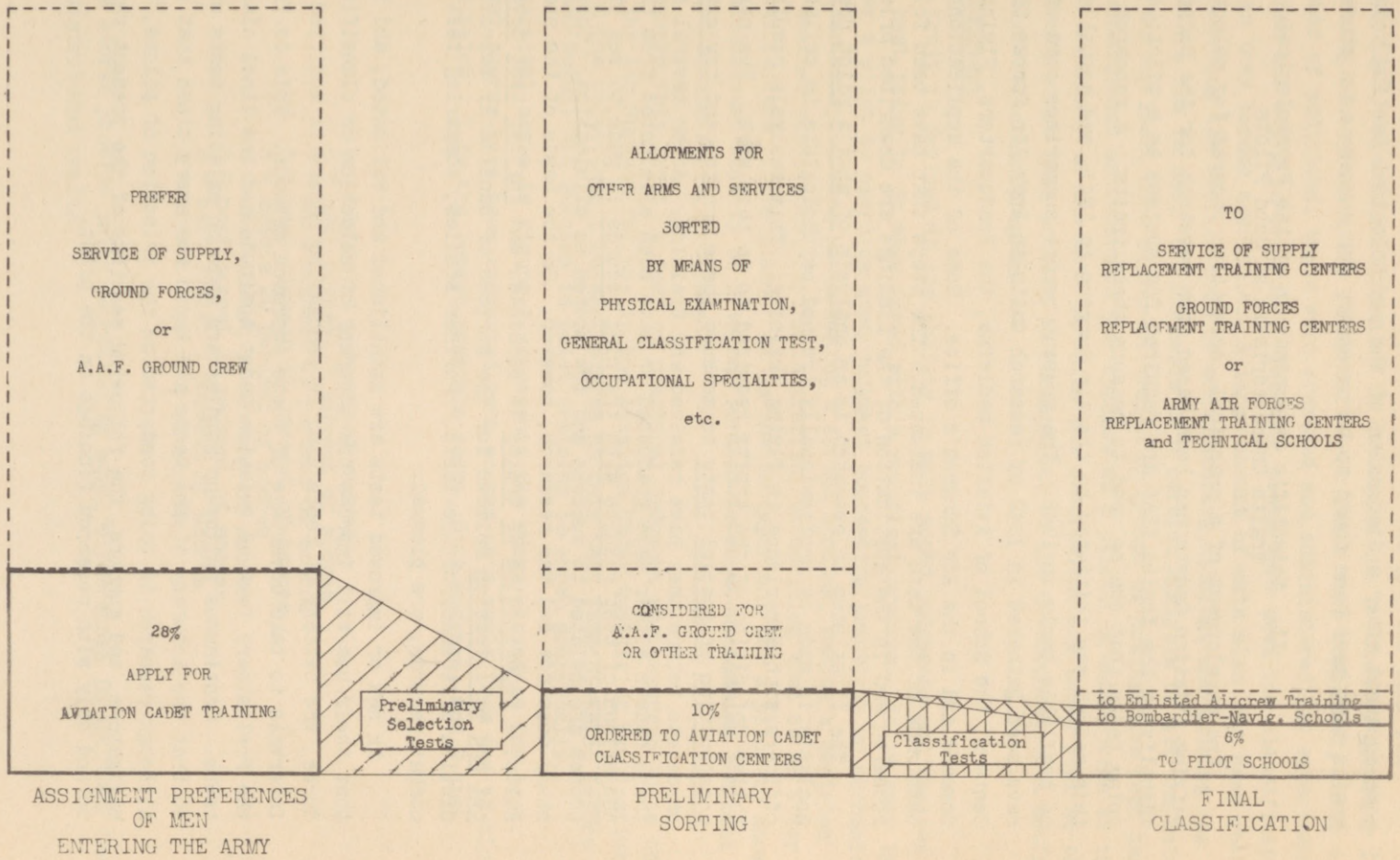
The first bar represents the assignment preferences of men who enter the Army. The exact number of men who will apply for Aviation Cadet training this year is not known, but it is not likely that a larger percentage will volunteer this year than last year. A reasonable expectation is that pilots must be drawn from a pool of volunteers approximating 23% of incoming men of Aviation Cadet age. This estimate is based upon the assumption that the ratio of men desiring this training to the total number of men taken into the Army this year will be the same as the ratio of men volunteering for Aviation Cadet training to the total number of men taken into the Army last year.

The second bar in Figure 1 represents the preliminary sorting process. The men required by the various arms and services will be sorted out and assigned after consideration of information secured from physical and psychological tests, interviews, etc. Many of the outstanding young men in the Army will not be available for assignment as Aviation Cadets, because they prefer other services. Those who do apply for Aviation Cadet training will be given the Preliminary Test of Aviation Cadet Aptitude and a Flight Physical Examination. On the basis of 1942 figures it is expected that approximately 35% of all applicants will pass both of these tests, providing standards are not altered. Applicants who do not pass these early screening tests for aircrew personnel will be processed with other enlisted men and assigned to training for which they are better qualified. Many applicants who do not qualify as Aviation Cadets will be assigned to the Army Air Forces as enlisted men.

The third bar in Figure 1 represents the final classification for specialized training. The men assigned to each branch of the Army will be classified in relation to their qualifications for the type of training that will make them most valuable to that arm or service. The ten percent of men tentatively assigned to Aviation Cadet Training after the first sorting will be given the battery of special psychological tests for determining Aptitude Scores as Pilots, Bombardiers, or Navigators (or as Bombardier-Navigators). Those who after careful examination with these apparatus and group tests are found to be deficient in the special aptitudes for these aircrew specialties can be sorted for gunnery, radio, flight engineer, or other special training in the Army Air Forces. It is expected that approximately 6 percent of the men between 18 and 26 years, inclusive, who enter the Army this year, will be found to be well suited for pilot training after this final sorting is completed.

FIGURE I

SUCCESSIVE SORTING AND FINAL CLASSIFICATION OF MEN
IN THE AVIATION CADET AGE GROUP
ENTERING THE ARMY IN 1943



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How this sorting out of the best pilot material can be accomplished will become apparent after a discussion of the psychological testing program and the traits that have been found to be necessary for success as a student pilot.

II. Scientific Determination of the Psychological Traits Characteristic of Good Pilots

The development of a practical, scientific program for selecting and classifying Aviation Cadets has been based upon research for the purpose of: (1) identifying the traits that are required for success as a pilot; and (2) developing tests that can be used to measure these traits. A research program of this nature was initiated by the Air Surgeon in 1941, and actual data began to be available early in 1942. The present report summarizes some of the data that have been gathered in 1942 by research units in Army Air Forces Classification Centers, the School of Aviation Medicine, the Headquarters, Flying Training Command and in the Air Surgeon's office. Some of the applications that have been made of the data are indicated. The steps that have been followed in the research and in the application of the findings are described briefly below.

The first step in research is an analysis of what a pilot does. This analysis is made by professionally trained psychologists in collaboration with officers with experience in flying training. This analysis results in a tentative definition of the traits required to do this work. The next step is construction of special tests to measure these traits, and try-out of the tests on cadets before they have received any training. After several months, when these cadets either have graduated or have been eliminated from training, a comparison of test results with training records is made to see if high test scores are related to success and low scores to elimination. This statistical study does not end the research, however. On the basis of the statistical results, a redefinition of traits is possible, and further test development, try-out and verification follows for the purpose of constantly improving the prediction efficiency of the tests. Further studies, comparing test results with combat records, are planned.

As new or improved tests are established and validated, and it is known that their use will improve the accuracy of selection or classification procedures, the battery of tests used in processing cadets is modified at periodic intervals to take advantage of these improved methods. This is true of both the Preliminary Test of Aviation Cadet Aptitude and the final classification tests. Continuous follow-up studies are made on existing tests and procedures so that the accuracy of the tests are known for every class that graduates. Although research is being conducted on the selection of pilots, bombardiers, navigators, and gunners, the following sections of the present report are concerned only with research findings on the pilot.

III. Traits of Successful Pilots

During 1942, experimental studies to determine the predictive accuracy for pilot training of approximately fifty different tests were completed, while a large number of additional tests were prepared and administered for experimental studies that are still in progress. The best tests were used for classification purposes as they became available. A large amount of data also has been obtained concerning the best methods of administering, timing, and scoring the tests that are now in use. On the basis of a careful analysis of all the data available during 1942, nine different traits or groups of traits have been tentatively established as important for success as a pilot. A description of these traits and a summary of the data on which the conclusions are based will be of wide interest, since this problem is fundamental to the development of a satisfactory pilot selection program.

A. Good Judgment

This trait is defined as the ability to make sound judgments and choices as to the best thing to do when faced with a practical problem. It is very important for a pilot to exercise good judgment concerning practical or mechanical problems, for example, when he is making a forced landing, making a decision involving weather conditions, flying in traffic, or deciding what to do after a mechanical failure of the plane. It is not as important for a pilot to show unusual intellectual ability of a verbal sort or to show outstanding judgment with respect to non-flying problems.

To measure this trait, a test of practical judgment was constructed in the Office of the Air Surgeon for use in the Aviation Cadet Qualifying Examination. In Figure 2 the relationship between scores on this test (administered before training had begun) and success in pilot training is shown graphically.

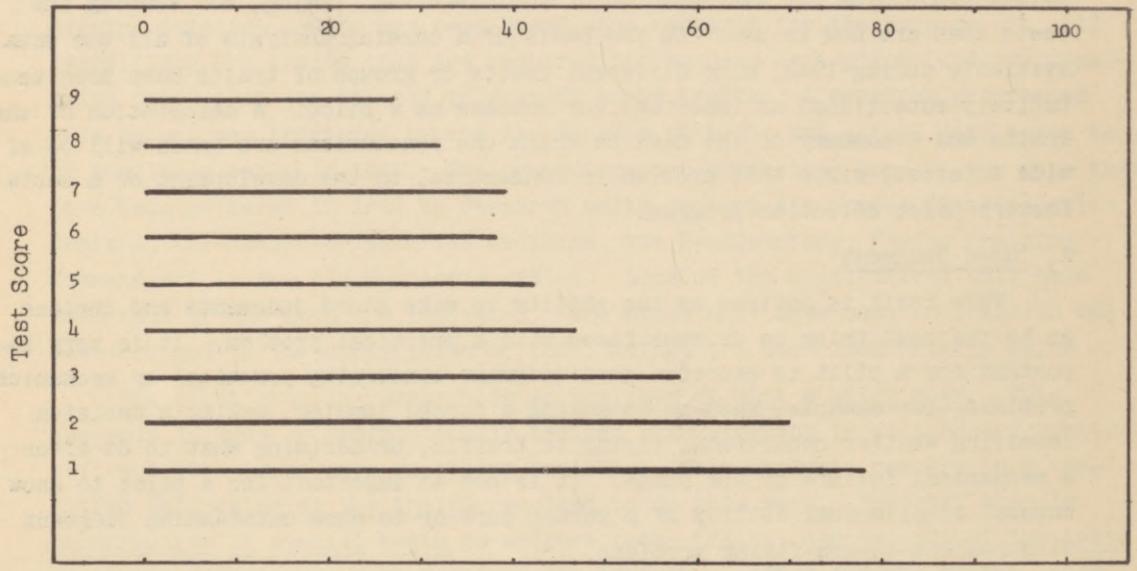
The vertical scale in Figure I represents the score earned on the test. All raw test scores have been converted into scores on a scale from one to nine as defined below. 1 is the lowest possible score, 5 is average, and 9 the highest.

9 = highest 4 percent of scores
8 = next highest 7 percent of scores
7 = next highest 12 percent of scores
6 = next highest 17 percent of scores
5 = middle 20 percent of scores
4 = next lowest 17 percent of scores
3 = next lowest 12 percent of scores
2 = next lowest 7 percent of scores
1 = lowest 4 percent of scores

These scores provide units representing equal differences in aptitude for normally distributed traits.

FIGURE 2: JUDGMENT TEST

Percent Eliminated from Pilot Training



15-Item Judgment Section, Aviation Cadet Qualifying Examination

1,858 Aviation Cadets and Students Biserial r = .29

The horizontal scale of the graph indicates the percent of men who were eliminated from pilot training. Only eliminations that were made because of failure in actual flying training are included in this and following figures. Cadets eliminated for medical reasons are not included. The horizontal bars beneath the horizontal scale indicate, for cadets who made each test score, the percent eliminated in elementary, basic, or advanced pilot training.

It will be noted that among the cadets who made the highest score on the Judgment Test, the elimination rate was 27% while among those who made the lowest score the elimination rate was 78%. The fact that 27% of the best group on this test were eliminated illustrates the fact that judgment, as measured by this test, is by no means the only trait that is required of a pilot. Even with a perfect test of judgment, it would not be possible to achieve a zero elimination rate for men who made top scores, because a number of other traits, not closely related to judgment, are also important in learning to fly. For

FIGURE 3

Aviation Cadets Taking Group Tests at One of the Psychological Research Units

example, a cadet with very good judgment might have only average muscular coordination. Such cases as this probably require very careful study by the check pilots responsible for recommending elimination or continued training.

The fact that the Judgment Test measures one of the traits that is important for flying is shown by the difference of more than three to one in chances of graduation between the men in this population scoring 9 and those scoring 1. In order to get 100 graduate pilots, it would have been necessary to send into training 137 men with scores of 9 as against 455 men with scores of 1 on this particular test.

An indication of the importance of good judgment is the frequency with which officers and instructors mention this trait. In an earlier analysis of 1,000 board proceedings on cadets eliminated from pilot training, it was found that bad judgment was mentioned as a cause for elimination in exactly half of the cases.

Extensive studies are now in progress to determine more accurately the relation of judgment to other traits and the nature of the functions measured by present judgment tests. It is probable that judgment is related to an individual's background of practical experience. It is probably also related to reasoning ability, although most problems that require good judgment cannot be solved by logical reasoning alone. Judgment requires the ability to consider various aspects of a problem and come to a decision based on all available information regarding the most practical thing to do in that situation.

The relatively independent nature of the judgment trait in pilots is illustrated by a remark made by the commander of a bombardment squadron who was discussing his experiences in the South Pacific area. When asked: "Are the best pilots outstanding in their judgment?", he replied: "Yes, so far as flying an airplane is concerned, but some of the best combat pilots are not good for anything on the ground. For instance, I know a pilot who can handle the crew of an airplane with no trouble, but he's just no good behind a desk."

The Judgment Test represented in Figure 2 is a pencil and paper test that can be administered to a large group of applicants at one time. In Figure 3 is shown a group of Aviation Cadets at Psychological Research Unit No. 3, Santa Ana Army Air Base, taking one of the group tests administered to all new cadets.

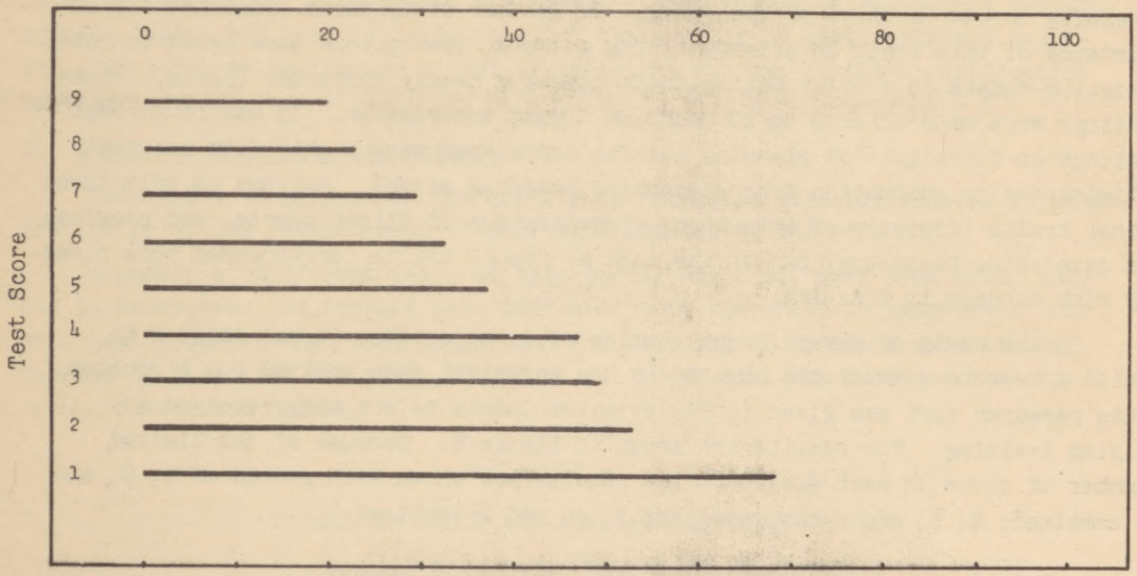
B. Mechanical Comprehension

This trait is defined as the ability to comprehend the design of equipment, to understand the method of operation of mechanical devices, to sense the effects of physical forces, and to apply physical principles.

Data indicating the importance of this trait, shown in Figure 4, are based upon 1,105 Aviation Cadets and Aviation Students tested with the Mechanical Comprehension section of the Aviation Cadet Qualifying Examination prior to pilot training. It will be seen that 19% of the men scoring 9 were eliminated from pilot schools during primary, basic, or advanced training, as compared with 68%

FIGURE 4: MECHANICAL COMPREHENSION TEST

Percent Eliminated From Pilot Training



15-Item Mechanical Comprehension Section, Test AC10A

1,105 Aviation Cadets and Students Biserial r = .28

of those scoring 1, a difference in elimination rate of over three to one. The results on other mechanical aptitude tests, including a test in which cadets assembled simple mechanical devices, have furnished additional evidence regarding the importance of this trait. It is not only one of the most important traits of successful pilots, but it is a trait that can be measured with a high degree of reliability.

Special studies are being undertaken to find out what form of mechanical comprehension tests give the best predictions of pilot success. It is believed that mechanical comprehension may depend upon several factors. For practical purposes, however, it has been determined that tests of mechanical information, tests of the ability to understand mechanical principles, and tests of ability to comprehend drawings and descriptions of mechanical devices make a valuable contribution to the prediction of success as a pilot.

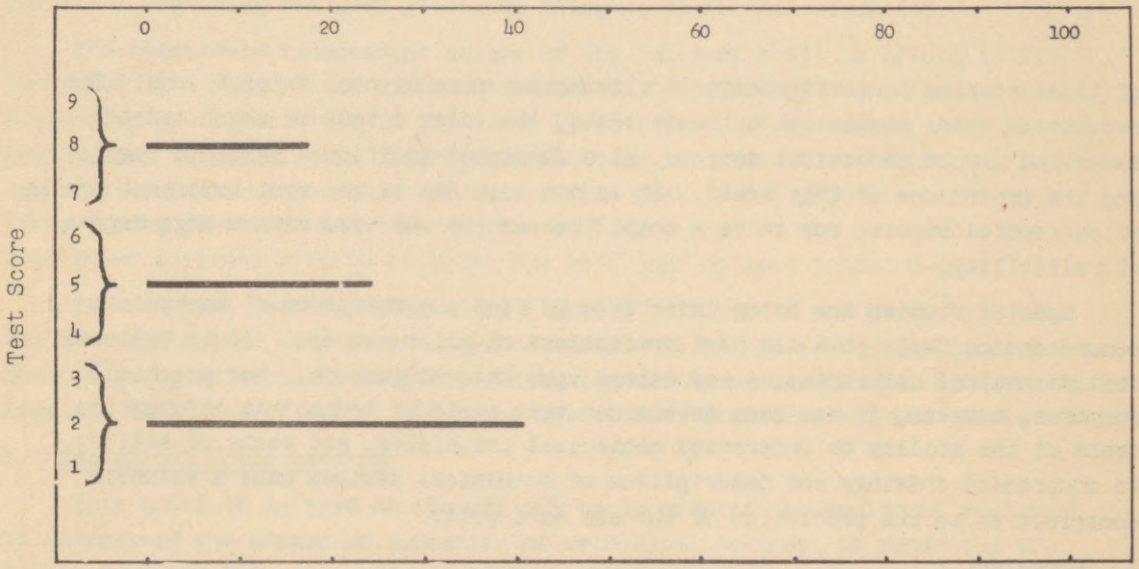
C. Foresight

This trait is defined as the ability to plan a series of maneuvers or activities and to foresee what will be the outcome or future result of present actions. Not as much evidence for the importance of this trait has been collected as is available for several other traits of the pilot.

In the analysis of 1,000 board proceedings referred to previously, lack of foresight and planning ability was recorded as a cause for failure in pilot training in over a third of the cases. In another study which indicated the importance of this trait in primary flying schools, instructors were asked to rate Aviation Cadets on a Pilot Rating Scale covering twenty different traits. These ratings were made after 8 to 10 hours of flying instruction. It was found that ratings on foresight and planning ability correlated very highly with eventual elimination or graduation from elementary training school. Ratings on only three other traits (division of attention, visualization of flight course, and progress in developing technique) out of the list of twenty traits corresponded more closely with success in training.

On the basis of several such studies of pilot duties, it was decided to build a test to measure the ability to use foresight when working out a problem. This research test was given to 316 Aviation Cadets before they received any flying training. The results are shown in Figure 5. Because of the limited number of cases in each subgroup, the results are shown with scores of 1, 2, and 3 combined; 4, 5, and 6 combined; and 7, 8, and 9 combined.

FIGURE 5: FORESIGHT TEST



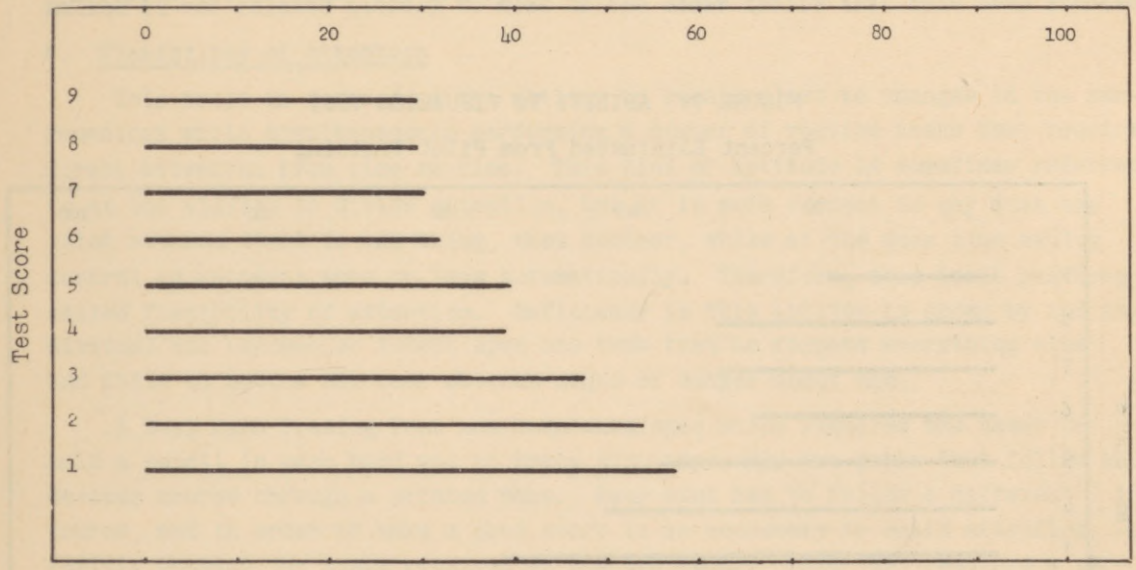
The elimination rate was highest for the group with lowest test scores. This is the only test that has been developed and tried out as a measure of foresight upon which the results are known. These initial findings are encouraging. Additional work is being done for the purpose of developing and securing additional validation on a test of foresight for use in the classification testing battery.

D. Quick and Accurate Observation

This trait is defined as the ability to recognize objects, shapes, patterns, and the relations between such stimuli with both speed and accuracy.

A number of different tests of this perceptual trait have been tried out, and in every case the results have indicated that the trait is important. One such test requires the rapid comparison and matching of airplane silhouettes. Results of this test are shown in Figure 6. These data are based on over six thousand Aviation Cadets.

FIGURE 6: QUICK AND ACCURATE OBSERVATION TEST



Speed of Identification Test

6,110 Aviation Cadets Biserial r = .20

Tests of this trait are important for several reasons. Most of the tests are short, requiring only a few minutes of working time. The Speed of Identification Test, for example, requires 4 minutes for 48 test items. Also, this

trait appears to be quite independent of many of the other traits that are characteristic of a good pilot. This means that even if a candidate shows excellent judgment, high mechanical comprehension, etc., it is still desirable to test the speed and accuracy of his observations.

In Figure 6 it will be noted that men who obtained low scores (1, 2, or 3) were eliminated from training more frequently than men who obtained scores of 4 or higher.

Several tests of orientation ability and speed and accuracy in comparing maps and photographs have been tried out and preliminary results indicate that these tests make a valuable contribution to the prediction of success.

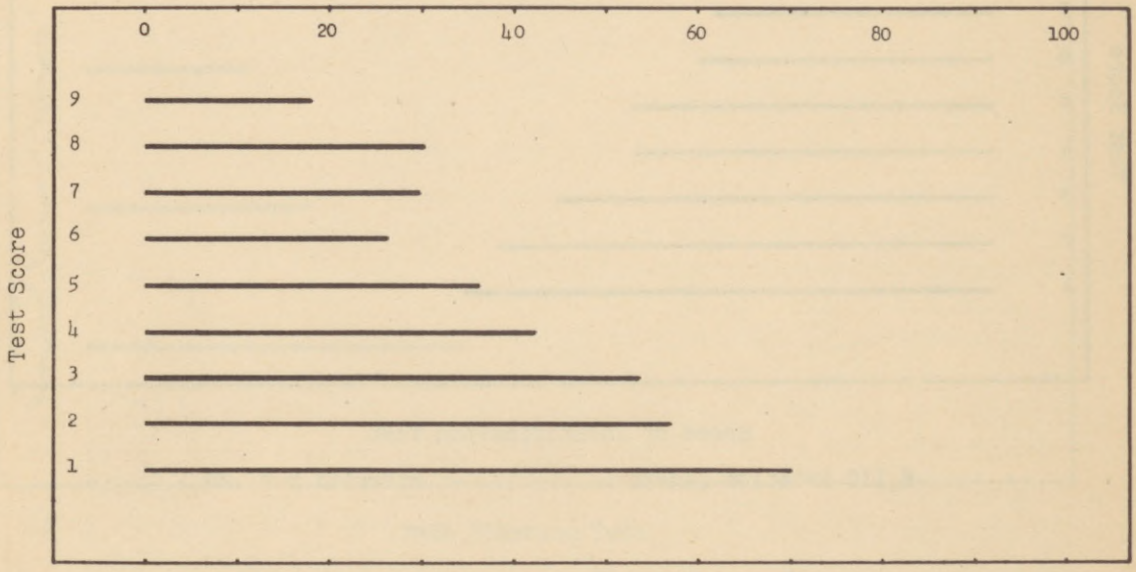
At the present time an extensive study is being made of all available tests of speed and accuracy of observation for the purpose of securing a better test of this trait by developing a single longer test containing one type of problem, or one combining several of the best types of problems.

E. Ability to Visualize

This trait is defined broadly as the ability to visualize spatial relationships. The results from experimental use of one test that measures components of this trait are given in Figure 7. These results are based on 929 Aviation

FIGURE 7: ABILITY TO VISUALIZE TEST

Percent Eliminated From Pilot Training



Gottschaldt Figures Test

929 Aviation Cadets Biserial r = .33

Cadets who were given the Gottschaldt Figures Test. This test requires that a pattern, viewed once in isolation, be recognized and abstracted from a much larger and interlacing pattern. In some respects, it is like the problem of recognizing the outline of an object after it has been camouflaged with many confusing lines and patterns, or the problem of keeping a constant pattern in mind while one's orientation is changing. The test used in the study, results of which are shown in Figure 7, was adapted by Dr. L. L. Thurstone.

The results shown in Figure 7 indicate clearly that the trait measured by this test is important for pilots. The rate of elimination was more than three times as high among the cadets with the lowest score as among those with the highest score.

Another point of interest with respect to this trait is the fact that in the study referred to previously, in which comparisons were made between instructors' ratings on twenty different traits and elimination of students from pilot schools, results showed that ratings on visualization of flight course correlated more highly with eventual elimination than did ratings on any characteristic other than ability to divide attention. There is some evidence that this trait is related to mechanical comprehension. However, the ability to visualize is not related closely to most of the other traits that have been studied.

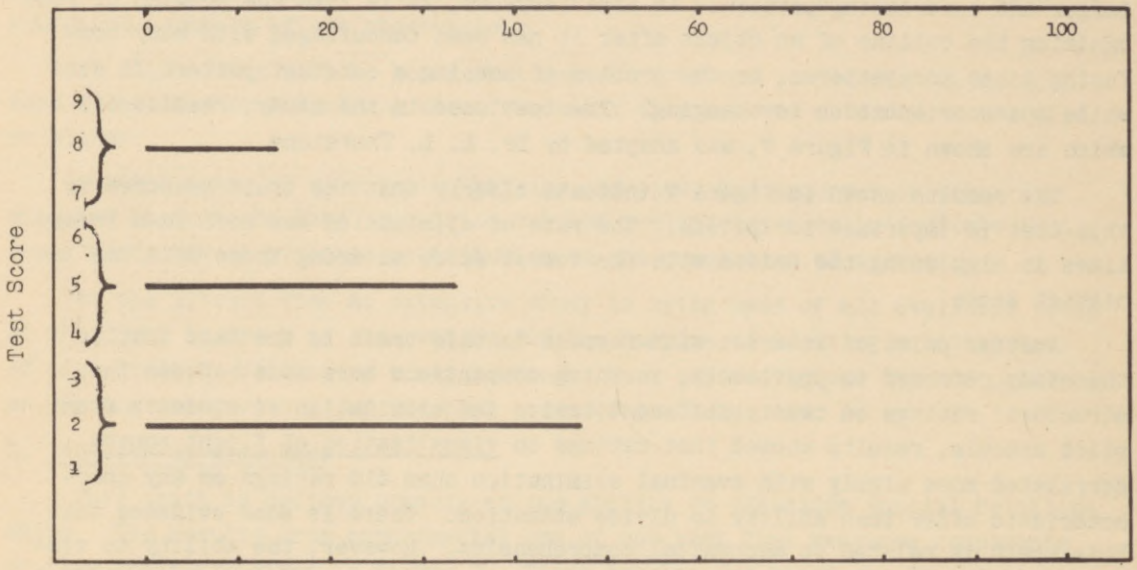
F. Flexibility of Attention

This trait is defined as the ability to remain alert to changes in the surroundings while simultaneously performing a number of routine tasks that require direct attention from time to time. This kind of aptitude is sometimes referred to as the ability to divide attention, but it is more correct to say that the pilot attends first to one thing, then another, while at the same time making control adjustments more or less automatically. Therefore, this trait has been called flexibility of attention. Deficiency in this ability is shown by the individual who becomes so intent upon one task that he forgets everything else and fails to notice the most obvious signs of danger about him.

A Dual Path Tracing Test has been developed which requires the cadet to hold a pencil in each hand and to trace simultaneously two paths that follow a devious course through a printed maze. Each hand has to follow a different course, and in order to make a good score it is necessary to shift attention rapidly between the tasks required of the two hands. This test requires a certain amount of hand skill and coordination, but the fact that its validity depends upon doing two tasks at once was strikingly shown by a comparison of one-hand performance with simultaneous performance with two hands. Cadets were required to follow one path at a time with the right hand alone and then with the left hand alone, and finally to follow two paths at once using both hands. The results showed that the scores when either task was performed alone had little relation to success as a pilot, but that the score when the two tasks were performed simultaneously gave a significant indication of success.

FIGURE 8: FLEXIBILITY OF ATTENTION TEST

Percent Eliminated From Pilot Training



Dual Path Tracing Test

185 Aviation Cadets Biserial r = .30

The results are shown graphically in Figure 8. Because of the limited number of cases available, the data have been grouped. The results, however, are definite and indicate that tests of this trait must be regarded as highly promising.

In another experimental test a group of cadets were required to operate a visual-motor pursuit apparatus and at the same time respond from time to time to a signal light. The results from the use of these apparatus tests were slightly better than the results from use of the Dual Path Tracing Test: Again it was found on the group tested that a score on the combined task gave better results than a score on either task performed singly.

At the present time a number of other tests for the measurement of flexibility of attention are being developed. These tests require the use of such skills as: keeping track of the readings of simultaneously changing dials, performing several mental tasks at once, and carrying on more than one visual-motor task at once. It is believed that further development of these materials may furnish a test that will be very valuable for the classification testing battery.

G. Traits Involving Visual-Motor Coordination

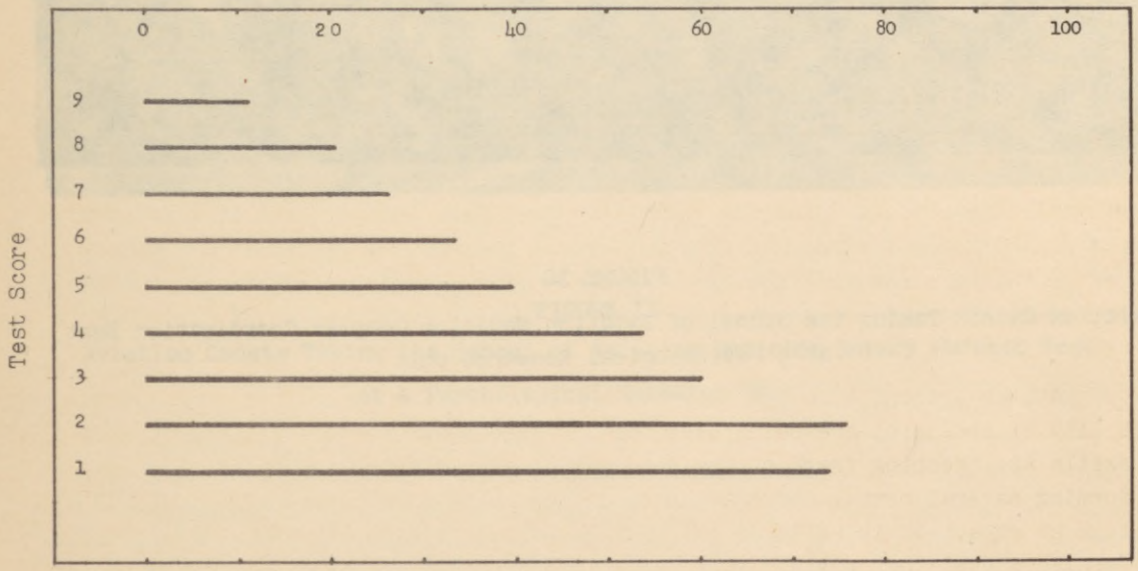
This group of traits is characterized by the ability to react on the basis

of visual cues in such a manner that combined or successive reactions of hands, arms, and legs will achieve the desired adjustment. In flying a plane, this involves the ability to achieve the correct sequences of control pressures in order to maneuver the plane smoothly and precisely. Visual-motor coordination is usually tested by requiring the cadet to move a set of controls in response to designated signals. Such tests require the use of individual testing apparatus for each cadet.

The test of visual-motor coordination that has been used most extensively with Aviation Cadets is the School of Aviation Medicine Complex Coordination Test (a revised version of tests developed by O'Rourke, Mashburn, Constable, Thorne, and others). A view of four sets of this test and a central control table is shown in Figure 10. The cadets are being tested at Psychological Research Unit No. 2, San Antonio Aviation Cadet Center. Three red lights appear, one in each double row, and the cadet must match these with corresponding green lights by appropriate coordination of stick and rudder. The stick controls the top and center rows of lights and the rudder controls the bottom row. The score is the number of correct adjustments made during the test period. Results of the administration of this test to over one thousand Aviation Cadets are presented in Figure 9.

FIGURE 9: VISUAL-MOTOR COORDINATION TEST

Percent Eliminated From Pilot Training



School of Aviation Medicine Complex Coordination Test

1,049 Aviation Cadets Biserial r = .37

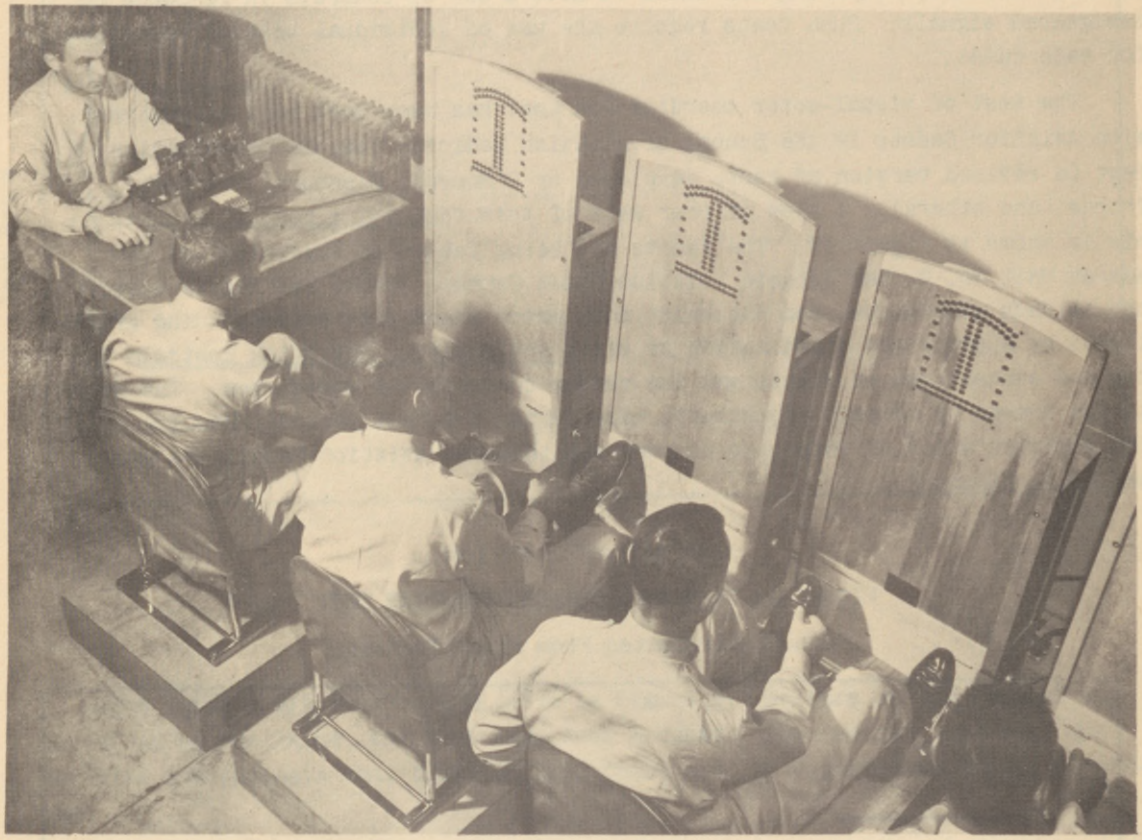


FIGURE 10

Aviation Cadets Taking the School of Aviation Medicine Complex Coordination Test at a Psychological Research Unit

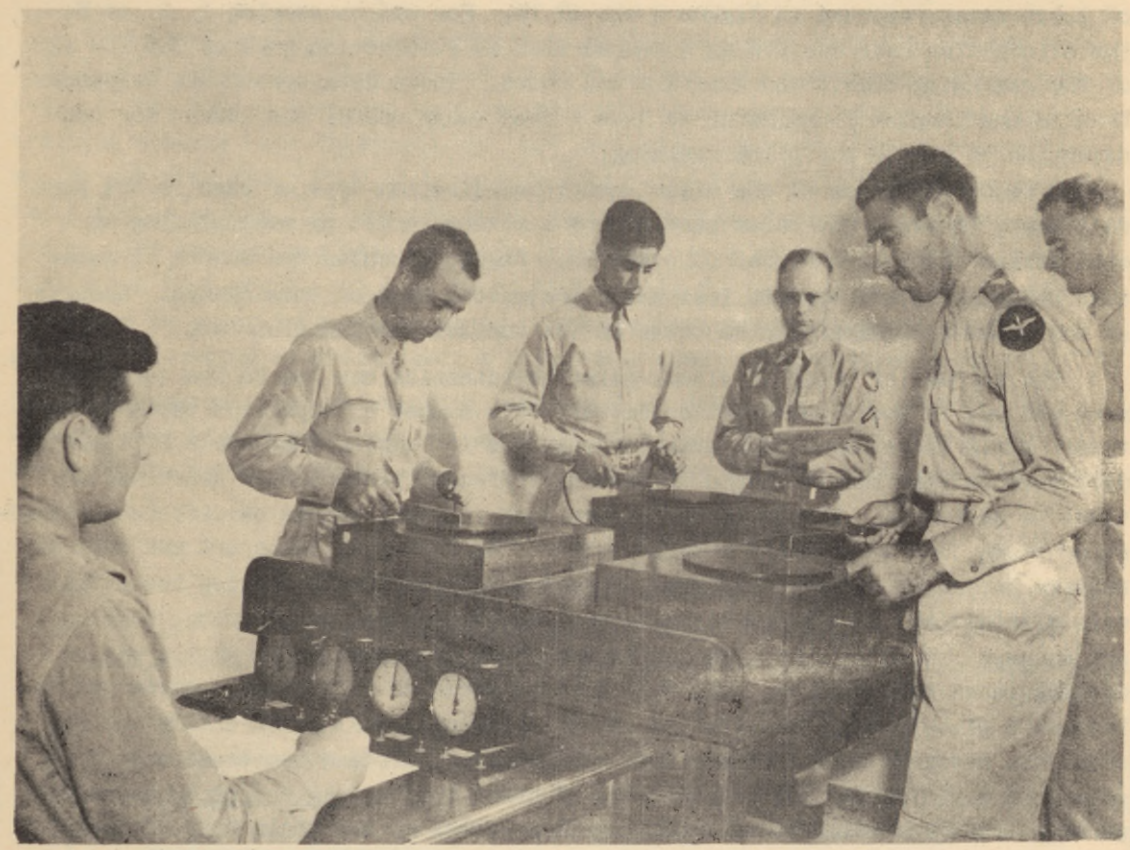


FIGURE 11

Aviation Cadets Taking the School of Aviation Medicine Rotary Pursuit Test at a Psychological Research Unit

Additional data concerning this test are available for other groups and are in agreement with the results shown in Figure 9. It will be noted that the elimination rate for men scoring 1 and 2 was 72% and 75% respectively, whereas the rate was only 11% for men scoring 9. The elimination rate on the entire group of 1,049 cases reported in Figure 9 was 43.1%. For cadets scoring 1, 2, or 3, the elimination rate was 67% as compared with an elimination rate of 36% for all of the remaining cadets who scored 4 and above. These data constitute evidence that in the Complex Coordinator we have a remarkably useful instrument for the selection of cadets for pilot training.

A major variation of the visual-motor coordination type of test is the pursuit test, in which the cadet must follow a moving target by manipulating an appropriate instrument or set of controls. Figure 11 shows the School of Aviation Medicine Rotary Pursuit Test which presents a task of this nature. Results on this test are comparable to those on the Complex Coordination Test.

The success of tests of visual-motor coordination has led to the development and use in the classification battery of a number of apparatus tests of this type. While these tests have numerous elements in common, they are sufficiently different so that the inclusion of several different visual-motor coordination tasks is desirable. Cadets differ a good deal in their scores on different visual-motor tasks just as some men make an outstanding record in one sport and only an average record in others. One aim of present research is to develop tests that will distinguish between the visual-motor skills required in piloting, bombing and gunnery. However, until the different kinds of visual-motor skills can be distinguished more clearly, they will be considered as a group of related traits. Because a pilot's work involves the use of numerous visual-motor skills and because the research data indicate that visual-motor coordination tests are of greater discriminating power than tests of other traits, the scores on these apparatus tests are weighted more heavily than scores on any other type of test used in the classification of men for pilot training. Development of these tests to the point where every Aviation Cadet can be tested on a series of visual-motor tasks, and objective scores obtained which are exactly comparable from one classification center to another, represents a major contribution of the 1942 research program to selection techniques.

H. Aviation Interest

This trait is defined in general as the possession of interests that are characteristic of successful pilots. This definition is not so general as it might seem, however, for it has been found that pilots have well-defined interests. In addition to a strong desire to fly, the typical man who will make a good pilot can be recognized by his likes and dislikes for other activities. It has been determined that the typical man who has made a good record in pilot training tended to like out-of-door activities and sports. He was not always an outstanding athlete, but he probably enjoyed taking part in games or competitive sports and usually either played well or learned a new game rapidly.

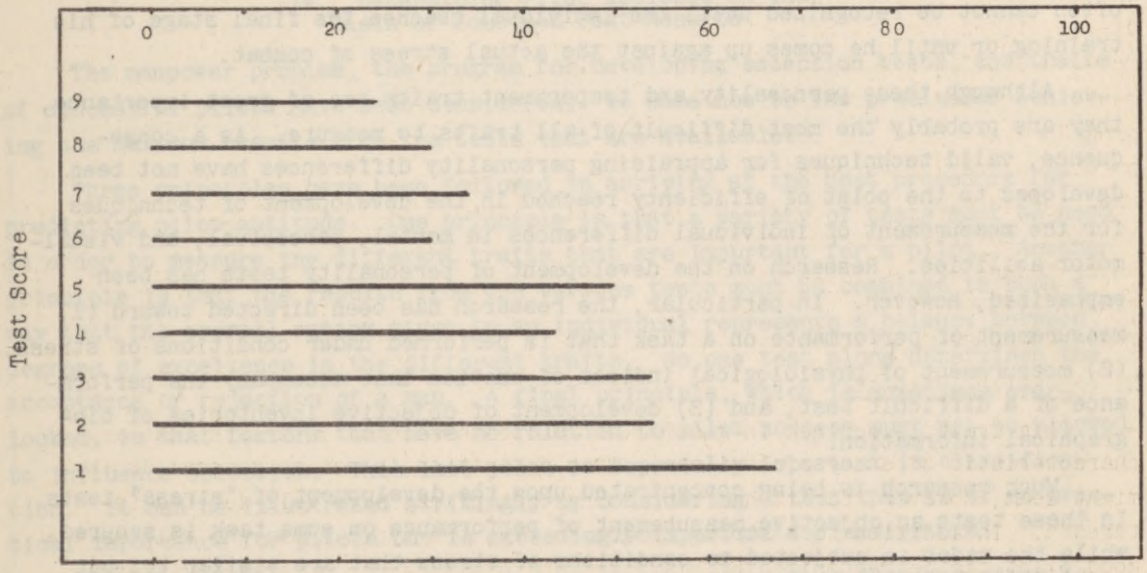
When he was in school, the typical pilot preferred industrial arts and shop work, the sciences, engineering, and mathematics. On the other hand he was inclined to dislike certain subjects, including history, speech, literature, economics, statistics, accounting, and political science. With respect to social activities and interests such as dancing, he did not differ from other individuals of his own age.

This description of the interests of a typical pilot does not fit any individual pilot exactly. With respect to each of the points mentioned above, however, it has been determined that the majority of men who graduate from flying training schools have interests that are definitely different from those of men who do not graduate. Much of this information has been collected by the use of tests of the cadets' information about various sports, hobbies, and other subjects. The man who has been actively interested in a sport will know a great deal about that sport, and this makes it possible to check objectively on his interests by using information tests. Studies have also been made using biographical inventories which cover a great many areas of past experience.

The results from one aviation interest test are shown in Figure 12. It will be seen that the percent of men eliminated from training is definitely related to the score on this test. Interest tests of this kind are among the more

FIGURE 12: AVIATION INTERESTS TEST

Percent Eliminated From Pilot Training



Knowledge of Recent Developments Test

719 Aviation Cadets and Students Biserial r = .22

useful and better established devices for use in selecting and classifying cadets. Based upon objective evidence of relatively permanent interests, such tests provide valuable information for use in classification.

Research on the improvement of interests tests is progressing. Objective measures of participation in various sports and hobbies are being developed. Studies are being made of the interests of bombardiers, navigators, gunners, and pilots. Plans are also being made to investigate the possibility of using interest tests to differentiate between men who should be classified as bomber pilots and men who should become fighter pilots.

I. Suitable Personality and Temperament Traits

Personality and temperament traits are undoubtedly among the most important traits required for success as a pilot, particularly for success in tactical and combat flying. The evidence for the importance of this group of traits comes from many sources. Typical of the evidence are results of an analysis that was made of the records of one hundred rated pilots who had been assigned at one time to operational training units and then subsequently had been reclassified and transferred to non-combat duties. The analysis of the records on these cases revealed that defects in personality and temperament accounted for more failures in tactical squadrons than did any other personal deficiency. It is important to note that in these cases the defects did not become apparent until the pilots were almost ready for combat. Many other personal deficiencies, such as lack of coordination, can be detected by observing the individual's behavior during the early stages of training, but lack of suitable personality and temperament often cannot be recognized until the individual reaches the final stage of his training or until he comes up against the actual stress of combat.

Although these personality and temperament traits are of great importance, they are probably the most difficult of all traits to measure. As a consequence, valid techniques for appraising personality differences have not been developed to the point of efficiency reached in the development of techniques for the measurement of individual differences in mental, perceptual, and visual-motor abilities. Research on the development of personality tests has been emphasized, however. In particular, the research has been directed toward (1) measurement of performance on a task that is performed under conditions of stress, (2) measurement of physiological indices of emotion that accompany the performance of a difficult test, and (3) development of objective inventories of biographical information.

Much research is being concentrated upon the development of "stress" tests. In these tests an objective measurement of performance on some task is secured while the cadet is subjected to conditions of stress that are similar to, but not as severe as conditions encountered in actual flying. For example, one test presents a visual-motor pursuit problem, with progressively increasing complication, until it becomes so difficult that it is an impossible task. Another

stress test that is still in the developmental stage employs a looping chair that makes it possible to subject the individual to a sudden rotation (the cadet wears a safety belt). The reaction to the sudden movement may reveal evidence of a tendency to become confused and apprehensive when difficulties are encountered. Still another test requires the cadet to aim a pointer steadily at a target while he is subjected to various distractions. All of these tests are being developed actively and data regarding their correlation with training records and with instructors' ratings will be available during 1943.

As a result of the research that is now under way, it is believed that it will be possible to put into use in the near future tests of several specific personality and temperament traits. It is probable that more rapid progress will be made as soon as it is possible to study the specific personality and temperament characteristics of some of the pilots who have succeeded in combat and some who have been found to be unsuited for combat flying.

J. Other traits

The preceding list of traits or groups of traits is not regarded as the final list of all the traits that are characteristic of pilot success. Instead, it is possible that further research will reveal that additional traits are important in pilot success or that two or more of the traits that are now thought to be sufficiently independent to warrant separate consideration are so similar that they can be treated together. As research proceeds, the list may be modified.

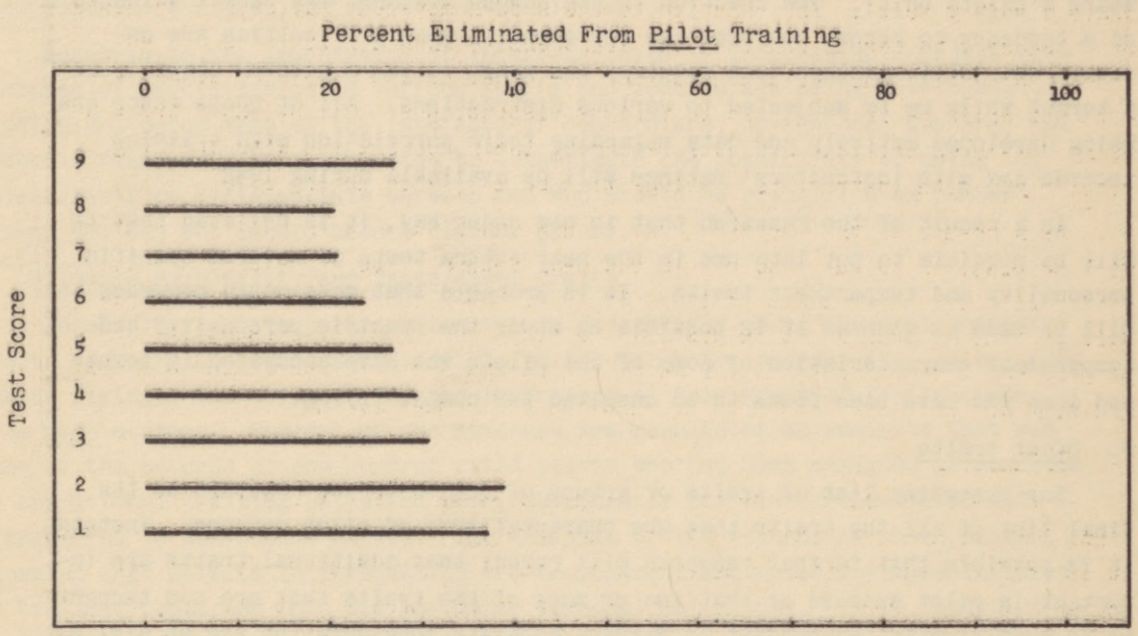
IV. Determining Pilot Aptitude on the Basis of Combined Test Results

The manpower problem, the program for developing selection tests, and traits of successful pilots have been considered. We come now to the problem of achieving the maximum results from the tests that are available.

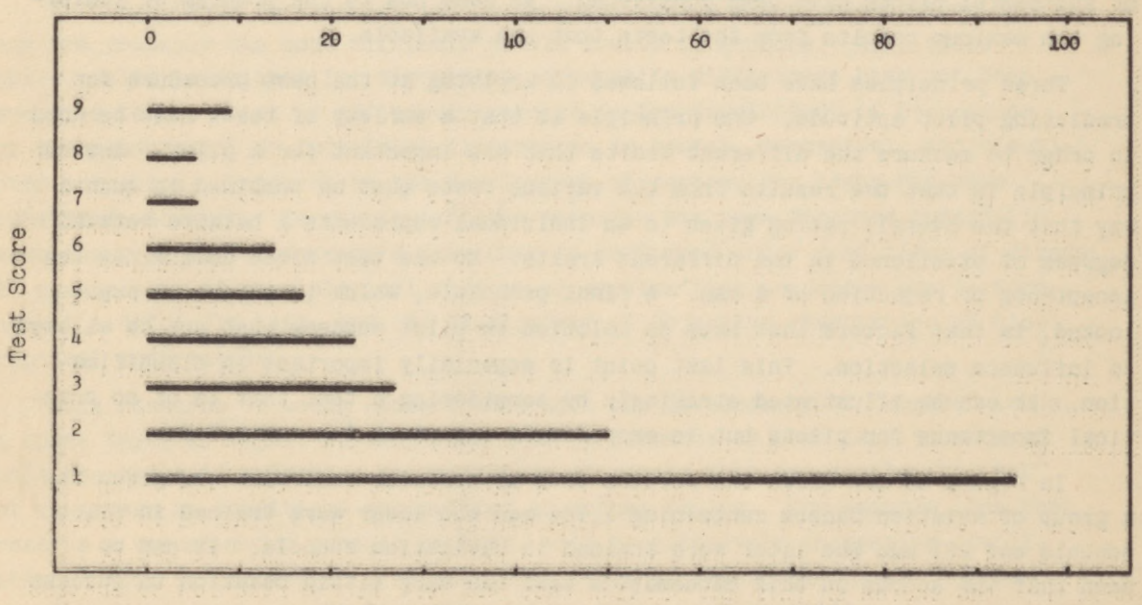
Three principles have been followed in arriving at the best procedure for predicting pilot aptitude. One principle is that a variety of tests must be used in order to measure the different traits that are important for a pilot. Another principle is that the results from the various tests must be combined in such a way that the overall rating given to an individual represents a balance between degrees of excellence in the different traits. No one test alone determines the acceptance or rejection of a man. A final principle, which is sometimes overlooked, is that factors that have no relation to pilot success must not be allowed to influence selection. This last point is especially important in classification. It can be illustrated strikingly by considering a test that is of no practical importance for pilots but is exceedingly important for navigators.

In Figure 13 are shown the results of a mathematics test that was given to a group of Aviation Cadets containing 1,134 men who later were trained in pilot schools and 221 men who later were trained in navigation schools. It can be seen that the scores on this mathematics test had very little relation to success

FIGURE 13: MATHEMATICS TEST



30-Item Mathematics Section, Test AC1OA
1,134 Aviation Cadets Biserial r = .13



30-Item Mathematics Section, Test AC1OA
221 Aviation Cadets Biserial r = .64

in pilot training, whereas they had a very striking relation to success in navigation training.

Verbal ability, as measured by vocabulary tests, is another trait that has been determined to be important for the navigator, but is of even less importance than mathematics for the pilot. In fact, in some groups which did not include individuals of the lowest verbal levels, vocabulary has been found to have a slight negative correlation with success as a pilot. Provided that they have the minimum verbal ability required for ground school subjects, it is probable that verbal ability should be disregarded entirely in selecting pilots.

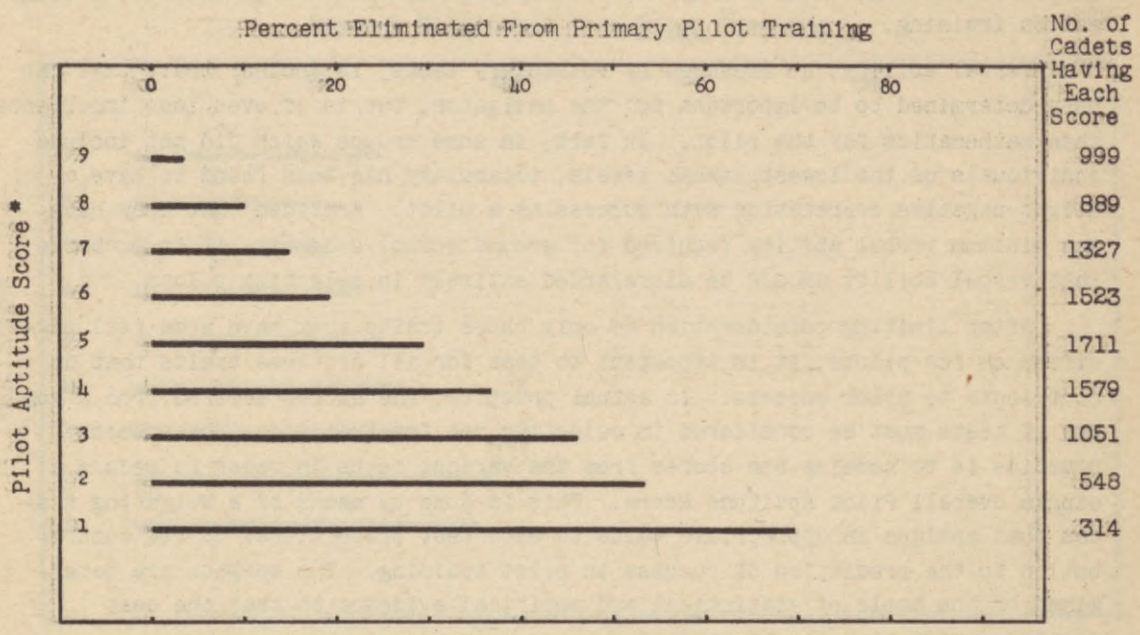
After limiting consideration to only those traits that have some real significance for pilots, it is important to test for all of these traits that do contribute to pilot success. In actual practice, the scores secured from a number of tests must be considered in selecting men for training. The present practice is to combine the scores from the various tests in order to secure a single overall Pilot Aptitude Score. This is done by means of a weighting system that assigns an appropriate value to each test proportional to its contribution to the prediction of success in pilot training. The weights are determined on the basis of statistical and empirical evidence so that the best possible prediction can be secured.

Excellent ability in one particular trait does not mean that an individual will be outstanding in other traits. It is true, however, that if a pilot is very good along one line, this may compensate in part for deficiencies along other lines. For example, a pilot with mediocre judgment might be able to keep out of trouble much of the time through excellent visual-motor coordination and flying skill. Or a cadet with good mechanical comprehension might be able to compensate in part for visual-motor coordination that is slightly below average. The weighting system used in determining the combined Pilot Aptitude Score takes this fact into account.

Preliminary evidence of the predictive value of the combined Pilot Aptitude Score, based on a variety of tests, is furnished by the results on Classes 43-D and 43-E for the Gulf Coast and West Coast Training Centers. The Aviation Cadets in these classes were tested during the latter part of the summer of 1942 at two Psychological Research Units. Approximately twenty different tests were administered, although some tests were used as measures of traits important only for Navigation or Bombardiering. Certain traits or groups of traits were measured by more than one test. Five of the nine traits and trait groups discussed in this report were covered by tests available at that time. Results on 9,941 men in these classes are shown in Figure 14. These results are complete for primary flying training only, and are for cadets eliminated for flying deficiencies, exclusive of eliminations for physical reasons.

It is clearly evident that the predictive accuracy of the Pilot Aptitude Scores is notably better than the scores on any single test that has been tried out. In these classes, approximately 1,000 men earned Pilot Aptitude Scores of 9.

FIGURE 14: RESULTS ON 9,941 CADETS IN CLASSES 43-D AND 43-E



Pilot Aptitude Score Based on Weighted Average of Tests in Use in Summer of 1942

9,941 Aviation Cadets *includes credit for previous flying training

Out of this group, only 37 men, or 3.7% failed to complete primary training because of flying deficiency. Only a small number (314 in all) of the men with a score of 1 were sent into training, but out of these men who were sent into pilot training in spite of low aptitude scores, 69% were eliminated for flying deficiency before they completed primary training. It is probable that many of the 31% who did finish this stage will have to be eliminated during basic and advanced training.

The results from the tests employed with these classes can be interpreted in several ways. If none of the 314 men with Pilot Aptitude Scores of 1 had been sent into training, the number of eliminees in this group would have been reduced by 8%, while the number of graduates would have been reduced by only 1%. If men with scores of 1 or 2 had not been sent into training, then the number of eliminees would have been reduced by 19%, and the number of graduates by 5%. It is true that some of the men with lowest aptitude were not sent into pilot training, because the tes' scores were actually used in classifying men for training. Had the tests not been available and had men been assigned without regard to pilot aptitude, it is probable that the elimination rate would have been considerably higher than it actually was.

As long as there are enough men in this country who have satisfactory aptitude for pilot training there are strong arguments for not sending men with poor aptitude into training. On the basis of the results shown in Figure 14, it can be predicted that it would have required 127 men with Pilot Aptitude Scores of 4 or above to provide 100 graduates of primary pilot training in West Coast schools. On the other hand, it would have required 209 men with scores of 1, 2, or 3, to provide 100 primary graduates. It is of course true that in order to secure enough men with aptitude scores of 4 or above it will be necessary to draw upon a somewhat larger pool than would be required if there were no selection.

There is good reason to believe that with the test battery in use at the beginning of 1943 the prediction of success in pilot training is even better than it was six months ago. Several improvements have been made in the test battery by application of some of the findings presented in this report and by the introduction of additional apparatus tests of visual-motor coordination.

V. The Future Selection Program

The outline of a practical, yet scientific, selection and classification program has been presented, and traits that should be considered in selecting pilots have been described. If this program is to function effectively as a part of the plan for building the best possible Air Force, the following conditions must be met:

A. It must be possible to sort out men from the largest possible pool. Good pilot material is scarce, and every man who is potentially a good pilot must have the opportunity to receive the right sort of training. First-rate pilot material must be used to build a first-class Air Force.

B. The use of the best scientific procedures for testing and classifying personnel must be continued and expanded. The research program, based on thorough job analyses and test development, must be carried forward and improved tests must be tried out and validated by rigorous techniques.

C. Tests must be employed to measure all of the traits known to be required of a good pilot, not just one or two of these traits. This requires the use of various types of tests administered under the direction of trained Aviation Psychologists.

D. The results of the tests must be interpreted according to scientific psychological procedures that are known to be valid, that are objective and standardized, and that will insure every applicant of equal consideration.

E. The program must be dynamic. Research must be encouraged and established research findings must be applied to refine the procedures now in use, thus constantly improving the results. Special support should be given to psychological studies in theaters of operation in order that the entire program will be geared to the changing tactics of air warfare for the purpose of producing an Air Force at the front that is greatly superior to that of our enemies.