total administrative cost should not exceed 1 per cent of the whole appropriation, namely, $1,000,000.

It is essential that the Council have power to recommend grants for construction of cancer facilities and for expenses of research over periods not to exceed 20 years. Expenditure of all grants by recipient institutions should be audited in accordance with the usual procedure of the U. S. Public Health Service. In selecting projects to be aided, the Council should have complete discretion. The expenditures outlined earlier are, of course, merely suggestions to indicate that $100,000,000 is needed for disbursement in the first 5 years. More will probably be required, and the administrative machinery outlined is intended to carry on for 20 years with the aid of subsequent appropriations establishing other lines of cancer research on an equally firm financial basis.

It would save time and avoid confusion and embarrassment if the Council were to take the initiative—that is, not merely to wait for the shower of high-pressure applications certain to be received if such a cancer bill is passed by Congress but, instead, actively to investigate needs and to invite and assist cancer research institutions considered worthy to formulate projects. No applications for financial aid not originally solicited by the Council should be accepted.

There is a chance that a bill along these lines would go down in history as marking a new era in human welfare in which all-out financial support is provided by government, not for war or for any commercial advantage, but to solve a definite problem in medicine. It is fitting that cancer should be the first disease so attacked. The public is of one mind in this matter. If the experts raise their sights and organize research with skill and wisdom on a large scale, and the policy is adopted of subsidy of long-term projects wherever it is most advantageous throughout the United States, the results will justify many times this expenditure, and the precedent will have been set for a similar approach to other devastating human diseases. Indeed, such a bill would signalize a new kind of emancipation—one of freeing the people from what is believed to be needless suffering and from untimely death.

Scientific Development of the Use of Human Resources:

Progress in the Army Air Forces

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THERE ARE FEW WHO WOULD QUESTION the fact that by far the most important of the resources available to us are human talents. It is also true that there are few areas in which so little progress has been made in the observation and classification of facts and the establishment of verifiable general laws as in the study of human resources and their utilization. This paper will attempt to show that a science can be developed regarding the use of human resources. Some of the recent findings resulting from the increased activity during the war years will be presented primarily to illustrate the types of research and experimentation which can be expected to be productive of results of practical significance.

The general field in which further research and experimentation is proposed includes the more accurate description of the individual in terms of his aptitudes, basic interests, temperament, and potentialities; the training and education of this individual with such methods and materials as to enable him to make maximum use of his personal endowment; his guidance into the types of vocational and avocational activities which will be of greatest assistance to him in his further development; and evaluation of his success in the activities in which he participates.

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In this field certain laws and principles were established by psychologists a number of years back. These relate especially to such matters as learning, forgetting, perception, and motivation. More recently, individual differences and trait differences and their implications for participation in various types of activities have been the subjects of extensive investigation. Scientific research on these matters requires very large groups of individuals, and some of the problems also necessitate waiting several years before final evaluation can be made. In most situations the extent of control of the individuals taking part in an experiment is also quite limited.

In many respects the military situation during wartime is ideal for this type of research. Large numbers are readily available. The life cycle from the time of individual analysis and classification, through training, and on to performing the job for which the individual was selected and trained is compressed into a period of only two or three years. Furthermore, the necessities of war give military authorities a much greater degree of control of the individual with public approval than would ordinarily be possible.

Having the resources of this large laboratory to work with, including the availability, for the staff, of a large

number of the best psychologists in the country, it has been possible to make important contributions to this branch of scientific knowledge in spite of the pressure to obtain immediately useful practical results in the military situation.

One of the most fundamental tests of the value of a body of knowledge including relationships is the ability to predict events on the basis of information already available. In working with human beings it is much more difficult to obtain full knowledge of all of the large number of relevant factors. In practical situations it is usually desirable to predict from a few relevant items

The higher the pilot stanine, the greater the chances of success in primary pilot training

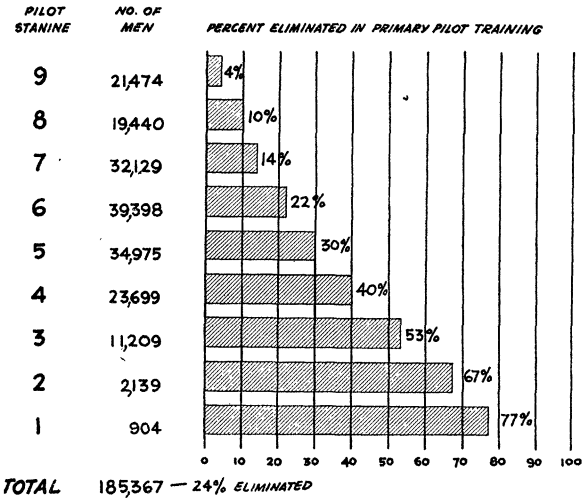

FIG. 1. The bars indicate the proportions eliminated at each pilot stanine. Elimination was for flying deficiency, fear, and own request. Flying experience credit is included in the stanine score. The data are from classes 43-F through 45-H. Men with low stanine scores are now disqualified for training; most of the men with low stanines included in the chart entered primary schools early in 1943.

known to represent an oversimplification and only partial coverage. Under these circumstances, the predictions must necessarily be in terms of probabilities which are far less than perfect. Such predictions, however, may be of very great value in certain practical situations.

The original research problem assigned to psychologists in the AAF for scientific investigation early in the period of the recent national emergency was to predict, on the basis of an evaluation of individuals before they begin flying training, which of them would later prove to be the most successful as airplane pilots. As the result of an initial analysis of the requirements of the job and a continuous program of research and follow-up, it was possible to assign weighted aptitude scores ranging from 1 to 9, for the designation of which the term *stanines* (standard nines) was coined. These were based on a battery of 6 apparatus tests of coordination and speed of decision and 14 printed tests including intellectual aptitudes and abilities, perception and visualization, and temperament and motivation. The weighted aptitude scores obtained from these tests were of great value in the selection and classification of applicants for pilot training throughout the recent war period.

Fig. 1 shows the experience during the war in the follow-up in primary pilot training schools of 185,000 men assigned these scores. It will be noted that of the more than 20,000 men obtaining the highest stanine (9) only 4 per cent were eliminated from training. Men obtaining lower stanines had progressively larger proportions eliminated, right on down to the group of about 1,000 men with the lowest stanine (1), 77 per cent of whom were eliminated in primary flying training.

Men with low pilot aptitude scores (stanines) on the AAF aircrew classification tests are very poor prospects for pilot training

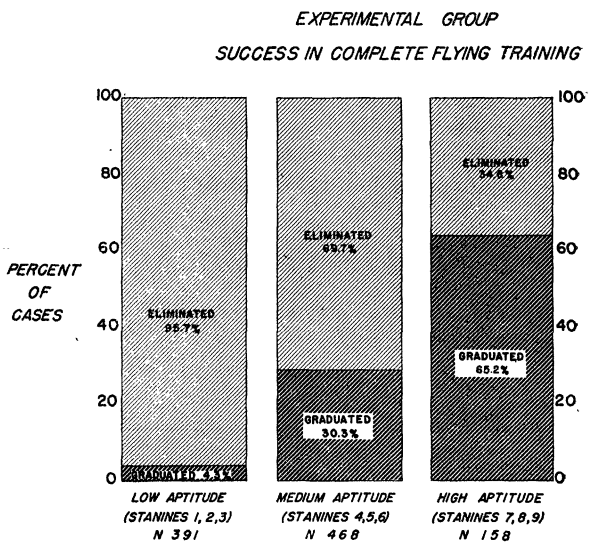

FIG. 2. Results for the experimental group.

Qualifying standards in terms of stanine scores were raised successively until, in the fall of 1944, only men with stanines of 7, 8, and 9 were admitted to pilot training. This improvement in the aptitude level of those sent into flying training made possible the raising of training standards and also resulted in the requirement of a higher degree of flying skill and general proficiency for graduation from flying schools.

In order to provide a comprehensive evaluation of the selection procedures under the new training conditions, an experiment was initiated in the summer of 1943. A sample of more than 1,000 men was selected by representative AAF Examining Boards throughout the country. All of the usual tests of aptitude, ability, temperament, and coordination were given to this group, but regardless of their scores on these tests, all those who met the physical standards of the medical examination were accepted and sent into pilot training. The scores for the various aptitude tests were combined according to current procedures, and the men were assigned the usual stanine scores for pilot aptitude. However, these records were sent directly to Headquarters of the AAF

Training Command, and no indication as to whether the man had obtained a high or low stanine was made available to the training schools.

The results of this experiment are shown in Fig. 2. Members of the experimental group were scattered in various schools and received their flying training in classes graduating in 1944 and 1945. Only 4 per cent of the men with low aptitude (stanine of 1, 2, or 3) were able to complete the full course of flying training. The remaining 96 per cent were eliminated at some stage of their training. Not one of the 125 men with the lowest aptitude score (1) was successful in flying training. Of

The pilot stanine was effective in predicting success in pilot training for West Point Cadets

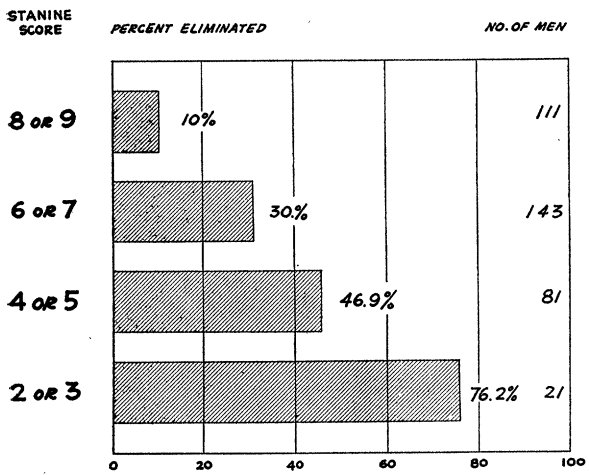

FIG. 3. Results for West Point Cadets.

the men with medium aptitude, 30 per cent were graduated. The men with stanines of 7, 8, and 9, which has been the qualifying standard since the fall of 1944, had a graduation rate of 65 per cent under the new standards in effect in flying training classes in 1944 and 1945. It is clear from these data that very important improvements in training efficiency resulted from the use of these objective selection procedures.

To check these findings with a group which had been carefully selected, but on other bases than pilot aptitude, an experimental study was made of the class of 1946 at the U. S. Military Academy at West Point. Here again, as shown in Fig. 3, the pilot stanine predicted success in flying training. Only 10 per cent of the 8's and 9's were eliminated, while almost half of the 4's and 5's and more than three-fourths of the small number of cadets whose scores placed them in the lowest group (those with 2's and 3's) were eliminated in primary flying training.

Follow-ups in regard to accident rates, success in transitioning to combat-type planes, and selection as airplane commanders rather than copilots confirm the predictive value of the pilot stanine. For example, 50 per cent more of the fighter pilots receiving combat training in the First Air Force with pilot stanines of 7, 8, and 9 scored in the top half of the class in hits on aerial and ground targets than did men with pilot stanines of 5 and below (see Fig. 4).

The initial emphasis in the psychological research program in the AAF was on pilot *selection*. However, this emphasis shifted rapidly in the practical situation to one of *classification*. Superior pilots are not of great value for bombing operations unless they are accompanied by superior navigators, bombardiers, flight engineers, radar observers, and gunners. Fortunately, it was found that the aptitudes and traits most important for each type of duty differ in various respects, so that by making an accurate analysis of each individual's potentialities in

High stanine pilots were likely to score more hits on aerial and ground targets

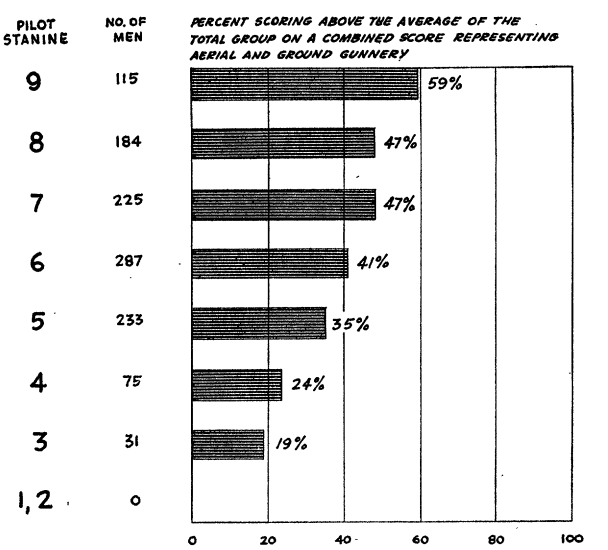

FIG. 4. Data collected from stations and commitments in the 1st Fighter Command between June 1944 and March 1945. Only newly rated pilots are included.

relation to the requirements of the various jobs, it is possible to improve the quality of the personnel available for all positions.

This is illustrated in Fig. 5, which shows the relation of the navigator aptitude score to success in navigation training for approximately 15,500 men. The men with navigator stanines of 8 and 9 were remarkably successful, with only 8 per cent and 3 per cent, respectively, failing to graduate. It is of great importance to the general problem of the use of human resources to note that most of these men had *pilot* stanines of only 6 and 7, and many of them were as low as 3, 4, and 5.

For bombardiers there was, in addition to the usual training school studies, an opportunity to follow up the actual combat results of these men in terms of the distance their bombs fell from the assigned enemy target. The radial or circular errors of 1,300 bombardiers were obtained from photographs taken at the moment of impact of the bombs and compared with the bombardier aptitude scores achieved by these men when they took the Aircrew Classification Tests prior to training, ap-

proximately two years earlier. These results are shown in Fig. 6. Although the differences are small, when it is remembered that combat conditions are far from standardized and many factors such as the skill of other members of the crew, weather conditions, the strength of enemy opposition, and the condition of the plane's equipment tend to attenuate the relations observed, the finding of a difference of 100 feet in the average accuracy of bombardiers with bombardier stanines of 7, 8, and 9, as contrasted with those with bombardier stanines of 5 and below, is of great practical significance. The group

The higher the navigator stanine, the greater the chance of success in advanced navigator training

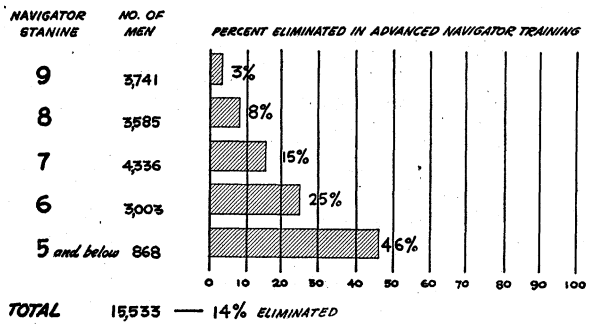

FIG. 5. The bars indicate the proportions eliminated at each navigator stanine. Elimination was for flying deficiency, fear, and own request. Only new aviation cadets are included. These data are from classes 43-12, 43-13, 43-14, 43-17, 43-18, and 44-1 through 45-13.

is also large enough so that this relationship cannot reasonably be regarded as due to chance.

The illustrations given above with regard to selection and classification indicate results achieved with respect to one aspect of the work of the Aviation Psychology Program. Similar results were achieved in the improvement of certain aspects of training and in the evaluation of success by applying the same scientific methods to problems in these areas.

In developing the battery of tests, the general procedure was to make a systematic survey and exploration of the requirements for success in the activity. This requires knowledge of basic psychological traits and professional insight and skill in translating the apparently critical requirements for success into testable hypotheses in the form of examining procedures. Experience in the AAF indicates that the most productive procedures for developing tests which will have predictive value involve the standardization of the test situation so that the individual knows exactly what his task is and how failure on specific parts of it will affect his score. It must be possible to make the task very nearly identical for all individuals. This means that, if apparatus tests are used, they must be accurately calibrated to insure comparability of difficulty. Although much ingenuity and judgment is required in setting up the sample of performance which is to constitute the test, the scoring should be as objective and free from the subjective judgment of the scorer as possible. The final result should be expressed in one or more simple numerical scores. Such scores are clearly abstractions and oversimplifications, but they represent data which can be evaluated.

Such tests representing hypotheses regarding the essential elements of a practical situation must be evaluated. The validity or predictive value in specific situations can be easily determined if a measure of success in the activity can be obtained. On the basis of such follow-up data the test can be revised, and the whole process of

Lead bombardiers with high bombardier stanine tend to have lower average circular errors

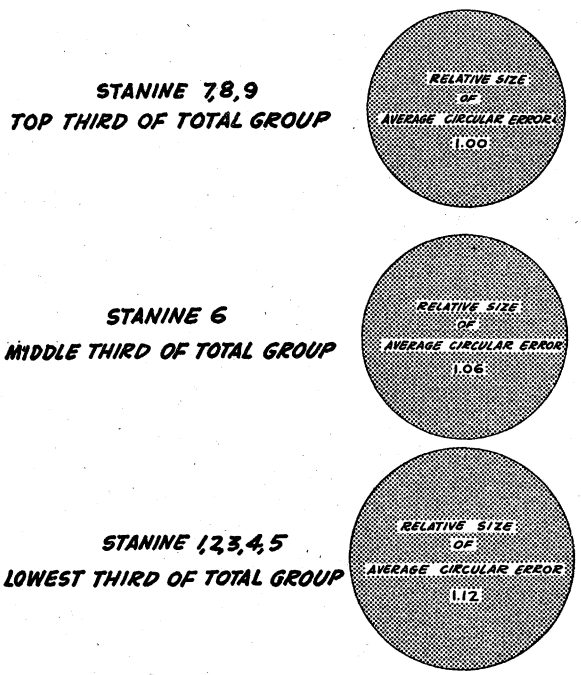

FIG. 6. These figures represent a composite of all of the data collected from the 8th and 15th Air Forces on the relation between circular bombing error and the bombardier stanine.

exploration, hypothesis, experiment, and evaluation repeated in the light of the new findings.

It is believed that the results of the past few years have demonstrated that the application of scientific methods to problems of human resources and their utilization can be of great practical value. Progress has been delayed in the development of this field of knowledge because of the need for large experimental groups, long periods of time, and substantial resources. However, the possible benefits are of great importance from the standpoint both of the general welfare and progress of the country and of the human values involved. It is therefore essential that strong support be given to a coordinated scientific research program on the use of human resources.