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PREDICTING SUCCESS IN TIME STUDY

A THESIS

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the Faculty of the Graduate Division

by

Hayne deYampert McCondichie

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PREDICTING SUCCESS IN TIME STUDY

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## ABSTRACT

### PREDICTING SUCCESS IN TIME STUDY

The inherent qualities that a man should possess in order to become a good time study man have been listed by almost every author in the Industrial Engineering field. An analysis of these lists reveals that the traits deemed necessary are not peculiar to success in time study work, but rather, that they are traits which would be essential to succeed in any field of endeavor. It is the purpose of this thesis to determine, in so far as possible, exactly what, if any, traits characterize the successful time study man, and to determine if success in this field can be predicted on the basis of certain aptitude tests which purport to measure these necessary traits.

Thirty-four practicing time study men were given aptitude tests, which purportedly measured their general intelligence, ability in structural visualization, personality, and degree of interest in certain types of activities. Two measures of job success were obtained for each man. His immediate supervisor was asked to rank him in overall performance and to grade him on each of seven factors listed on a rating sheet. It was then determined what degree of correlation existed between job success and those aptitudes listed above.

The results indicated that intelligence is the one trait most essential for success in time study work, and that ability in structural visualization is helpful. A high degree of interest in mechanical

activities may be indicative of success in this field. A lack of interest in the literary and musical fields was found to be one of the characteristics of the successful time study men. On the personality test the successful men tended to make scores which indicated co-operativeness.

The correlation coefficients between job success and aptitudes, although statistically significant, were relatively low. For this reason it was concluded that the aptitudes measured by the tests used in this study do not alone constitute a sound basis for predicting success in time study work. However, it is felt that the problem merits further investigation.

## CHAPTER I

### INTRODUCTION

#### Stop-Watch Time Study

The term stop-watch time study as used in this paper refers to the practice of setting a time standard by having a qualified individual go into the shop and actually time a job by means of a stop-watch. The term should connote the idea of a time study man observing an operation with clipboard and stop-watch in hand. In no way should this term be confused with the practice of arriving at the standard time by the synthesis of predetermined time values.

Throughout the remainder of this paper reference to time study men means those men who practice stop-watch time study.

#### Duties of a Time Study Man

A time study man in the course of his job of arriving at the standard time for a particular operation will perform the following duties.

Job Analysis.--The first duty of a time study man should be that of analyzing the job. This includes the application of the "questioning" attitude as to the necessity of and logical sequence of the individual sub-operations. Obvious violations of the principles of motion economy should be corrected, and any methods improvements which can be readily effected should be carried out. Once this has been done the corrected standard method will be prescribed and recorded. The time study man should have the movements which constitute the standard method well

fixed in his mind, since throughout the actual timing operation he will be required to make certain that the standard method is adhered to at all times.

Job Description.--Next a narrative description of the job is recorded.

This should tell briefly in simple language what steps the operator performs to complete the job.

Recording of Pertinent Data.--Here the time study man should make note of the operator's name, the time and location of the study, the names and types of jigs, fixtures, and equipment used, and any other miscellaneous information which is deemed pertinent. In addition, a sketch or diagram of the work place layout should always be included.

Elemental Break-down.--The job is then divided into elements which can be effectively timed. The good time study man will perform the break-down in such a manner that element beginning and end points are easily identified and thus readily timed.

Actual Timing.--After all of the above duties have been performed, the time study man is then ready to carry out the actual timing of the operation. This consists of observing and recording, by elements, the actual time taken to perform the job.

Rating.--Rating is that process by which the time study man compares pace or speed of movement of the operator being studied with a preconceived standard pace. A rating factor may be assigned to the operator's overall speed on the entire study, or on a cycle or elemental basis.

Normal Time.--The normal time is then arrived at by multiplying the mean or average time for any one element by the appropriate rating factor, which is an index of the operator's pace. The summation of the

individual normalized elemental times gives the normal time for performing the operation.

Determination of the Standard Time.--Allowances for the operator's personal time, fatigue, unavoidable delays, and factors of this nature are then determined. These are added together to form an allowance factor. The normal time plus the normal time multiplied by the allowance factor make up the final standard time.

#### Nature of the Work

The time study man is in an important but many times unenviable position. Time standards are in many cases used to compute wage incentive rates, which in turn determine the actual wages carried home by the worker. The effects that this factor has on the workers' attitude toward the time study man are far-reaching to say the least. In some cases the workers have developed, due to certain past malpractices of time study men, attitudes which are antagonistic and unfavorable to the atmosphere of mutual co-operation which should be present for the best results to be obtained in arriving at the standard time.

And all too often the time study man is caught between two forces - labor, which seeks "loose" standards; and management, which exerts pressure to create a situation favorable to higher production rates and lower unit labor cost. It is the role of the time study man to reconcile these two forces and educate the labor forces, showing how increased productivity benefits all concerned, while at the same time pointing out to management that a satisfied worker is a highly productive worker.

From the foregoing it is obvious that throughout the course of his work the time study man will be called upon to solve numerous

problems in human relations. In the actual mechanics of his job he is required to analyze, to observe, to exercise good judgment, and be competent in clerical work.

### Desirable Qualities in Time Study Men

Knowing the duties of a time study man and something about the nature of the job he must perform, the next most logical question to consider is what qualities are desirable in time study men?

Shumard (1) lists twenty-four inherent and acquired qualities which are necessary in the make-up of a successful time study man. These range from those essential for success in any walk of life, such as honesty and sense of fair-play, to salesmanship and leadership. Judgment, analytic ability, and observational powers are among the more important traits listed.

It is believed that the make-up of a good time study man is comprised of 80% -- 20%. The 80 per cent can be called contact. The other 20 per cent can be called education and common sense. A time study man might be equipped with the 20 per cent make-up and fail miserably. Despite his brilliance and common sense, he would not reach first base without contact.

The above paragraph indicates the importance Shumard places on the time study man's ability to get along with other people.

"A good time study man should have, primarily, an analytical mind, accuracy, initiative and optimism," state authors Lowery, Maynard, and Stegemerten (2). In addition they list personality, tact, patience, better-than-normal judgment, and self-confidence as being important factors.

Carroll (3) states that the type of mind required for a good time study man is not unlike that of the sales engineer. He must possess

"a pleasant personality, a desire to be helpful, tact, persistence, energy and a mechanical bent." Sound judgment is also emphasized.

#### Some Qualities Actually Found in Time Study Men

In 1941 the Northern New Jersey Chapter of the Society for the Advancement of Management appointed a committee, headed by R. D. Mansfield, to work on The Development of Aids in the Selection of Time Study Men.

The Committee gave various tests to small groups of industrial engineers actually employed in time study work. The findings of this committee are reported in a series of articles by Phil Carroll (4,5) in Modern Management, 1946. Traits tested were divided into three main categories:

(1) human relations; (2) aptitudes; and (3) interests. A further breakdown of these traits, results of tests given, and other pertinent information is given below.

#### Human Relations

##### Personality

Test Used: Guilford-Martin Personnel Inventory I

Personality was measured in terms of these three traits:

Objectivity -- as opposed to personal reference or a tendency to take things personally.

Agreeableness -- as opposed to beligerence or a dominating disposition and an overreadiness to fight over trifles.

Co-operativeness -- as opposed to fault finding or



Over-criticalness of people and things.

Trait:	Sample Size:	Time Study Man's Score:
Objectivity	Small	Mean score corresponding to the 75th percentile
Agreeableness	Small	Mean score corresponding to the 58th percentile
Co-operativeness	Small	Mean score corresponding to the 73rd percentile

### Aptitudes

#### General Intelligence

Test Used: Otis Employment Test Form 2A. Intelligence is divided into these elements: Number(arithmetic), Verbal Meaning(vocabulary), Space(structural), Word Fluency, Reasoning, and Memory.

Based on a sample of size forty, results showed that the industrial engineer's mean score corresponded to the 90 percentile and an IQ of 121.

#### Structural Visualization

Test Used: Minnesota Paper Form Board Test

Based on a sample of size fifty, results showed that the industrial engineer's mean score corresponded to the 93rd percentile of all male adults and the 45th percentile of freshmen engineering school students.

### Arithmetic Reasoning

Test Used: Problems devised by B. V. Moore of Pennsylvania State College.

Based on a small sample size, results showed that the industrial engineer's mean score corresponded to the 87th percentile of the all adult population and the 81st percentile of high school graduates.

### Mechanical Comprehension

Test Used: Bennett AA Mechanical Comprehension

Based on a sample of size sixty, results showed that the industrial engineer's mean score corresponded to the 65th percentile of candidates for technical courses, the 20th percentile for engineering positions, and the 45th percentile for engineering school freshmen.

### Interests

Test Used: Kuder Preference Test (technically called Kuder Preference Record)

Measured the following interests with percentile scores<sup>1</sup> as indicated:

Persuasive -- 78th  
 Mechanical -- 75th  
 Social Service -- 73rd  
 Computational -- 60th  
 Musical -- 50th

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<sup>1</sup>A mean score corresponding to the 75th percentile or above is considered indicative.

Literary interest -- 50th

Scientific -- 45th

Artistic -- 37th

Clerical -- 35th

### Selection of Time Study Men

It takes all kinds of people to make the world and it would seem that we have representatives of all types in timestudy work. This may be so for a number of reasons, but probably two are important in this discussion. To begin with, many of us do not fully understand the requirements for success in the work. This lack of understanding would account for some portion of those in time study who were incorrectly selected. These men may be working diligently, but without success because they are doing the wrong things. The fault lies with the men or their managements for not taking the trouble to find out what the job requires.

Secondly, too many men get into time study work accidentally like they do in most other fields of endeavor....

It is because of this large proportion of misplacements that testing and selection are so important. It is such a waste of manpower to have people working at jobs they don't like. More particularly in time study, the wrong types of men can and do play havoc with one of our most fundamental and highly important economic factors - wage incentive.

In these paragraphs Carroll (4) forcefully sums up the state of affairs as they now exist, while indicating that testing and selection techniques are the answer to the problem. And it may well be that testing and selecting are the answer - but at this date it is not known what qualities are essential to success in time study work, and therefore it is not known what to test for or how to select. True, it has been generally stated in rather broad terms what traits are essential for time study success; but a careful analysis reveals that these traits are essential to success in almost any field. What part does general intelligence play in the success of a time study man? What significance does

proficiency in structural visualization have? What type of personality makes for success in time study work? Does the successful man in this field possess a large degree of mechanical interest? Is he characterized by his objectivity in dealing with problems? Can we identify job success with any of these traits - or do they have no bearing on the problem at all?

#### Purpose of The Research

Briefly, it is the purpose of this research to determine in so far as possible what inherent qualities make for success in time study. If the questions brought forward in the previous section can be answered satisfactorily, a major portion of the problem of selecting men for time study will have been solved. For once those qualities essential to success are known, there remains only to develop adequate means for measuring these qualities, and it is entirely possible that a battery of currently existing psychological tests can be adapted for these purposes.

One goal of the industrial engineering profession and studies such as this should be the design of a battery of tests the results of which would indicate a man's suitability for and chances of success in time study work. It should be emphasized that the results of this particular research can in itself give no sound basis for the design of the test battery, but it is hoped that it will contribute to that end.

## CHAPTER II

### PROCEDURE

#### Job Success and Inherent Qualities

In attempting to correlate job success with the time study man's inherent qualities, obviously, the first tools needed are some means of measuring each.

#### Job Success

In this study two measures of job success were used. One was a man's rank within his own group as to overall performance and the other was the total number of points he received on a rating sheet, which was intended to be a measure of success in terms of seven key factors. In both cases the man's ability was judged by his immediate supervisor.

Ranking.--The time study man's immediate supervisor was asked to rank each man from best to worst with regard to overall performance on the job. The supervisor was urged to differentiate between the men, if at all possible, and thus avoid having two or more men ranked at the same level.

Rating.--The supervisor was also asked to rate each man according to these factors: quality of work, quantity of work, personal contact, rating ability, judgment, observational power, and analytical ability. Each factor was divided into five degrees by writing five descriptive phrases, each denoting some state of proficiency for that particular factor.

The arrangement of descriptive phrases under each factor followed

no set pattern. That is, the phrase denoting the highest proficiency was not always at the extreme right with the phrase denoting the lowest proficiency at the extreme left with others graduated between these two extremes, but rather the phrases were arranged in a random fashion. This was done to eliminate in so far as possible the "halo" effect.

One point was arbitrarily assigned to the lowest degree for each factor and five points to the highest degree. Thus the maximum number of points any one man could receive would be five points for each of the seven factors, or a total of thirty-five points.

### Inherent Qualities

It was decided to attempt to obtain some measure of the time study man's personality, general intelligence, interests, and spatial visualization ability. The four tests chosen for this purpose were the Guilford-Martin Personnel Inventory, the Wonderlic Personnel Test, the Kuder Preference Test, and the Minnesota Paper Form Board Test. These tests were recommended by Dr. Joseph Moore, head of the Department of Psychology at Georgia Tech, and are reported to possess a high degree of reliability. Even so, it would have been desirable to have given other tests in addition to these. Unfortunately the time element would not permit it. This battery of four tests takes approximately two hours to administer.

Guilford-Martin Personnel Inventory I.--This is a 150-question test which purports to measure personality in terms of objectivity, agreeableness, and co-operativeness. This is the exact same test that was used by the Society for the Advancement of Management Committee in their study, which was briefly described in Chapter I. There is no time limit on this test but most people complete it in about thirty minutes.

Wonderlic Personnel Test, Form A.--This test has a time limit of twelve minutes and consists of fifty questions of problem-solving ability. The results is a measure of general intelligence. Very rarely does an individual complete the test.

Kuder Preference Test, Form BM.--Interests are measured and divided into nine categories: mechanical, computational, persuasive, social service, musical, literary, artistic, scientific, and clerical. This is a non-time limit test and consists of 170 questions, each of which contains three types of activities. Those being tested are asked to select the activity they would most like to do and the one they would least like to do, leaving the intermediate choice blank. Forty-five minutes is considered the average time required to complete this test.

Minnesota Paper Form Board Test, Series MB.--In sixty-four questions this test purports to measure structural visualization. Occasionally some individuals finish before the twenty-minute time limit expires.

#### Obtaining the Samples

Samples in this case, naturally, refer to time study men. A conservative estimate of the number of men who practice time study work in the Atlanta area would be one hundred and fifty. It was hoped that fifty of this group could be persuaded to participate in this research project. Actually only thirty-four men were tested. The reasons for this are numerous. Many men considered the time required to take the test (two hours) objectionable; not a small number were employed in industries which were working overtime and they were too busy to take the tests on the job and too tired to be interested in an after-hours basis; in numerous cases company policy did not permit the release of employee ratings or rankings

no matter what security was offered; in some companies the supervisors just did not care to co-operate; and in others the time study men themselves were cold to the proposition, possibly due to fear that the results would find their way back into the hands of the supervisors, who would in turn use them as a basis for dismissal. These are some of the reasons why the sample size is small; they are listed not as an excuse but rather as an explanation.

How the data were obtained, the conditions under which they were obtained, and other information pertinent to the testing is listed below.

#### Contacting

Initial Contact.--The initial contact was in all cases with the supervisors by telephone, at which time the program was broadly outlined. If he appeared interested and likely to co-operate a second meeting was arranged at his office.

Secondary Contact.--At the second meeting the program was outlined in detail. The supervisor was told exactly what was hoped to be accomplished by the research. At this time it was emphasized that the time study men would be assigned numbers so that no personalities would be involved and that only he, the supervisor, would ever have knowledge of the name-number key. It was further emphasized that the name of his or any other company would not be mentioned in the writeup, and that no comparisons would be made of companies, as such. It was felt that the time study men, the supervisors, and the companies should be given all the security possible, and certainly this would in no way hamper or affect the outcome of the research.



Approaching the Time Study Men.--In thirty-two out of thirty-four cases participation was voluntary with no pressure whatsoever being exerted by the supervisor. The time study men were told that the research was for purposes of learning some characteristics of time study men. They were not told that they were to be rated or ranked. They were familiarized with the security system and told that their test scores in percentiles would be sent to them under sealed envelope in care of the company according to the number assigned to them by their supervisor.

If the men were receptive to the idea of being tested a suitable place, date, and time were then agreed upon.

Testing Location.--In some cases the men were allowed to take the tests during working hours on company property while in other cases the tests were given on the men's own time at some convenient location.

Sample numbers one through four, thirty-two through thirty-six, and forty through forty-one were given the tests during work hours on the company's premises. Sample numbers thirty-seven through thirty-nine were given the tests during off hours in the annex of a church adjacent to the company's plant. All the others were tested on the men's personal time in the A. French Building at Georgia Tech.

An Explanation.--It will be noted that thirty-four samples were taken yet the sample numbers range from one to forty-one. This is due to the fact that some of the men who were assigned numbers were never able to take the tests.

Administration.--In the actual administration of the tests the directions were carried out to the letter; thus all the men were told exactly the same thing. The tests were, in all cases, given in this order:

(1) Guilford-Martin Personnel Inventory; (2) Wonderlic Personnel Test; (3) Kuder Preference, and (4) Minnesota Paper Form Board. The men, if they so desired, were permitted a short break between tests, and they were allowed to smoke at any time. The administrator was careful not to notice the results of any tests while those being tested were present and tried to maintain an impersonal attitude at all times.

Timing.--The timing, where necessary, was done by means of a decimal-minute stop watch.

Scoring.--The scoring of the wonderlic Personnel Test, and the Guilford-Martin Personnel Inventory test was done by hand. The other two were scored by machine.

Division of the Group.--Time study men from six different organizations make up the total group of thirty-four. Partly because there is no way to integrate individual sub-group rankings and partly for convenience of analysis the group was split into six sub-groups, numbered one through six, according to companies. The largest group consists of sixteen men and the smallest of two men. So that the companies may remain anonymous they are not listed in this report.

Type of Work.--All of the men tested are actively engaged in time study work. Most of them do other types of industrial engineering work also, but they are primarily employed to set time standards.

#### Methods of Analysis

The data are such that they lend themselves to many and varied types of statistical analysis. Doubtless there are available almost a countless number of mathematical manipulations which can be applied to

these sets of data. However, there is no particular merit in carrying out these manipulations except in those cases where they will prove the means to a worth-while end.

The techniques employed were those that were deemed to be the most fruitful for the purposes of this research. These are listed below.

### The Average

As a matter of general interest and as a basis of comparison of this group with other groups the arithmetic mean score of all thirty-four samples for each test was calculated. These raw scores were then converted to a percentile score.

### Simple Correlation

Simple linear correlation, treating the six sub-groups as one single sample, was run between raw test scores and total number of points received on the rating sheet.

Significance Tests.--After the coefficients of correlation were computed, they were tested to see if they were significant from zero at various levels of confidence.

Scatter Diagrams.--Scatter diagrams were plotted for each pair of coordinates and in those cases where the correlation coefficients were significant at a high level of confidence a straight line was fitted to the data by the means of least squares.

### Rank-Correlation

There is no sound method to integrate the rankings of the individual sub-groups, but each sub-group can be treated as a separate sample. A rank-correlation between test rank and overall job performance rank

was calculated for the sub-groups of size four or above. For groups smaller than size four the rank-correlation coefficient is for all practical purposes meaningless.

Significance Tests.--Each rank-correlation coefficient was then subjected to a significance test, the hypothesis being that the coefficient of correlation equals zero. It was then determined at what level of confidence this hypothesis could be rejected.

#### Difference Between Mean Scores

The time study men were ranked from one through thirty-four, according to the total number of points received on the rating sheet. Those men who formed the bottom 12 ranks and those men who formed the top 12 ranks were selected for this analysis.<sup>2</sup>

The mean test score of those men who constituted the bottom 12 ranks was compared with the mean test score of those men who constituted the top 12 ranks for those traits which showed significant correlation with the total number of points received on the rating sheet.

The null hypothesis, which assumes that these two sample mean scores were drawn from populations having identical means, was stated. It was then determined at what level of confidence this hypothesis could be rejected. A rejection of the hypothesis constituted proof that the two mean scores were significantly different.

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<sup>2</sup>The original intention was to divide the group into two sections of 17 men each, but a tie of seven men (each received 26 points) for ranks 13 through 19 prevented this.

### CHAPTER III

#### RESULTS

##### Tests

A complete list of individual test results by raw and percentile scores has been included in the Appendix, Tables 4 through 17.

##### Mean Scores

Mean(arithmetic) scores for the various tests and the equivalent percentile scores are listed in Table 1, which is included in this chapter. In addition the lowest and the highest test scores obtained, with their corresponding percentile scores, have been tabulated.

The following facts, plus some pertinent comments, summarize the results found in Table 1.

General Intelligence (As measured by the Wonderlic Test).--The mean intelligence score for the group was 31.2 correct answers out of a possible 50. This score corresponds to a percentile score of 76.1. On the surface this score may appear rather low; however, in fairness to this group it should be pointed out that a mean score eight-tenths of a point higher would have placed them in the next percentile bracket, which is 85.6.

Structural Visualization (As measured by the Minnesota Paper Form Board Test).--The range of scores on this test was particularly large. They varied from the first percentile to the 95th percentile. The mean score on this test was 47.3. This score places the group in about the 43rd

percentile bracket, which is extremely low.

Personality (As measured by the Guilford-Martin Personnel Inventory).--

Mean scores obtained for objectivity, agreeableness, and co-operativeness were equivalent to percentile scores of 89, 77, and 89, respectively. These scores would seem to indicate that the group ranked relatively high on three personality traits.

Interests (As measured by the Kuder Preference Test).--Percentile scores indicate that the group was most interested in activities of a mechanical, computational, or scientific nature. The group was least interested in activities of a clerical, social service, or persuasive nature.

Comparison with Results of the Society for the Advancement of Management

Study.--A comparison of the percentile scores of this group with the percentile scores of those tested by The Society for the Advancement of Management (see Chapter 1, pp. 5, 6, 7, 8) reveals that: (1) this group ranked slightly lower in general intelligence<sup>3</sup>; (2) in structural visualization the S.A.M. group and this group's abilities were approximately the same; (3) this group ranked considerably higher than the S.A.M. group did in objectivity, agreeableness, and co-operativeness; and (4) the S.A.M. group showed the highest interest in activities of a persuasive, mechanical, or social service nature, while this group was most interested in activities of a mechanical, computational, or scientific nature; under the heading of least interested, the S.A.M. group lists clerical, artistic, and scientific activities, while this group lists clerical, social service, and persuasive activities.

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<sup>3</sup>It should be noted that these two groups did not use the same intelligence test.

### Results of Measures of Job Success

The total number of points received on the rating sheet, plus the number of points received for any one factor, and his ranking within his own group is listed for each time study man in Tables 18 and 19, in the Appendix.

Rank.--Analysis of the table reveals that there were only two instances where the time study men were ranked at the same level in overall performance. This occurred in sub-group three, where two men were ranked 14th, and in sub-group four, where three men were tied for the second, third, and fourth positions.

Rating Sheet.--The minimum total number of points received any individual was  $12.8^4$  and the maximum number received was 34. The arithmetic mean score was 26.3, the median score was 26.0, and a total of 26.0 points was awarded to seven different men, making 26.0 points also the mode score. Five men received a score of 29 points, and an analysis of all the scores shows that 24 out of 34 men received a total score which was between 24 and 30 points. It should be noted that this is a range of only seven points. All these facts would seem to indicate that the rating sheet did not provide adequate discrimination between the time study men. However, some justification for this variability can be established by the fact that all of these men are acceptable to management, as evidenced by the fact that they retain their jobs.

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<sup>4</sup>In five instances the time study man's rating ability was not known, and thus his total score was based on only six factors, whereas all the others were based on seven factors. To compensate for this, these men's scores were multiplied by a factor of seven-sixths. This accounts for the fact that five of the scores are expressed as decimals.

The man who was ranked first in overall performance in sub-group one, received 26 points on the rating sheet; in sub-group two the man who was ranked first received 31.5 points; in sub-group three he received 33 points, in sub-group four he received 34 points; in sub-group five he received 29 points; and in sub-group six he received 25 points. These data suggest that each of the supervisors, when filling out the rating sheet had a different concept of what constituted average proficiency in terms of the seven factors listed on the rating sheet.

### Results of Analyses

#### Linear Correlation

Correlation and Significance.--The correlation coefficients obtained from the individual raw test scores and total points received on the rating sheet are listed in Table 20, in the Appendix. In Table 2, in this chapter, there is listed by traits, the coefficients which were comparatively high, and also the level of confidence<sup>5</sup> at which any particular coefficient could be proved significant from zero.

Scatter Diagrams.--In those cases where the correlation coefficient was small, the scatter diagrams have been placed in the Appendix. (See Figures 9 through 14) Where the correlation coefficient was proved to be significant at a reasonably high level of confidence, straight lines were fitted to the points and these figures are included in this chapter. (See Figures 1 through 8)

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<sup>5</sup>A confidence level of 95% would indicate that only five times out of a hundred would the particular coefficient being tested be that high due to chance.



### Rank Correlation

The complete results of the correlation coefficients obtained between individual test ranks and job performance rank are listed by sub-groups in Table 22, in the Appendix. In Table 3, in this chapter, are listed by traits, those coefficients which could be proved significant at, or above, the 80 per cent level of confidence.

### Difference Between Mean Scores

Eight pairs of mean scores for eight traits were tested to determine if there were a significant difference between the mean score of those men who were ranked in the bottom 12 and those men who were ranked in the top 12. The traits tested were: intelligence, structural visualization, co-operativeness, mechanical interest, scientific interest, artistic interest, literary interest, and musical interest. The complete results of these tests are tabulated in the Appendix, Table 24.

The difference between the mean scores proved significant in only one instance. In intelligence those men who were ranked in the top 12 had a mean score of 34.33, while those who were ranked in the bottom 12 had a mean score of 26.67. This difference proved significant at the 99.5 per cent level of confidence. No other difference in mean scores could be proved significant even at the 80 per cent level of confidence.

## Discussion of Results of Analyses

### Linear Correlation and the Differences in Mean Scores

The linear correlation coefficient obtained between intelligence test scores and total points on the rating sheet, of .240, would on the basis of a superficial analysis indicate that intelligence and job per-

formance are not closely related. However, it should be remembered that there was a significant difference between the mean score of those men who were ranked in the top twelve of the group and the mean score of those men who were ranked in the bottom 12 of the group. This fact is important, especially in view of the extremely high level of confidence (99.5%) at which this difference was established.

Other noteworthy facts about the intelligence test results and job success are, that, in three out of six sub-groups those men who were ranked first in overall performance within their group also received the highest test score for intelligence within their group. In two cases, those who were ranked first received the second-highest test score for their group, and in only one instance did the man who was ranked first in overall performance, do any worse than second in intelligence. Conversely, those who were ranked last in overall performance within their sub-group, made the lowest intelligence test score for their group in four out of six cases.

These facts suggest that, for this group, general intelligence and job success are closely related.

Ability in structural visualization, a co-operative personality, and an interest in mechanical activities are apparently related positively to job success. It seems that a negative relationship exists between both literary and musical interest, and job success. The correlation coefficients obtained for these five traits were all relatively high, and all were proved to be significant at, or above, the 90 per cent level of confidence.

### Rank-Correlation

Sub-Group Three.--This group, composed of 16 men, is by far the largest of the six sub-groups. The rank-correlation coefficients for this group were low. The highest coefficient obtained, .354, was between job rank and artistic interest. This coefficient was significant between the 80th and the 90th per cent level of confidence. No other coefficients were significant.

A possible explanation of the low coefficients obtained for this group may be found in the consideration of these facts: (1) these men came from a particularly large organization, where close, continual contact with the supervisor is not possible; and (2) this organization has just recently started production and none of the time study men have been working there for more than two years, while not a small number have been with the company for a period of only six months, or less. In view of these facts it is very likely that the supervisor of this group was not able to rank properly these time study men as far as overall performance is concerned.

Other Sub-Groups.--For sub-groups one, two, and four, which consisted of four, four, and five men, respectively, rank-correlation coefficients as high as 1.00 were obtained in two instances, and other coefficients, only slightly lower than these were obtained on eight occasions. Many of the coefficients proved significant at a high level of confidence.

Ordinarily, due to the extremely small size of the sub-groups, a high correlation coefficient obtained under these circumstances would probably be attributed to chance. However, reasonably high coefficients were obtained in 15 instances, and all were significantly different from

zero at the 80 per cent, or above, level of confidence.

These sub-groups are composed of men from companies with relatively small time study departments. The men, no doubt, are in constant and close contact with their respective supervisors. The supervisors should, under these conditions, be able to evaluate their men properly. It is therefore felt that the rank-correlation coefficients obtained from these three sub-groups are of some importance, and cannot logically be discounted merely because the sample size were small.

Table 1. Mean Scores and Range of Scores  
For All Tests and All Samples

Test	Raw Scores			Equivalent Percentile		
	Low	Mean	High	Low	Mean	High
Wonderlic Personnel (Intelligence)	14	31.2	46	13.8	76.1	99.7
Minnesota Paper Form Board (Structural Visualization)	24	47.3	58	1	43.5	95
Guilford-Martin Personnel Inventory (Personality)						
Objectivity	29	55.4	70	23	89	99
Agreeableness	20	38.2	57	11	77	99.9
Co-operativeness	58	78.4	97	60	89	99.9
Kuder Preference (Interests)						
Mechanical	64	93.4	117	26	71	99
Computational	19	42.8	67	5	77	99.9
Scientific	45	73.0	94	11	71	98
Persuasive	38	62.7	100	3	32	87
Artistic	24	47.4	76	3	58	97
Literary	29	45.5	78	8	48	96
Musical	2	16.7	34	1.5	59	93
Social Service	28	67.5	108	.51	37	98
Clerical	23	45.0	76	.8	30	95

Table 2. Significant Linear Correlation Coefficients

Total Rating Sheet Points and:	Correlation Coefficient	Confidence Level at which coefficient is significant from zero
Intelligence	.240	83%
Structural Visualization	.334	94%
Co-operativeness	.375	97%
Mechanical	.372	96%
Scientific	.239	83%
Artistic	.243	83%
Literary	-.411	98%
Musical	-.300	91%

Table 3. Significant Rank-Correlation Coefficients

Job Rank and Test Score Rank in:	Sub-Group Number	Correlation Coefficient	Confidence Level at which coefficient is significant from zero
Intelligence	1	1.00	96%
	2	0.80	83%
Structural Visualization	1	1.00	96%
	4	0.70	83%
Objectivity	4	0.70	73%
Agreeableness	2	-0.80	83%
	4	0.90	96%
Co-operativeness	1	-0.80	83%
	4	0.70	88%
Mechanical Interest	2	0.80	83%
Scientific Interest	1	-0.60	79%
Persuasive Interest	2	0.80	83%
Artistic Interest	3	0.35	80-90%
	4	0.90	96%
Literary Interest	1	-0.80	83%
Social Service Interest	1	0.60	79%
	2	-0.60	79%
Clerical Interest	2	0.95	96%

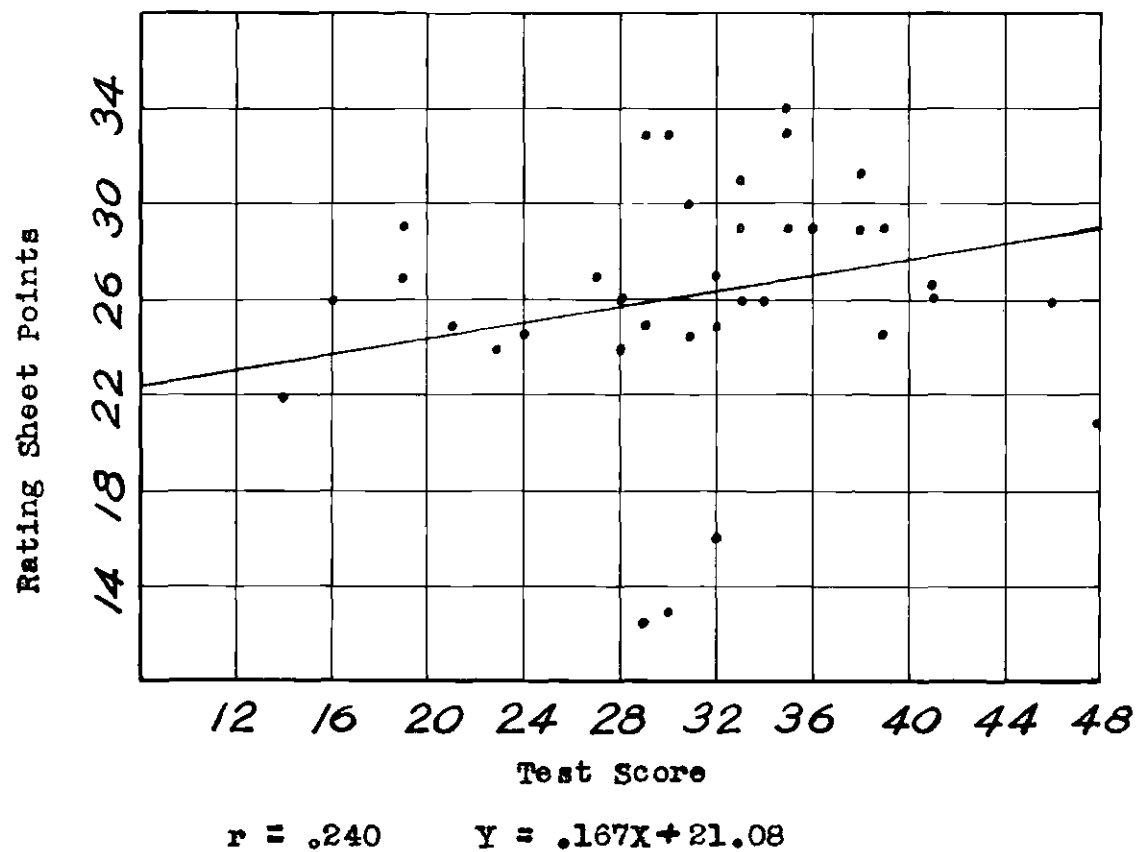


Figure 1. Scatter Diagram, Linear Correlation -- Intelligence



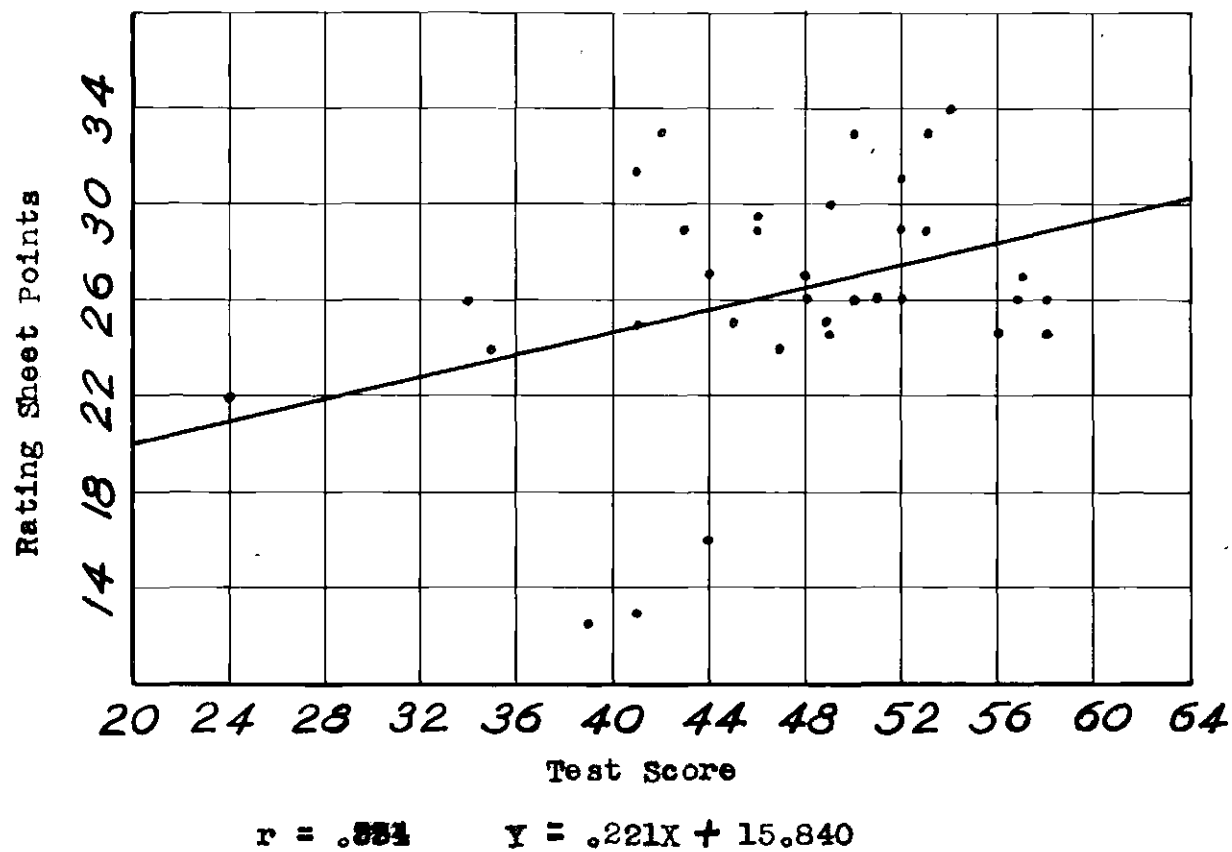


Figure 2. Scatter Diagram, Linear Correlation -- Structural Visualization

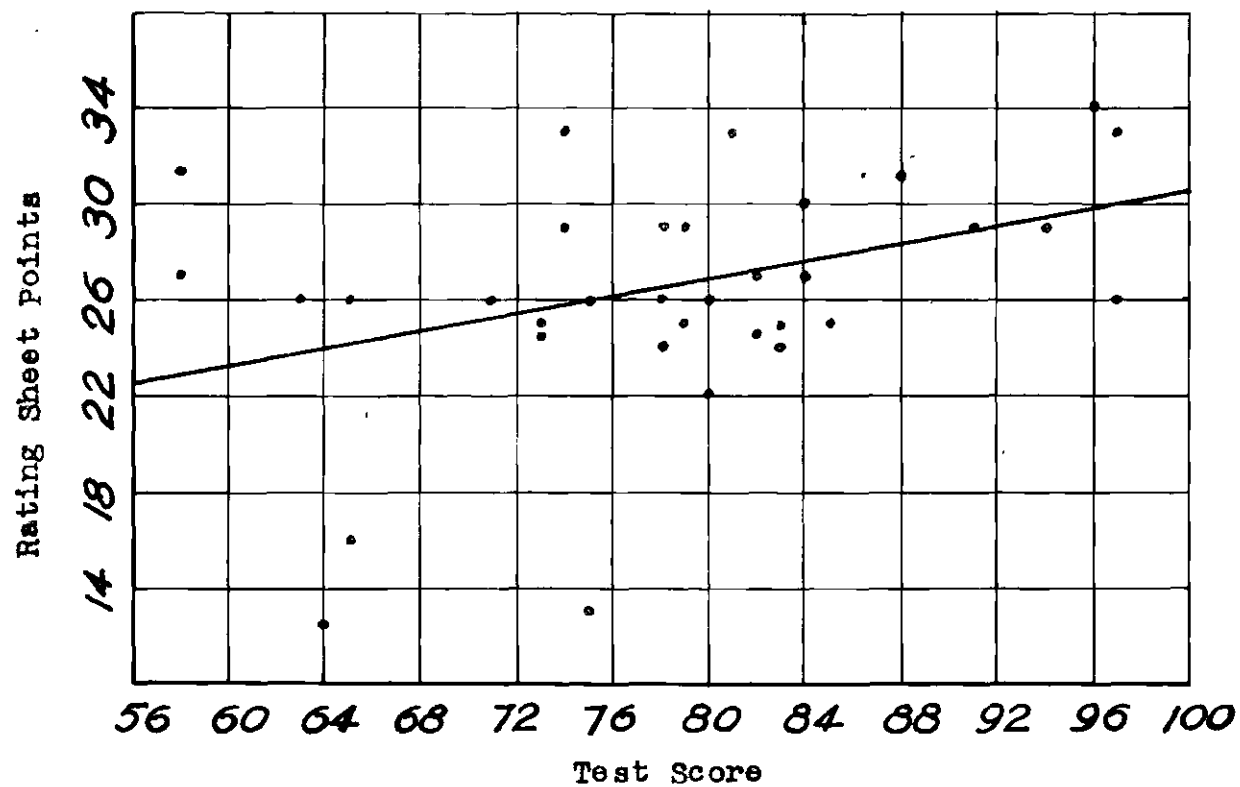


Figure 3. Scatter Diagram, Linear Correlation -- Co-operativeness

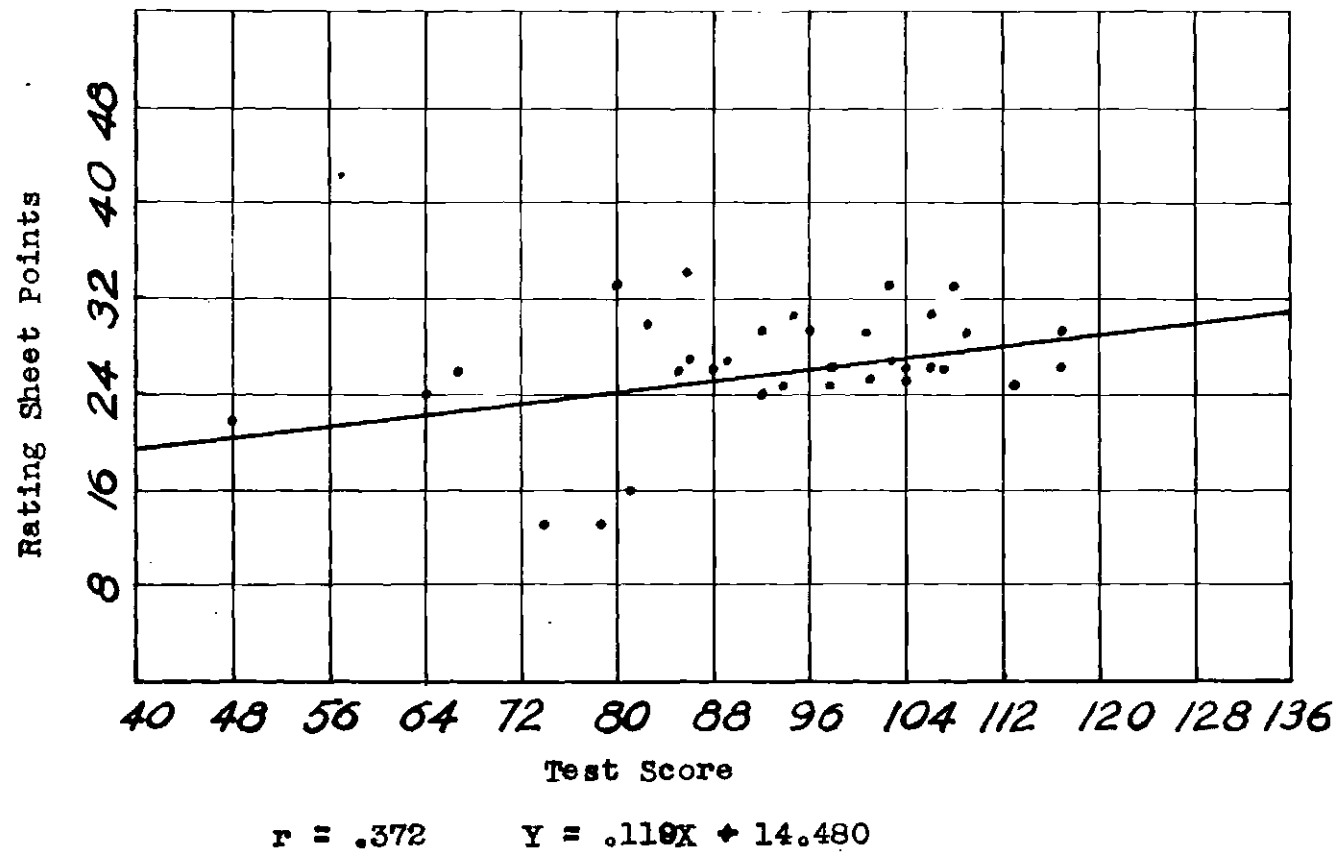


Figure 4. Scatter Diagram, Linear Correlation -- Mechanical Interest

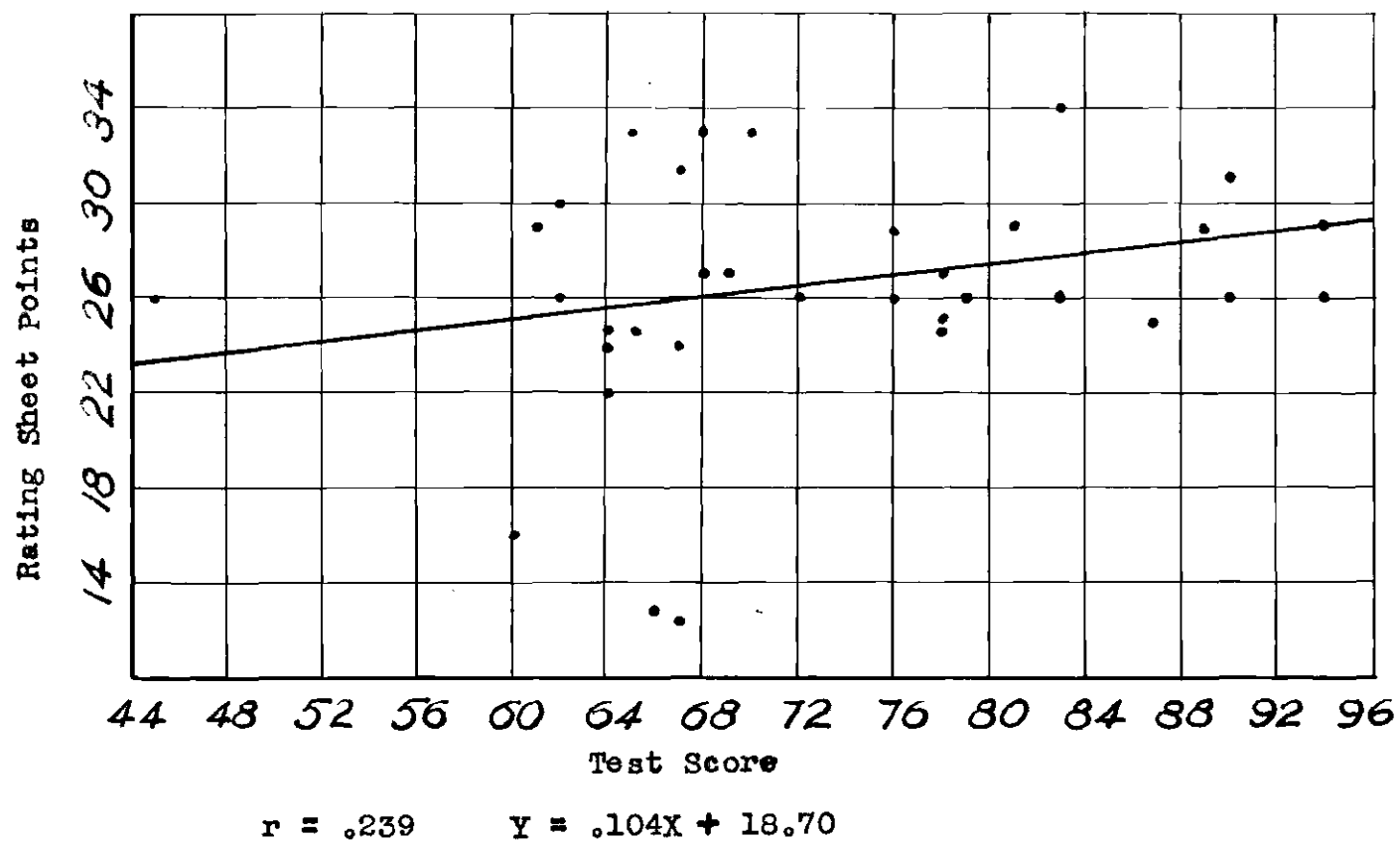


Figure 5. Scatter Diagram, Linear Correlation -- Scientific Interest

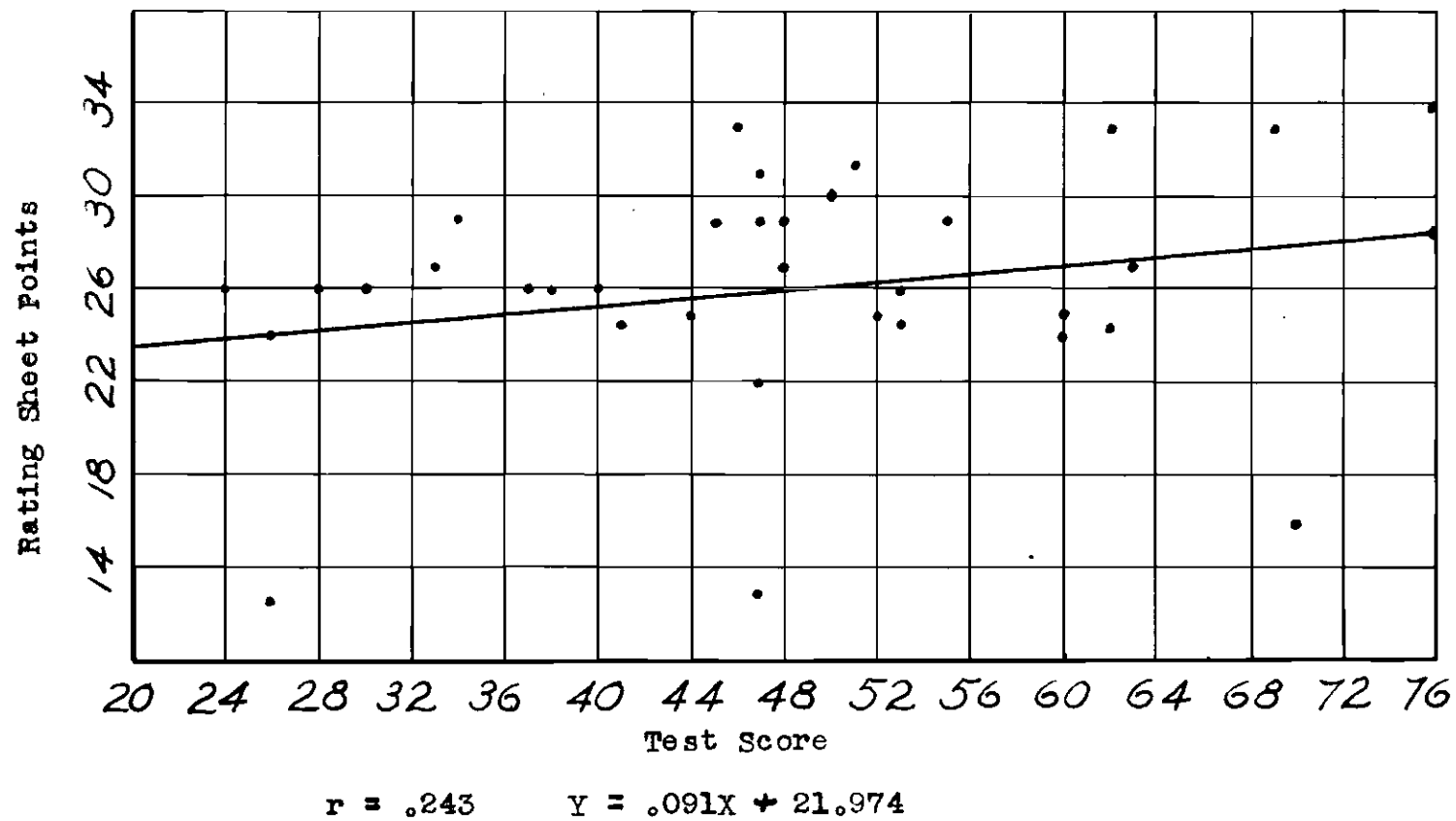


Figure 6. Scatter Diagram, Linear Correlation -- Artistic Interest

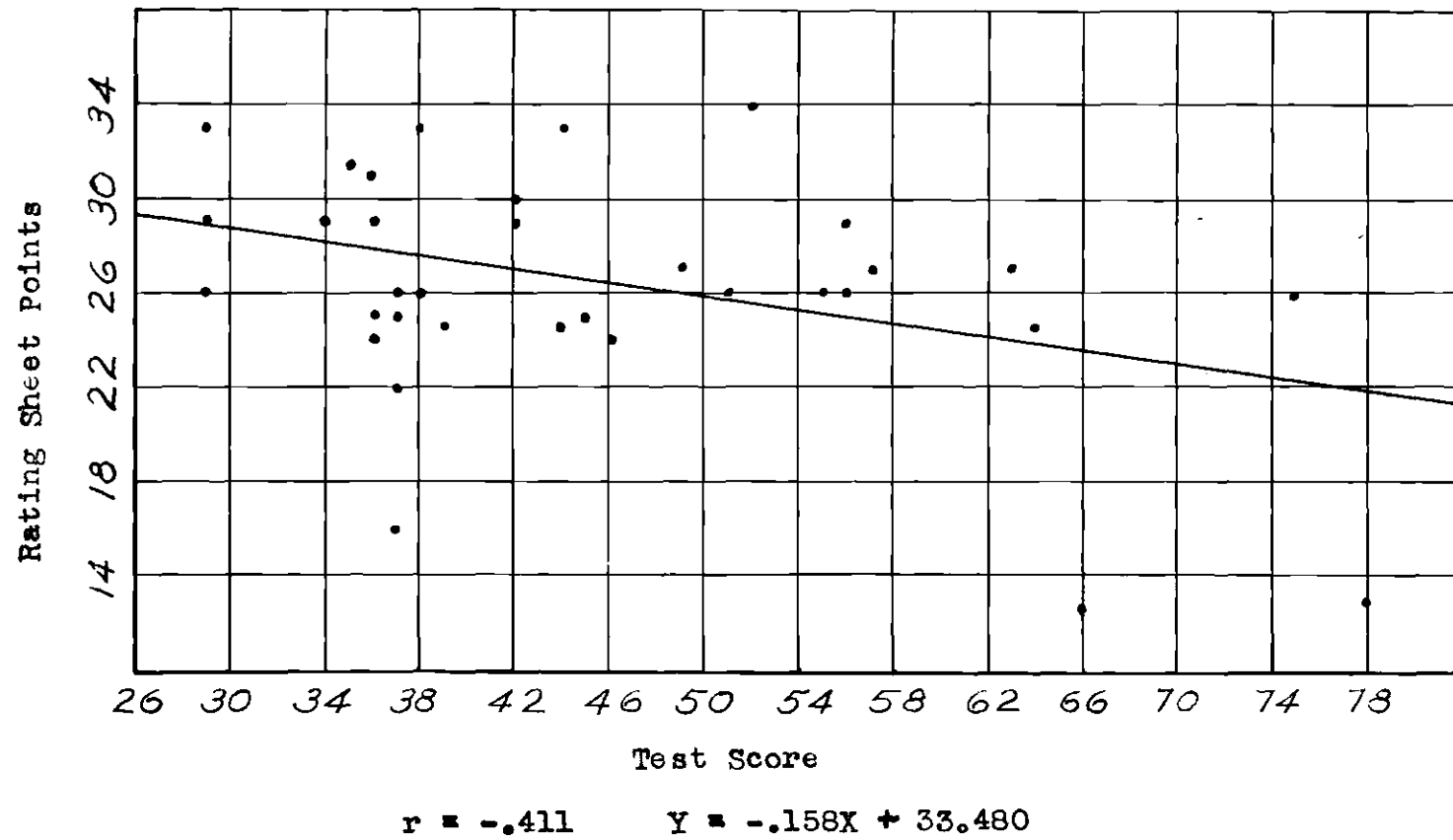


Figure 7. Scatter Diagram, Linear Correlation -- Literary Interest

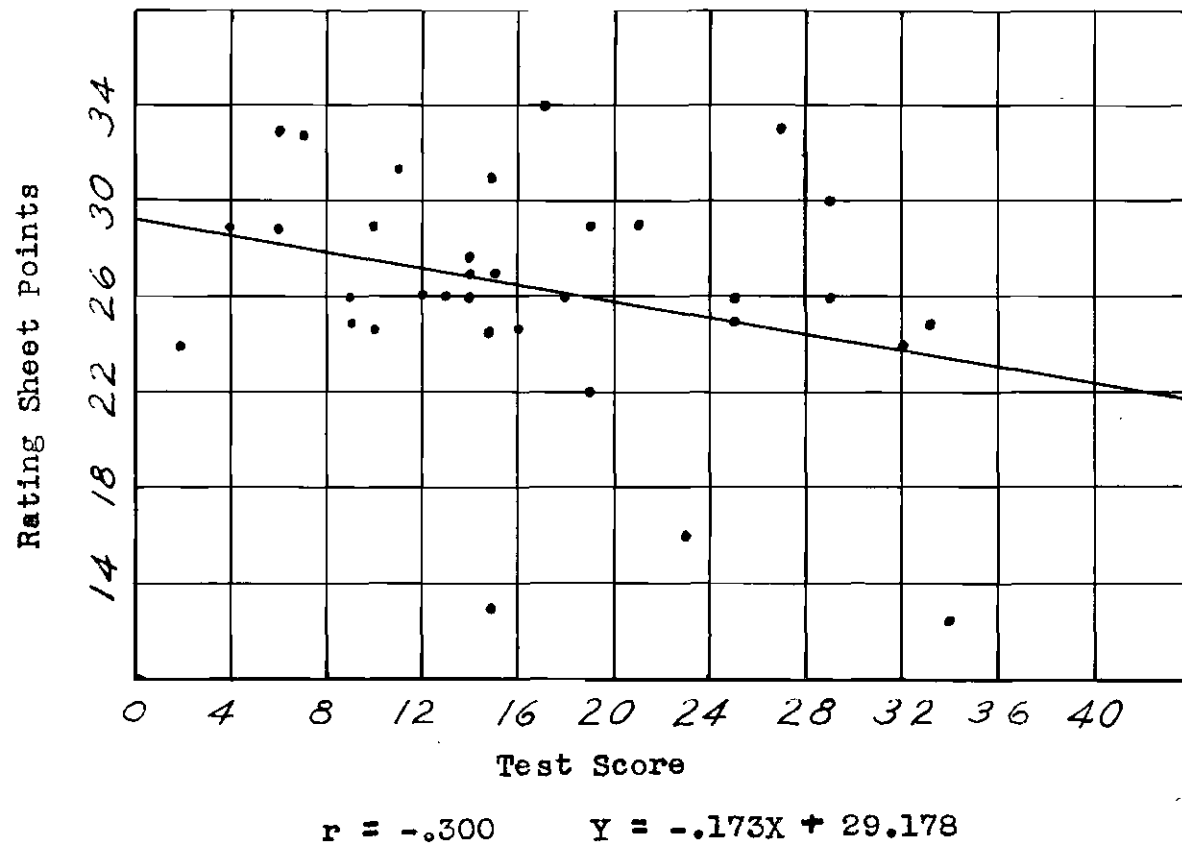


Figure 8. Scatter Diagram, Linear Correlation -- Musical Interest

## CHAPTER IV

### CONCLUSIONS AND RECOMMENDATIONS

#### Conclusions

Limitations.--Any conclusions drawn from the results of this study should be interpreted only after due consideration has been given to these limitations:

- (1) The investigation was conducted on a particularly small sample.
- (2) The men tested did not constitute a homogeneous group in that they came from six different organizations, which were engaged in four principal types of industrial activity. Biographical sketches of the men are not available and thus their educational background and other pertinent facts are not known. However, it is known that not all of the men were college graduates. In addition the pay brackets for time study men were not the same for all six companies.
- (3) These men were, of necessity, ranked and rated by different supervisors. This introduces into the study another variable which, for the most part, cannot be controlled.
- (4) It has been stated that there is no sound method to integrate the rankings of the individual sub-groups. The integration of the sub-groups with respect to the point totals on the rating sheet, no doubt, introduced some error.
- (5) Only four tests were used. Maybe other tests, if given, would have yielded different results.
- (6) The group tested was essentially composed of men who volunteered to



help in the study. Hence, they may have been a select group.

Conclusions.--

- (1) General intelligence is probably the one inherent trait most necessary for success in time study work.
- (2) An aptitude for structural visualization is helpful in achieving success in time study work.
- (3) Those men who earn a high score for co-operativeness on the Guilford-Martin Personnel Inventory will probably be good time study men.
- (4) A high mechanical interest is indicative of success in time study work.
- (5) Some successful time study men show a lack of interest in literary or musical activities.

Generalizations.--The conclusions establish the type of person the successful time study man is likely to be. That is, he will probably be of better-than-average intelligence, show some proficiency in visualizing objects in space, and be co-operative in his dealings with others. In addition, he may possess a mechanical bent and be interested in things of a scientific nature, while showing little interest in subjects which pertain to the musical or literary fields.

Whereas the successful time study man may possess all of the above traits, the chances are just as good that he may not possess all, or any of these traits.

The correlation coefficients between job success and aptitudes, although highly significant in some cases, were relatively low. It may be stated that the aptitudes measured by the tests used in this study do not necessarily constitute a sound basis for predicting whether or not a man will succeed in time study work. Furthermore, judging from the

results obtained in this study, it does not appear that success in time study work can be accurately predicted solely on the basis of aptitude tests.

### Recommendations

After careful consideration of the conclusions and the generalizations obtained from the conclusions, the following recommendations are made:

- (1) Further investigations of this subject should be encouraged.
- (2) A larger, more homogeneous sample should be obtained.
- (3) It would be desirable to select as a sample a large number of time study men who had been working under one supervisor long enough for him to know well the exact capabilities of each man.
- (4) Rank in overall performance should continue to be one measure of job success. The rating sheet which was used in this study should be improved upon. It could be that some factors, other than those listed, are more important as far as success in time study work is concerned. Also, a graphical rating scale would probably better discriminate being those being rated.
- (5) The aptitudes which were sampled in this study, and others not sampled in this study, should be investigated in future studies.
- (6) For each aptitude selected, several tests which purport to measure the aptitude should be considered.

## APPENDIX

Table 4. Raw and Percentile Test Scores  
Wonderlic Personnel Test

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	General Intelligence	
				Raw	Percentile
1	1	1	26	41	97.8
1	2	2	26	34	89.3
1	3	3	25	32	85.6
1	4	4	13	30	76.1
2	5	1	31.5	38	96.2
2	6	2	24.5	39	96.2
2	7	3	24.5	31	76.1
2	8	4	24.5	24	48.3
3	12	10	24	28	67.2
3	13	11	24	23	40.7
3	14	8	27	27	57.6
3	15	4	25	29	67.2
3	16	12	29	36	93.3
3	17	6	26	46	99.7
3	19	7	33	35	89.3
3	20	14.5	27	19	25.1
3	21	2	31	33	85.6
3	22	16	26	28	67.2
3	23	5	30	31	76.1
3	26	1	33	29	67.2
3	28	3	33	30	76.1
3	29	14.5	26	16	19.1
3	30	13	26	41	97.8
3	31	9	29	39	96.2
4	32	1	34	35	89.3
4	33	3	29	33	85.6
4	34	3	16	32	85.6
4	35	3	27	32	85.6
4	36	5	26	33	85.6
5	37	1	29	35	89.3
5	38	2	29	38	96.2
5	39	3	12.8	29	67.2
6	40	2	22	14	13.8
6	41	1	25	21	67.2

Table 5. Raw and Percentile Test Scores  
Minnesota Paper Form Board Test

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	Structural Visualization	
				Raw	Percentile
1	1	1	26	58	95
1	2	2	26	48	50
1	3	3	25	45	40
1	4	4	13	41	20
2	5	1	31.5	41	20
2	6	2	24.5	58	95
2	7	3	24.5	56	85
2	8	4	24.5	49	50
3	12	10	24	47	50
3	13	11	24	35	5
3	14	8	27	48	50
3	15	4	25	49	50
3	16	12	29	43	25
3	17	6	26	52	70
3	19	7	33	50	60
3	20	14.5	27	44	30
3	21	2	31	52	70
3	22	16	26	50	60
3	23	5	30	49	50
3	26	1	33	53	73
3	28	3	33	42	20
3	29	14.5	26	57	90
3	30	13	26	51	65
3	31	9	29	46	40
4	32	1	34	54	75
4	33	3	29	46	40
4	34	3	16	44	30
4	35	3	27	57	90
4	36	5	26	34	5
5	37	1	29	53	73
5	38	2	29	52	70
5	39	3	12.8	39	15
6	40	2	22	24	1
6	41	1	25	41	20

Table 6. Raw and Percentile Test Scores  
 Guilford-Martin Personnel In-  
 ventory Test

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	Objectivity	
				Raw	Percentile
1	1	1	26	57	89
1	2	2	26	70	99
1	3	3	25	45	60
1	4	4	13	67	96
2	5	1	31.5	29	23
2	6	2	24.5	70	99
2	7	3	24.5	59	89
2	8	4	24.5	65	96
3	12	10	24	52	77
3	13	11	24	55	89
3	14	8	27	57	89
3	15	4	25	62	96
3	16	12	29	64	96
3	17	6	26	38	40
3	19	7	33	61	89
3	20	14.5	27	59	89
3	21	2	31	59	89
3	22	16	26	67	96
3	23	5	30	63	96
3	26	1	33	56	89
3	28	3	33	58	89
3	29	14.5	26	56	89
3	30	13	26	54	77
3	31	9	29	64	96
4	32	1	34	69	99
4	33	3	29	58	89
4	34	3	16	31	23
4	35	3	27	53	77
4	36	5	26	46	60
5	37	1	29	35	23
5	38	2	29	45	60
5	39	3	12.8	40	40
6	40	2	22	64	96
6	41	1	25	54	47

Table 7. Raw and Percentile Test Scores  
 Guilford-Martin Personnel In-  
 ventory Test

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheet	Agreeableness	
				Raw	Percentile
1	1	1	26	38	77
1	2	2	26	39	77
1	3	3	25	32	60
1	4	4	13	54	99
2	5	1	31.5	20	11
2	6	2	24.5	30	40
2	7	3	24.5	47	96
2	8	4	24.5	38	77
3	12	10	24	39	77
3	13	11	24	48	96
3	14	8	27	33	60
3	15	4	25	36	60
3	16	12	29	40	77
3	17	6	26	25	23
3	19	7	33	57	99.9
3	20	14.5	27	39	77
3	21	2	31	40	77
3	22	16	26	20	11
3	23	5	30	46	89
3	26	1	33	39	77
3	28	3	33	40	77
3	29	14.5	26	31	40
3	30	13	26	44	89
3	31	9	29	30	40
4	32	1	34	54	99
4	33	3	29	41	77
4	34	3	16	26	23
4	35	3	27	37	77
4	36	5	26	24	23
5	37	1	29	39	77
5	38	2	29	36	60
5	39	3	12.8	39	77
6	40	2	22	50	96
6	41	1	25	47	96

Table 8. Raw and Percentile Test Scores  
 Guilford-Martin Personnel In-  
 ventory Test

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheet	Co-operativeness	
				Raw	Percentile
1	1	1	26	63	60
1	2	2	26	65	77
1	3	3	25	83	96
1	4	4	13	75	89
2	5	1	31.5	58	60
2	6	2	24.5	82	96
2	7	3	24.5	73	89
2	8	4	24.5	73	89
3	12	10	24	78	38
3	13	11	24	83	96
3	14	8	27	84	96
3	15	4	25	79	89
3	16	12	29	91	99
3	17	6	26	75	89
3	19	7	33	97	99.9
3	20	14.5	27	58	60
3	21	2	31	88	96
3	22	16	26	80	89
3	23	5	30	84	96
3	26	1	33	81	96
3	28	3	33	74	89
3	29	14.5	26	78	89
3	30	13	26	97	99.9
3	31	9	29	79	89
4	32	1	34	96	99
4	33	3	29	94	99
4	34	3	16	65	77
4	35	3	27	82	96
4	36	5	26	71	77
5	37	1	29	74	89
5	38	2	29	78	89
5	39	3	12.8	64	60
6	40	2	22	80	89
6	41	1	25	85	96



Table 9. Raw and Percentile Test Scores  
Kuder Preference Test --Interests

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheet	Mechanical	
				Raw	Percentile
1	1	1	26	67	30
1	2	2	26	85	56
1	3	3	25	104	89
1	4	4	13	74	40
2	5	1	31.5	106	91
2	6	2	24.5	113	96
2	7	3	24.5	98	80
2	8	4	24.5	94	72
3	12	10	24	92	68
3	13	11	24	64	26
3	14	8	27	103	87
3	15	4	25	104	89
3	16	12	29	101	84
3	17	6	26	88	60
3	19	7	33	103	87
3	20	14.5	27	86	57
3	21	2	31	95	74
3	22	16	26	98	79
3	23	5	30	83	52
3	26	1	33	80	47
3	28	3	33	108	93
3	29	14.5	26	106	91
3	30	13	26	117	99
3	31	9	29	96	76
4	32	1	34	86	57
4	33	3	29	117	99
4	34	3	16	81	48
4	35	3	27	89	62
4	36	5	26	107	92
5	37	1	29	109	94
5	38	2	29	92	68
5	39	3	12.8	79	45
6	40	2	22	48	11
6	41	1	35	101	84

Table 10. Raw and Percentile Test Scores  
Kuder Preference Test - Interests

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	Computational	
				Raw	Percentile
1	1	1	26	62	99
1	2	2	26	26	20
1	3	3	25	45	83
1	4	4	13	46	85
2	5	1	31.5	50	92
2	6	2	24.5	26	19
2	7	3	24.5	19	15
2	8	4	24.5	53	95
3	12	10	24	55	96
3	13	11	24	34	45
3	14	8	27	38	60
3	15	4	25	40	68
3	16	12	29	28	25
3	17	6	26	58	98
3	19	7	33	36	52
3	20	14.5	27	37	56
3	21	2	31	55	91
3	22	16	26	52	94
3	23	5	20	47	87
3	26	1	33	30	31
3	28	3	33	34	45
3	29	14.5	26	42	75
3	30	13	26	42	75
3	31	9	29	58	98
4	32	1	34	47	87
4	33	3	29	39	64
4	34	3	16	35	48
4	35	3	27	39	64
4	36	5	26	44	80
5	37	1	29	32	38
5	38	2	29	67	99.9
5	39	3	12.8	47	87
6	40	2	22	43	77
6	41	1	25	48	88

Table 11. Raw and Percentile Test Scores  
Kuder Preference Test - Interests

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	Scientific	
				Raw	Percentile
1	1	1	26	62	46
1	2	2	26	45	11
1	3	3	25	76	77
1	4	4	13	66	54
2	5	1	31.5	67	56
2	6	2	24.5	64	50
2	7	3	24.5	65	52
2	8	4	24.5	78	82
3	12	10	24	64	50
3	13	11	24	67	56
3	14	8	27	69	61
3	15	4	25	78	82
3	16	12	29	76	77
3	17	6	26	79	84
3	19	7	33	65	52
3	20	14.5	27	78	82
3	21	2	31	90	95
3	22	16	26	90	95
3	23	5	30	62	45
3	26	1	33	68	59
3	28	3	33	70	64
3	29	14.5	26	72	70
3	30	13	26	83	89
3	31	9	29	94	98
4	32	1	34	83	89
4	33	3	29	81	87
4	34	3	16	60	40
4	35	3	27	68	59
4	36	5	26	94	98
5	37	1	29	89	94
5	38	2	29	61	43
5	39	3	12.8	67	57
6	40	2	22	64	50
6	41	1	25	87	93

Table 12. Raw and Percentile Test Scores  
Kuder Preference Test - Interests

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	Persuasive	
				Raw	Percentile
1	1	1	26	48	10
1	2	2	26	97	84
1	3	3	25	52	14
1	4	4	13	72	49
2	5	1	31.5	77	56
2	6	2	24.5	100	87
2	7	3	24.5	73	50
2	8	4	24.5	67	40
3	12	10	24	58	24
3	13	11	24	72	49
3	14	8	27	97	84
3	15	4	25	78	59
3	16	12	29	90	75
3	17	6	26	75	53
3	19	7	33	99	87
3	20	14.5	27	96	83
3	21	2	31	66	39
3	22	16	26	67	40
3	23	4	30	74	52
3	26	1	33	80	61
3	28	3	33	83	66
3	29	14.5	26	81	64
3	30	13	26	64	35
3	31	9	29	83	66
4	32	1	34	38	3
4	33	3	29	52	15
4	34	3	16	80	61
4	35	3	27	88	73
4	36	5	26	57	22
5	37	1	29	48	9
5	38	2	29	56	21
5	39	3	12.8	71	48
6	40	2	22	67	40
6	41	1	25	59	25

Table 13. Raw and Percentile Test Scores  
Kuder Preference Test - Interests

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	Artistic	
				Raw	Percentile
1	1	1	26	38	26
1	2	2	26	30	10
1	3	3	25	60	86
1	4	4	13	47	56
2	5	1	31.5	51	68
2	6	2	24.5	41	36
2	7	3	24.5	53	73
2	8	4	24.5	62	89
3	12	10	24	60	86
3	13	11	24	26	9
3	14	8	27	48	60
3	15	4	25	44	46
3	16	12	29	48	60
3	17	6	26	24	3
3	19	7	33	62	89
3	20	14.5	27	33	16
3	21	2	31	47	56
3	22	16	26	28	12
3	23	5	30	50	65
3	26	1	33	69	95
3	28	3	33	46	54
3	29	14.5	26	40	34
3	30	13	26	53	72
3	31	9	29	34	18
4	32	1	34	76	97
4	33	3	29	45	50
4	34	3	16	70	95
4	35	3	27	63	90
4	36	5	26	37	24
5	37	1	29	47	57
5	38	2	29	55	76
5	39	3	12.8	26	4
6	40	2	22	47	57
6	41	1	25	52	70

Table 14. Raw and Percentile Test Scores  
Kuder Preference Test - Interests

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	Literary	
				Raw	Percentile
1	1	1	26	37	25
1	2	2	26	51	63
1	3	3	25	45	46
1	4	4	13	78	96
2	5	1	31.5	35	20
2	6	2	24.5	64	84
2	7	3	24.5	39	30
2	8	4	24.5	44	44
3	12	10	24	36	21
3	13	11	24	46	50
3	14	8	27	57	75
3	15	4	25	37	25
3	16	12	29	42	38
3	17	6	26	75	95
3	19	7	33	29	9
3	20	14.5	27	49	59
3	21	2	31	36	21
3	22	16	26	55	71
3	23	5	30	42	38
3	26	1	33	44	44
3	28	3	33	38	28
3	29	14.5	26	29	8
3	30	13	26	38	28
3	31	9	29	56	73
4	32	1	34	52	65
4	33	3	29	29	8
4	34	3	16	37	25
4	35	3	27	63	84
4	36	5	26	56	73
5	37	1	29	36	21
5	38	2	29	34	17
5	39	3	12.8	66	87
6	40	2	22	37	25
6	41	1	25	36	21

Table 15. Raw and Percentile Test Scores  
Kuder Preference Test - Interests

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	Musical	
				Raw	Percentile
1	1	1	26	29	86
1	2	2	26	25	81
1	3	3	25	33	92
1	4	4	13	15	51
2	5	1	31.5	11	33
2	6	2	25.5	16	55
2	7	3	24.5	10	27
2	8	4	24.5	15	51
3	12	10	24	2	15
3	13	11	24	32	92
3	14	8	27	15	51
3	15	4	25	25	81
3	16	12	29	19	66
3	17	6	26	18	62
3	19	7	33	6	11
3	20	14.5	27	14	47
3	21	2	31	15	51
3	22	16	26	12	38
3	23	5	30	29	86
3	26	1	33	27	84
3	28	3	33	7	14
3	29	14.5	26	9	24
3	30	13	26	13	43
3	31	9	29	21	73
4	32	1	34	17	60
4	33	3	29	4	5
4	34	3	16	23	77
4	35	3	27	14	48
4	36	5	26	14	48
5	37	1	29	10	27
5	38	2	29	6	11
5	39	3	12.8	34	93
6	40	2	22	19	65
6	41	1	25	9	23

Table 16. Raw and Percentile Test Scores  
Kuder Preference Test - Interests

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	Social Service	
				Raw	Percentile
1	1	1	26	63	27
1	2	2	26	73	47
1	3	3	25	28	0.5
1	4	4	13	30	0.7
2	5	1	31.5	61	24
2	6	2	24.5	47	6
2	7	3	24.5	93	86
2	8	4	24.5	65	31
3	12	10	24	88	79
3	13	11	24	108	98
3	14	8	27	58	17
3	15	4	25	68	38
3	16	12	29	76	54
3	17	6	26	62	25
3	19	7	33	60	21
3	20	14.5	27	90	82
3	21	2	31	80	64
3	22	16	26	57	16
3	23	5	30	56	14
3	26	1	33	72	46
3	28	3	33	72	46
3	29	14.5	26	84	72
3	30	13	26	80	64
3	31	9	29	37	1
4	32	1	34	37	1
4	33	3	29	77	57
4	34	3	16	75	52
4	35	3	27	65	31
4	36	5	26	70	43
5	37	1	29	78	59
5	38	2	29	57	16
5	39	3	12.8	56	14
6	40	2	22	95	89
6	41	1	25	76	55



Table 17. Raw and Percentile Test Scores  
Kuder Preference Test - Interests

Sub-Group Number	Sample Number	Rank	Total Points on Rating Sheets	Clerical	
				Raw	Percentile
1	1	1	26	16	95
1	2	2	26	43	25
1	3	3	25	47	37
1	4	4	13	58	70
2	5	1	31.5	56	65
2	6	2	24.5	41	19
2	7	3	24.5	37	12
2	8	4	24.5	37	12
3	12	10	24	50	46
3	13	11	24	44	28
3	14	8	27	42	21
3	15	4	25	33	7.0
3	15	12	29	23	0.8
3	17	6	26	57	68
3	19	7	33	45	30
3	20	14.5	27	39	15
3	21	2	31	43	25
3	22	16	26	51	49
3	23	5	30	49	43
3	26	1	33	28	2
3	28	3	33	41	19
3	29	14.5	26	42	21
3	30	13	26	29	3
3	31	9	29	56	65
4	32	1	34	46	34
4	33	3	29	57	68
4	34	3	16	40	46
4	35	3	27	31	5
4	36	5	26	32	6
5	37	1	29	26	2
5	38	2	29	58	70
5	39	3	12.8	42	21
6	40	2	22	55	63
6	41	1	25	65	84

Table 18. Points Received on Rating Sheet, by Factors

Sample Number	Quantity of Work	Quality of Work	Personal Contact	Rating Ability	Judgment	Observational Powers	Analytical Ability
1	3	3	4	4	4	4	4
2	4	4	3	3	4	4	4
3	3	4	3	4	4	4	3
4	1	2	2	2	2	2	2
5	5	5	3	--	4	5	5
6	4	4	3	--	4	3	3
7	3	3	4	--	4	4	4
8	3	3	4	--	4	4	3
12	4	3	3	4	4	3	3
13	2	4	3	4	4	3	4
14	4	5	3	4	4	4	3
15	3	3	4	4	4	4	3
16	4	4	4	4	4	5	4
17	4	4	4	2	4	4	4
19	4	4	5	5	5	5	5
20	4	4	3	4	4	3	5
21	5	4	5	4	4	5	4
22	4	4	3	4	4	4	3
23	5	4	4	4	4	5	4
26	5	5	5	5	4	5	4
28	5	5	4	5	4	5	5
29	4	4	4	4	3	4	3
30	3	4	3	4	4	4	4
31	4	4	4	4	4	4	5
32	5	5	5	4	5	5	5
33	4	5	3	4	4	5	4

Table 18. Points Received on Rating Sheet, by Factors (Continued)

Sample Number	Quantity of Work	Quality of Work	Personal Contact	Rating Ability	Judgment	Observational Powers	Analytical Ability
34	1	3	2	4	2	2	2
35	3	4	4	4	4	4	4
36	3	4	3	4	4	5	3
37	4	5	4	3	3	5	3
38	5	3	4	3	5	5	4
39	1	2	2	--	2	2	2
40	3	4	3	3	4	3	2
41	4	4	3	4	4	4	2

Table 19. Rank Within Group  
and Total Points Received on Rating Sheet

Sub-Group Number	Sample Number	Rank Within Group	Total Points Received on Rating Sheet
1	1	1	26
1	2	2	26
1	3	3	25
1	4	4	13
2	5	1	31.5
2	6	2	24.5
2	7	3	24.5
2	8	4	24.5
3	12	10	24
3	13	11	24
3	14	8	27
3	15	4	25
3	16	12	29
3	17	6	26
3	19	7	33
3	20	14.5	27
3	21	2	31
3	22	16	26
3	23	5	30
3	26	1	33
3	28	3	33
3	29	14.5	26
3	30	13	26
3	31	9	29
4	32	1	34
4	33	3	29
4	34	3	16
4	35	3	27
4	36	5	26
5	37	1	29
5	38	2	29
5	39	3	12.8
6	40	2	22
6	41	1	25

Table 20. All Linear Correlation Coefficients

Total Rating Sheet Points and:	Correlations Coefficient	Confidence Level at which coefficient is significant from zero
Intelligence	.240	83%
Structural Visualization	.334	94%
Objectivity	.155	Not Significant
Agreeableness	.020	Not Significant
Co-operativeness	.375	97%
Mechanical Interest	.372	96%
Computation Interest	-.010	Not Significant
Scientific Interest	.239	83%
Persuasive Interest	-.001	Not Significant
Artistic Interest	.243	83%
Literary Interest	-.411	98%
Musical Interest	-.300	91%
Social Service Interest	.027	Not Significant
Clerical Interest	-.166	Not Significant

Table 21. Sample Calculation  
Linear Correlation -- Intelligence

Sample Number	Test Score X	Points on Rating Sheet Y
1	41	26
2	34	26
3	32	25
4	30	13
5	38	31.5
6	39	24.5
7	31	24.5
8	24	24.5
12	28	24
13	23	24
14	27	27
15	29	25
16	36	29
17	46	26
19	35	33
20	19	27
21	33	31
22	28	26
23	31	30
26	29	33
28	30	33
29	16	26
30	41	26
31	39	29
32	35	34
33	33	29
34	32	16
35	32	27
36	33	26
37	35	29
38	38	29
39	29	12.8
40	14	22
41	21	25
<hr/>		
$\Sigma X^2 = 34,775$	$\Sigma X = 1061$	$(\Sigma X)^2 = 1,125,721$
$\Sigma Y^2 = 24,301$	$\Sigma Y = 893.8$	$(\Sigma Y)^2 = 798,878$
$\bar{X} = 31.21$	$\bar{Y} = 26.29$	$\Sigma XY = 28,169.2$

Table 21. Sample Calculation  
Linear Correlation -- Intelligence (Continued)

---


$$r = \frac{N\sum XY - \sum X \times \sum Y}{\sqrt{N\sum X^2 - (\sum X)^2} \sqrt{N\sum Y^2 - (\sum Y)^2}}$$

$$r = \frac{34 \times 28,169.2 - 1061 \times 893.8}{\sqrt{34 \times 34,775 - 1,125,721} \sqrt{34 \times 24,301 - 798,878}}$$

$$r = .240$$


---

Determining the Significance of the Correlation Coefficient

$$Z = \frac{r}{\sigma_r}; \text{ where } \sigma_r = \frac{1}{\sqrt{N-1}} = \frac{1}{\sqrt{34-1}} = .174$$

$$Z = \frac{.240}{.174} = 1.38, \text{ significant at the } 83\% \text{ level of confidence}^6$$


---

Fitting a Line to the Data by the Means of Least Squares

$$Y_c - \bar{Y} = r \frac{\sigma_y}{\sigma_x} (X - \bar{X});$$

$$\text{where } \sigma_y = \frac{\sqrt{N\sum Y^2 - (\sum Y)^2}}{N} = \frac{\sqrt{34 \times 24,301 - 798,878}}{34} = 4.86$$

and

$$\sigma_x = \frac{\sqrt{N\sum X^2 - (\sum X)^2}}{N} = \frac{\sqrt{34 \times 34,775 - 1,125,721}}{34} = 7.00$$

$$Y_c - 26.29 = .240 \times \frac{4.86}{7.00} (X - 31.20)$$

$$Y_c = 21.08 + .167X$$


---

<sup>6</sup>Dixon, W. J. and Massey, F. J., Jr., Introduction to Statistical Analysis. McGraw-Hill Book Company, Inc., 1951, Table 3, p. 305

Table 22. All Rank-Correlation Coefficients

Job Rank and Test Score Rank in:	Sub-Group Number	Correlation Coefficient	Confidence Level at which coefficient is significant from zero
Intelligence	1	1.00	96%
	2	0.80	Not Significant
	3	0.31	Not Significant
	4	0.41	Not Significant
Structural Visualization	1	1.00	96%
	2	-0.20	Not Significant
	3	0.18	Not Significant
	4	0.70	83%
Objectivity	1	0.00	Not Significant
	2	-0.40	Not Significant
	3	-0.08	Not Significant
	4	0.70	83%
Agreeableness	1	-0.40	Not Significant
	2	-0.80	83%
	3	0.22	Not Significant
	4	0.90	96%
Co-operativeness	1	-0.80	83%
	2	-0.25	Not Significant
	3	0.70	88%
	4	0.70	Not Significant
Mechanical Interest	1	-0.40	Not Significant
	2	0.80	83%
	3	-0.14	Not Significant
	4	-0.30	Not Significant
Computational	1	0.20	Not Significant
	2	-0.20	Not Significant
	3	-0.04	Not Significant
	4	0.33	Not Significant
Scientific	1	-0.60	79%
	2	-0.40	Not Significant
	3	-0.21	Not Significant
	4	-0.10	Not Significant



Table 22. All Rank-Correlation Coefficients  
(Continued)

Job Rank and Test Score Rank in:	Sub-Group Number	Correlation Coefficient	Confidence Level at which coefficient is significant from zero
Persuasive	1	-0.40	Not Significant
	2	0.80	83%
	3	0.03	Not Significant
	4	-0.30	Not Significant
Artistic	1	0.40	Not Significant
	2	-0.50	Not Significant
	3	0.35	80-90%
	4	0.90	96%
Literary	1	-0.80	83%
	2	-0.40	Not Significant
	3	-0.12	Not Significant
	4	0.05	Not Significant
Musical	1	0.40	Not Significant
	2	0.00	Not Significant
	3	0.31	Not Significant
	4	0.43	Not Significant
Social Service	1	0.60	79%
	2	-0.60	79%
	3	-0.07	Not Significant
	4	-0.30	Not Significant
Clerical	1	0.20	Not Significant
	2	0.95	96%
	3	-0.06	Not Significant
	4	0.30	Not Significant

Table 23. Sample Calculation  
Rank-Correlation Coefficients -- Intelligence

Sub-Group Number	Sample Number	Test Score	Test Rank	Job Rank	Difference d
1	1	41	1	1	0
1	2	34	2	2	0
1	3	32	3	3	0
1	4	30	4	4	0

$$\sum d^2 = 0$$

$$r = 1 - \frac{6 \times \sum d^2}{N(N^2 - 1)} = 1 - \frac{6 \times 0}{60} = 1.00^7$$

---

<sup>7</sup>For confidence limits, see Annals of Mathematical Statistics, Volume IX, 1939, E. G. Olds, Distributions of Sums of Squares of Rank Differences For Small Numbers of Individuals, Table IV, pp. 145-6,7.

Table 24. Summary of Comparisons of Mean Scores

Trait:	Mean Score Lower 12 Ranks	Mean Score Upper 12 Ranks	Confidence Level at which difference is significant
Intelligence	26.67	34.34	99.5%
Structural Visualization	44.00	47.58	Not Significant
Co-operativeness	76.67	82.83	Not Significant
Mechanical Interest	87.67	98.00	Not Significant
Scientific Interest	69.67	75.50	Not Significant
Artistic Interest	49.00	52.50	Not Significant
Literary Interest	47.08	39.42	Not Significant
Musical Interest	19.42	14.83	Not Significant

Table 25. Sample Calculation, Comparisons of Mean Scores -- Intelligence

Sample Number	Lower 12 Ranks Points on Rating Sheet	Test Score $X_1$	Sample Number	Upper 12 Ranks Points on Rating Sheet	Test Score $X_2$
39	12.8	29	16	29	36
4	13	30	31	29	39
34	16	32	33	29	33
40	22	14	37	29	35
12	24	28	38	29	38
13	24	23	23	30	31
6	24.5	39	21	31	33
7	24.5	31	5	31.5	38
8	24.5	24	19	33	35
3	25	32	26	33	29
15	25	29	28	33	30
41	25	21	32	34	35

$$\sum X_1 = 332 \quad \bar{X}_1 = 26.67 \quad N_1 = 12 \quad \sum X_2 = 412 \quad \bar{X}_2 = 34.34$$

$$(\sum X_1)^2 = 110,224 \quad \sum X_1^2 = 9,638 \quad N_2 = 12 \quad (\sum X_2)^2 = 169,744 \quad \sum X_2^2 = 14,260$$

Table 25. (Continued) Sample Calculation

$$\begin{aligned}
 s_1^2 &= \frac{\sum X_1^2 - \frac{(\sum X_1)^2}{N_1}}{N_1 - 1} \\
 &= \frac{9638 - \frac{110,224}{12}}{11} \\
 &= 41.15
 \end{aligned}$$

$$\begin{aligned}
 s_2^2 &= \frac{\sum X_2^2 - \frac{(\sum X_2)^2}{N_2}}{N_2 - 1} \\
 &= \frac{14,260 - \frac{169,744}{12}}{11} \\
 &= 10.42
 \end{aligned}$$

Approximate degree of freedom =  $N_1 - 1 + N_2 - 1 = 22$

$$H: u_1 = u_2$$

$$\begin{aligned}
 t &= \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}} \\
 &= \frac{26.27 - 34.34}{\sqrt{\frac{41.15}{12} + \frac{10.42}{12}}} = -3.71
 \end{aligned}$$

Reject Hypothesis if:  $-3.22 > t > + 3.22$ <sup>8</sup>

Therefore the hypothesis is rejected and 99.5% of the time this difference in mean scores will not be due to chance.

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<sup>8</sup>Dixon, W. F. and Massey, F. J., Jr., Introduction to Statistical Analysis. McGraw-Hill Book Company, Inc., Table 5, P. 307.

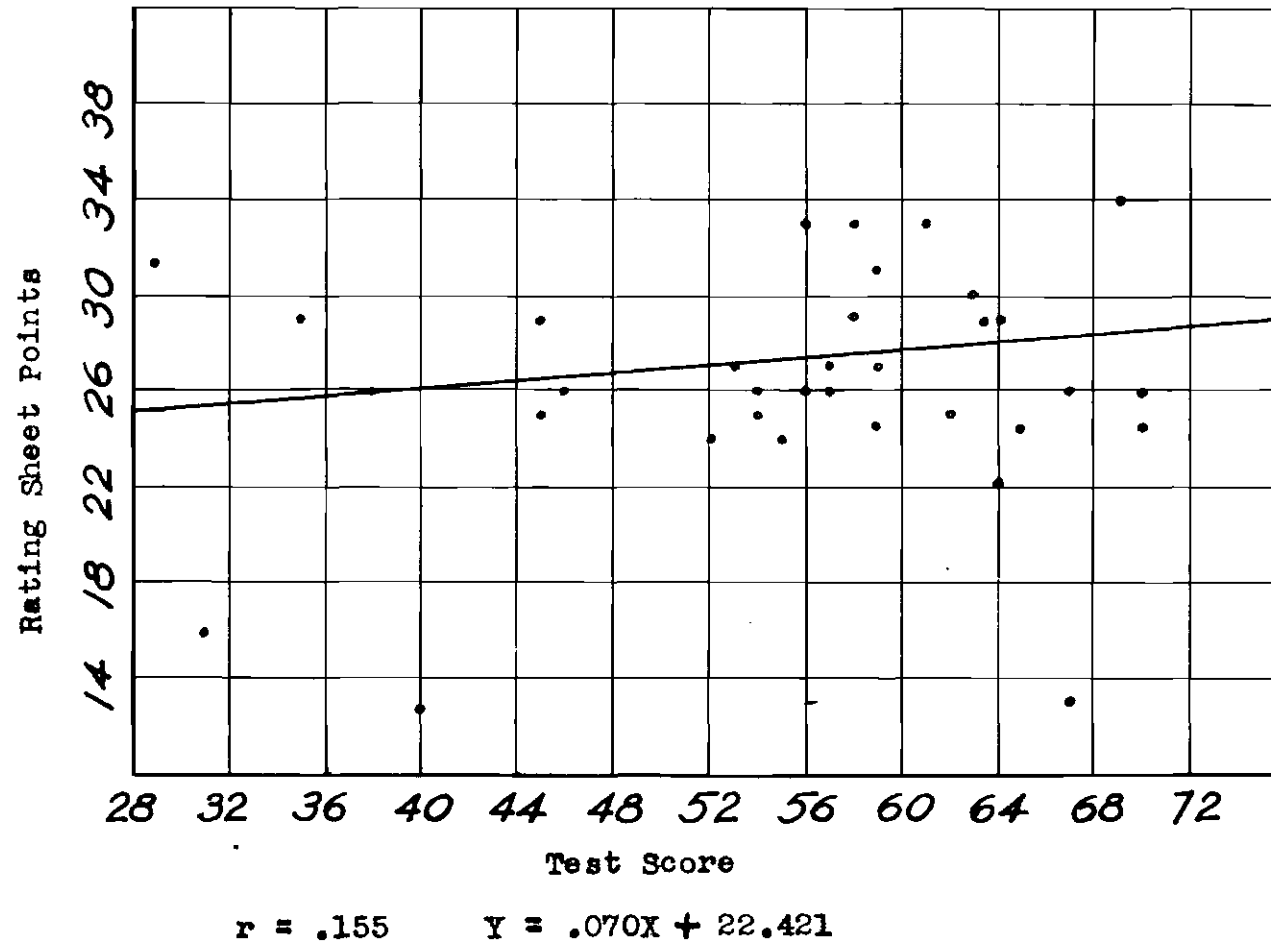
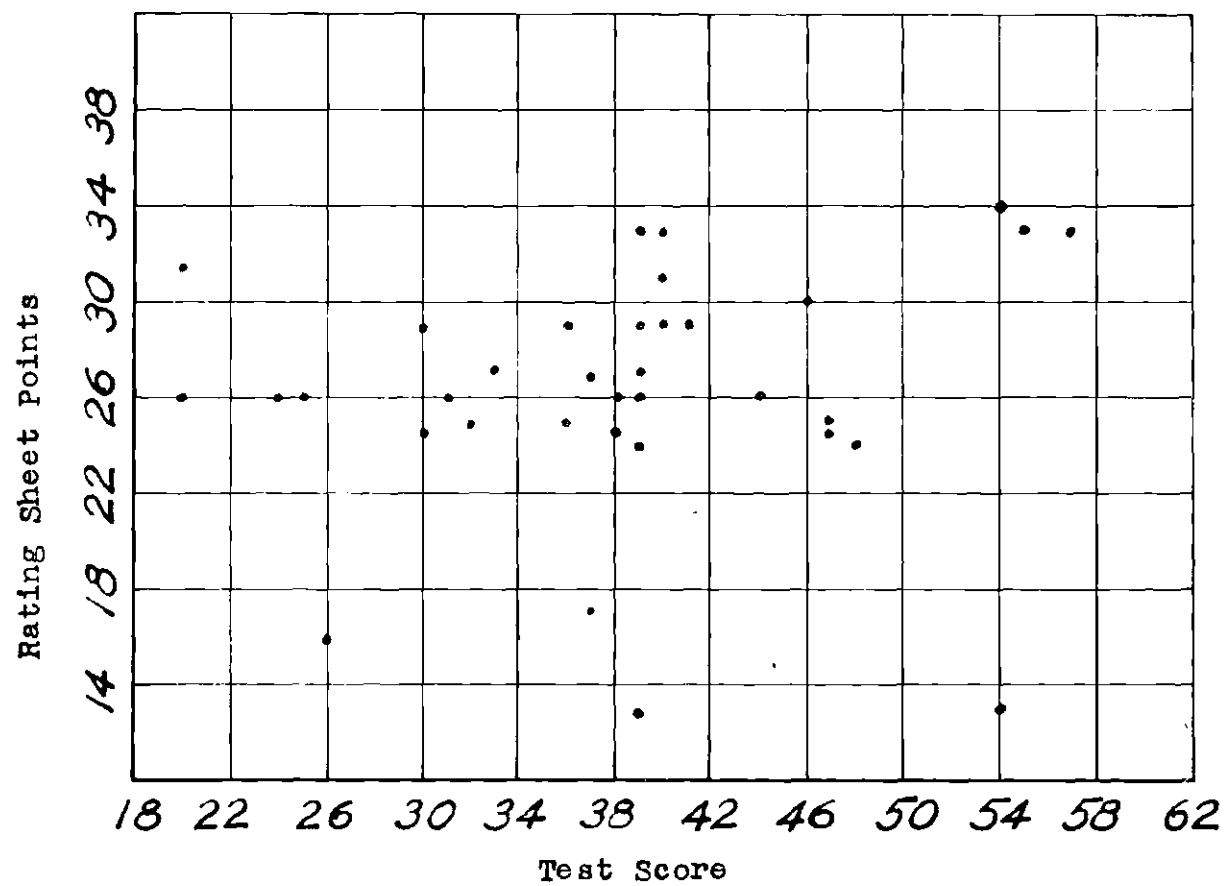


Figure 9. Scatter Diagram, Linear Correlation -- Objectivity



$$r = .022$$

Figure 10. Scatter Diagram, Linear Correlation -- Agreeableness

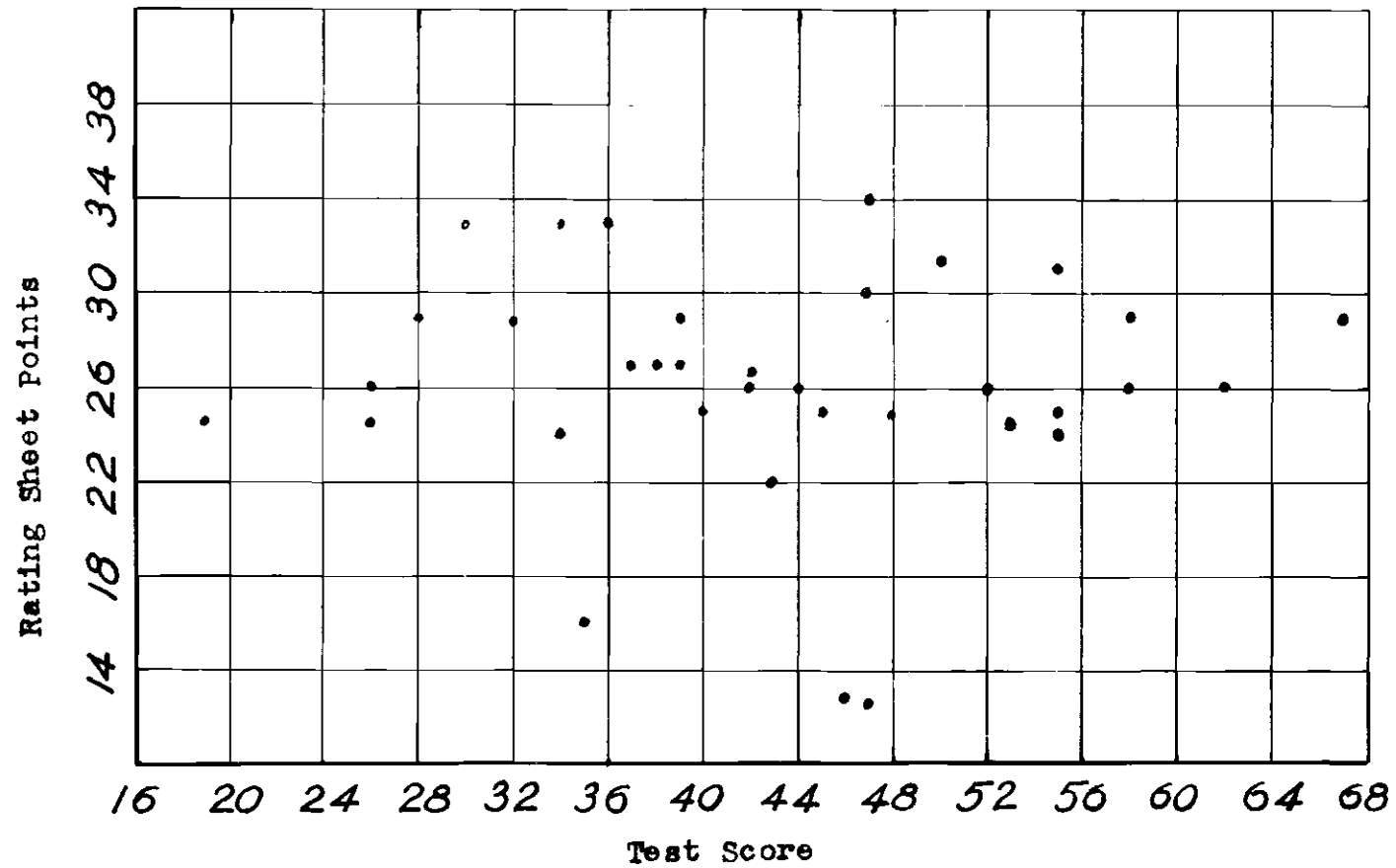


Figure 11. Scatter Diagram, Linear Correlation -- Computational Interest



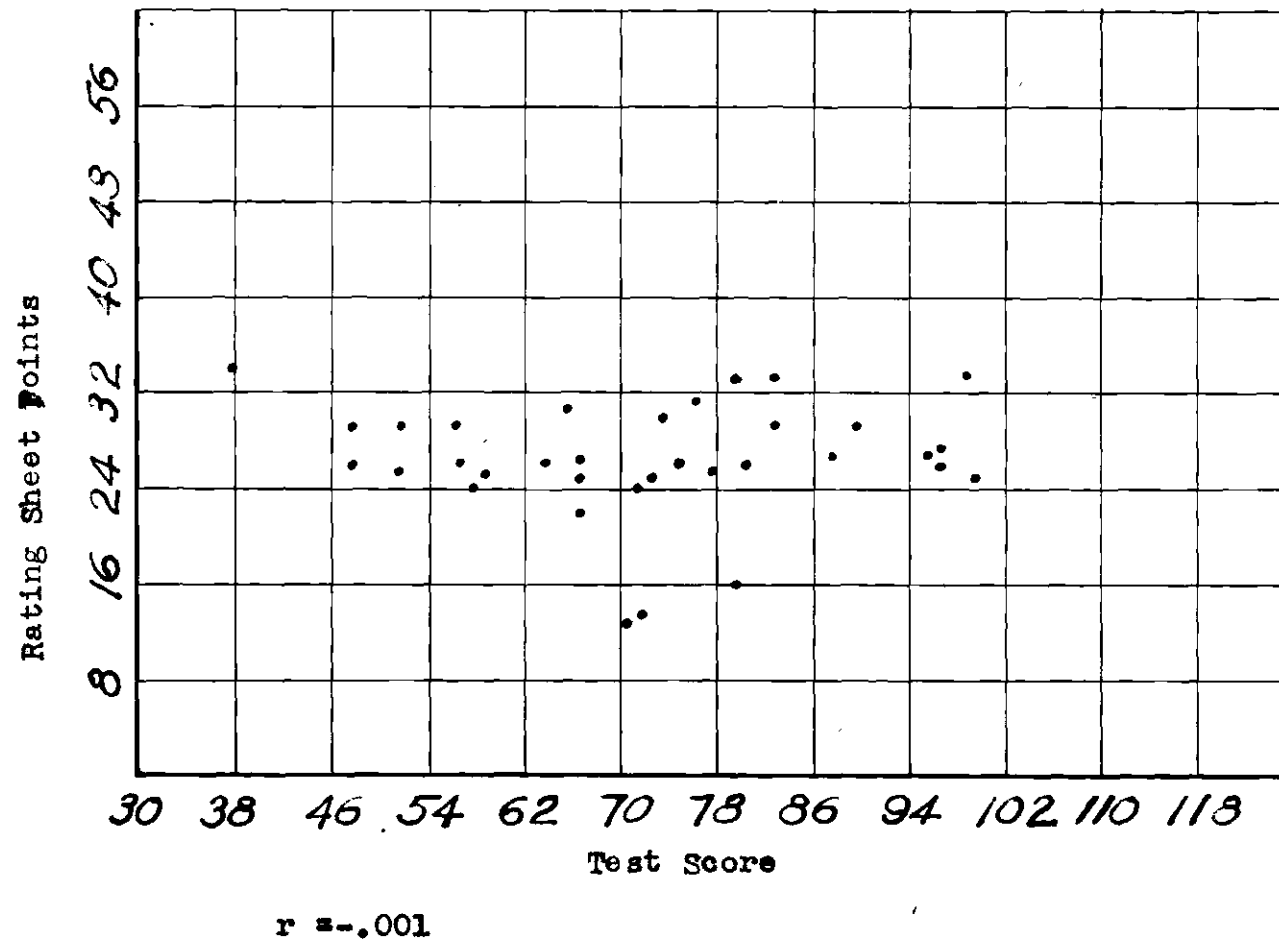


Figure 12. Scatter Diagram, Linear Correlation -- Persuasive Interest

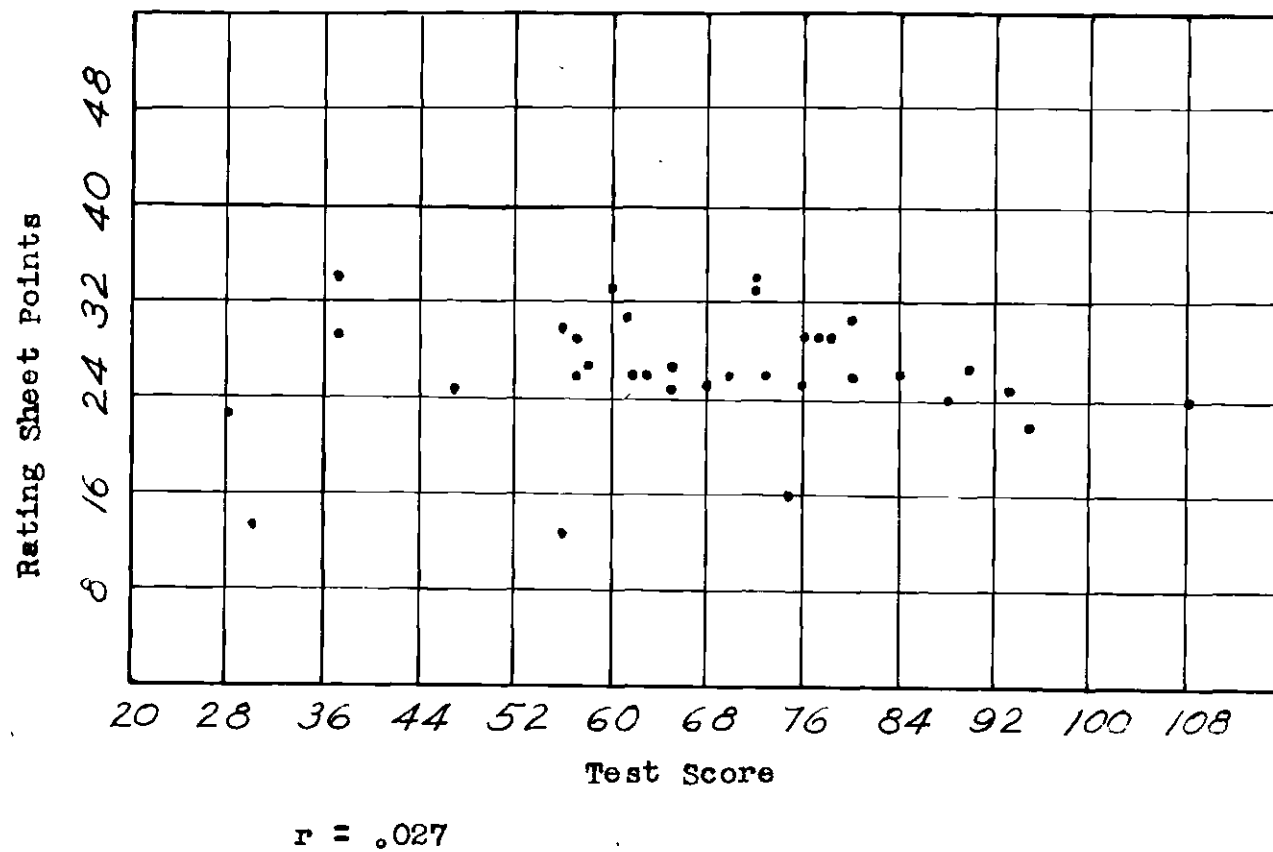
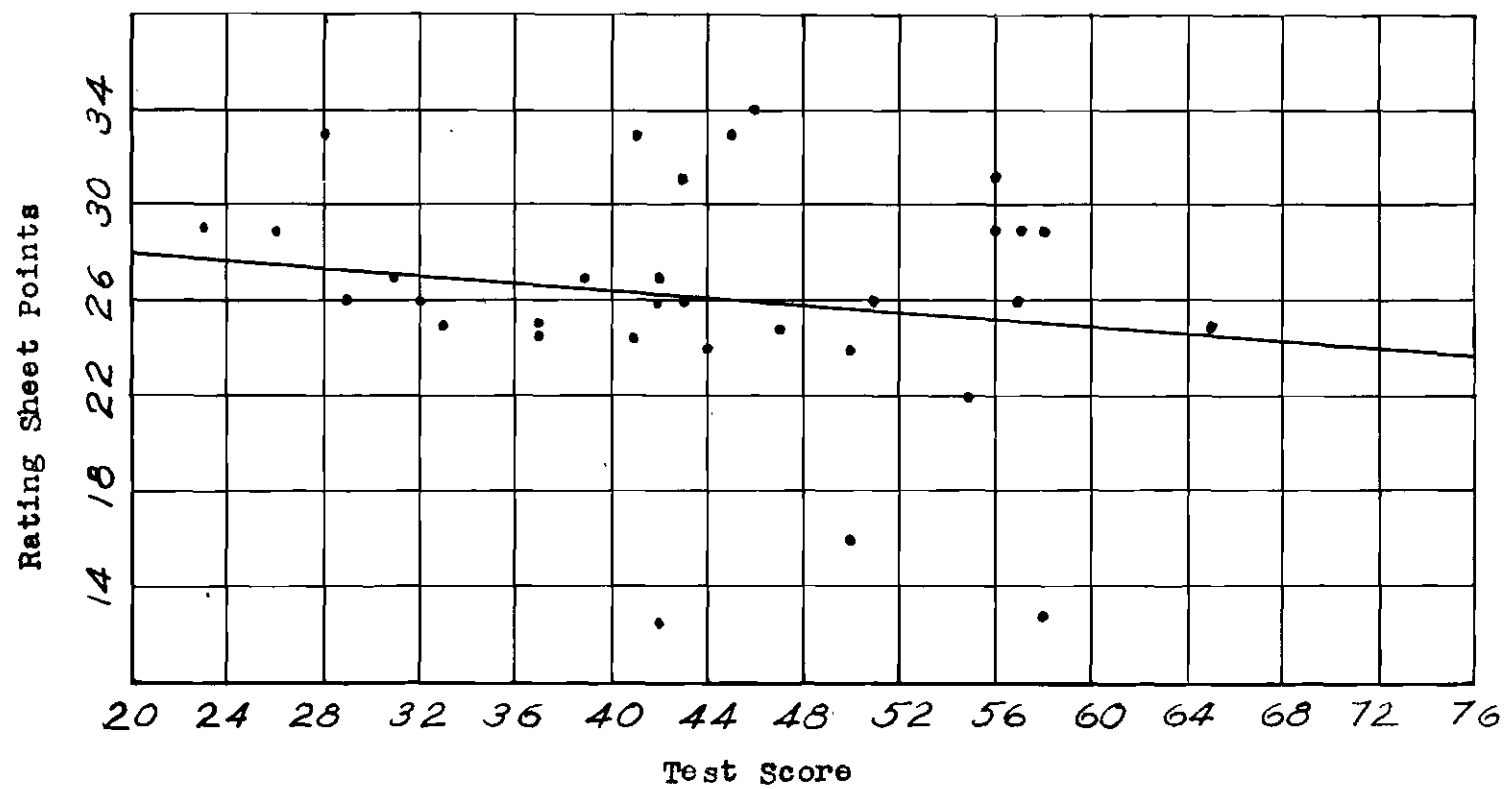


Figure 13. Scatter Diagram, Linear Correlation -- Social Service Interest



$$r = -.166$$

Figure 14. Scatter Diagram, Linear Correlation -- Clerical Interest

NAME \_\_\_\_\_

RANK \_\_\_\_\_

NUMBER \_\_\_\_\_

Directions: Rate this individual on the basis of the seven factors listed below. Please read the definitions of the factors carefully and then place a (✓) mark through the degree of the factor which in your opinion best describes this individual. Weigh your decisions carefully.

1. Quantity of Work

What volume of work is produced.

1	4	2	5	3
Never turns out as much work as others.	Usually turns out more work than others.	Seldom turns out as much work as others.	Always turns out more work than others.	Turns out average amount of work.

2. Quality of Work

Accuracy and Neatness.

3	5	2	4	1
On the average his work is neat and accurate.	Always turns out neat accurate work.	Seldom turns out neat accurate work.	Usually turns out neat accurate work.	Never turns out neat accurate work.

3. Personal Contact

Tact, patience, ability to get along with other people, ability to sell himself and his ideas, ability to handle a "touchy" situation.

4	1	3	5	2
Usually good in personal contact.	Should avoid personal contact.	Could handle any situation any time.	Average in personal contact.	Not usually good in personal contact.

4. Rating Ability

Ability to accurately and consistently judge pace or speed of movement.

2	4	1	3	5
Usually doesn't rate accurately.	Usually rates accurately.	Never rates accurately.	Rates accurately as often as not.	Always rates accurately.

5. JudgementThe power of arriving at a wise decision or conclusion on the basis of indications or probabilities when the facts are not clearly ascertained -- embodying a logical conclusion.

3	5	4	1	2
Always uses sound judgement.	Uses sound judgement as often as the average man does.	Usually uses sound judgement.	Never uses sound judgement.	Seldom uses sound judgement.

6. Observational Powers

Ability to perceive and note, attentiveness.

1	5	2	4	3
Never keen.	Always keen.	Seldom keen.	Usually keen.	Average.

7. Analytical Ability

Ability to divide a problem into its component parts and see each in its true perspective and relationship to the other and to the whole, to "size up" a situation and "think it through", to objectively consider all possible alternative actions and accurately weigh the consequences of any proposed action.

3	1	4	5	2
Average in analytical ability.	Never shows good analytical ability.	Usually shows good analytical ability.	Always shows good analytical ability.	Seldom shows good analytical ability.

Figure 15. - Sample Rating Sheet - This is an exact copy of the rating sheet which the supervisors were asked to fill out for each time study man. The number typed above each phrase is the point value for that degree of proficiency in each factor. These point values did not appear on the sheets actually used.

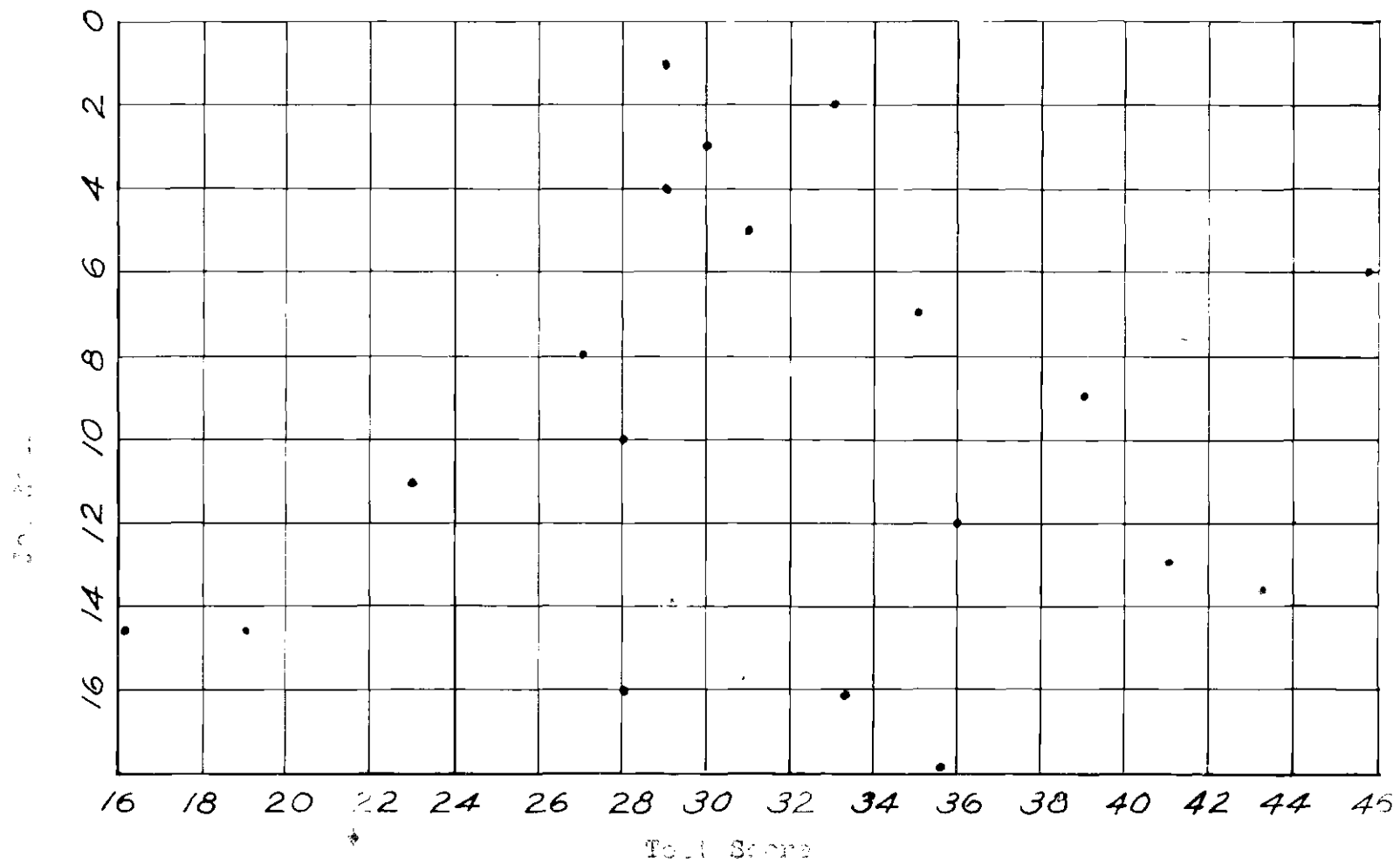


Figure 11. Scatter Diagram, Rank-Correlation -- Intelligence, Social Group 5

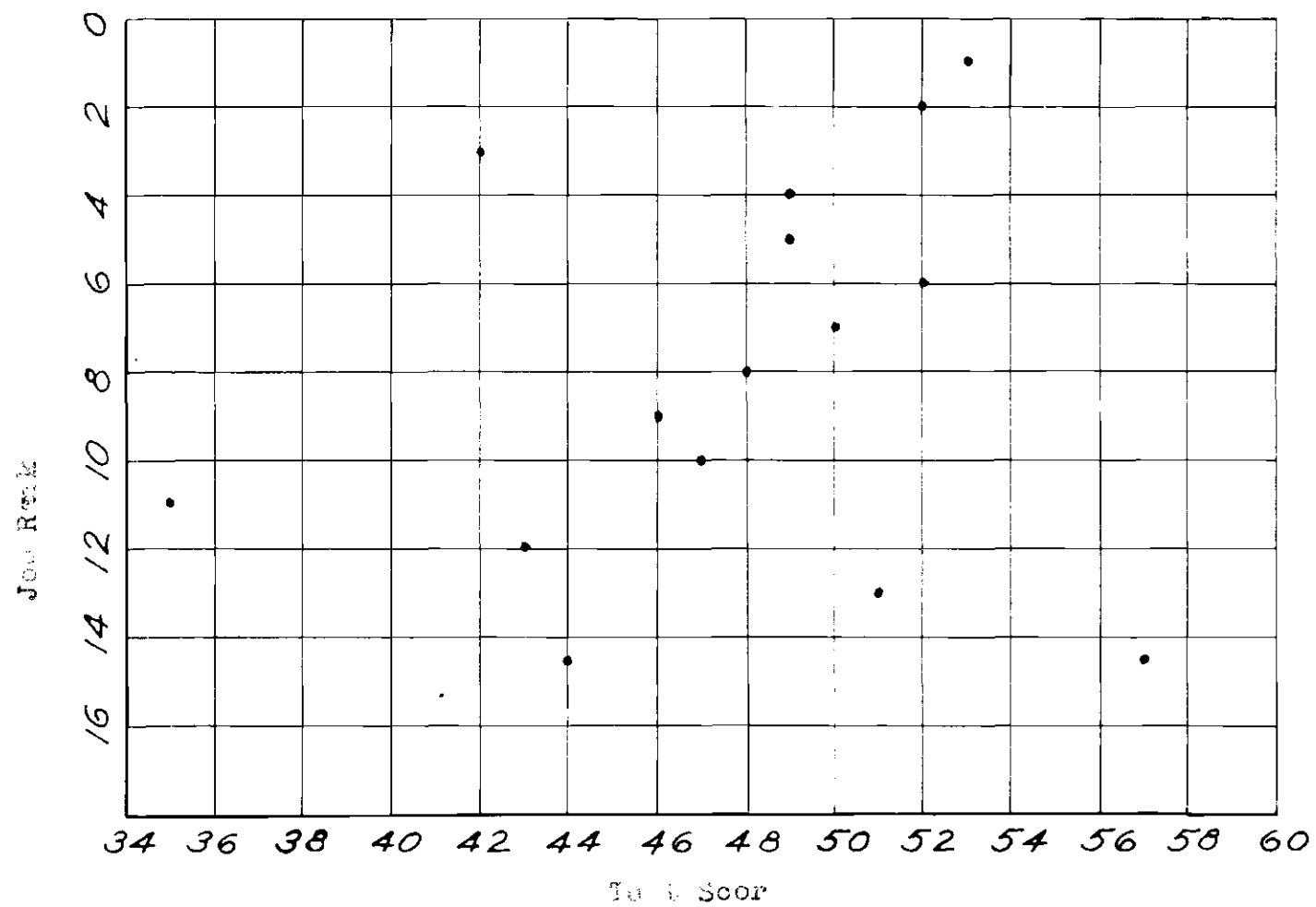


Figure 17. Scatter Diagram, Rank-Correlation -- Structural Visualization, Sub-Group 3

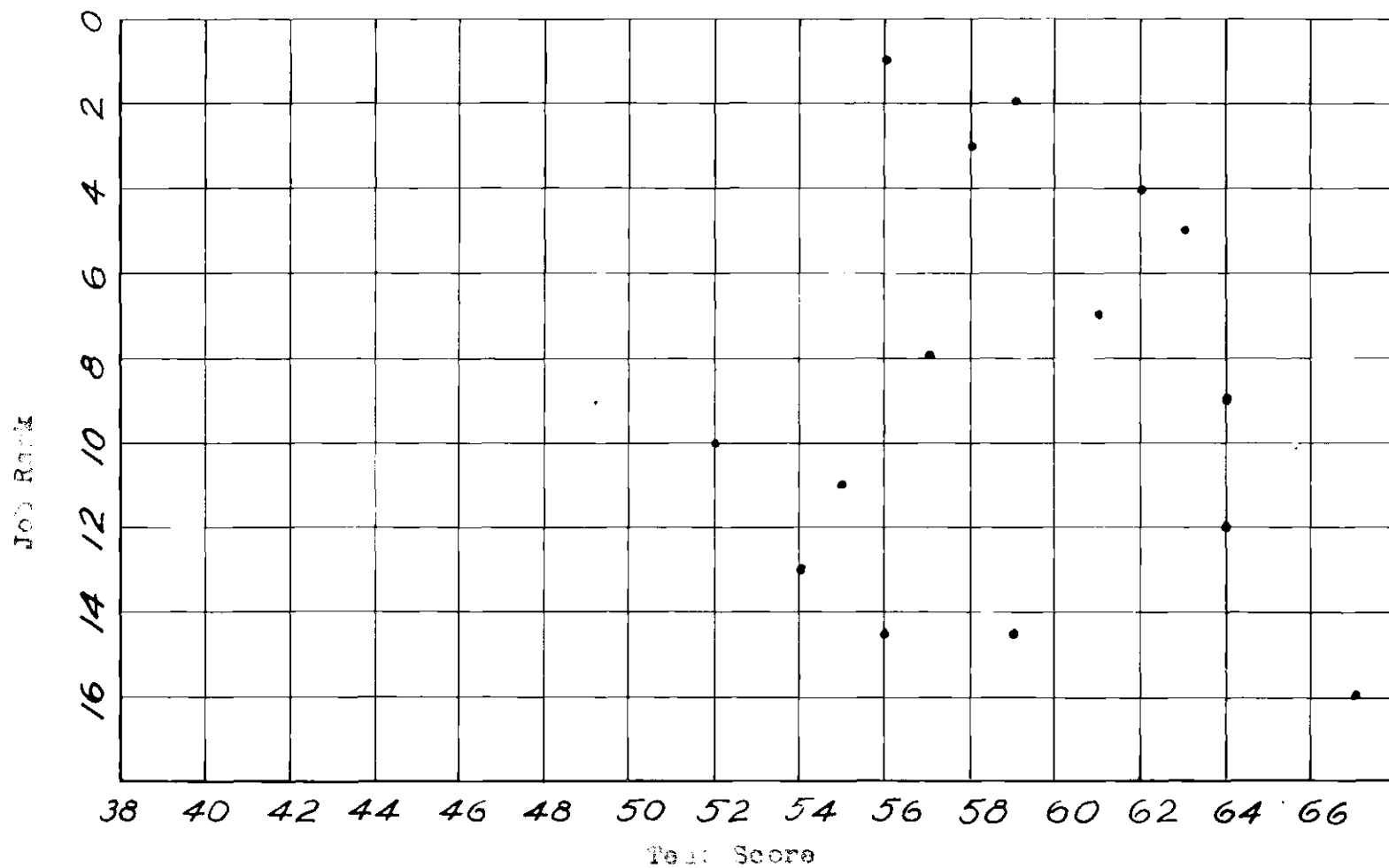


Figure 1A. Scatter Diagram, Rank-Correlation -- Objectivity, Sub-Group 3

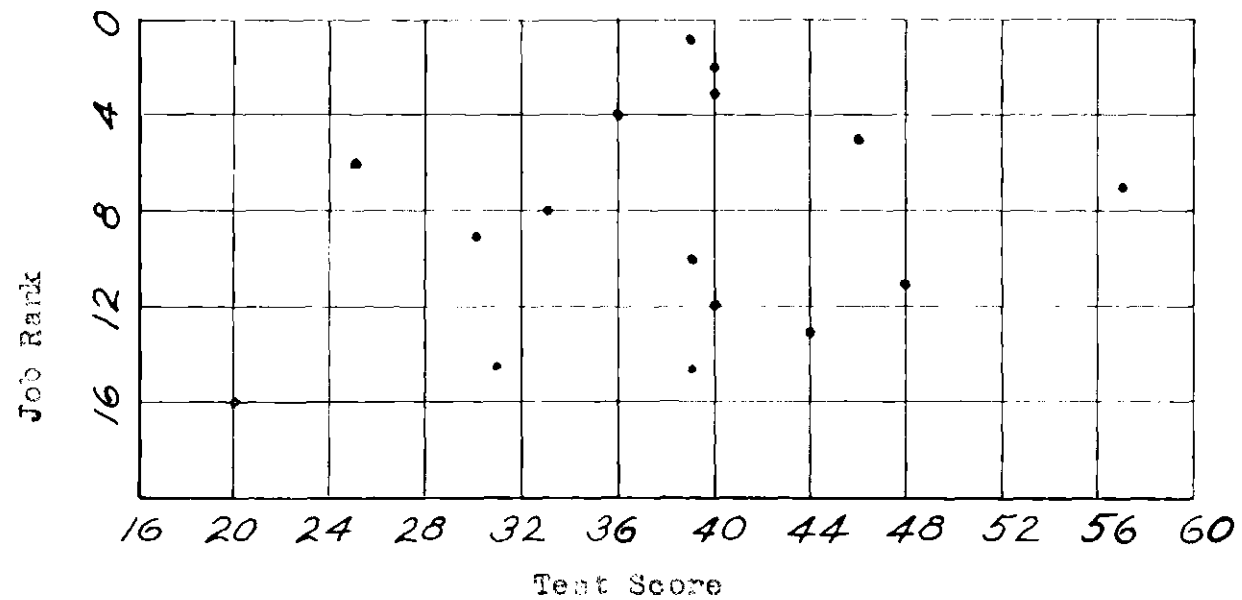


Figure 19. Scatter Diagram, Rank-Correlation -- Agreeableness, Sub-Group 3



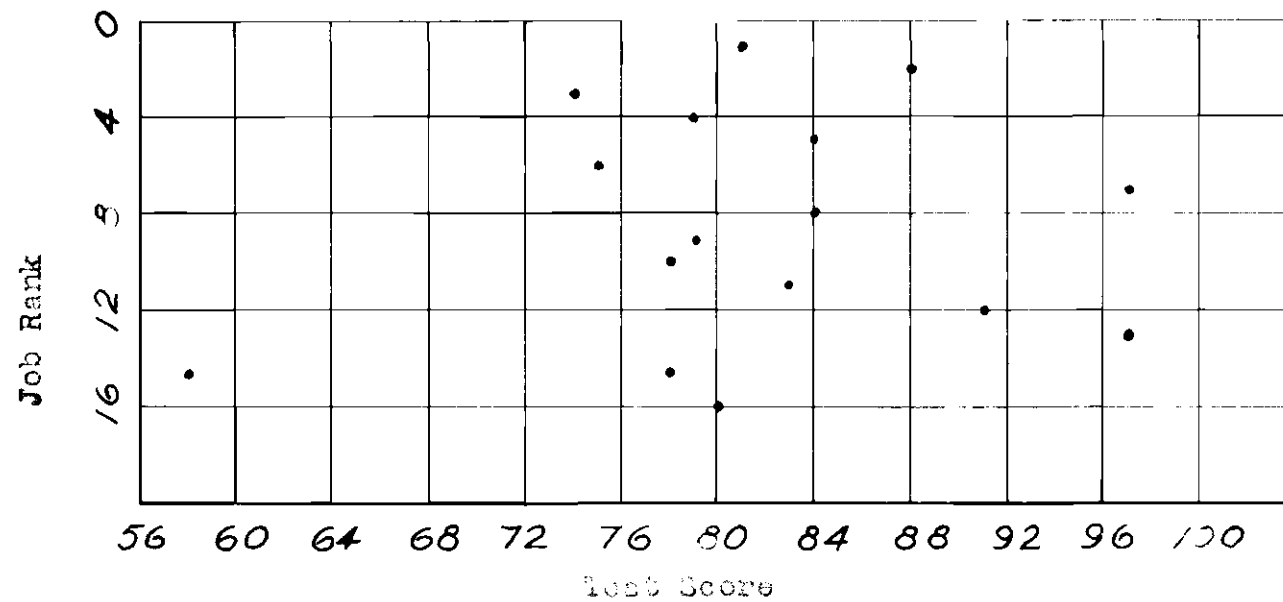


Figure 20. Scatter Diagram, Rank-Correlation -- Co-operativeness, Sub-Group 3

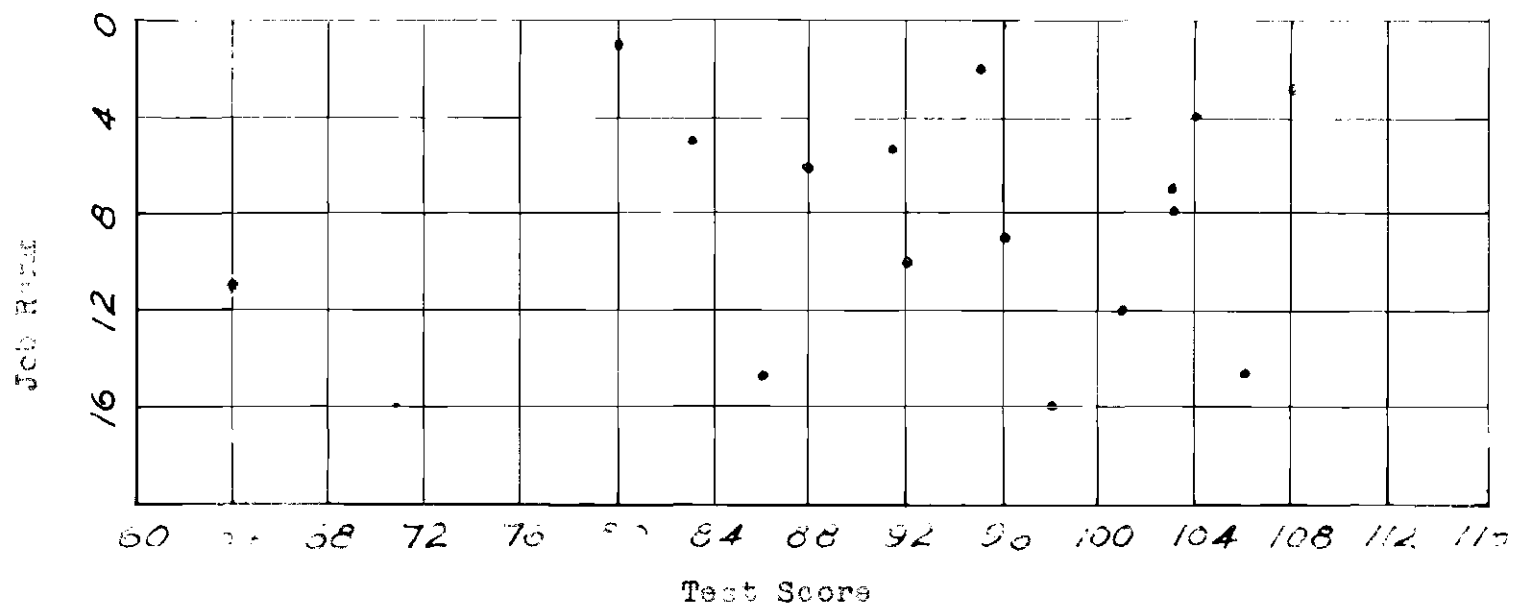


Figure 21. Scatter Diagram, Rank-Correlation -- Mechanical Interest, Sub-Group 3

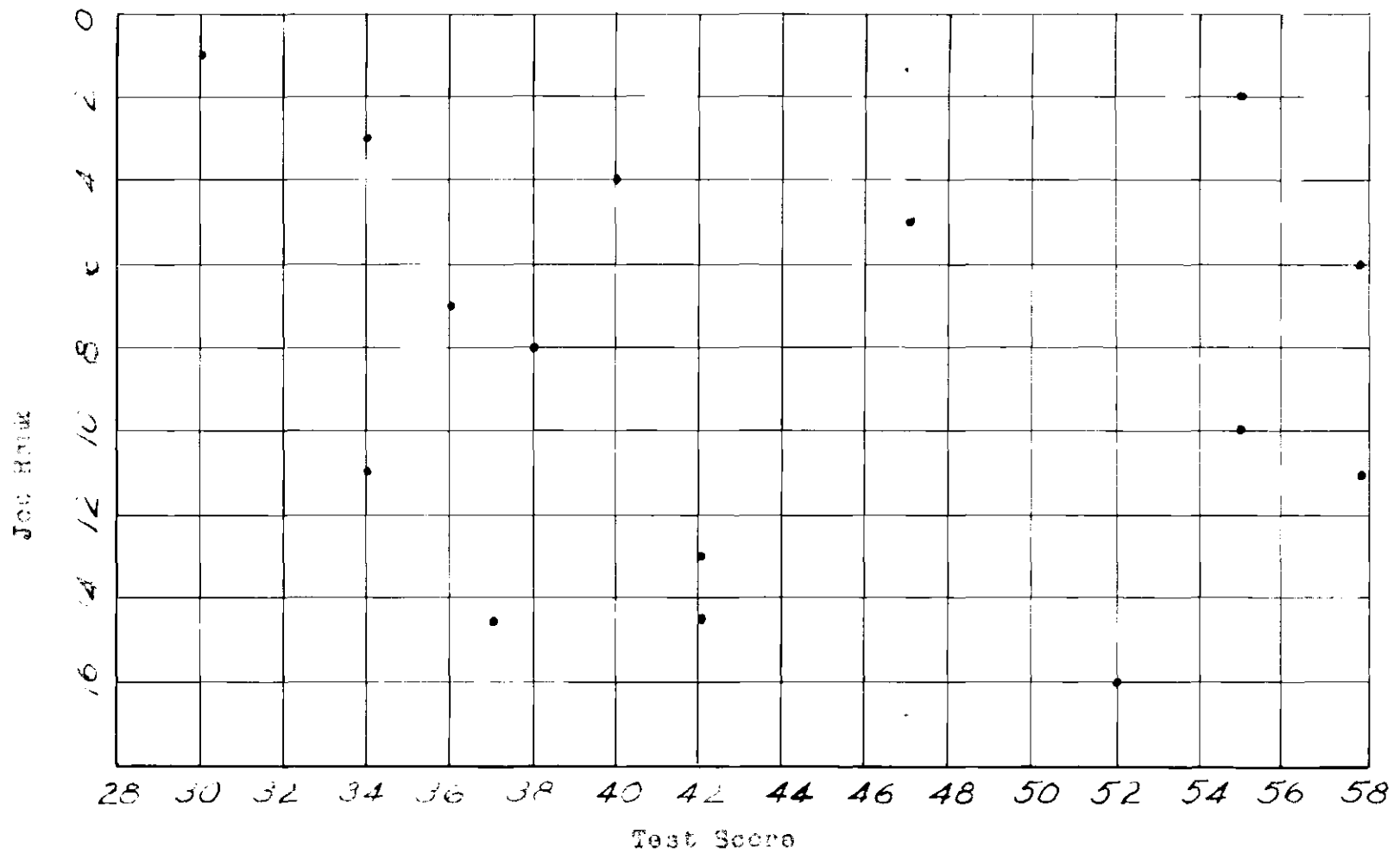


Figure 22. Scatter Diagram, Rank-Correlation -- Computational Interest, Sub-Group 3

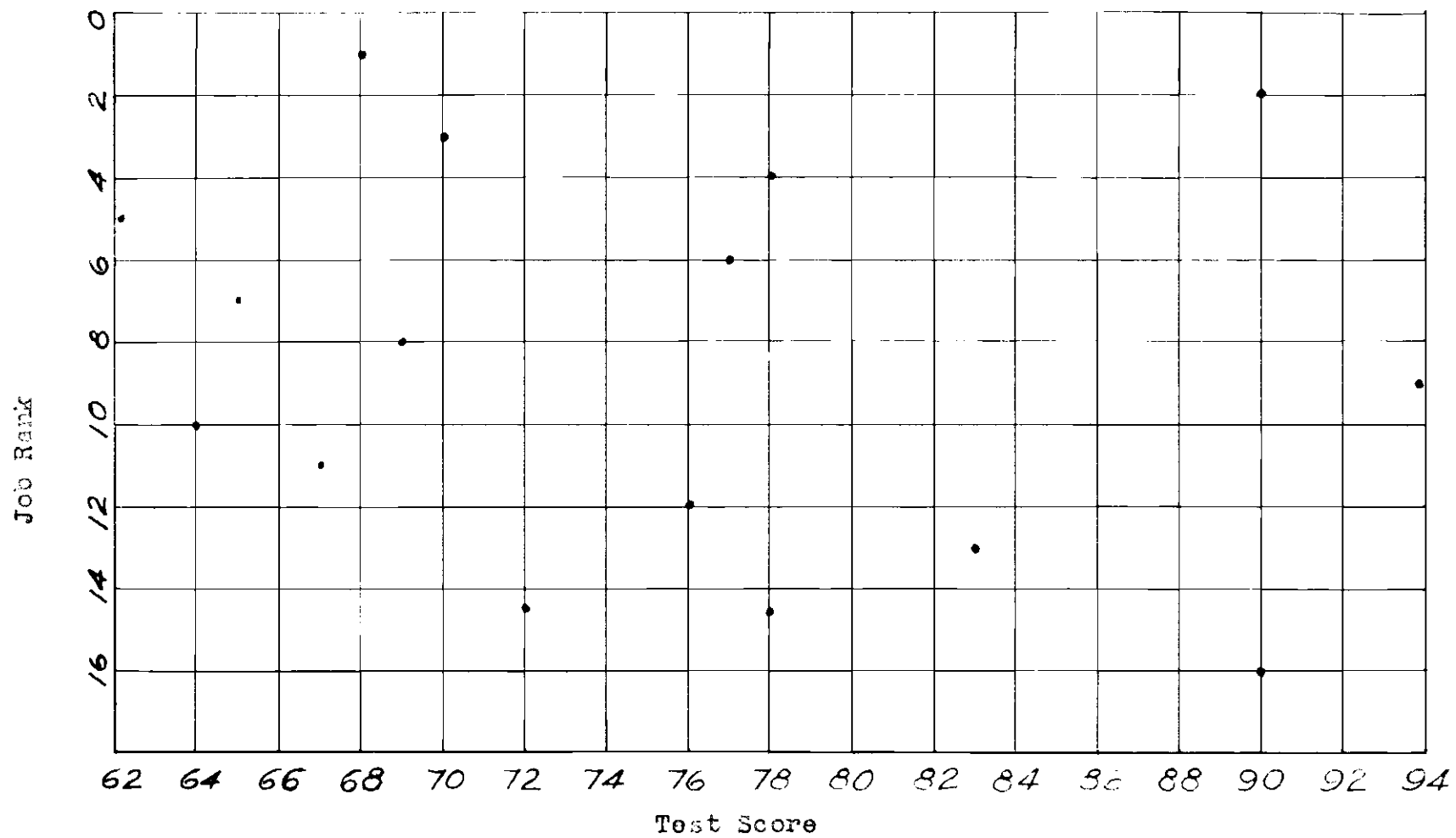


Figure 23. Scatter Diagram, Rank-Correlation -- Scientific Interest, Sub-Group 3

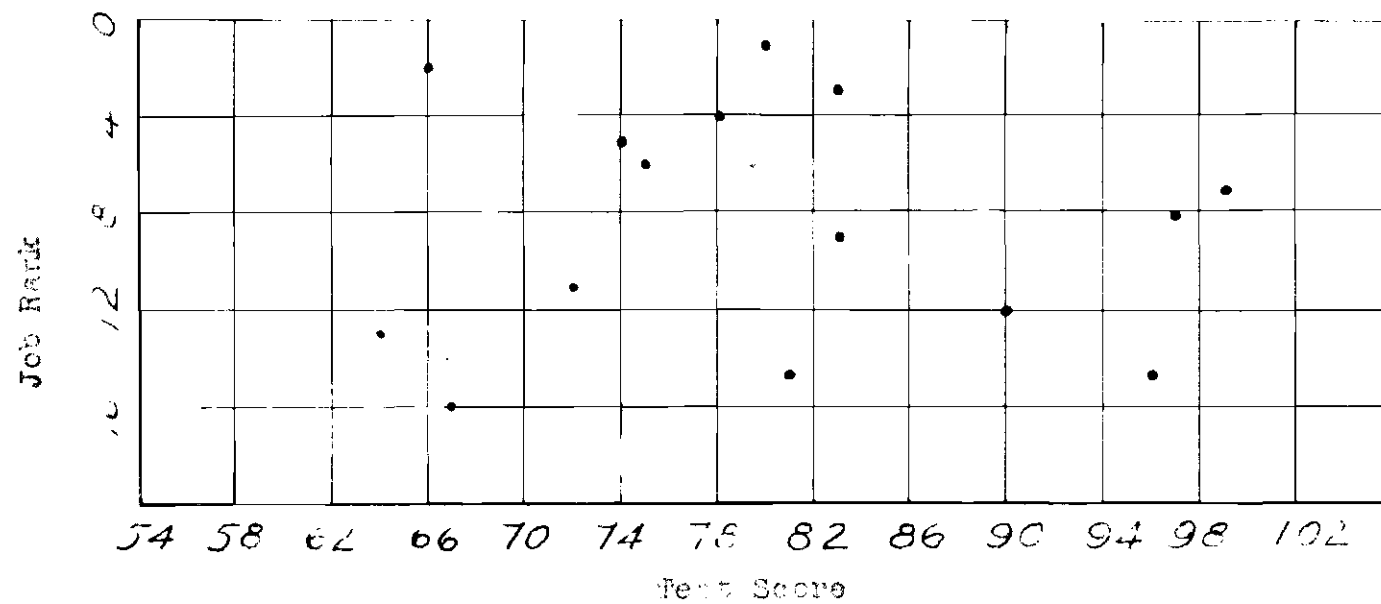


Figure 24. Scatter Diagram, Rank-Grouped -- Performance Interest, Sub-Group 3

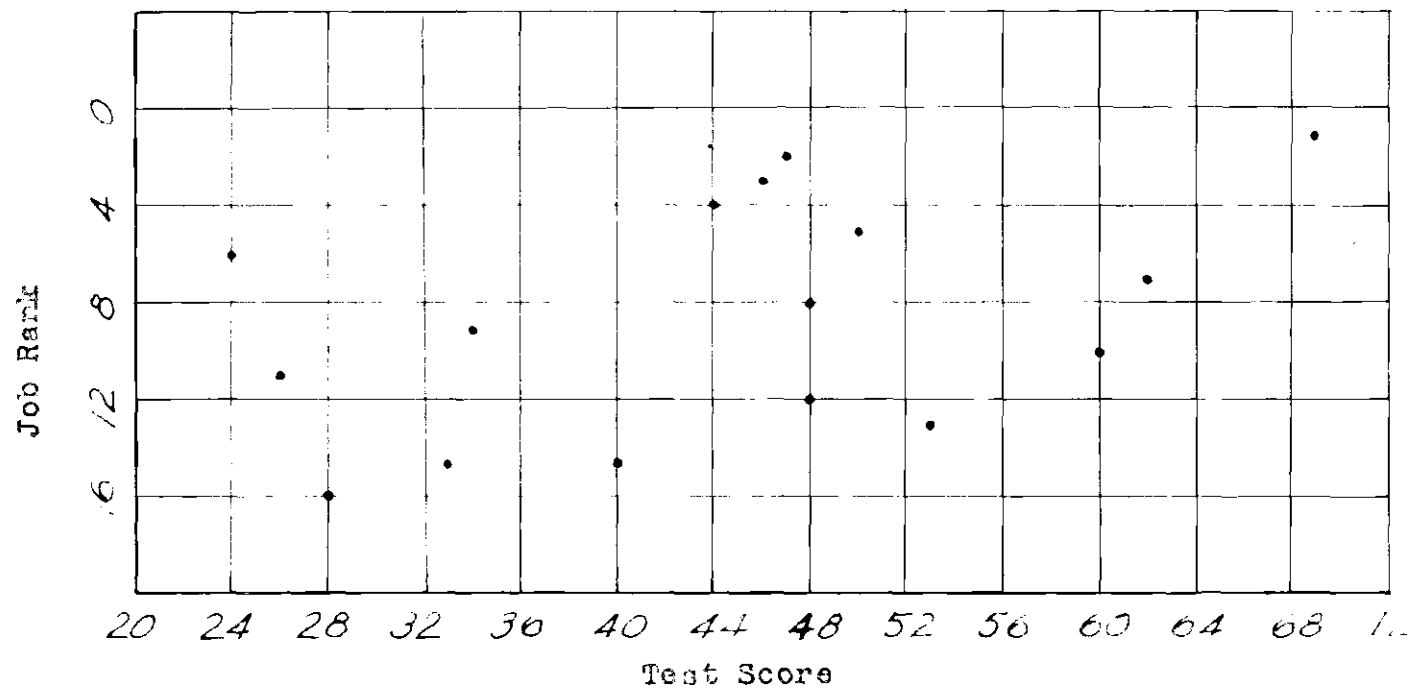


Figure 25. Scatter Diagram, Rank-Correlation -- Artistic Interest, Sub-Group 3

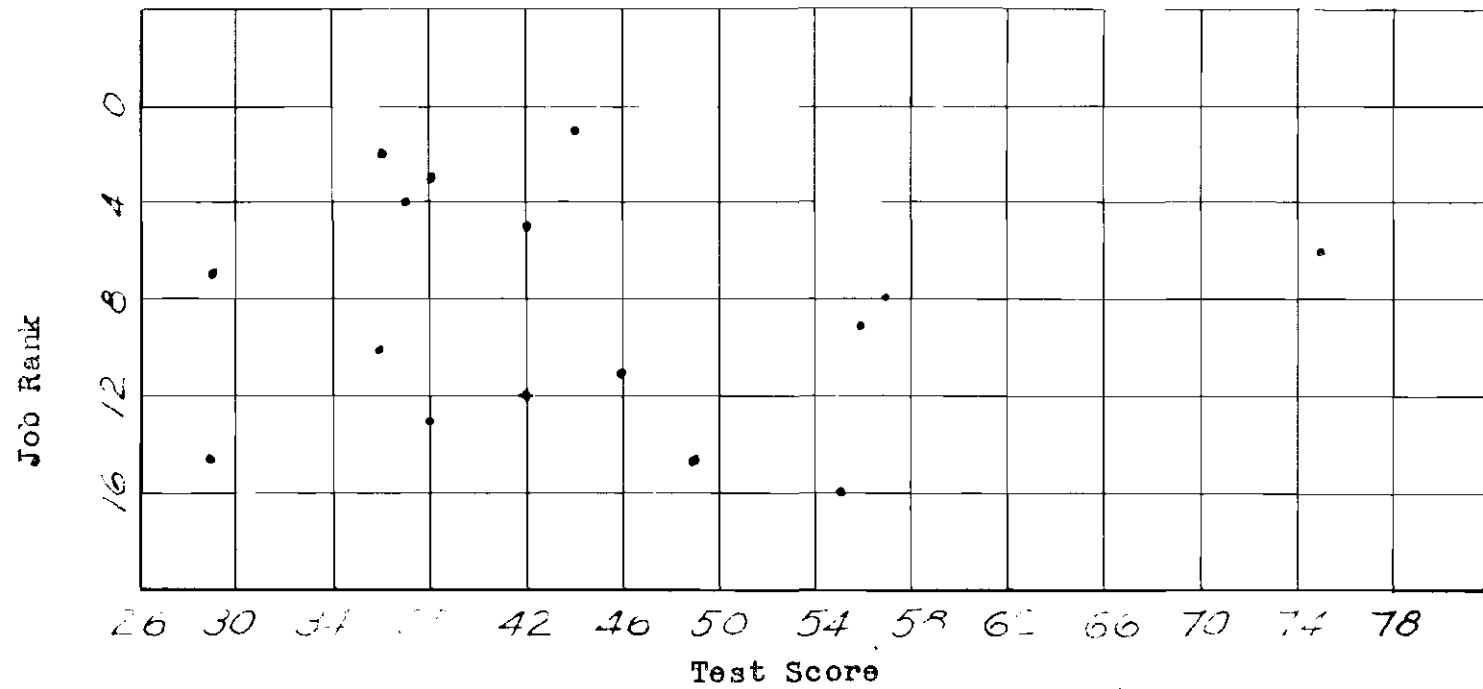


Figure 26. Scatter Diagram, Rank-Correlation -- Literary Interest, Sub-Group 3

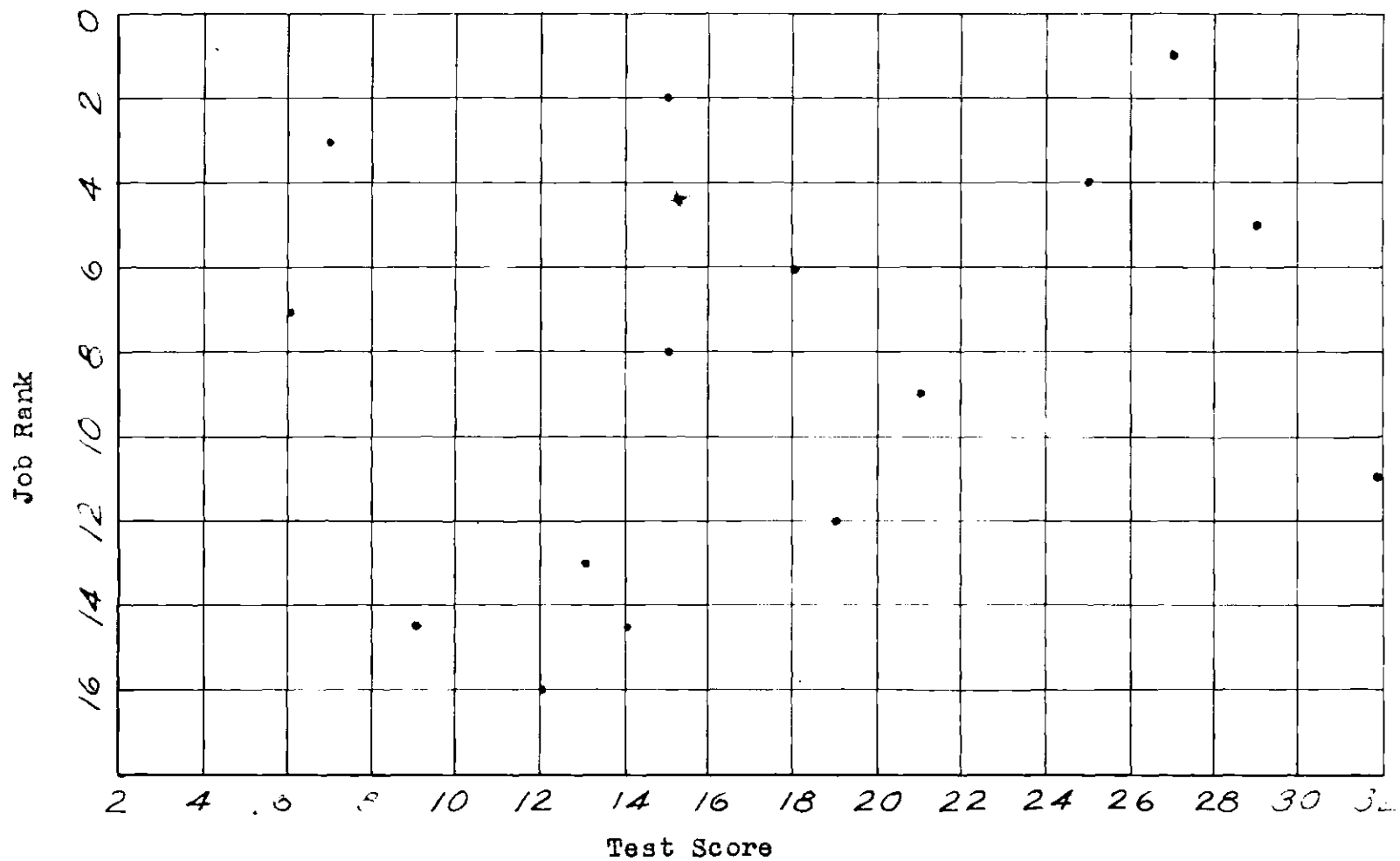


Figure 27. Scatter Diagram, Rank-Correlation -- Musical Interest, Sub-Group 3



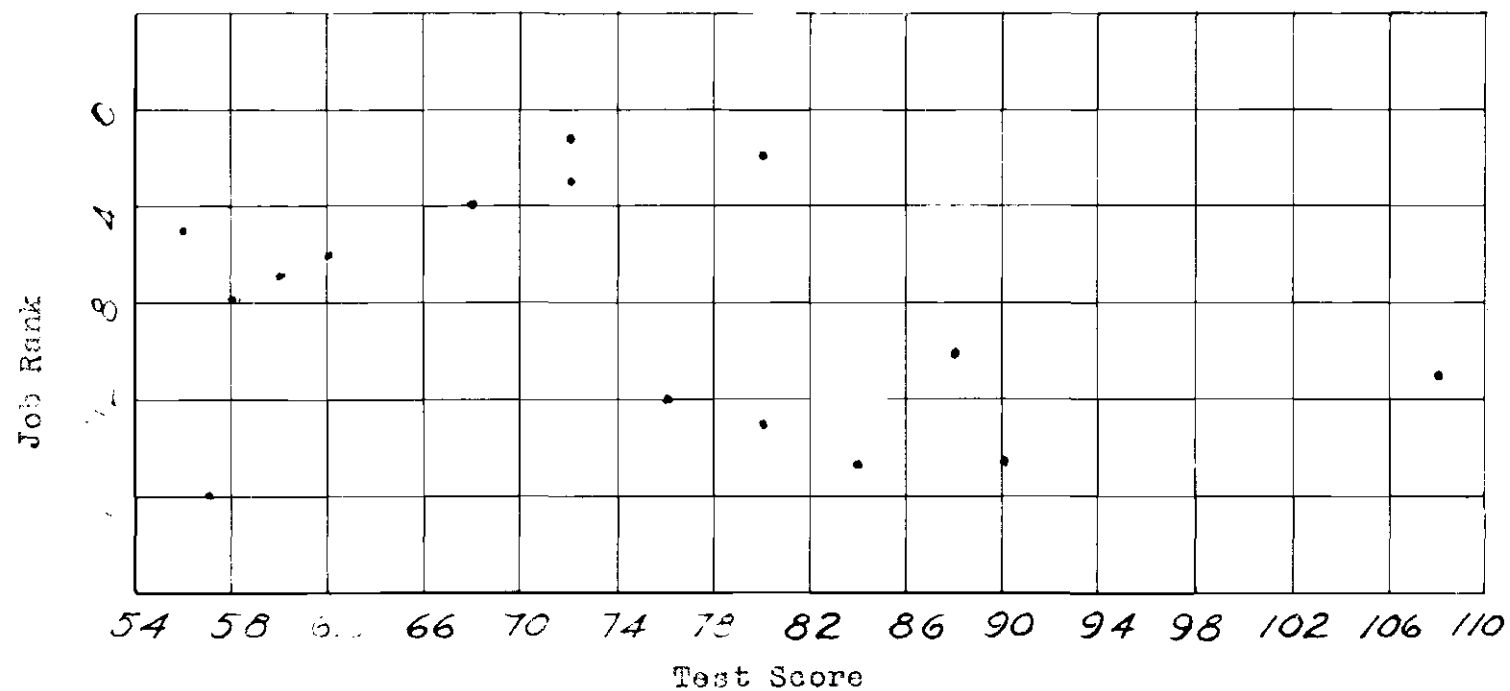


Figure 28. Scatter Diagram, Rank-Correlation -- Social Service Interest,  
Sub-Group 3

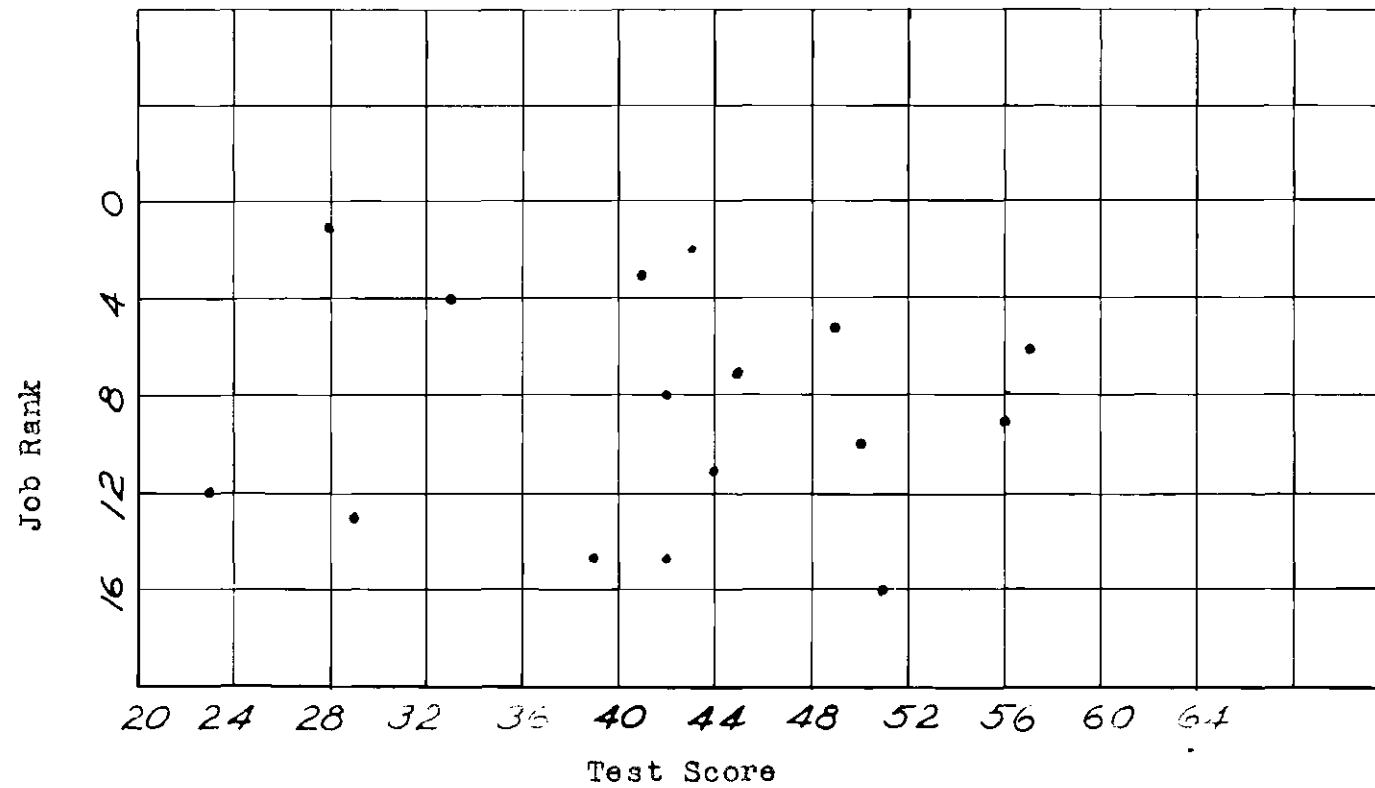


Figure 29. Scatter Diagram, Rank-Correlation -- Clerical Interest Sub-Group 3

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