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## OCCUPATIONAL ABILITIES

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An Introduction to the McGill Programme of Research in the Social Sciences.

By Leonard C. Marsh.

**THE BRITISH IMMIGRANT:**

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# OCCUPATIONAL ABILITIES:

*A Study of Unemployed Men.*

by

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*With an Introduction by*

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## INTRODUCTION.

This volume by Dr. Morton, based upon researches carried on during the last four years under my general supervision, is the first to be issued of a number of psychological studies within the field of employment research which we expect to publish in the McGill Social Research Series.

When proposing as one of the projects for research by this department, a survey, by psychological methods, of the abilities of the unemployed, I had in mind three main problems:—

(1) To what extent is the current unemployment problem a permanent one, not merely one for the duration of the depression?

(2) Can we, by psychological test methods, discover any measurable differences in intelligence, mechanical or clerical skills, educational level, or any character traits, between representative groups of unemployed and employed persons, so as to reveal the relative importance of the various phases of personality for securing and keeping jobs?

(3) Can we, by test methods, acquire more exact knowledge of the requirements for success in a wide range of specific occupations,—the requirements not merely in general intelligence level (already known to a fair degree of approximation), but in as many aspects of personality as are now readily in some sense measurable?

The first of these problems appears to have come now into public notice, since it has become apparent that public relief cannot be discontinued as soon as it had been expected a few years ago. It is plain that the answer depends upon (a) the percentages of the population of working age at the various ability levels; (b) the birth rates at these levels; (c) death rates; and (d) the trends towards or away

from mechanization, or changes in the nature of mechanization, of various lines of production, with corresponding changes in the demand for labour at the various ability levels. While the sample groups of unemployed which yielded the data reported here are not as adequately representative of the total unemployed population as could be desired, the results, when weighted to secure more nearly proportionate representation of the known totals of unemployed in different lines of work, offer at least a rough indication of the true distribution of the traits measured by the tests (Cf. Chapter VI).

Granting that the test scores are not direct measures of industrial capacity, but only fairly reliable estimates of abilities which appear to be of some importance as phases of that capacity, the data, when evaluated in terms of previous experience and summed up in the variants of the Taussig occupational scale, are of value as a means of estimating the true occupational status of the men examined. There is no reason to suppose that the previous occupations reported, or ambitions expressed by the men, represented accurate placement in accordance with real abilities, so the overlapping of the distributions of test scores of the different occupational groups based on the Taussig scale need hardly be taken as invalidating the tests. In general, and especially in the case of the unemployed—some of whom at least must have been industrial misfits—a man's standing in the tests as a whole probably shows approximately the occupational level at which he is most likely to succeed. The data cannot alone solve the problem set; but, when interpreted in the light of evidence from other sources bearing upon the items listed above, they will help to make estimates of the long-run needs for relief or readjustment of the conditions of employment at the different occupational levels something better than guesswork.

Turning now to the question of the occupational signifi-

cance of the various personality traits measured, the data do not offer any clean-cut evidence that test measures are adequate to differentiate between individuals, at any given occupational level, as likely to keep or to lose jobs under such conditions as have prevailed during this depression, but the group comparisons are at least suggestive. Obviously, a very large proportion of the unemployed must have had no defect in skill or personality sufficient to account for their status; they must have lost, or never obtained, jobs simply and solely because there was no work for them to do. If it had been possible to secure from various business establishments sample groups of those employees first discharged, and comparison groups from those retained through the depression, much more striking differences in test scores might have been expected. Local conditions did not permit any such detailed study; indeed, except in the case of clerical workers, Dr. Morton found it impracticable to get employed comparison groups at all. However, the tests appear to have been reasonably adequate to their purpose as psychological measures; so, even though the results are limited, the demonstration of method here offered is of definite value.

In considering the practical value of the techniques herein discussed, it should be stressed that, although some use was made of individual tests, it was deliberately planned to use as far as possible the relatively inexpensive group tests. This necessitated completion of my revision of U. S. Army Beta, and "try-out" testing of various groups of children and adults by Dr. Morton, to secure norms, so that we might have a workable non-verbal general intelligence test. As our ultimate aim was not merely to secure insight into current local business conditions, but to develop personnel methods that may be of real service in industry, economy both in time and in the cost of materials was an important consideration, as also was ease of administration and evaluation of results.



For a more complete theoretical study of individual adaptability for employment, as well as in actual employment procedure, the results of a medical examination should be linked up with the test data. Some medical studies of the unemployed have been undertaken by the McGill Department of Public Health in contribution to the general programme of which our psychological studies are also a part, but, unfortunately, it was not possible to arrange for such study of the groups investigated psychologically.

There are many other aspects of the problem of individual employability concerning which such a psychological study as this has little to say, but which could not be neglected in any complete theoretical treatment of the causes of unemployment, or in any worth-while attempt to make practical suggestions for relief and reform. For example, while it is perhaps true that a study of large sample groups from different races or religious sects might reveal significant differences in the averages with respect to certain special interests and aptitudes, it is quite plain that the overlapping of the distributions would be so great as to preclude prognosis of individual abilities on the score of race or sect. Yet who can claim that under existing circumstances these matters should be ignored by a vocational counsellor? Discussion of such factors as are not amenable to study by psychological methods is hardly appropriate here, but it is essential to recognize their existence and importance, and to insist that a successful approach to such a broad social problem as that of unemployment requires the close co-operation of all the social sciences.

The McGill Social Research Council is an embodiment of the realization of this fact. The organization and its general programme of research, having been fully described in the introductory volume of this series, need no discussion here. Instead, and by way of indicating from the standpoint of the psychologist the part played by the present

volume, and others in the course of preparation, in a comprehensive study of unemployment, I reproduce, somewhat abridged, a memorandum offering a rough analysis of the problems in this field, written in the spring of 1930, when we were first considering the possibilities of co-operation in research.

"Unemployment is due to such causes as lack of adjustment of individuals to jobs in accordance with mental level, temperament, etc; lack of vocational education; child labour; fluctuations in economic conditions; difficulties in adjustment of immigrants; overproduction, in some cases seasonal, but a new factor is present world overproduction. . . . The causes concern several departments, and a solution can be found only by co-operative investigation, since the problems open to study by the various departments are so closely interrelated. E.g.,

*Biology and Medicine.*

Eugenics, public hygiene, epidemiology, immunity—racial and individual, school hygiene, industrial hygiene, etc.

*Psychology.*

Individual, sex, and race differences in intelligence, temperament, etc; special aptitudes and defects, with a view to educational and vocational guidance; efficient methods of learning in both education and industry; scientific management; industrial relations—employment, wage scales, relationship between age and efficiency, etc; advertising and salesmanship.

*Education.*

Reform of teaching methods so as no longer to drive children out of school into employment; adjustment of education to allow for individual differences in ability and interests; education for harmless enjoyment of leisure on the part of persons of average ability and less—instead of merely the superior; practical development of vocational guidance and less expensive methods of vocational education; extension of education for *all* through adolescence—putting a stop to child labour both for the sake of the children and to lessen adult unemployment.

*Sociology.*

Studies in educational sociology, adult education, social service, etc; problems of recreation, preservation of rural community life, treatment of immigrants, influence of employment of women on family life, social factors in industrial relations, etc.

*Economics.*

Industrial re-organization to take advantage of scientific methods; the low-wage low-production versus the high-wage high-production system; question of further reduction of hours of employment; craftsmanship in modern life; unemployment insurance schemes that will not penalize the industrious in favour of loafers; co-operative ownership, etc.

*Law and Politics.*

Simplification of legal terminology and procedure to inculcate respect for law on the part of a shifting population with more time for leisure; the question of residence requirements for voting, poor relief, etc., as related to seasonal labour; public works to take up the slack in employment; tariffs, immigration, etc."

A companion study to the present one is nearing completion by Mr. Kenneth E. Norris. Dealing largely with the same groups or subjects, it will link up some of the data reported by Dr. Morton with a more detailed analysis of the vocational significance of knowledge and skills in the various branches of the elementary school curriculum.

A comparative study of employed and unemployed female clerical workers, along lines similar to those followed by Dr. Morton with male clerical groups, has been completed by Miss Barbara M. Robertson, and will probably be published in the near future, as one of a series of bulletins planned to supplement this series of larger volumes.

An extended study of the problems and possibilities of vocational guidance, supervised by Dr. William D. Tait, Chairman of the Department of Psychology, has been carried on for some years by Mr. E. C. Webster, whose work is now being prepared for publication. While the other investigations have attempted to throw light on the nature of the individual differences in abilities required for success in various occupations, Mr. Webster's problem is to discover whether such differences can be revealed at an early stage in the development of the individual, and by what

methods this can most conveniently and economically be accomplished.

Concerning the psychological requirements of the many specific occupations, the third of the problems mentioned above, the evidence offered by the present report is very meagre. Dr. Morton is planning to carry on with work in this field. Much superficial information about the duties and requirements of various jobs is of course already available. Thorough analysis in terms of fundamental abilities is another matter, and will require many years of intensive research by students in different regions who have access to sufficiently large samples of workers. Piecemeal research is tedious, but there seems to be no alternative, short of a most marked and rather unlikely change in the social recognition of the importance of psychology.

Everyday experience justifies the expectation that the results of further research will show that the types of human ability required for vocational success are much less numerous than the specific kinds of employment in industry, business, and professional life; also that the abilities of individuals, especially in regions where "division of labour" is marked, will in general meet the demands of more than one type of occupation—when these are eventually defined in psychological terms. Successful transfer from one occupation to another apparently quite distinct has not been unfamiliar. More adequate knowledge of basic requirements should facilitate such transfer, and so help to relieve the overcrowding in some lines of work. In dealing with adults, whether unemployed or employed but desirous of a change, it is plain that in the case of all the more skilled occupations, attention must be given not only to basic capacities, but to the actual degree of relevant knowledge and skill possessed by each applicant. Accordingly, such tests as those used in the present study should be supplemented in actual employment-office practice by

specific trade tests. In our further studies of various occupations, efforts will be made to improve upon existing trade tests or devise new ones as required.

As training has in the past been mostly aimed at specific occupations, complete flexibility of employment in accordance with basic capacities cannot reasonably be hoped for in the case of the present adult population. We must therefore look to the future for realization of such an ideal. In the course of a memorandum dealing with educational and vocational guidance, set down shortly after the one cited above, I proposed:

"A statistical and job-analysis study of occupations, and the working out of a complete classification of occupations with reference to nature of abilities required, pay, number of openings, stability of employment; etc., so as to establish groups of related jobs for which pupils might be given a broad technical and cultural training.

"A study of economic trends and vocational opportunity,—the probable results of mechanization upon industry in coming years; can invention be guided towards the mechanization of jobs that people do not like, and away from the mechanization of work that people enjoy doing? Can similar account be taken of the number of persons possessing and jobs calling for various abilities, so that more people can find jobs they can do well, and fewer will have to stay in work not suited to their real capacities?"

Obviously, these questions remain open. We may be confident that research will eventually yield the requisite information. Application of this information in practical life presupposes the recognition of business leadership as a profession—the evaluation of success in business on the score of achievement for the general good, as in medicine, teaching, engineering, and other professions, instead of on the score of financial receipts. This granted, we may hope for reasonably continuous employment in some socially useful activity on the part of all citizens except the feeble-minded, insane, or otherwise incapacitated, not merely as a right, but as an obligation to contribute in return for benefits received. This implies the practical abolition of seasonal unemployment, either by changes in technique or

trade practices, or by seasonal transfer of individual workers from one occupation to another requiring similar abilities—with due provision for maintenance of rights to seniority, shares in reserves for unemployment benefits and pensions, citizenship rights and obligations despite changes in residence. Stabilization of employment also presupposes the establishment of a decent standard of living for all members of the community, with due allowance for differences in cultural level and in the expense of preparation for and maintenance of efficiency in the various occupations. Such general reforms cannot of course be based merely upon psychological researches. They require technical contributions from all the social sciences and the collaboration of experienced business men, labour leaders, and government authorities. But in the system of labour exchanges which is essential to secure continuity of employment, psychological methods must play an important part. This volume represents the first stages of an attempt to improve upon earlier techniques, and will accordingly be of interest and, we hope, of considerable practical value to personnel managers, employment-office workers, and others who are concerned with the perfecting of employment methods. In this connection, special attention is invited to the case studies presented on pages 193-233.

In conclusion, I wish to add to those of Dr. Morton my grateful acknowledgements to those whose co-operation made this study possible, and to Mr. Leonard C. Marsh, who as general editor has given us much valuable assistance in preparing this volume for the press.

CHESTER E. KELLOGG.

Montreal,  
November, 1935.

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The management and employees of nine firms in Montreal assisted actively in permitting the examination of employees often as well placing at the investigator's disposal facilities for testing employees on company property and within company time. These firms, whose sympathy and co-operation is gratefully acknowledged, are as follows: The American Can Company, the Canadian National Railways, the Canadian Pacific Railway Company, the Dominion Rubber Company Limited, the Montreal Tramways Company, Murray's Lunch Limited, the Northern Electric Company Limited, the Star Company Limited of Montreal, and the Sun Life Assurance Company of Canada. To the last-named company an additional debt is owing as well for providing facilities for administering tests to certain groups of unemployed men.

The Imperial Tobacco Company of Canada Limited and W. C. Macdonald Incorporated very kindly furnished a

large number of packages of cigarette tobacco for use as rewards to the men to whom tests were given at the Day Shelter for Unemployed Men.

Lastly must be recorded the thanks of the investigator to the subjects of the investigation themselves—the many anonymous individuals, employed and unemployed, who so willingly gave their time and energies to a pursuit which must often have been of none too great an immediate interest to them, but without whose aid this report would not have been possible.

N. W. M.



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## APPENDIX A: TESTS AND QUESTIONNAIRES.

The primary data of the present study fall into two classes: first, facts relating to the personal history and occupational background of each subject included in the investigation; and secondly, his scores upon a battery of psychological tests. Data of the first class were secured mainly through the use of a four-page printed questionnaire, which was filled in by each individual.<sup>1</sup> This questionnaire, which is shown on page 245, covered the following main sections of enquiry:

- (1) The individual's name, age, and address, together with information concerning his parents: their nationality, and the occupational experiences of his father.
- (2) Information as to individual's personal history, under several main headings:
  - A. Place of birth, marital status, religion, length of domicile in Canada and in Montreal, number of dependents, etc.
  - B. His regular occupation, regularity of employment during the past three years, part-time employment during the previous twelve months, length of time unemployed.
  - C. Education and training, including apprenticeship, with reasons for leaving school (possible reasons were cited, and were checked by the individual).
  - D. Occupational history (i) from time of leaving school until aged twenty, and (ii) since aged twenty.
  - E. Reason or reasons for present unemployment. Possible reasons were enumerated, and were checked by the person interviewed. The individual was further required to indicate whether the loss of his last job was due to discharge, lay-off, or voluntary resignation, and whether he had any physical incapacities such as to interfere with his employment, and if so, what their nature and duration were.
  - F. Statements concerning domestic relationships, such as employment of wife, education and employment of children, etc.

The psychological tests and questionnaires which were used were selected almost wholly from those already exist-

<sup>1</sup>The questionnaire was drawn up by the Executive Committee for joint use in a number of the studies included in the McGill Social Research programme.

ing and standardized. The reasons for this were two. First, the construction and standardization of a psychological test requires as a rule a great deal of time, effort, and expense. Secondly, the use of tests which have been employed in previous researches often makes possible advantageous comparisons, in addition to providing information beforehand as to the appropriateness of the test. One test was developed (as a revision of a previous test) for the particular purposes of the present study: Revised Beta Examination. All other tests had been used in investigations prior to 1931, or had at least been developed and standardized by that time.

The tests used were as follows:

- (1) *Revised Beta Examination.* This, a non-verbal test of general mental alertness, is a revision of United States Army Beta Examination, which was employed extensively during 1918 for the testing of army recruits who were illiterate or of foreign origin.<sup>1</sup> It includes in its revised form six sub-tests, of which the content is exclusively non-verbal. As the instructions for the test can be given by demonstration, and as fore-exercises for practice are included, it is well suited for dealing with men for whom a language test involves a definite handicap.

The total possible score upon the test is 123, and the letter-grades (following Army Alpha and Beta Examination) are as follows:

A	100-123
B	87- 99
C+	75- 86
C	65- 74
C-	55- 64
D	45- 54
E	0- 44

The time necessary for administration ranges from 25 to 40 minutes, depending upon the size and character of the group tested, and the number of assistants. Its reliability coefficient, determined by the odd-even half method, and augmented by the Spearman-Brown formula, is .987.<sup>2</sup>

- (2) *Army Alpha Examination.* This is the 1925 Psychological Corporation Revision of Army Alpha, executed by Dr. E. O.

<sup>1</sup>Yerkes, R. M. "Psychological Examining in the U. S. Army." *Memoirs of the National Academy of Science*, Vol. 15 (1920).

<sup>2</sup>Kellogg, C. E. and Morton, N. W. "Revised Beta Examination." *Personnel Journal*, Vol. 13 (1934), pp. 94-100.

Bregman, and following in the main Form 8 of U.S. Army Alpha. Time of administration is forty minutes; reliability coefficient, approximately .97.<sup>1</sup>

- (3) *Otis Self-Administering Test of Mental Ability, Higher Examination Form A.* This, like Army Alpha, is a group-type verbal test of intelligence. Time of administration is thirty-five minutes; reliability (alternative forms) .935.<sup>2</sup>
- (4) *New Stanford Achievement Test, Advanced Examination, Form V.* The tests included within this examination serve as a measure of achievement in a number of school subjects. Certain tests, namely, Test 5 (Literature), Test 6 (History and Civics), and Test 8 (Physiology) were not used, because their content was not altogether appropriate to the men tested. Tests 1 (Paragraph Meaning), 2 (Word Meaning), 3 (Dictation), 4 (Language Usage), 7 (Geography), 9 (Arithmetic Reasoning), and 10 (Arithmetic Computation), having a total time of administration of about two and one-quarter hours, were used. This group of tests had a joint reliability of about .95, while individual test reliability coefficients ranged from .84 to .96.<sup>3</sup>
- (5) *Thurstone Clerical Examination, Form A.* This test, which is supposed to serve as a measure of clerical ability, is scored in terms of both speed and accuracy. The total score is the weighted sum of the errors made in the course of the examination, and the total number of minutes required for completion. One alteration in the procedure of scoring seemed advisable: Test 5, consisting in the classification by cities of a list of mixed names, included in its instructions the injunction to place these names in alphabetical order within each city group. Placement in alphabetical order was not made in a great many cases, and this would have resulted in what appeared to be undue penalization, quite uncorrelated with the total score for the remainder of the examination. Accordingly, the necessity of placement in alphabetical order was disregarded. Thurstone cites the test as having a validity coefficient of .61, with office ratings as a criterion.<sup>4</sup> When age and schooling are added, by the device of multiple correlation, the coefficient is raised to .67. Stedman, using it to predict grades of students in book-keeping, found that it correlated .74 with book-keeping grades, and correlated .73 with the

<sup>1</sup>For norms, see Bregman, E. O. "On Converting Scores on Army Alpha Examination into Percentiles of the Total Population." *School and Society* 23 (1926).

<sup>2</sup>Otis, A. S. *Manual of Directions for the Otis S-A Tests of Mental Ability.* (World Book Company, Yonkers, N.Y., 1928).

<sup>3</sup>Kelley, T. L., Ruch, G. M., and Terman, L. M. *Guide for Interpreting* (Second Revision). (World Book Company, Yonkers, N.Y., 1929), p. 9.

<sup>4</sup>Thurstone, L. L. "A Standardized Test for Office Clerks." *Journal of Applied Psychology*, Vol. 3, (1919), 248-251.

Carlson Book-keeping Test.<sup>1</sup> The correlation between the Terman Group Test and grades was .58. Time of administration varies from forty-five to ninety minutes, according to the individual subject. The reliability of the test is not known, but is probably adequate.

- (6) *National Institute of Industrial Psychology Clerical Test (Moore American Revision)*. This test, a revision of the English test of clerical ability, is reported by Moore to have shown validity coefficients of .87 and .94 with two groups of office clerks in Springfield, Massachusetts (N=18 and 26).<sup>2</sup> The criterion was in each case ratings by two officers of the firm. The range of scores reported for office workers is 39 to 117, and for a general population of over seven hundred, 12 to 134, with a possible maximum of 161. A score of 80 or over appears to be requisite for satisfactory work. Administration time is thirty to thirty-five minutes. The reliability of the test is not known, but is probably quite high.
- (7) *Scott Company Filing Test*. This test was developed by the Scott Company as a test for filing clerks, but was considered equally valid for predicting success at general clerical work. According to Paterson, the extent of correlation between rated trade status and score, for a group of 43 filing clerks, is .82, while the correlation between mental alertness and trade status is .63.<sup>3</sup>
- (8) *Minnesota Paper Formboard, Forms A and B*. This test, a development of the formboard test of Army Beta Examination, considerably lengthened and increased in scope, was used by investigators of the Minnesota mechanical ability project as one of the tests selected for their final battery. It was determined to have a validity coefficient of .52 (uncorrected for attenuation) when the quality of shopwork was used as a criterion, and to have a reliability coefficient of .90.<sup>4</sup> Similarly, Hall found it moderately diagnostic in the determination of promising pressman apprentices and to have in this case a validity coefficient of .58 when correlated with rankings.<sup>5</sup>
- (9) *O'Connor Wiggly Blocks Test*. This constitutes a performance test of engineering aptitude, the material used being nine pieces of wood which are required, after being laid before the subject in a prescribed fashion, to be placed together so as to form a

<sup>1</sup>Stedman, M. B. "Factors Influencing School Success in Book-keeping." *Journal of Applied Psychology*, Vol. 14 (1930), pp. 74-82.

<sup>2</sup>Moore, H. "The Institute's Clerical Test in America." *Human Factor*, Vol. 7 (1933), pp. 407-409.

<sup>3</sup>Paterson, D. G. "The Scott Company's Filing Clerk's Test." *Journal of Personnel Research*, Vol. 1 (1922-23), pp. 547-561.

<sup>4</sup>Paterson, D. G. et al. *Minnesota Mechanical Ability Tests*. (University of Minnesota Press, Minneapolis, 1930), pp. 57 ff., 299.

<sup>5</sup>Hall, O. M. "An Aid to the Selection of Pressman Apprentices." *Personnel Journal*, Vol. 9 (1930-31), pp. 77-81.

10" x 5" x 5" block. Three trials are given, a time score being used. The second and third trials, according to O'Connor's instructions, are weighted for practice effect, and the final score is the mean of the three weighted trial scores.<sup>1</sup> O'Connor states that these blocks have been used successfully in the selection of engineering apprentices at the General Electric Company plants, and gives some indication of definite grade norms.<sup>2</sup> Scott, Clothier, and Mathewson, in their discussion of test uses and results, provide further data regarding the validity of this test.<sup>3</sup> Its reliability is relatively low. O'Connor states the correlation between trials 1 and 2 to be .36, and between trials 2 and 3, .38. These coefficients are confirmed by Remmers and Schell, who suggest that the reliability of the three trials together is about .57.<sup>4</sup>

- (10) *Kent-Shakow Formboard (4b)*. This formboard, one of a series designed by the same authors, consists of twenty pieces of wood which are to be fitted into five slots of different size and shape. Four pieces are required for each slot, and the pattern of cut for the pieces of each slot is the same. The test is scored by the time required to complete the formboard.<sup>5</sup>
- (11) *Cuba Construction Test (N.I.I.P.)* Developed by the National Institute of Industrial Psychology and the Industrial Health Research Board, this test has been used as one of a series of performance tests of intelligence. It involves the fitting together of cubes, painted on different sides, so that a prescribed relationship of the cubes is obtained. Raw scores, based on time and the number of movements made in assembling the blocks, are converted into point scores. The test correlates from .27 to .44 with a group test of intelligence, and correlates .63 with Spearman's "g".<sup>6</sup>
- (12) *Stenquist Mechanical Aptitude Test I*. This is a picture test requiring the pairing of 190 mechanical objects, presented in sets of five pairs, so as to indicate those which normally go together (as screw and screwdriver, brace and bit, etc.). It was employed originally by Stenquist for purposes of vocational guidance, on the assumption that in the case of boys, knowledge of the relationship of mechanical objects was indicative of

<sup>1</sup>Keane, F. L. and O'Connor, J. "A Measure of Mechanical Aptitude." *Personnel Journal*, Vol. 6 (1927-28), pp. 15-24.

<sup>2</sup>O'Connor, J., *Born That Way*. (Williams and Wilkins, Baltimore, 1928).

<sup>3</sup>Scott, W. D., Clothier, R. C., and Mathewson, S. B. *Personnel Management*. (McGraw-Hill, N.Y., 1931), pp. 227-229, 275-276.

<sup>4</sup>Remmers, H. H. and Schell, J. W. "Testing the O'Connor Wiggly Blocks Test." *Personnel Journal*, Vol. 12 (1933-34), pp. 155-159.

<sup>5</sup>Kent, G. H. and Shakow, D. "A Graded Series of Formboards." *Personnel Journal*, Vol. 8 (1929-30), pp. 115-120.

<sup>6</sup>Earle, F. M., Milner, M. et al. *The Use of Performance Tests of Intelligence in Vocational Guidance*. Industrial Health Research Board Report No. 53, London, 1929, pp. 28-31, 48-49, 52.

mechanical aptitude. He cites the validity coefficient of the test as having a median value of .67, and as ranging as high as .84.<sup>1</sup> The final findings of the Minnesota investigators indicated it to have a validity co-efficient for their quality criterion of .24, and to have a reliability co-efficient of .74.<sup>2</sup> Simpson, in a study of mechanical aptitudes among a group of convicts, found that it displayed a reasonably significant relationship to the individual's occupational experience: 53% of the persons scoring in the highest quartile had held as their longest job (for an average of 54.1 months) one essentially involving mechanical operations, while only 14% of the lowest quartile (for an average period of 51.3 months) had had similar experience.<sup>3</sup> It appeared in this investigation to be positively related to Army Alpha Examination, the coefficient of correlation being  $+.46 \pm .03$ . The Minnesota investigators, on the other hand, found it to correlate only to the extent of  $+.04$  with Otis I.Q., and  $+.11$  with Otis mental age.<sup>4</sup> These differences are probably explicable in terms of different ranges of ability, however.

- (13) *Minnesota Mechanical Assembly Tests, Sets I and II.* These tests involve the assembly, within a given limit of time, of twenty dis-assembled mechanical appliances and tools. Scoring is based on the number of units correctly, or partially correctly, assembled. The tests in their longest form (36 units as against the present 20) correlated .55 with the Minnesota shop operations quality criterion. The coefficient of reliability is probably about .90.<sup>5</sup> Time of administration, over one hour.
- (14) *Cox Mechanical Aptitude Test, Form M1.* This test consists in the selection by the subject of the unseen essential features of a working wooden model (involving pulleys, levers, etc.), using as a guide a plan of the model which includes irrelevant additions to the working parts.<sup>6</sup> The test is made up of nine models, which increase in complexity, and for which there is a total (perfect) score of 46 points. Its reliability, determined in the present investigation on the basis of the inter-correlation of scores on odd and even models (compensated by the Spearman-Brown formula) was found to be .64. Time of administration was about forty-five minutes.
- (15) *O'Connor Tweezer Dexterity Test.* This test is used as one measure of the individual's capacity to deal dexterously and

<sup>1</sup>Stenquist, J. L. *The Stenquist Mechanical Aptitude Tests.* (World Book Company, Yonkers, N.Y., 1922), p. 11.

<sup>2</sup>*Loc. cit.*, p. 299.

<sup>3</sup>Simpson, R. M. "The Mechanical Aptitudes of 312 Prisoners." *Journal of Applied Psychology*, Vol. 16 (1932), pp. 485-495.

<sup>4</sup>*Loc. cit.*, Appendix IV.

<sup>5</sup>*Loc. cit.*, pp. 299, 315-327.

<sup>6</sup>Cox, J. W. *Mechanical Aptitude.* (Methuen, London, 1928), p. 206.

quickly with small objects. Its procedure involves picking up one hundred small brass pegs, one at a time, with a pair of sharp-nosed tweezers, and inserting them into a like number of small holes drilled in a metal plate.<sup>1</sup> One trial is given, and is scored in minutes and hundredths. The reliability of the test is not known, but it is probably adequate, for it correlates from .42 to .67 with a similar test, the O'Connor Finger Dexterity Test, the reliability of which is .93 (first vs. second half).<sup>2</sup>

- (16) *Nuts and Bolts Assembly Test*. Devised by investigators of the National Institute of Industrial Psychology as a measure of manual dexterity, this test involves the assembly of ten small bolts, an inch and a half long, and ten corresponding nuts.<sup>3</sup> The test has shown some promise for predictive purposes by positive correlations with trade proficiency in occupations requiring manual dexterity. The reliability of the test, as measured by the correlation between successive trials, is high. It appears, however, to be subject to much practice effect, at least within the limit of six trials. In the use of the test in the present investigation, one trial only was given. Correlation between the first and second halves of this trial was  $.794 \pm .039$ , furnishing a reliability coefficient of .89.
- (17) *Allport-Vernon Study of Values*. This consists in a scale designed to measure the relative strength of certain basic interests in the individual: theoretical, economic, aesthetic, social, political, and religious, as developed in the theory of Spranger.<sup>4</sup> It has a split-half reliability of .72.<sup>5</sup>
- (18) *Bernreuter Personality Inventory*. This forms, on the basis of responses to 125 questions concerning personal attitudes, interests and behavior, a series of four scales designed to measure certain aspects of personality known as (a) neurotic tendency, (b) self-sufficiency, (c) introversion-extroversion, and (d) dominance-submission. It was validated on the basis of four previous single scales, with which it has correlations ranging from .67 to .91 (uncorrected for attenuation).<sup>6</sup> Its reliability

<sup>1</sup>O'Connor, J. *Born That Way*. (Williams and Wilkins, Baltimore, 1928).

<sup>2</sup>Darley, J. C. *The Reliability of the Tests in the Standard Battery*. Bulletin of the Employment Stabilization Research Institute, Minneapolis, 1934, Vol. 3, No. 4, pp. 42-44, 46.

<sup>3</sup>Earle, F. M. et al. *The Measurement of Manual Dexterities*. Report No. 4, National Institute of Industrial Psychology, London, 1930, pp. 22, 44-47, 84-85.

<sup>4</sup>Spranger, E. *Types of Men*. Translated from the German by P. J. W. Pigors. (Halle, 1928).

<sup>5</sup>Vernon, P. E. and Allport, G. W. "A Test for Personal Values". *Journal of Abnormal and Social Psychology*, Vol. 26 (1931), pp. 231-248.

<sup>6</sup>Bernreuter, R. G. "The Validity of the Personality Inventory". *Personnel Journal*, Vol. II (1932-33), pp. 303-308. Also: *Manual for the Personality Inventory*. (Stanford University Press, 1931).



coefficients range, for the four scales, from .85 to .88 (split-half method, corrected by the Spearman-Brown formula). Clinical application of the Inventory has suggested relationships between scores on certain of the scales and some types of neurosis.<sup>1</sup> The four scales are not independent: it is impossible to discriminate in practice between the scales of neurotic tendency and introversion-extroversion, and both of these are correlated highly with the scale of dominance-submission.<sup>2</sup>

A typical individual record card, used to assemble the main information of the general questionnaire and the results of tests given, is shown on p. 249.

<sup>1</sup>Marshall, Helen. "Clinical Applications of the Bernreuter Personality Inventory". *Psychological Bulletin*, Vol. 30 (1933), pp. 601-602.

<sup>2</sup>Cf. also: Bernreuter, R. G. "The Imbrication of Tests of Introversion-Extroversion and Neurotic Tendency". *Psychological Bulletin*, Vol. 30 (1933), pp. 665-666. Perry, R. C. "Analysis of Group Factors in Certain Adjustment Questionnaires". *Psychological Bulletin*, Vol. 30 (1933), pp. 598

## GENERAL QUESTIONNAIRE.

*N.B.—This information is not required in any way for official purposes, but only in order to understand your particular problem.*

Name ..... Age ..... Date ..... 1933  
 Address: No. and Street .....  
 District ..... Age ..... years.  
 How long have you lived in this district? .....

### PARENTS.

	Mother	Father	Number of your brothers    sisters
Country of birth	_____	_____	
Racial origin (e.g., Scottish, Jewish, etc.)	_____	_____	
Has he or she taken out naturalization papers?	_____	_____	_____

Occupation(s) of Father	Length of Time followed	Place in which followed
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____

### PERSON INTERVIEWED.

A. *General.* Country of birth ..... Religion .....  
 Racial origin ..... Married or single .....  
 Born in city, town or country? ..... Children Other  
 How long have you lived in Canada? ..... Dependents  
 How long have you lived in Montreal? .....  
 If you have lived in Montreal less than six months, what was the last  
 place in which you lived for six months or more? .....  
 When did you leave this last place? .....

B. *Regular Occupation* .....  
 (Give details: if "labourer", state kind of work usually done).  
 If your occupation has not given you steady work over last 3 years, i.e.,  
 you have usually been unemployed for a time between jobs, put  
 X here .....  
 If your employment has been part-time (i.e., regular but only part  
 of the week) during any part of the last 12 months put X here .....  
 How long is it since you last worked at your regular occupa-  
 tion? .....

C. *Education and Training.*

Age on entering regular day school \_\_\_\_\_

Age on leaving regular day school \_\_\_\_\_

Last grade or standard completed in regular day school \_\_\_\_\_

## EDUCATIONAL OR TRAINING INSTITUTIONS ATTENDED, ETC.

Type of School	Name of School	Location of School	Dates of Attendance	Did you finish courses?
Elementary (Public School)				
High School				
University or College				
University Extension (evening)				
Business School or College (day)				
Business School or College (evening)				
Technical School (day)				
Technical School (evening)				
Correspondence Course				
Other types, day or evening (e.g., trades school, barber college, art school, telegraphy courses, etc.)				

What school subjects, if any, did you like best? \_\_\_\_\_

If you have ever served regular apprenticeship give details:—

Trade \_\_\_\_\_ Firm \_\_\_\_\_

No. of years \_\_\_\_\_ Dates \_\_\_\_\_

D. (a) *Employments from time of leaving school till aged 20.*

Occupation	Industry or Employer	How Obtained*	Duration (give dates if possible)
------------	----------------------	---------------	--------------------------------------

1 \_\_\_\_\_

2 \_\_\_\_\_

3 \_\_\_\_\_

4 \_\_\_\_\_

5 \_\_\_\_\_

\*How obtained. Specify according to following list:

- |                             |                                |
|-----------------------------|--------------------------------|
| 1. School or teacher's help | 5. Advertisements              |
| 2. Parents                  | 6. Employment agency (specify) |
| 3. Friend(s)                | 7. Some other way (specify)    |
| 4. Personal search          |                                |

GENERAL QUESTIONNAIRE

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D. (b) *Occupational Experience (since age of 20).*

Occupation	Industry or Employer	Where?	Approximate Dates	Average Monthly Earnings
1	_____	_____	_____	_____
2	_____	_____	_____	_____
3	_____	_____	_____	_____
4	_____	_____	_____	_____

Have you ever wished to enter any other occupation in the past? If so, state occupations for which you think you are fitted: \_\_\_\_\_

E. *Reason for Present Unemployment.*

N.B.—Mark with X the reason which best fits your case. If you think more than one reason necessary, mark the second reason by figure 2. Read them all before giving your answer.

1. Slack month in regular occupation \_\_\_\_\_
2. Firm reduced staff owing to depression \_\_\_\_\_
3. Firm closed down or bankrupt \_\_\_\_\_
4. Your type of labour not required owing to new machinery or other equipment being adopted \_\_\_\_\_
5. Discharged because considered too old \_\_\_\_\_
6. Displaced because juvenile or female workers doing work at cheaper rates \_\_\_\_\_
7. Left voluntarily to find better-paid work \_\_\_\_\_
8. Left voluntarily to find more suitable work \_\_\_\_\_
9. Left because otherwise dissatisfied with conditions of work \_\_\_\_\_
10. Lost job after period of sickness \_\_\_\_\_
11. Permanent disablement or other physical handicap (see below) \_\_\_\_\_
12. Other reason (give details) \_\_\_\_\_

Would you describe your last loss of your regular job as "discharge", "lay-off", or "left voluntarily" (D, LO, or V.)? \_\_\_\_\_

Have you had any serious illness or other bodily incapacity, which has prevented your regular employment since the age of 20? \_\_\_\_\_

Nature (specify)      Duration  
(give dates)

F. *Status of Family (if married).*

- (a) How long have you been married? \_\_\_\_\_ years.
- (b) Is your wife usually a wage-earner? \_\_\_\_\_ If so, at what occupation? \_\_\_\_\_  
 Approximate number of weeks she worked during 1931 \_\_\_\_\_  
 Average monthly earnings during 1931 \$ \_\_\_\_\_  
 Amount, if any, expended during the year, for any domestic help \$ \_\_\_\_\_

## GENERAL QUESTIONNAIRE

- (c) Has your wife been forced to seek work since January 1931 because of your unemployment? .....
- If so, at what work? ..... part time or full time? .....
- Approximate number of weeks she worked during 1931 .....
- Average monthly earnings during 1931 \$.....

(d) *Children in Family.*

Age	Sex	Living at Home?	At School	Left School but unemployed	IF AT WORK Occupation	Average Monthly Earnings	Years spent at school	Present grade, or grade at leaving
1						\$		
2						\$		
3						\$		
4						\$		

## A TYPICAL RECORD CARD.

11AM SMITH, John A. 32 M-2 England 0.4 x—NR A—Engineer											
Mechanical Engineer				Mining Engineer							
Mechanical Draftsman				Prot.		3:6		2		L	
Gr. 11. 1917. Apprentice engineer & Tech. Sch. 1917-1922. Min. Sch. 1922-23											
65	7	28	18	16	17	21	107	A	NPC 118/1		
129	124	105	127	—	—	121	—	120	117	//	120
32.0	37.5	30.0	36.0	29.5	15.0	—177	153	—109	163	+2 N.K.	
83 Cox: 26.											
WB. 7.72, 1.49, 1.67, 0.78, 1.03, 0.53						TD. 6.75		CC. 22.			
NB. 44/38—82.				R 52, 45;		L 46, 39.		RH.			

*Interpretation:* John Smith, of Group III, is age 32 years at last birthday, is married, and has two children. He has been unemployed four months, and has been employed irregularly during the last three years, with no regular part-time work in the last twelve months. He is not on relief. Main occupation: mechanical engineer; subsidiary, mining engineer. Taussig Class A (Engineering). His father's main occupation was that of mechanical draftsman. Smith is a Protestant, and has been in Canada three years and six months. He was laid off from his last job by reason of the depression. He completed Grade 11 in 1917, was apprenticed as an engineer from 1917 to 1922, and at the same time attended technical school. From 1922 to 1923 he attended mining school. He has a score of 65 upon the Otis Test, and a total score upon Revised Beta Examination of 107 (sub-test scores are also given). His total score upon the N.I.I.P. Clerical Test is 118, placing him in the first tenth of the population. The average score upon the New Stanford Achievement Test is 120 (sub-test scores are also given). Scores upon the Allport-Vernon Study of Values range from 15.0 to 37.5, the highest being for economic interest, the lowest for religious interest. His scores upon the four scales of the Bernreuter Personality Inventory are —177, 153, —109, and 163. He has a score of +2 upon the Neymann-Kohlstedt Diagnostic Test of Introversion-Extroversion. The score upon the Stenquist Mechanical Aptitude Test I is 83; upon the Cox Mechanical Ability Test, 26. Scores for six successive trials upon the O'Connor Blocks Test range from 7.72 minutes to 0.53 minutes (unweighted). The score upon the O'Connor Tweezer Dexterity Test is 6.75 minutes, and upon the N.I.I.P. Cube Construction Test, 22 (points). Scores upon two trials of the N.I.I.P. Nuts and Bolts Assembly Test are 44 and 38 seconds, making a total score of 82 seconds. Records of performance (in pounds pressure exerted) upon the Smedley Hand Dynamometer are 52 and 45, for the right hand, and 46 and 39, for the left. Smith is right-handed.

## APPENDIX B: STATISTICAL TERMS AND METHODS.

*The Frequency Distribution.* The statistical concepts used in this and other psychological studies are largely based upon, and determined by, the qualities of the frequency distribution. By a frequency distribution is meant a citation of the number of cases for each possible score upon a test, from the highest score made to the lowest. Such a distribution may either be shown graphically or by a table. In the former case, points on the horizontal axis (or abscissa) represent the successive possible scores for the test, and points on the vertical scale indicate for each of the successive possible scores the number of persons making those scores. In tabular form, the number of cases is cited for each score in ordinary numerical fashion. Figs. 8-15 in the preceding text are examples of graphic representation of frequency distribution, while Tables VIII-XI show some frequency distributions in tabular form.

Frequently, where the "population", or number of cases, of the entire distribution is great enough (say, 50 or more), so-called "step-intervals" embracing two or more successive possible scores are used instead of single scores. Thus, instead of an enumeration of cases for successive scores of 1, 2, 3, 4, 5, 6, \_\_\_\_\_, there is arranged a grouping of the cases for step-intervals of, say, three successive scores: 1-3, 4-6, 7-9, \_\_\_\_\_. This eventually involves the assumption, when certain constants for the distribution are computed, that the middle score for each step-interval (2, 5, 8; \_\_\_\_\_ in the above example) may be used to represent the entire step-interval. Under ordinary circumstances this assumption involves only a negligible error if the population is large, and the error is more than counter-balanced by the reduction in physical size of the frequency table which the use of step-intervals makes possible.

After a test has been administered to a group of subjects, the first step in studying the test scores is to plot them in the form of a frequency distribution. When this has been done, it is usually desirable to know certain facts about the distribution. Such questions as the following may be asked: Does the frequency distribution assume a "normal", bell-shaped form such that the majority of the cases is found near the middle of the range of scores, with the remainder tailing out symmetrically toward the extremes?<sup>1</sup> If not, to what extent does the distribution tend to be biased toward one extreme? What score may be used as an average, to describe the central tendency of all the others? Are the cases bunched together around this average, or are they relatively dispersed from it, so that the average becomes less typical of them?

*The Mean, the Median, and the Standard Deviation.*—These questions are answered by deriving from the distribution certain constants, each one of which is descriptive of one of the characteristics of the distribution. To answer the question regarding the central tendency of the scores, it is necessary to compute either or both of two forms of average: the mean and the median. By the former is meant what is in ordinary parlance called the "average"—the sum of all the scores divided by their number. By the median is meant the scale-value of the middle case of the distribution, or that point in the range of scores which has just one-half of the cases above it and one-half below. These two forms of average, the mean and the median, are identical if the distribution is a perfectly symmetrical one; that is, if it slopes off at an equal rate on each side of the highest ordinate, which lies in the exact middle of the distribution. If this condition is not met, then the two will differ slightly, and the

<sup>1</sup>A "normal" distribution is a completely symmetrical curve which has a number of definite mathematical properties (cf. Holzinger, K. J. *Statistical Methods for Students in Education*, Ginn & Co., Boston, 1928. Chap. XII). It is of great usefulness in psychological measurements because of all the curves which might be employed, it gives the best single approximation to the ordinary test score distribution.



difference will tend to vary with the degree of asymmetry of the distribution.

If the mean is used as an average or measure of central tendency, a third constant, called the standard deviation, is derived in order to describe the extent to which the scores tend to be clustered around, or dispersed from, the mean. This measure is found by determining the distance of each score from the mean, squaring that amount, adding together all these squared deviations, dividing their total by their number (the "population" of the distribution), and calculating the square root of the resulting quotient. Thus, if a distribution has a mean of 56.0, and one of the cases is a score of 25, the deviation of that score from the mean is  $56.0 - 25$ , or 31.0, and its square is 961.0. To this squared deviation is added all the others of the distribution, and the square-root of the mean of all the squared deviations is the measure of dispersion—the standard deviation. This measure, often expressed by the Greek letter  $\sigma$ , is larger if the scores tend to be dispersed from the mean, smaller if they tend to cluster around the mean.

*Skewness.*—Three measures, or constants, now having been found, it is possible to derive an index of the extent to which the distribution tends to be biased from the normal symmetrical shape to one extreme or the other. If, for example, the cases tend to be grouped to the lower end of the scale, or range of scores, and to tail out more sparsely toward the upper end, the mean will be higher in value than the median, because the former is unduly affected by a few very high scores. The greater the amount of bias (or skewness, as it is usually termed), the more this will be so. It is apparent therefore, that the size of this difference may be used as an index of the amount of skewness present in the distribution, and that its sign, positive or negative, will vary with the direction of the skew. To use it as such, however, it must be divided by the standard deviation of the distribution. The reason for this is evident upon examination.

If of two distributions one has a standard deviation of 20.0, and the second a standard deviation of 10.0, and if the difference between the mean and the median is the same, namely 3.0, in each, it is apparent that this difference of 3.0 is (relative to the total tendency to dispersion of scores) much less where the standard deviation is 20.0 than where it is only 10.0. Therefore, in order to make the index, or coefficient, of skewness comparable from one distribution to another, the deviation of the median from the mean is in each instance divided by the standard deviation. If there is no skewness inhering in the distribution at all, the coefficient will be zero, and ordinarily it does not vary beyond  $\pm 1.00$ .

*Sampling.*—A further problem occurs when it is desired to compare any two distributions. This problem arises if, for example, it is necessary to determine whether one group of subjects tends to be superior to another group in respect of any given tested trait. It does not do simply to find the mean of the distribution of scores for each group of subjects, and to conclude that Group A is superior to Group B if the mean score of the former is higher than that of the latter. This simple comparison is insufficient because each group must be regarded as being only a *sample* of a much larger group which it represents, and it is known in practice that a sample of a larger group is not necessarily typical of that group. Thus, if a group of 100 unemployed office clerks is compared with a group of 100 employed office clerks, each must be regarded as being a sample of a much larger group, from which this small body has been drawn. Accordingly, it must be expected that the sample will be subject to purely chance fluctuations in its composition, and that it will be perhaps somewhat better, perhaps somewhat worse, than the total group from which it is taken. Since this is the case, two samples may be drawn from two major groups of exactly equal status in some respect, and it may be found that simply by chance one sample from one group is superior to the other sample from the other group. The

statistician, in order to protect himself from possibly unjustified conclusions resulting from such errors in sampling, is forced to insist that the difference between the means of any two samples must, to be considered as real, be demonstrably such that it could not in the ordinary course of events be caused by chance.

To determine how much allowance must be made for sampling errors in the comparison of the means of any two distributions of scores for the same test, recourse is had to two statistical laws. The first of these is that the larger the sample of a source group, the more typical it tends to be of that parent group. The second is that the less scattered are the items of a distribution, the more the mean becomes typical of that distribution. Combining these two generalizations, it may be concluded that the mean of a distribution may be regarded as being a more trustworthy measure, the larger the number of cases and the smaller the standard deviation. This is usually expressed the other way about by saying that the standard error of a mean of a distribution varies directly with the standard deviation and inversely with the (square root of the) number of cases thus:

$\sigma_m = \frac{\sigma}{\sqrt{N}}$ . In ordinary practice, when it is desired to compare the means of two distributions for the same variable, as in the example above, the standard error of each mean is computed, and from these the standard error of the difference is derived by the formula

$\sigma_{\text{diff}} = \sqrt{\sigma_{M_1}^2 + \sigma_{M_2}^2}$ . The difference between the two means is then compared with the standard error of the difference, and if the ratio of the former to the latter is 3.0 or greater it is virtually assured that the difference is greater than chance would permit. The ratio of 3.0 is taken as a criterion because the ordinary limits of a distribution are  $\pm 3.0$  times the standard deviation of that distribution. Thus a mean of, say, 56.0 with a standard error of 1.5 will

not ordinarily vary by chance, in any sample of the same size and standard deviation, above 60.5 or below 51.5. In the same way, a difference of 10.5 points with a standard error of 2.1 cannot ordinarily by chance fluctuation be less than  $10.5 - (3 \times 2.1)$ , or 4.2—in other words, the difference must have some residual value above zero, and is a real, indisputable difference. A warning, however, should be added at this point. This notion of sampling and sampling error, and of provision for the latter by computation of the standard error, deals only with *chance* sampling, and does not extend toward the influences of *selective* sampling. The latter variety always involves some special factor or factors which contribute to make the sample atypical of its source. Such a condition arises as when, in the case of Group IV of the present study, men for testing could be obtained only from educational classes, which would be likely to be composed only of the brighter and keener individuals.

*Correlation.*—Correlation means simply joint variation of two variables, and a coefficient of correlation is an index of the extent to which such joint variation is present in a given instance. The user of psychological tests often wishes to know the extent to which a high score upon one test is accompanied by a high score upon another. Moreover, he wishes to have a precise quantitative expression of this degree of correspondence, beyond being able to say that it is “high”, “low”, or “middling”. To obtain this, he takes fifty, a hundred, or more cases to whom both tests have been administered under comparable conditions. Setting out the cases in parallel, he then computes the ratio which the algebraic sum of the products of the deviations from the mean of each test bears to the geometric mean<sup>1</sup> of the sums

<sup>1</sup>“The geometric mean of a series of observation is the value obtained by finding the product of all the observations, and then obtaining the root of that product with an index equal to the number of items in the group.” (Holzinger, *op cit.*, p. 91). Thus, in the above instance, it is the square root of the product of  $\Sigma x^2$  and  $\Sigma y^2$ .

of the squares of the deviations from the mean of each test. This ratio, which is the Pearson product-moment coefficient of correlation, is usually expressed by the formula  $\frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}}$ . It may vary between the limits of + 1.00 and -1.00. If the coefficient is + 1.00, it indicates that a unit deviation in one variable corresponds perfectly with a unit deviation in the other, and in the same direction. A correlation coefficient of - 1.00 indicates the same perfect agreement, but in an inverse direction. A coefficient of zero indicates complete unrelatedness. It is very seldom that a raw correlation coefficient rises above  $\pm .95$ .

The degree of accuracy with which a score on one test can be predicted from a score on another does not vary in exact proportion to the size of the correlation between the two tests. It increases much more slowly than the correlation coefficient. Thus, as a coefficient of .00 indicates complete chance prediction of one variable from another, a coefficient of .30 has a forecasting efficiency of 5 per cent. (5 per cent. better than chance), one of .60 an efficiency of 20 per cent., one of .87 an efficiency of 50 per cent., and one of .98 an efficiency of 80 per cent.

Thus far, it has been assumed that the relationship between the two variables which are correlated is a rectilinear one; that is, that it can be expressed by a straight line if the relationship is perfect, and that otherwise it tends to approach this form. While this is usually the case with test data, sometimes the relationship is other than rectilinear. It may then, for example, take the form of a curve. If this is the case, the rectilinear coefficient described above does not do justice to the relationship, but understates it, and it is necessary to use another statistical mechanism, called the "correlation ratio", to express the relationship between the two variables adequately. The correlation ratio, which has the same limits as the correlation coefficient ( $\pm 1.00$ ), is always equal to or greater than the latter, as it may always

include the rectilinear relationship as one of its forms, and may take into account slight deviations from rectilinearity which are reducing factors for the correlation coefficient. However, it is not often necessary to use the correlation ratio with ordinary test data, because its superiority with such data is not as a rule very great.

The correlation coefficient, like the mean, is subject to ordinary errors of sampling. In just the same way, its trustworthiness is expressed by a standard error (or more usually, by the "probable error", which is always .6745 times the standard error, for a normal or near-normal distribution). The standard error is derived by the formula  $\sigma r = \frac{1-r^2}{\sqrt{N}}$ , where  $r$  is the correlation coefficient, and  $N$  is the population upon which it is based. The value of the probable error is usually appended to the correlation coefficient whenever the latter is cited, thus:  $r = .69 \pm .03$ . This expression is interpreted to mean that the observed value of the correlation coefficient is .69, and that there are 50 chances in 100 that the real value of the coefficient is between .66 and .72.

## APPENDIX C: THE BARR RATING SCALES AND THEIR CORRELATION WITH TEST SCORES.

In order to classify occupations according to the amount of a given skill or ability required, a method of grading which involves the use of a numerical scale to represent the skill or ability has been devised. The method has been employed in at least two extensive investigations: in the Terman study of gifted children, where Mr. F. E. Barr developed this type of scale to rate fathers' occupations for intelligence;<sup>1</sup> and in the Minnesota research into mechanical ability, where the method was used for rating fathers' occupation for intelligence and mechanical ability.<sup>2</sup> In the former case it was found that the average rating for fathers of the gifted children included within the survey was significantly higher than the average rating for the general population, as determined from census data. In the Minnesota study no significant relationship was found between test scores and either the Barr intelligence ratings or mechanical ability ratings. Certain of the "environmental" ratings (that is, for cultural status, literary interests, tools owned by father, etc.) correlated significantly with the Barr ratings, however.

The procedure through which the original Barr scale was constructed commenced by having thirty judges rate one hundred representative occupations on a scale of 0 to 100, according to the grade of intelligence that each occupation was believed to demand. Probable error values were then determined from a distribution of the averages of these thirty ratings, and the probable error value, which ranged from zero ("Hobo") to 20.71 ("Inventive Genius"), was used

<sup>1</sup>Terman, L. M. et al. *Genetic Studies of Genius*, Vol. 1. (Stanford University Press, 1925).

<sup>2</sup>Paterson, D. G. et al. *The Minnesota Mechanical Ability Tests*. (University of Minnesota Press, Minneapolis, 1930).

as an index of the occupation to which it was attached.<sup>1</sup> The mean probable error value for the general population was estimated to lie between 7.92 and 8.88.

By a similar method, the Minnesota investigators developed the Barr-type scale for mechanical ability. Standard deviation values were used instead of probable error values, however. These ranged from 0.27 ("High National Official") to 5.73 ("Inventive Genius").

It was attempted in the present investigation to determine something of the inter-relationship of these scales, and their correlation with test scores, for the individuals themselves tested (not those one generation removed), in order to throw some light upon the scales and the tests. Accordingly, a group of 246 unemployed men, representing a wide range of occupations and abilities, was selected, and these individuals were rated on the basis of the Barr scales for their own and their fathers' occupations. All of these men had taken the Beta Examination and the Stenquist Mechanical Aptitude Test I, and the majority had taken also the Otis Test ( $N = 109$ ) and the O'Connor Blocks Test ( $N = 194$ ). As the Minnesota Paper Formboard had been administered to only 79 of the group, it was thought inadvisable to use it for correlation purposes. Test 4 of Beta Examination, involving substantially the same type of content, was used in its stead. This was considered justified in the main by the fact that the Minnesota Paper Formboard and Test 4 of Beta Examination correlated  $+ .875 \pm .014$ .<sup>2</sup>

The Barr ratings were then correlated with each other and

<sup>1</sup>The *probable error* (P.E.), like the *standard deviation* (S.D.), measures dispersion from the mean of a distribution. In a normal frequency distribution, 50 per cent of the cases are included within the limits of one probable error unit above and below the mean. If desired, an arbitrary zero point, based upon the position of the limiting case, may be set at the bottom extreme of the distribution, and all scores may be translated into probable error units above the arbitrary zero point. Exactly the same procedure may be used in the case of standard deviation units. It is to be noted that the zero point on such a scale does not mean "no ability at all", but simply indicates that such a rating or score is at the very bottom of the distribution.

<sup>2</sup>Uncompensated for attenuation. Taking the reliability of the Minnesota Paper Formboard to be .82 (single form), the coefficient, adjusted for attenuation, becomes .966.



with test scores. These coefficients of correlation are presented in the table on p. 267. In addition, the Barr intelligence and mechanical ability ratings were correlated as between father and son. The coefficients of correlation for the father-son relationship were, for intelligence rating,  $+ .647 \pm .025$ , and for mechanical ability rating,  $+ .300 \pm .039$ .

Fifteen of the twenty-one coefficients derived were found to be fully significant, that is, four or more times the probable error. The Barr intelligence scale correlated positively and significantly with all five tests except the O'Connor Blocks. Its highest correlation was with Beta Examination, being  $+ .609 \pm .027$ . The mechanical ability scale, on the other hand, was correlated significantly in only two instances: with the Stenquist Mechanical Aptitude Test I ( $+ .332 \pm .032$ ) and the O'Connor Blocks Test ( $+ .206 \pm .047$ ). The relationship between the Stenquist Test and the mechanical ability scale ( $+ .332 \pm .032$ ) was no higher than the relationship between the Stenquist Test and the intelligence scale ( $+ .348 \pm .038$ ).

The two scales themselves intercorrelated to the extent of  $+ .100 \pm .043$ . This correlation is, of course, not fully significant. Inspection of the scatter of tallies in the correlation chart indicated, however, that the principal reason for the lack of linear relationship was the fact that while the mechanical ability ratings of 3.00 and over were correlated positively with intelligence ratings, those under 3.00 tended to be correlated negatively.<sup>1</sup> The cause of this was that clerical and commercial occupations, while given a high

<sup>1</sup>Where a correlation between two such sets of measures is positive (that is, high values on one scale tend to accompany high values on the other, and conversely) it is generally shown by a scatter of tallies in a scatter diagram similar to Fig. 16, proceeding from the bottom left hand corner to the upper right hand corner. If the correlation is negative, the scatter approximates a line drawn from bottom right to upper left. In Fig. 16 it will be seen that both such tendencies are present, and consequently a line drawn through the middle of the scatter of tallies would tend to take a form like that of a parabola, with the "open" side facing downwards. For such a form, the correlation ratio is a better means of expression than the correlation coefficient, as may be judged by the difference between .830 and .100.

rating on the intelligence scale, were rated at the inferior end of the mechanical ability scale, which was contrary to the general trend. The correlation ratio for the regression of the intelligence scale upon the mechanical ability scale was therefore computed, and was found to be  $.830 \pm .013$ . Blakeman's test for linearity of function<sup>1</sup> gave a resultant indicating clearly the predominance of the curvilinear trend, zeta being over 28 times its probable error. The linear correlation coefficient between the two scales is given by the Minnesota investigators as being  $+ .04$ , no attempt apparently having been made to determine whether the relationship were other than linear.

Following this clue, it was found that the same curvilinear relationship held, though to a less degree, between the Barr mechanical ability ratings and each of Beta Examination, Test 4 of Beta, and the Stenquist Test, the correlation ratios (regression of each on the Barr mechanical ability scale) being respectively  $.553 \pm .030$ ,  $.381 \pm .037$ , and  $.471 \pm .033$ . These were in each case significantly greater than the corresponding rectilinear coefficients.<sup>2</sup> The scatter diagrams illustrative of the various relationships are shown in Figs. 16 to 19.

Three general conclusions may be drawn from these data. First, the Barr intelligence scale bears an appreciable positive relationship to the intelligence test scores of the individuals whose occupations are rated. The coefficient of correlation

<sup>1</sup>The correlation ratio is never less than the correlation coefficient and is generally greater. The former may, of course, be greater owing to chance fluctuation. To determine whether the predominance of the curvilinear trend over the linear is significant, a statistical criterion known as Blakeman's test is used. If the difference between the squares of the correlation ratio and the correlation coefficient is three or more times its standard error the existence of the curvilinear trend is judged to be real.

<sup>2</sup>Cf. Kelley, T. L. *Statistical Method*. (Macmillan, N.Y., 1924). Formulas 195, 196. The zetas, together with their probable errors, were as follows:

	ZETA	P.E.
Barr Intelligence — Barr Mechanical Scale _____	.679	.024
Beta Examination — " " " _____	.306	.033
Test 4 of Beta — " " " _____	.125	.027
Stenquist Test — " " " _____	.112	.026

**BARR INTELLIGENCE SCALE  
BARR-TYPE MECHANICAL ABILITY SCALE**

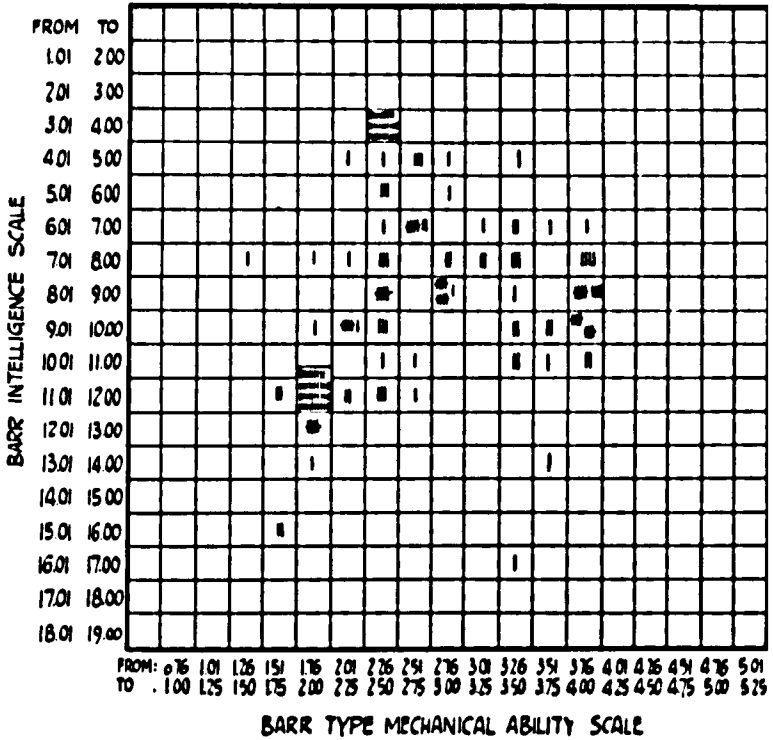


FIG. 16. Scatter-diagram for correlation between Barr Intelligence Scale and Barr-Type Mechanical Ability Scale.

**REVISED BETA EXAMINATION TOTAL  
BARR TYPE MECHANICAL ABILITY SCALE**

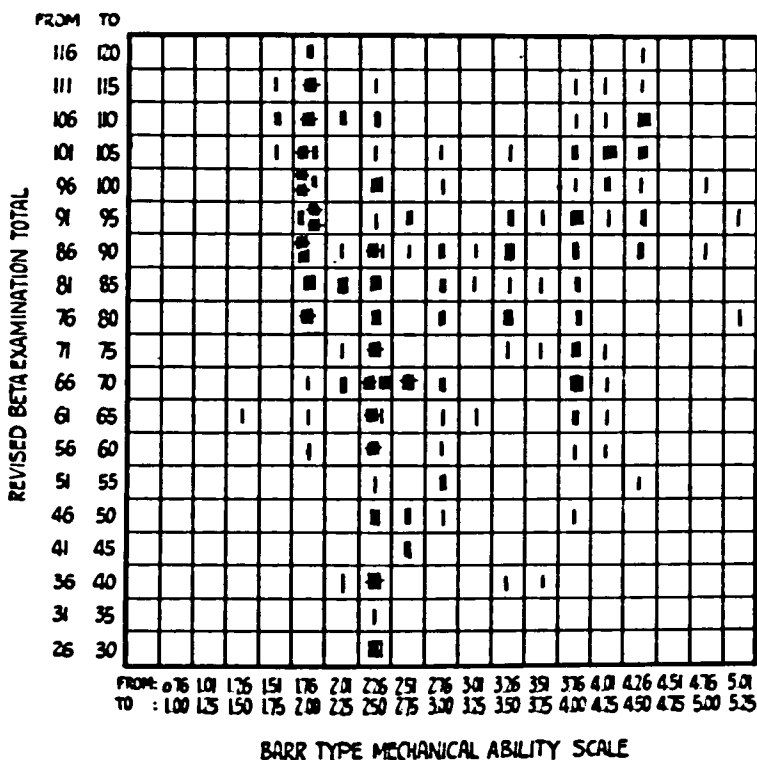
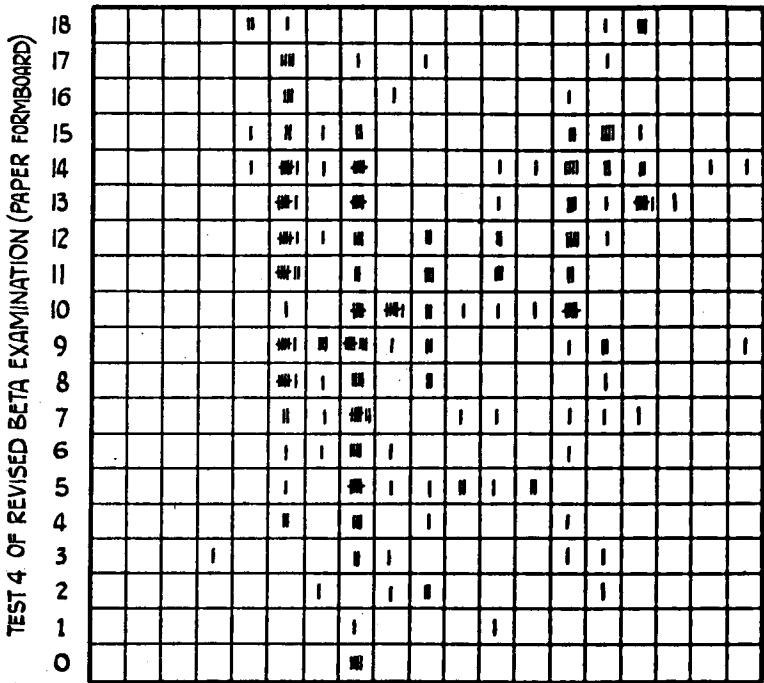


FIG. 17. Scatter-diagram for correlation between Revised Beta Examination and Barr-Type Mechanical Ability Scale.

**TEST 4 OF REVISED BETA EXAMINATION  
(PAPER FORMBOARD)  
BARR-TYPE MECHANICAL ABILITY SCALE**



FROM: 0.76 1.01 1.26 1.51 1.76 2.01 2.26 2.51 2.76 3.01 3.26 3.51 3.76 4.01 4.26 4.51 4.76 5.01  
 TO : 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 4.25 4.50 4.75 5.00 5.25

**BARR-TYPE MECHANICAL ABILITY SCALE**

**FIG. 18.** Scatter-diagram for correlation of Test 4 Revised Beta and Barr-Type Mechanical Ability Scale.

**STENQUIST MECHANICAL APTITUDE TEST 1  
BARR TYPE MECHANICAL ABILITY SCALE**

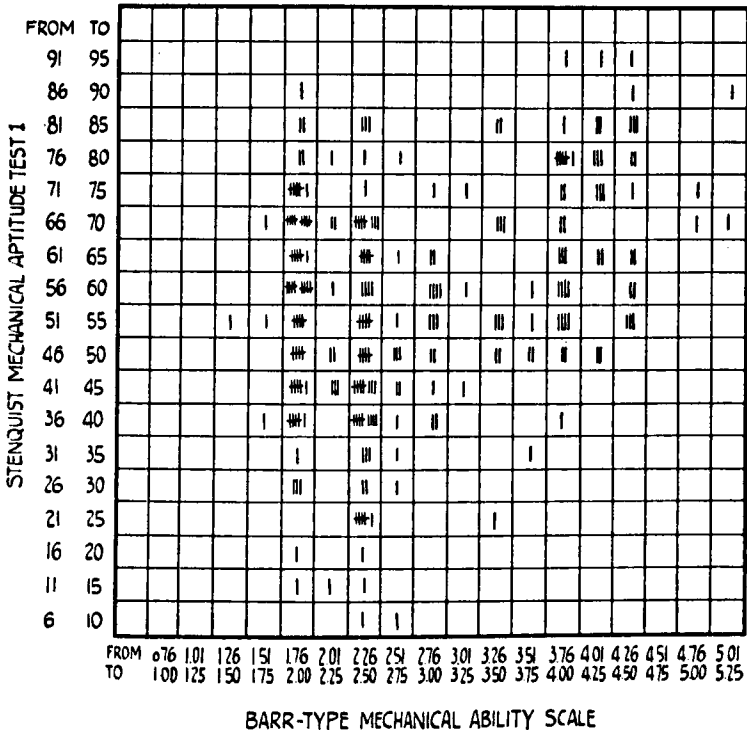


Fig. 19. Scatter-diagram for correlation between Stenquist Mechanical Aptitude Test 1 and Barr-Type Mechanical Ability Scale.

is approximately .60 with the Beta Examination, .30 with the Otis Test. Secondly, the Barr mechanical ability scale tends to have a definitely curvilinear correlation with the Barr intelligence scale and test scores, including those of the Stenquist Test and the formboard test (Test 4 of Beta Examination). The relationship of the Stenquist Test to Beta Examination is known, however, to be approximately rectilinear, and is believed to be so in the case of the Stenquist Test and intelligence tests other than Beta Examination.

Thirdly, certain judgments may be made, tentatively, concerning the tests themselves. It is noteworthy that the O'Connor Blocks Test, while (if it measures anything very consistently) containing something of a general intelligence factor, is most highly correlated with Test 4 of Beta (paper formboard). One might possibly infer that this implies a similarity in function in that they both call for a visualization of spatial relationships. It may be noted in this connection that the Minnesota group found their test of spatial relations to correlate + .63 with the paper formboard. Again, with respect to the paper formboard itself, the bulk of the evidence here seems to show that its function is much better related to general intelligence than to mechanical ability. While it correlates + .476 with the Stenquist Test, its relationship is much higher ( $+ .651 \pm .037$ ) with a purely verbal test like the Otis. In addition, it is to be observed, for what the distinction is worth, that the rectilinear relationship between the paper formboard and the Barr intelligence scale is much higher than between the formboard and the Barr mechanical ability scale, and higher also than the correlation ratio for the regression of the formboard on the Barr mechanical ability scale.

THE BARR RATING SCALES

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COEFFICIENTS OF CORRELATION FOR BARR INTELLIGENCE AND MECHANICAL ABILITIES, RATINGS AND TEST SCORES.

	Barr Intelligence Scale	Barr Mechanical Scale	Otis
Barr Intelligence Scale.....	—	.100 ± .043	.319 ± .058
Barr Mechanical Scale.....	.100 ± .043	—	.085 ± .064
Otis.....	.319 ± .058	.085 ± .064	—
Beta.....	.609 ± .027	.018 ± .043	.700 ± .033
Stenquist.....	.348 ± .038	.332 ± .038	.219 ± .062
O'Connor Blocks.....	.039 ± .048	.206 ± .047	.315 ± .082
Beta, Test 4.....	.456 ± .034	.142 ± .042	.651 ± .037

	Beta Total	Stenquist	O'Connor Blocks	Beta Test 4
Barr Intelligence Scale...	.609 ± .027	.348 ± .038	.089 ± .048	.456 ± .034
Barr Mechanical Scale.....	.018 ± .043	.332 ± .038	.206 ± .047	.142 ± .042
Otis.....	.700 ± .033	.219 ± .062	.315 ± .082	.651 ± .037
Beta.....	—	.517 ± .032	.373 ± .042	.786 ± .016
Stenquist.....	.517 ± .032	—	.384 ± .041	.476 ± .033
O'Connor Blocks.....	.373 ± .042	.384 ± .041	—	.461 ± .038
Beta, Test 4...	.786 ± .016	.476 ± .033	.461 ± .038	—



**APPENDIX D: CONSTANTS OF THEORETICAL DISTRIBUTIONS  
SHOWN IN FIGS. 7-15.\***

Test	Mean	Median	S.D.	Coefficient of Skewness
Education.....	7.7	7.8	2.3	-0.13
Beta Total.....	72.9	74.7	21.5	-0.25
Test 4 of Beta.....	8.8	9.0	4.0	-0.15
New Stanford.....	91.0	92.9	19.4	-0.29
N.I.I.P. Clerical.....	37.5	30.0	24.8	+0.91
Stenquist.....	53.0	53.2	19.8	-0.03
Cox.....	6.2	2.5	7.0	+1.59
O'Connor Blocks.....	—	3.92	—	—
Bernreuter B1-N.....	-37.8	-34.1	90.3	+0.12 <sup>a</sup>
Bernreuter B2-S.....	38.7	36.6	49.3	+0.13 <sup>a</sup>
Bernreuter B4-D.....	41.7	44.5	65.8	-0.13

\*See Chapter VI.

<sup>a</sup>i.e., the distribution is skewed slightly to the right. (See Figs. 13).

**APPENDIX E. CRITICAL RATIOS, TEST-SCORES FOR  
OCCUPATIONAL GROUPS.**

## APPENDIX E: CRITICAL RATIOS, TEST-SCORES FOR OCCUPATIONAL GROUPS.

The letter-number symbols in the table facing, denote occupational groups as follows:

<i>Symbol</i>	<i>Occupational Group</i>	<i>Symbol</i>	<i>Occupational Group</i>
A <sub>1</sub>	Engineers	C <sub>3</sub>	Carpenters, cabinetmakers
A <sub>2</sub>	Accountants and auditors	C <sub>4</sub>	Electricians
B <sub>1</sub>	Office clerks	C <sub>5</sub>	Plumbers
B <sub>2</sub>	Draughtsmen	D	Semi-skilled trades (street-
B <sub>3</sub>	Book-keepers		car motormen, factory
B <sub>4</sub>	Salesmen, salesclerks		hand, auto-body polisher,
C	Skilled trades (inclusive of C <sub>1</sub> -C <sub>5</sub> )		etc.)
C <sub>1</sub>	Machinists	E	Unskilled (labourers,
C <sub>2</sub>	Mechanics		farm hands, etc.)

For each occupational comparison (A<sub>1</sub>A<sub>2</sub>, A<sub>1</sub>B<sub>1</sub>, etc.), the first column ( $\frac{D}{\sigma_{diff}}$ ) gives the ratio of the difference between the two means for the variable concerned to its standard error. The second column (Chances in 100) gives the number of chances in 100, of a true difference greater than zero being represented.

Where no asterisk appears, the score of the first occupational group cited is superior to that of the second; presence of the asterisk indicates the contrary.



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References here cited are those of which some mention has been made in the text, or which bear directly upon some part of the discussion. Where the item is in book or pamphlet form, the name of the author, the title, publisher, and place and year of publication are given. Where the item is an article in a journal, there are given in order the name of the author, the title of the article (in quotes), the title of the journal (in italics), the volume, year, and pages.

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