SOME CHARACTERISTIC RELATIONSHIPS BETWEEN INTRA-INDIVIDUAL SCATTER PATTERNS OF MARKS AND INTELLIGENCE

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PREFACE

For some time the writer has been interested in the various questions which, within the field of intra-individual variability and inter-test variability, concern the problems involving specific mental abilities as being associated with specific academic achievement, and more precisely, has been interested in the questions which concern the problems involving specific sub-test scores of the Wechsler-Bellevue Intelligence Scale as being related to the specific marks that a pupil obtains in various classes of academic subject matter in the secondary schools.

This study is an attempt to discover certain characteristic relationships between specificity in intelligence sub-tests and specificity in academic mark areas.

The writer wishes to express his appreciation to Dr. S. L. Reed and Dr. Melvin Rigg for their helpful suggestions and criticisms in the formulation of the problem. To the schools wherein this study was made, the writer wishes to express his appreciation for their cooperation in making the collection of the data possible.

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CHAPTER I

INTRODUCTION

Orientation

The question of specificity of mental abilities is one about which much controversy has prevailed among psychologists. The concept of specificity of mental abilities as being associated with specificity of school achievement is also a point of controversy, not only in the field of psychology but in the field of education. Regardless of whatever it is that is being measured by intelligence tests, the evidence of multi-score intelligence tests has revealed that there is variation in the individual's ability to achieve on the various sub-tests of multi-score intelligence tests. Will the meaning of this variation continue to be ignored or treated lightly? An answer to this question, which is also a point of departure for this investigation, may be expressed in the words of Anastasi.[1]

> There is a rapidly growing realization, however, that the question of variation among the individual's abilities deserves serious and systematic consideration and should be investigated in its own right. This problem is gradually coming to be regarded as even more important than the establishment of the individual's general level of performance.

She further writes:[2]

> In planning an educational program for a given individual, or in helping him to choose a vocation, it is of the greatest importance to know his strong and his weak points. Total scores on intelligence tests can be used only in a very crude and general sort of educational and vocational guidance. . . .

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[1]Anne Anastasi, Differential Psychology, (New York, 1947), pp. 258-59

[2]Ibid., pp. 259-60.

If the individual's abilities were all more or less on a dead level, a single summary score would be quite informative. But if appreciable variation in the individual's standing in different traits is the rule, then such a score is crude at best and may upon occasion be definitely misleading. It is essential, therefore, to inquire into the extent of variation within the individual.

It has been the observation of the writer that it is common practice in some schools either to disregard the question of specificity of the individual's mental abilities or to treat his mental abilities as being more or less on an even level. The effect of this practice is to expect the performance of an individual in any given school subject to be in line with the general level of his mental abilities, i.e., his intelligence quotient. For general purposes, intelligence quotients may have great utility in predicting the general level of a pupil's marks, i.e., his mark average. However, a study of the literature does not necessarily justify the prediction of marks in a given school subject from the knowledge of intelligence quotients. For instance, while studies have been made showing that intelligence quotients will predict some mark averages (i.e., marks in some, not all, subjects may be predicted), the literature does not show that, within the area of school subjects in which an intelligence quotient has efficiency as a predictive device, differential predictions can be made; i.e., that a given pupil will do better in English than in Mathematics.

Also, the literature suggests that global predictions of mark averages from intelligence quotients account for only a part of the difference in school achievement. Since global predictions do not take into account the variation within the individual to achieve on intelligence sub-tests and school subjects (although variation is known to exist), it may be likely that inquiry into this variation, for the purpose of differential prediction, will account for another part of the difference in school achievement. If so, and if the instrument of prediction is a multi-score intelligence test, the inclusion of the evidence of differential prediction with the evidence of global prediction would be expected to increase the efficiency of intelligence tests as a predictive device.

Proceeding on the assumption that more evidence is needed for a fuller understanding of the problems of relationship between school achievement and intelligence, this study seeks to go beyond global predictions of mark averages from intelligence quotients and inquire into variation within the individual in order to show relationships between patterns of marks in school and patterns of sub-test scores in intelligence tests. More accurately, from patterns of variation within the individual, this study seeks to show relationships between scatter patterns of marks in mark areas and scatter patterns of mental ability scores in mental ability areas as these terms are defined in the sub-heading "Definitions." Furthermore, this study seeks to make possible differential predictions of pupil scatter patterns of marks from knowledge of pupil scatter patterns of intelligence sub-tests. In order to do this, the patterns must be found and the relationships calculated. It is to this task that the effort of this investigation is directed.

Organization of the Study

The preceding pages have introduced the origin, need, purpose, and character of the study, and have briefly discussed certain implications; the following pages of Chapter I state the problem, define the terms, list the basic assumptions, and state the basic hypothesis. Chapter II summarizes research in scatter and related studies. Chapter III defines the research population and the sources of the original data, reports the methods of collecting and quantifying the data, and briefly reviews the procedures and problems involved in the quantification of the data. Chapter IV relates the intelligence sub-test data to the mark data and further develops the data. Chapter V applies the methods and techniques selected for approaching an analysis of the original data, and reports the results of applying the techniques to each area of investigation. Chapter VI is a report of the cross-validation of the study. Chapter VII gives a summary of the development of the problem, evaluates the results, notes implications, makes suggestions, and formulates conclusions.

The Problem

The problem was to discover whether patterns of marks[3] which pupils receive in school studies are related to patterns of sub-test scores which pupils receive in the Wechsler-Bellevue intelligence[4] scale, and if so, what characteristic relationships[5] exist.

In order to bring the problem within the scope of an adequate investigation, three general areas of school studies and three combinations of the Wechsler-Bellevue sub-tests were selected. The areas of school studies selected were English, Mathematics, and Social Science. These areas were selected because each pupil had taken these courses of study and had received marks in them which contributed to the data.[6] The various sub-tests of the Wechsler-Bellevue were reduced, through statistical treatment,[7] to three combinations of sub-tests by reason of

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[3]See Marks under sub-heading "Definitions."

[4]See Intelligence, Ibid.

[5]See Characteristic relationships, Ibid.

[6]See sub-heading "Mark Data," Chapter III.

[7]The statistical treatment is described in Chapter IV.

their agreement in mean scatter[8] relationships within good and poor pupil categories. The combinations found were called mental ability areas,[9] and each mental ability area was represented by a composite ability called Mental Ability A, Mental Ability B, and Mental Ability C. The problem was then reduced to finding the relationships between intra-individual[10] scatter patterns[11] of marks as derived from three areas of school studies and intra-individual scatter patterns of mental ability scores[12] as derived from three areas of mental abilities.[13]

Principal Assumptions

In as much as the hypotheses to be tested concerned the measurement of scatter,[14] the principal assumptions underlying the formulation of hypotheses deal primarily with the principles of scatter. They may be stated as follows: (1) in dealing with differences of normalized scores and their means, the operation of subtraction by which such differences are obtained cancels out the general factor which is involved in the scores and in the means;[15] (2) the differences obtained from this operation are comparable for any two individuals, regardless of intelligence

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[8] See Mean scatter under sub-heading "Definitions."

[9] See Mental ability area, Ibid.

[10] See Intra-individual, Ibid.

[11] See Scatter pattern, Ibid.

[12] See Mental ability score, Ibid.

[13] See Mental ability, Ibid.

[14] See Scatter, Ibid.

[15] David Rapaport, Merton Gill, and Roy Schafer, Diagnostic Psychological Testing, Vol. 1, (Chicago, 1946), p. 49.

quotient or mark average; and (3) since the individual normalized scores and their mean represent the general position of the individual's ability in relation to the research population, it is presumed that his scores in marks and intelligence are comparable.

Basic Hypothesis

Since it is known that there is variation in the individual's ability to achieve on the various sub-tests of multi-score intelligence tests, and since it is known that there is variation in the individual's ability to achieve in various school subjects, the basic hypothesis which underlies the problems of consideration in this investigation is stated as follows: characteristic relationships exist between scatter patterns of marks and scatter patterns of intelligence.

Definitions

Marks. Marks are the scores which have been derived from teacher evaluation of a pupil's school work in a given school subject for the duration of one semester.

Intelligence. Intelligence is defined by the administration and scoring, by the writer, of the Wechsler-Bellevue Intelligence Scale, Form I.

Scatter.[16] Scatter is a term borrowed from the literature of research in clinical psychology. It is used to denote differences of scores within a group of scores. Any difference may imply either a raw difference between two scores or a difference of a score from the mean of the scores. As used in this study, scatter is defined as mean scatter.

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[16] David Rapaport, Merton Gill, and Roy Schafer, Diagnostic Psychological Testing, Vol. 1, p. 48.

Mean scatter.[17] Mean scatter is the difference between any single score and the mean of all the scores.

Scatter pattern. A scatter pattern may be defined as the configuration or composite shape of two or more points of deviation such as is revealed on a profile or scattergram.[18] Scatter pattern, as used in this study, is the pattern found by the deviation of three scores from the mean of the three scores.

Intra-individual. Intra-individual is defined as being within the individual.

Mental ability area. A mental ability area is a particular combination of Wechsler-Bellevue sub-tests.

Mental ability. A mental ability is the composite ability which represents a particular combination of Wechsler-Bellevue sub-tests.

Mental ability score. A mental ability score is the mean score of a particular combination of Wechsler-Bellevue sub-tests.

Characteristic relationships. Characteristic relationships are, in this study, statistically significant relationships in agreement, or in difference.

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[17] *Ibid*., p. 53.

[18] *Ibid*., p. 48.

CHAPTER II

RESEARCH IN SCATTER AND RELATED STUDIES

Studies of scatter and scatter patterns in multi-score situations are comparatively new to educational research literature. Scatter studies first appear in the literature as studies in clinical psychology. The review of the literature on scatter studies is divided into two groups of studies: (1) scatter in inter-test comparisons, and (2) scatter on the Wechsler-Bellevue Intelligence Scale. Research related to this study was found to be somewhat limited. The related studies included in the review are those which, in the opinion of the writer, had some bearing on the study which the writer was making.

Summary of Research in Scatter Studies

The greater part of the summary of research in scatter studies was taken from the review of the literature by the Rapaport study.[1]

Scatter in inter-test comparisons. Inter-test means between tests. Research in clinical psychology made use of various test scores to find relationships between the scatter of test scores in one diagnostic group of patients and the scatter of test scores in another diagnostic group of patients.

Hunt and Cofer,[2] in a study of scatter in inter-test comparisons, reviewed some studies by English factor analysts who attempted to study scatter in terms of Spearman's factors: general ability (g), persevera-

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[1]D. Rapaport, M. Gill, and Roy Schafer, Diagnostic Psychological Testing, Vol. 1, Appendices.

[2]Ibid., p. 551.

tion (p), fluency (f), will (w), and speed. These investigators found that manics low in "g" were high in "f", and that depressives had "f" scores relatively lower than "g" scores. Schizophrenics with a very high "p" were relatively inaccessible.

Bijou[3] reviewed investigations which made use of patterns of inter-test comparisons in four different diagnostic classifications: "psychotics, habitual criminals, adolescent delinquents, mental defectives and children."

Psychotic patients regardless of diagnosis showed the same general pattern: highest score on Terman vocabulary, second highest on Stanford-Binet, lowest on any of the performance tests. . . . Bijou found the same pattern to hold for habitual criminals. . . . Most delinquents and mental defectives exhibited a strikingly different pattern: low vocabulary and Stanford-Binet scores, with relatively high Performance I.Q.'s.

Hunt and Older,[4] in another study of scatter in inter-test comparisons,

administered a battery of four short verbal tests, two written and two oral, to naval recruits with psychopathic personality, organic involvement, and schizophrenia. The psychopaths were distinctly better on the written than on the oral tests.

Three studies of inter-test comparisons show relationships between verbal and performance scores. "Piotrowski[5] showed that schizophrenic children were poorer on performance tests, whereas congenitally defective children were poorer on verbal tests."

Brody[6] reviewed investigations in which performance tests were compared with verbal tests. There was general agreement that psychiatric patients (especially psychotics) were less proficient on the performance than on the verbal tests.

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[3] *Ibid.*

[4] *Ibid.*, p. 552.

[5] *Ibid.*

[6] *Ibid.*, p. 551.

Bijou and Bijou and McCandless[7] showed that those with impaired performance I.Q.'s were the most poorly behaved, most unstable, and least likely to adjust adequately in the training school situation, while those whose performance I.Q. was better made a good life adjustment.

Some studies introduce evidence that other factors are related to inter-test comparisons. "Jastak and Bijou[8] report that a disparity between arithmetic achievement scores and reading achievement scores apparently parallels the disparity between performance and verbal I.Q.'s." "Bijou[9] showed that using the two patterns together makes possible a more accurate prediction of 'behavior efficiency'." Also, "Earl[10] demonstrated that a discrepancy in scores on two verbal tests or on two performance tests can also be used as an indicator of emotional instability."

Scatter on the Wechsler-Bellevue Scale. Since the Wechsler-Bellevue Scale consists of eleven sub-tests, it is easily adapted to inter-test comparisons. The first studies of scatter in the Wechsler-Bellevue were used as a means of evaluating scatter methods.

One of the first studies was by Gilliland.[11] "He found scatter to be 35 per cent greater in psychotics than in normals" and by the use of sub-test inter-correlations, he found that there were also pattern differences between the groups.

In a following study by Gilliland, Wittman, and Goldman,[12] scatter methods were used to determine: "(a) the significance of differences

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[7] Ibid., p. 552.

[8] Ibid.

[9] Ibid.

[10] Ibid.

[11] Ibid.

[12] Ibid., p. 553.

between mean weighted scores of various clinical groups on each subtest and (b) the significance of differences in amount of intra-test variance." No statistically significant results were found.

Weider,[13] also studying differences in mean weighted scores, showed that young schizophrenics were significantly less proficient on the Digit Symbol subtest than were normals; older schizophrenics were less proficient on Digit Symbol, Object Assembly, and Picture Arrangement.

Weider,[14] in another investigation, compared groups with respect to "the rank order of mean subtest scores." He found that schizophrenics were superior on Information and Comprehension and inferior on Object Assembly.

Rabin,[15] seeking "specific patterns of subtest scores, ranked the subtests in order of magnitude of mean weighted scores and compared the patterns thus obtained from a group of schizophrenics and a group of nurses." No results were reported, but the procedure was considered to be an advance in scatter methods.

Rabin[16] also devised an index of sub-test scores, "a 'schizophrenic index' which was the ratio of Information plus Comprehension plus Block Design to Digit Symbol plus Object Assembly plus Similarities." Using clinical diagnosis as the criterion, the index "successfully differentiated the schizophrenics from the neurotics, normals, and in a later study from the manics."

The method of intra-individual scatter comparisons was first suggested by Brown, Rapaport, et al.[17] This brings research in scatter

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[13] _Ibid._

[14] _Ibid._

[15] _Ibid._

[16] _Ibid._

[17] _Ibid._

closer to the methods used by the writer.

These investigators determined the deviation of each of an individual's subtest scores from the mean of all of his subtest scores; they computed also the deviation of each of his verbal subtest scores from his verbal mean, and of each of his performance subtest scores from his performance mean. The mean deviation scores of schizophrenics, neurotics, depressives, and character disorders on each subtest were compared.

The method proved fruitful in that differences were found in various phases of psychological testing and diagnosis of mental maladjustments.

Wechsler,[18] in the "Measurement of Adult Intelligence," reported the clinical impressions gained from using various scatter methods. He gave illustrative cases and showed tables of plus and minus scatter of the sub-test scores for: "(1) organic brain disease, (2) schizophrenics, (3) neurotics, (4) psychopaths, and (5) mental defectives." For example, schizophrenics scored highest in Vocabulary and Information, and lowest in Digit Symbol and Object Assembly; they may or may not score low on Comprehension, Similarities, and Picture Completion, depending on the type of schizophrenia.

Magaret[19] found that the scores made by schizophrenics scatter more than the scores made by non-psychotics. Specifically, the Vocabulary and Information scores of the schizophrenics were significantly farther above the mean than were the Vocabulary and Information scores of the non-psychotics, and the Digit Symbol and Comprehension scores of the schizophrenics were significantly farther below the mean than were the Digit Symbol and Comprehension scores of the non-psychotics.

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[18]David Wechsler, The Measurement of Adult Intelligence, pp. 146-67.

[19]D. Rapaport, M. Gill, and Roy Schafer, Diagnostic Psychological Testing, Vol. 1, p. 554.

"In a later paper, Magaret and Wright[20] demonstrated significant differences between schizophrenics and mental defectives in the deviation scores on several subtests."

Rabin[21] also used intra-individual methods of scatter in a later study.

An inspection of his data reveals a pattern of mean deviation scores in schizophrenics similar to that obtained by Magaret. This was especially true for patients who were retested about a year after they were admitted to the hospital.

Torrance,[22] in a case study of two boys, made profiles of intra-individual variability in the sub-test scores of the Wechsler-Bellevue Scale. He showed how two boys with similar intelligence quotients at a high level reflected different backgrounds and different patterns of intelligence, although the general level of intelligence of each boy was approximately the same.

The next step in the development of scatter analysis was to use a combination of intra-individual scatter methods. The use of these measures for differential diagnosis was first suggested by Wechsler.[23] The measures that Wechsler recommended were: "(1) verbal minus performance scores, (2) deviation of subtest scores, and (3) specific subtest relationships."

The first study demonstrating the advantage of using a combination of measures was made by Levi.[24] He differentiated adolescent psychopaths

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[20] Ibid.

[21] Ibid.

[22] P. Torrance, "Getting More Than an I.Q. from Elementary School Children," Elementary School Journal, XXXXVIII (June, 1948), pp. 550-56.

[23] D. Rapaport, M. Gill, and Roy Schafer, Diagnostic Psychological Testing, Vol. 1, p. 554.

[24] Ibid.

from non-psychopaths; the former have a significantly higher percentage of cases with (1) performance I.Q. eleven or more points above verbal I.Q., and (2) Picture Arrangement plus Object Assembly scores higher than Picture Completion plus Block Design scores.

Schafer and Rapaport[25] "defined several measures of subtest inter-relationships. . . ." They were: "(1) vocabulary scatter, (2) modified mean scatter, (3) inter-subtest comparisons, and (4) very high or very low weighted scores."

The sub-tests of the Wechsler-Bellevue began to be used as a means of differential diagnosis in clinical psychology and had introduced a need for research studies in clinical psychology to give a rationale or summary of functions underlying proficiency on each of the sub-tests.

Wechsler,[26] the author of the Wechsler-Bellevue Scale, had given a description of the sub-tests and had offered scattered comments of rationale in the text which reported his work in developing the sub-tests. Later, Magaret[27] expressed the need for determining the reasons for the successes and the failures which she observed in schizophrenics. She found that neither difference of time limits nor motivation could account for the successes or the failures. Machover[28] "offered some rationale to account for his findings, but did not present a rationale for each of the subtests." Rabin[29] referred "only to impairment of 'alertness and speed of association', or to 'initiative in seeking and

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[25]Ibid.

[26]David Wechsler, The Measurement of Adult Intelligence, pp. 73-101.

[27]D. Rapaport, M. Gill, and Roy Schafer, Diagnostic Psychological Testing, Vol. 1, p. 554.

[28]Ibid.

[29]Ibid.

achieving an unknown goal'." The first systematic approach to the rationale and various functions underlying the specific sub-tests was offered by Rapaport, Brown, et al,[30] and was developed further by Reichard and Schafer.[31]

Later, in virtually a sequel to the Rapaport study, Schafer[32] reported his findings from a study of both quantitative and qualitative features in sub-test relationships. He found that certain patterns of qualitative features were of value in differentiating clinical features of mental patients.

Summary of Research in Related Studies

Relatively few studies closely related to the present investigation, other than those reviewed in the foregoing section, were found. The studies reviewed here are considered to be closely related to the present investigation because they either used methods similar to scatter methods, attempted predictions of school achievement from sub-test scores of multi-score tests, attempted differential prediction of school achievement from intelligence test scores, or showed a need for the present investigation.

Tilton[33] reviewed studies of mental unevenness and brightness by Woodrow, and made a study of evenness at different levels of the intelligence quotient. Using the group tests of National Intelligence

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[30]Ibid.

[31]Ibid.

[32]Roy Schafer, The Clinical Application of Psychological Tests, (New York, 1948), pp. 346.

[33]J. W. Tilton, "Relation between I.Q. and Trait Difference as Measured by Group Intelligence Tests," Journal of Educational Psychology, XXXVIII (October, 1947), pp. 343-52.

Scale, Detroit Primary Intelligence Test, Pintner General Ability Test, Kulmann-Anderson, and the Terman-McNemar Test of Mental Ability, he found that bright pupils were 8 per cent more even than average pupils, and that dull pupils were 10 per cent less even than average pupils with regard to the scatter of scores from the intelligence tests.

Goodman[34] reviewed several studies and found that the scores on the Thurstone Primary Abilities Tests correlated with mark averages used as the criterion of college success, and that the test scores correlated with marks in certain courses to some degree. Verbal ability showed the highest correlation with school marks of any ability measured by the tests. It was suggested that the scores can be used for prediction of success in college.

Shaw[35] used Chicago Tests of Primary Abilities to find relationships between primary mental abilities and certain achievement tests. Combinations of selected primary mental abilities were found to be highly related to the achievement scores; however, not all of the mental abilities contributed to the relationships.

Hudson,[36] in part of a larger study sponsored by the American Council on Education, made an investigation of the relationship of primary mental abilities and scholastic success in professional schools. Using the Wherry-Doolittle test selection method, he found multiple correlation

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[34]Charles H. Goodman, "Prediction of College Success by Means of Thurstone's Primary Mental Abilities Tests," Educational and Psychological Measurement, IV, No. 2 (1944), pp. 125-40.

[35]D. C. S haw, "Study of the Relationships Between Thurstone's Primary Mental Abilities and High School Achievement," Journal of Educational Psychology, XXX (April, 1949), pp. 239-49.

[36]H. H. Hudson, "Relation of Primary Mental Abilities to Scholastic Success in Professional Schools," Journal of Experimental Education, X (March, 1942), pp. 179-82.

scores of .614, .577, and .416, respectively, between the criterion of scholastic success and the factor scores of engineering, journalism, and medicine, respectively. The results suggested that tests for primary abilities have some value in educational and vocational counseling.

Ryan,[37] in a study of native capacity of intelligence in relation to achievement tests in Mathematics, found that correlations of general intelligence scores with scores representing quartiles of success in Algebra, and with scores representing quartiles of success in General Mathematics, tended to disagree. He indicated that further study was needed.

Hingsburg[38] made a study in which he compared the median intelligence quotient of four different group intelligence tests to achievement in (1) academic courses, (2) commercial courses, and (3) general courses. Strong similarities were found in the results, and it was suggested that it was not wise to classify pupils on the basis of the general level of intelligence alone.

Borow[39] made a survey of numerous studies in which intelligence test scores were used. He found that the average correlation of intelligence test quotients with mark averages in college was approximately .45; multiple correlation coefficients range from .38 as reported by Darley to .64 as reported by Ellison and by Edgerton. He suggests that the

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[37]M. M. Ryan, "Intercorrelations in Native Capacity and Accomplishments in Mathematics Courses," School and Society, LXX (September, 1949), pp. 183-84.

[38]O. Hingsburg, "Relationship of Scholastic Average to the I.Q.," High Points, XXXII (April, 1950), pp. 73-76.

[39]Henry Borow, "Current Problems in the Prediction of College Performance," Journal of the American Association of College Registrars, XXII (October, 1946), pp. 14-26.

greater part of the difference among college students in school achievement is still unaccounted for by the instruments of prediction in current use.

CHAPTER III

COLLECTION AND QUANTIFICATION OF THE ORIGINAL DATA

The Research Population

The research population defined. The research population selected for this investigation may be defined as the senior pupils of Class B (under 200 high school pupils) oil field high schools in Rusk County, Texas, for the school year of 1950-51. The research population consisted of 130 high school seniors, 74 boys and 56 girls, chosen to be representative of four oil field high schools, namely: Gaston High School, Joinerville, Texas; Carlisle High School, Price, Texas; Leverett's Chapel High School, Overton, Texas; and Overton High School, Overton, Texas.

Background of the research population. The geographic area of the population is the north central part of East Texas. Although the area is essentially rural, the density of the area population, the proximity of the different schools to each other, various community enterprises, modern civic improvements, the interlacing of good highways, and the nearness to large towns and industrial centers tend to make the area population virtually a cross-section of rural and urban areas.

The economic structure is chiefly the result of the oil industry, either directly or indirectly. Incomes, in general, may be regarded as having a narrow spread and as being above the mean income of the American working class.

The social structure is chiefly of rural origin but is gradually becoming absorbed in the multifarious activities of the urban centers.

Community stability has replaced the "boom" structure of early days in the development of the oil fields.

Sources of the data. The data were obtained from two sources. (1) Each member of the population was given the Wechsler-Bellevue Intelligence Scale, Form I, by the writer; the scores obtained comprised the first source of data. (2) The individual pupil marks (grades 9 to 12, inclusive) were obtained from the records of each high school for each member of the population.

Intelligence Sub-Test Data

Division of the intelligence sub-test data. There are eleven sub-tests of the Wechsler-Bellevue Intelligence Scale. The Scale may be divided into verbal and performance sub-tests. The six verbal sub-tests are: Information, Comprehension, Digit Span, Arithmetic, Similarity, and Vocabulary. The five performance sub-tests are: Picture Arrangement, Picture Completion, Block Design, Object Assembly, and Digit Symbol.

Rationale of the sub-tests

Information. (1) It is one of the most satisfactory in the battery; (2) it tests the general range of information; and (3) items selected are those calling for the sort of knowledge that an average individual with average opportunity may be able to acquire for himself.

Comprehension. (1) It is a test of judgment; (2) success depends on (a) practical experience, (b) general ability to evaluate past experience, and (c) common sense; and (3) poor verbalizers tend to not do well on it.

Digit Span. (1) It is essentially a test of attention; (2) it requires the employment of specifically deployed energies; (3) immediate memory span is involved; and (4) low scores are associated with (a) attention defects, (b) organic defects, (c) anxiety, and (d) lack of 'Mental control'.

Arithmetic. (1) It is essentially a test of concentration; (2) it requires mental alertness; (3) it involves the ability to employ energies not specifically deployed; (4) it involves conscious and ordered thought processes in abstract thinking; (5) it is affected by attention and transient emotional conditions; and (6) it correlates highly with global measures of intelligence.

Similarities. (1) It is another verbal test which is one of the best in the battery; (2) it is primarily a test of concept formation; (3) it differentiates abstract from concrete thinking; (4) it indicates adult mentality; and (5) it contains a lot of the "g" factor, i.e., general intelligence.

Vocabulary. (1) It is the best measure of general intelligence; (2) it is the most stable measure of intelligence, and experience has shown that schooling factors influence the effective range of an individual's vocabulary much less than is commonly suspected; (3) the verbalization of the responses may reveal qualitative indicators; and (4) it may be used as an alternate for another verbal test.

Picture Arrangement. (1) It is a measure of the ability to comprehend and size up a total situation; (2) it measures the ability to anticipate and plan; (3) it measures what corresponds to that which is called social intelligence; and (4) bizarre explanations are suggestive of some disorganization in the mental orientation.

Picture Completion. (1) This is a test which measures perceptual and conceptual abilities in so far as these abilities are involved in the visual recognition and identification of familiar objects and forms;

(2) it is a test of visual concentration; (3) it involves the ability to differentiate the essential from the unessential; and (4) it may not be able to discriminate between the higher levels of intelligence.

Block Design. (1) This is a test of synthesis and analytical ability; (2) it tests the abstract attitude; (3) it tests the ability to perceive patterns; (4) it involves the ability to coordinate visual and motor functions in creative ability; (5) it samples the difference in attitude and emotional reaction between the hasty, the deliberate, and the careful; and (6) it is another good test of general intelligence.

Object Assembly. (1) This is essentially a test of visual motor coordination; (2) it tells something about (a) one's mode of perception, (b) the degree to which one relies on trial and error methods, and (c) the manner in which one reacts to mistakes; (3) high scores are suggestive of creative, artistic, or mechanical ability; and (4) low scores are suggestive of poor manipulative ability, or anxiety, or depressive features.

Digit Symbol. (1) This is essentially a test of visual organization; (2) it is a test of psycho-motor speed; (3) it involves the ability to work with symbols; and (4) it contains a good deal of the general factor of intelligence.

The outline of the rationale of the sub-tests was abstracted from the writings of Wechsler,[1] Rapaport,[2] Rhinehart,[3] and Schafer.[4] It is

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[1]Wechsler, Measurement of Adult Intelligence, pp. 79-103.

[2]Rapaport, Diagnostic Psychological Testing, pp. 87-299.

[3]Rhinehart, "Quotes and Notes," (Abstract of note 6).

[4]Schafer, The Clinical Application of Psychological Tests, scattered references to the rationale throughout the test.

not intended that the outline should be complete nor that it should be considered as definitive. Rather, the purpose of the outline is to give the reader a general idea of the development of the rationale at the time of this writing. Although qualitative factors are indicated in the rationale of the sub-tests and may be very useful in getting information more than an I.Q., it should be noted that the scoring of the sub-tests is derived only from the quantitative measurements. Any reader interested in an analysis of the qualitative factors is referred to the study by Schafer.

Methods of collecting the data. The intelligence test data were collected by the writer through the administration and scoring of the Wechsler-Bellevue Intelligence Scale, Form I. The technique involved in administering this test was in strict accordance with the standardization precepts of the Wechsler manual[5] and was followed rigidly except for certain suggestions as proposed by the Rapaport study.[6] Before the test was administered, the high school seniors of the particular school were assembled together in a convenient room with the Principal and the writer. After an introduction by the Principal, a brief talk was made by the writer for the purpose of getting group rapport. During this brief talk, the writer indicated that an intelligence test would be administered, and then passed on to an outline of the need and incentives for taking such a test. Although the writer talked about the type of an intelligence test which is designed to measure different aspects of mental abilities, he at no time described or gave clues as to the exact nature of the test

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[5]Wechsler, "General Instructions," pp. 171-254.

[6]Rapaport, "Administration," p. 200, p. 276.

itself. When the seniors, as a group, appeared to be satisfied as to the value of taking the test, and when the initial alarm regarding the test had subsided, the writer ended his remarks. In so far as the pupils were concerned, the procedure was made to appear as routine as possible. No particular time was scheduled with the pupils for taking the test; the writer, with the cooperation of the Principal of the school, worked out the testing schedule. Pupils were summoned for testing by the Principal or his representative.

The actual testing was done in the privacy of a room in the school, which at the time was not being used for classes. The nature of the physical surroundings pertinent to the room differed from school to school, but the psychological set and the arrangement of the physical equipment of the examiner remained the same. The physical equipment consisted of an oblong table, one chair for the pupil and one chair for the examiner; and the standard equipment of the Wechsler-Bellevue Intelligence Scale, Form I. The test equipment was concealed in boxes (until time for presentation) on the right side of the table closer to the pupil's side of the table. The record sheet of Form I was partially concealed behind the boxes and open to the proper place for the examiner to record the data. The problems were presented to the pupil on the left side of the table and toward his side of the table. When the problem was one of a verbal nature, the pupil was permitted to dispose himself in any manner he chose. The manual of the test was kept open in front of the examiner, and directions were stated as memorized. The examiner kept his eyes to the manual to prevent any deviation in stating the directions and also to make the directions appear impersonal, thereby insuring standardization of the directions and minimizing any effect in the pupil.

Although no rigid sequence was followed in the presentation of the various sub-tests, the verbal tests were presented first. The reason for presenting the verbal sub-tests first was twofold: first, any problem of rapport which might affect the results probably would be less likely to do so on the verbal sub-tests than it would on the performance sub-tests; and second, since the possibility existed that answers to questions of the verbal sub-tests might become known to pupils not yet subjected to the tests, there was a need for completing the verbal sub-tests as quickly as possible. Therefore, the first session was limited to the administration of the verbal sub-tests of Information, Similarities, and Vocabulary. When each of the pupils of the population in a particular school had finished with this portion of the scale, the second session was begun. The first sub-test administered in the second session was Comprehension, because it was thought that one verbal sub-test to start the second session would help to re-establish the rapport created by the previous session. Also, answers to questions of the Comprehension sub-test are less likely to be passed from pupil to pupil than are answers to questions of the other verbal sub-tests. Comprehension was followed by Object Assembly, Digit Span, Arithmetic, Picture Completion, Picture Arrangement, Block Design, and Digit Symbol. Deviations in the order of presentation were made in accordance with the Wechsler manual. Most of the variation was in the presentation of Digit Span and Picture Completion; i.e., the order of Digit Span and Picture Completion in the battery was sometimes exchanged. If rapport was deemed to be secure after the presentation of Object Assembly, then Digit Span was presented next; however, if rapport was not deemed to be secure, or if the pupil had done rather badly on Object Assembly, then Picture Completion (in the writer's experience a test less likely to arouse anxiety) was presented; and the general order of presentation was continued.

As each task of the sub-tests was completed, the indicated symbol was entered in the appropriate place on the record form. When timing was demanded, the writer held the stop watch in his left hand, and in partial view of the pupil; no attempt was made to encourage or discourage the pupil's awareness of the stop watch. The raw scores of each task were later summated and translated into weighted sub-test scores as provided for in the Wechsler manual.[7]

Service to the schools. As a reciprocal service to the participating schools, test scores for each pupil of the research population were entered in the appropriate places on mimeographed forms. The forms were then grouped according to schools and presented to the respective principals. Each form was made to show general intelligence,[8] verbal intelligence, performance intelligence, all weighted sub-test scores, and a profile of the sub-test scores. Also, consulting service with the school principals and counseling with pupils (subject to the school policy) about test scores were provided upon request.

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[7]Wechsler, "General Instructions," pp. 171-188.

[8]The mean I.Q. of the research population was 102.08. Other computed statistics are:

standard deviation	9.12
standard error of the mean	.80
standard error of the sigma	.56
quartile	6.28
percentile ten	90.82
quartile one	95.34
median	104.02
quartile three	107.90
percentile ninety	114.54
skewness	-1.34
sigma of the skewness	1.30
t of the skewness	.10
kurtosis	.26
sigma of the kurtosis	.03
t of the kurtosis	.10

Basic quantification. The weighted intelligence sub-test scores of each pupil were recorded on Wechsler-Bellevue record forms. This gave each pupil a score for each of the eleven Wechsler-Bellevue sub-tests. Then the distribution of scores in each sub-test was normalized by converting the originally recorded scores into "T" scores.[9] This was done in order to convert the eleven sub-test distributions into eleven distributions of equivalent scores[10] of equal ability units which could be comparable to the data derived from the school marks.[11]

For convenience, and in order to facilitate the computation of the data, the normalized intelligence sub-test scores for each individual of the population were recorded on four-by-six cards. The cards were made to indicate the name, school, the normalized scores of each sub-test, and the total mean score[12] for each individual.

Mark Data

Division of the mark data. The mark data were taken from different areas of school studies. The school studies were divided into six areas. Therefore, the mark data were divided into six areas, namely: marks in English (English I, II, III, and IV); marks in Mathematics (general mathematics, algebra, geometry, and trigonometry); marks in Social Science (all history and civics); marks in General Science (biology, physics, chemistry, and general science); marks in Clerical Studies

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[9]Henry E. Garrett, Statistics in Education and Psychology, (New York, 1947), pp. 156-57.

[10]"Equivalent scores are defined as measures which indicate the same levels of ability." Ibid., p. 149.

[11]The school marks were also normalized. See "Mark Data."

[12]The total mean score is the mean of the individual's eleven Wechsler-Bellevue sub-tests.

(typing, shorthand, secretarial training, and junior business training); and marks in Homemaking for girls and Shop for boys.

Data selected for investigation. Only three areas of school studies contained marks for every member of the population. The three areas of school studies were English, Mathematics, and Social Science. Therefore, in order to have a consistent population of marks, the marks in English, Mathematics, and Social Science were selected for investigation. These divisions of marks will be referred to as mark areas.

Basic techniques of quantification. In as much as the marking system differed somewhat among the four schools used, the population of marks was first divided so that the marks from each school became a sub-population. All of the high school marks of each sub-population were translated into numerical values appropriate to the particular marking system of the school. For example, a mark of "B" might receive a numerical value of 85. The numerical values of the marks for each school subject were then recorded separately for each pupil and for each school.

Next, the mean and the standard deviation of the numerical values of all marks within the mark area of Mathematics[13] were computed for each school; the same was done for English and for Social Science. Then, each pupil's semester marks in Mathematics were averaged,[14] and the average score was used as the pupil's raw score in Mathematics; the same was done for English and for Social Science. Finally, each pupil's raw score was converted into a "Z"[15] score (standard score) relative to the mark

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[13]For example, in each school the numerical scores of all of the semester marks in each class of general mathematics, algebra, geometry, and trigonometry were combined in one distribution of marks in mathematics.

[14]See second paragraph under paragraph heading "Rationale and criticism."

[15]Henry E. Garrett, Statistics in Education and Psychology, pp. 156-57.

area distribution of the school from which the raw score was obtained. The completion of this step formed twelve distributions of "Z" scores,[16] one distribution for each of the three mark areas in the four schools.

Next, steps were taken to normalize the data of each mark area. First, the "Z" scores of each mark area within each school were combined with the "Z" scores of like mark areas in the other schools. The effect of this grouping was to set up three distributions of "Z" scores, one distribution for each mark area of English, Mathematics, and Social Science.[17] Then the whole population of marks in each mark area was normalized, within limitations,[18] by scaling the "Z" scores of each mark area distribution into "T" scores.[19] Then, each pupil's "Z" scores were converted into "T" scores.

Finally, when normalization of the data of each mark area was completed, each pupil's "T" score in English, Mathematics, and Social Science, and the mean of his three "T" scores, were recorded in tables, of which Table I is an example.

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[16] See third paragraph under paragraph heading "Rationale and Criticism."

[17] Ibid.

[18] See fourth paragraph, Ibid.

[19] See fifth paragraph, Ibid.

TABLE I

EXAMPLE OF "T" SCORES IN MARK AREAS

Pupil	T-Scores			Mean of "T" Scores
	English	Mathematics	Social Science	
1	55	47	48	50
2	48	62	70	60
-	-	-	-	-
-	-	-	-	-
n				

Rationale and criticism. During the course of this investigation, certain difficulties were encountered in keeping selective factors to a minimum. Alternate techniques of handling the difficulties were recognized and explored. The techniques used were those which revealed the least tendency to error. The procedure by which the mark area scores in Table 1 were obtained may be subject to criticism; therefore, some comment about this procedure may be worthy of being noted.

The technique which combines scores of specific school subjects, in Mathematics, for example, is subject to a certain amount of error. There is a certain arbitrariness in assuming that all courses of a given mark area should be equally considered in obtaining mark area scores, e.g., the error which may be involved in expecting a specific mental ability to function to the same degree in algebra as it does in geometry. Also, although each pupil took courses in Mathematics, all pupils did not take the same number of courses in Mathematics.

The reason for computing "Z" scores in transition to "T" scores may be questioned. If the marking systems of the different schools had been the same, and if there had been no significant differences in the mean scores of each sub-population, the distributions of raw mark scores might have been immediately converted into "T" scores. This was not the case; therefore, standard scores were computed. Furthermore, standard scores of various sub-populations are more comparable and subject to less error in aggregation than are raw scores. For example, standard scores in each school located the pupil's mark position relative to pupils with whom he had actually competed under similar circumstances; e.g., in a given school, pupils tended to have the same teachers, take the same tests, be marked by the same marking system, and be governed by the same school policies. As a result, when sub-groups were aggregated, the differences in the teacher factor, the marking system factor, and the school policy factor were kept to a minimum.

The technique which scales sub-group distributions into one distribution of "T" scores assumes a normal distribution for each of the sub-groups of the population; and while standard scores convert the distributions of sub-groups into relatively normal distributions, there is (theoretically) the problem of fitting overlapping sub-group distributions. The scaling of the standard deviational values will further enhance normality of the distribution of the greater part of the scale, but the extremities of the scale will tend to remain unreliably scaled. Although this method of transforming ordinal scales into an interval scale, on the assumption that ordinal scales can be expected to assume normality, has historical precedence and is used in the measurement of many situations, it should be observed that the assumption of normality may not always be warranted. In certain situations, it may be more warranted to assume a skewed distribution. E. F. Gardner[20] has introduced a method of attacking this scale synthesis problem without necessarily assuming the normality of the sub-group distributions. His fitting procedure for sub-group ordinal scales may be a very important step forward, but the technique apparently is not yet perfected. It lacks efficiency and may be subject to errors of fluctuation.[21]

The "Z" scores were scaled into "T" scores for the purpose of transforming like mark area data into equivalent scores of equal ability units which could be compared directly to other distributions likewise transformed. Standard scores do not represent equal units, but equal units can be obtained by the use of scaling techniques[22] such as the "T" score.

It should become clear at this point that any method of handling these problems will obviously contain, at the present time, a certain amount of arbitrariness which may introduce some error, even though the degree of error may be expected to be slight. To reduce the probability of error in this study further, one would need to administer not only all of the intelligence tests but also all of the subject matter tests in school. To do this, of course, one would be required to teach, as well as measure, all of the population of pupils in all of the classes in each area of school studies. It is not presumed that all of the

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[20]E. F. Gardner, "Comments on Selected Scaling Techniques with a Description of a New Type of Scale," Monograph Supplement number 7, "Symposium on Statistics for the Clinician," Journal of Clinical Psychology, (January, 1950), pp. 38-43.

[21]John W. Tukey, "Discussion," Ibid., p. 68.

[22]Anne Anastasi, Differential Psychology, p. 273.

selective factors could have been or should have been isolated in this investigation. An attempt, however, was made to reduce them to a minimum.

CHAPTER IV

RELATING THE INTELLIGENCE SUB-TEST DATA TO MARK AREA DATA

Finding the Sub-Test Combinations

Foreword

Before patterns of intelligence sub-test combinations can be compared with patterns of mark area data, the intelligence sub-test combinations which show relationships with mark area data must be found. The general purpose of this part of the investigation was to attempt to locate these sub-test combinations which have some relationships with mark area data. More specifically, the following pages will report the investigation of: (1) whether there are any differences between the mean scatter of intelligence sub-test scores of good pupils[1] in any given mark area, e.g., English, and the mean scatter of the intelligence sub-test scores of poor pupils[2] in the same mark area; and if so, (2) whether the mean of the deviations of good students of any given sub-test tends to be markedly above the total sub-test mean and whether the mean of the deviation of poor students tends to be markedly below the total sub-test mean.

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[1]A good pupil was one who had a normalized mark area score, e.g., English, which was above the mean of his three normalized scores of English, Mathematics, and Social Science. A score which fell on the mean was considered to be "good."

[2]A poor pupil was one who had a normalized mark area score which was below the mean of his three normalized scores of English, Mathematics, and Social Science.

Categorization of the Data

Step 1. The first step was to select a pupil mark area. For example, marks in English were selected.

Step 2. Good pupils in English were found by inspecting Table 1 and selecting each pupil who had a "T" score in English which was above his mean "T" score.

Step 3. Poor pupils in English were found by inspecting Table 1 and selecting each pupil who had a "T" score in English which was below his mean "T" score.

Step 4. The mark area was dichotomized into two categories: (a) good pupils in English, and (b) poor pupils in English. The categorization was actually accomplished by placing prepared cards of each pupil in the appropriate card stack, i.e., either the good pupil stack or the poor pupil stack. This procedure resulted in two stacks of cards for each mark area, one stack for the good pupil category and one stack for the poor pupil category.

Step 5. Since the cards contained the intelligence test scores for a particular pupil, the two stacks at once categorized the intelligence sub-test scores. For each stack, scores of the same intelligence sub-tests were summated, the means were computed, and the mean of the eleven intelligence sub-test means was computed. This gave two sets of computations for each mark area, one for the good pupil category and one for the poor pupil category.

Step 6. The computations of step 5 were recorded in tables, and the deviations of the sub-test means from the mean of the eleven sub-test means were computed and entered to the right of each sub-test mean. The computations are shown in Table 2.

Step 7. The cards were reassembled, and the techniques of the first six steps were completed for each of the other two mark areas of Mathematics and Social Science.

Mean Scatter[3] Comparisons

Within each good and poor pupil category of a given mark area, e.g., within each good and poor pupil category in English, the mean scatter of the mean intelligence sub-test scores was plotted and the points connected to form a profile. The two profiles of mean scatter for each good and poor pupil category, when plotted against each other with zero as the mean of the means, immediately brought into focus the differences in the mean scatter of intelligence sub-test scores within each category, and revealed that the mean scatter of certain sub-tests was above the mean of the means in the category of good pupils and below the mean of the means in the category of poor pupils.

Each table shows the total score, the mean score, the total mean, and the mean scatter of each intelligence sub-test within the good pupil category of a given mark area, and also within the poor pupil category of the same mark area.

Mean scatter comparisons can be made by comparing the mean scatter of each sub-test in the good pupil category with the mean scatter of the same sub-test in the poor pupil category. Mean scatter is found by subtracting the total mean score from the sub-test mean score.

Intelligence sub-test abbreviations in the tables are as follows: Information is Infor., Comprehension is Compre., Digit Span is D. Span,

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[3]Mean scatter is the difference between any single sub-test mean score and the total mean score of the eleven sub-test mean scores.

Arithmetic is Arith., Similarities is Simil., Vocabulary is Vocab., Picture Arrangement is P. Arr., Picture Completion is P. Com., Block Design is Bl. Des., Object Assembly is Obj. A., and Digit Symbol is D. Sym.

Differences in the mean scatter of intelligence sub-test means in categories of English. Inspection of the intelligence sub-test mean scatter in good and poor pupil categories of English, as shown in Table 2, reveals mean scatter differences of deviation as follows: (1) the mean scatter of the Digit Span and Digit Symbol mean scores is above the total sub-test mean in the good pupil category, and (2) the mean scatter of the Digit Span and Digit Symbol mean scores is below the total sub-test mean in the poor pupil category.

TABLE 2

INTELLIGENCE SUB-TEST MEAN SCATTER IN GOOD AND POOR PUPIL CATEGORIES OF ENGLISH

	Good Pupil Category N is 59			Poor Pupil Category N is 71		
	Total Score	Mean Score	Mean Scatter	Total Score	Mean Score	Mean Scatter
Infor.	2837	48.08	-0.94	3678	51.80	1.08
Compre.	2879	48.80	-0.22	3622	51.01	0.29
D. Span	3045	51.61	2.59	3462	48.76	-1.96
Arith.	2801	47.47	-1.55	3710	52.25	1.53
Simil.	2896	49.08	0.06	3582	50.45	-0.27
Vocab.	2891	49.00	-0.02	3591	50.58	-0.14
P. Arr.	2876	48.75	-0.27	3640	51.27	0.55
P. Com.	2835	48.05	-0.97	3644	51.32	0.60
Bl. Des.	2823	47.85	-1.17	3651	51.42	0.70
Obj. A.	2873	48.69	-0.33	3607	50.80	0.08
D. Sym.	3058	51.83	2.81	3427	48.27	-2.45
Total Mean		49.02			50.72	

Differences in the mean scatter of intelligence sub-test means in categories of Mathematics. Inspection of the intelligence sub-test mean scatter in good and poor pupil categories of Mathematics, as shown in Table 3, reveals mean scatter differences of deviation as follows: (1) the mean scatter of the Arithmetic, Block Design, and Picture Completion mean scores is above the total sub-test mean in the good pupil category, and (2) the mean scatter of the Arithmetic, Block Design, and Picture Completion mean scores is below the total sub-test mean in the poor pupil category.

TABLE 3

INTELLIGENCE SUB-TEST MEAN SCATTER IN GOOD AND POOR PUPIL CATEGORIES OF MATHEMATICS

	Good Pupil Category N is 56			Poor Pupil Category N is 74		
	Total Score	Mean Score	Mean Scatter	Total Score	Mean Score	Mean Scatter
Infor.	2777	49.59	0.12	3738	50.51	0.20
Compre.	2761	49.30	-0.17	3740	50.54	0.23
D. Span	2765	49.37	-0.10	3742	50.57	0.26
Arith.	2850	50.89	1.42	3661	49.47	-0.84
Simil.	2686	47.96	-1.51	3792	51.24	0.93
Vocab.	2743	48.98	-0.49	3739	50.53	0.22
P. Arr.	2683	47.91	-1.56	3833	51.80	1.49
P. Com.	2811	50.20	0.73	3668	49.57	-0.74
Bl. Des.	2889	51.59	2.12	3585	48.45	-1.86
Obj. A.	2790	49.82	0.35	3690	49.86	-0.45
D. Sym.	2718	48.54	-0.93	3767	50.91	0.60
Total Mean		49.47			50.31	

Differences in the mean scatter of intelligence sub-test means in categories of Social Science. Inspection of the intelligence sub-test mean scatter in good and poor pupil categories of Social Science, as shown in Table 4, reveals mean scatter differences of deviation as follows: (1) the mean scatter of the Information, Similarities, and

Picture Arrangement mean scores is above the total sub-test mean in the good pupil category, and (2) the mean scatter of the Information, Similarities, and Picture Arrangement mean scores is below the total sub-test mean in the poor pupil category.

TABLE 4

INTELLIGENCE SUB-TEST MEAN SCATTER IN GOOD AND POOR PUPIL CATEGORIES OF SOCIAL SCIENCE

	Good Pupil Category N is 63			Poor Pupil Category N is 67		
	Total Score	Mean Score	Mean Scatter	Total Score	Mean Score	Mean Scatter
Infor.	3244	51.49	1.06	3271	48.82	-0.68
Compre.	3207	50.90	0.47	3294	49.16	-0.34
D. Span	3133	49.73	-0.70	3374	50.36	0.86
Arith.	3130	49.68	-0.75	3381	50.46	0.96
Simil.	3241	51.44	1.01	3237	48.31	-1.19
Vocab.	3180	50.48	0.05	3302	49.28	-0.22
P. Arr.	3259	51.73	1.30	3257	48.61	-0.81
P. Com.	3161	50.17	-0.26	3318	49.52	0.02
Bl. Des.	3072	48.76	-1.67	3402	50.78	1.28
Obj. A.	3194	50.70	0.27	3286	49.04	-0.46
D. Sym.	3129	49.67	-0.76	3356	50.09	0.59
Total Mean		50.43			49.50	

In order to gain a better insight into the data, and in order to check against chance fluctuations of the distributions of mark data, the mark categories of each mark area were further divided arbitrarily into trichotomous and quinchotomous categories and then treated in the manner of the dichotomous categories. The findings essentially substantiated the indications of the dichotomous treatment.

Logical analysis. Since the mean scores of Digit Span and Digit Symbol occur above the mean of the intelligence sub-test means in the good pupil category of English and do not occur above the mean of the intelligence sub-test means (being below the mean) in the poor pupil category of English, a causal comparative relationship is suggested between the mean scores of Digit Span and Digit Symbol and good and poor pupil categories of English. The same logic will apply to Arithmetic, Block Design, and Picture Completion with reference to pupil categories of Mathematics, and to Information, Similarities, and Picture Arrangement with reference to pupil categories of Social Science.

Development of the Mental Ability Areas

Purpose. The development of the mental ability areas was undertaken in order to satisfy five considerations: (1) the composite development and induction of the data of the intelligence sub-tests, (2) a needed reduction of the variables under investigation, (3) the laws of parsimony, (4) the numerical consistency of the two areas, and (5) the elimination of superfluous and non-significant data.

Formulation of Composite Scatter Sub-Hypotheses

Postulate. If the sub-test associations of directional agreement will occur in relation to the mean of all of the intelligence sub-tests, they should occur when common factors (non-associated sub-tests) of the intelligence sub-tests are eliminated. Furthermore, they should continue to occur when the mean of each combination of sub-test associations is compared to the mean of the means of each combination of sub-tests.

Grouping of the intelligence sub-test associations. The sub-tests associated in directional agreement, relative to the mean scatter of all of the intelligence sub-tests, were grouped so as to form an over-all hypothesis with respect to the pertinent mark area. For example, since the intelligence sub-test scores of Digit Span and Digit Symbol have a tendency to be directionally associated with English, it would be expected that the mean of the scores from the two sub-tests should show a like relationship.

Proceeding from the postulate, the sub-tests of Digit Span and Digit Symbol, each considered as being a component part of a mental ability, were grouped to form a sub-test combination. The composite ability which is measured by this particular sub-test combination was called Mental Ability A. Likewise, the sub-tests of Arithmetic, Block Design, and Picture Completion were grouped as a measure of Mental Ability B; and the sub-tests of Information, Similarities, and Picture Arrangement were grouped as a measure of Mental Ability C.

The mental ability score for each mental ability area is the mean of the sub-test scores in a particular sub-test combination. For example: (1) the Mental Ability A score is the mean of Digit Span and Digit Symbol scores; (2) the Mental Ability B score is the mean of Arithmetic, Block Design, and Picture Completion scores; and (3) the Mental Ability C score is the mean of the Information, Similarities, and Picture Arrangement scores.

Composite scatter sub-hypotheses. The composite scatter sub-hypotheses may be stated as follows: (1) the differences of the deviations in the mean scatter of Mental Ability A, Mental Ability B, and Mental Ability C, respectively, are to the mean of the mental ability area means as the differences of the deviations in the mean scatter of marks in English, Mathematics, and Social Science, respectively, are to the mean of the mark area means; (2) likewise, the mental ability areas will differentiate good and poor marks in the respective mark areas.

Categorization of the Data

Step 1. Using Table 2 as the data for the computations, the total score of Digit Span and Digit Symbol were summated and averaged to find the total score and the mean score for Mental Ability A in the good pupil category of English.

Step 2. The techniques of step 1 were used to find the total score and the mean score for Mental Ability A in the poor pupil category of English.

Step 3. The techniques of the first two steps were used to find the total score and the mean score of: (a) Mental Ability B relative to the sub-test combination of Arithmetic, Block Design, and Picture Completion, and (b) Mental Ability C relative to the sub-test combination of Information, Similarities, and Picture Arrangement.

Step 4. The techniques of the first two steps were used to find each total score and mean score of: (a) Mental Ability B in good and poor pupil categories of Mathematics, and (b) Mental Ability C in good and poor pupil categories of Social Science.

Step 5. For each mark area category, the three mental ability mean scores were summated and divided by three to find the mean of the means for each category; then each of the three means, within each category, was subtracted from the mean of the means to find the positive or negative mean scatter of each mental ability within each good and poor pupil category.

Step 6. The computations of the preceding steps were recorded in tables and are shown in Tables 5, 6, and 7.

Mean Scatter Comparisons

The mean scatter of each sub-test combination, as represented by mental ability scores, is now ready to be compared in good and poor pupil categories of each mark area. As stated before, mean scatter comparisons can be made by comparing the mean scatter of each sub-test in the good pupil category with the mean scatter of the same sub-test in the poor pupil category. Mean scatter is found by subtracting the total mean score from the mental ability mean score.

Differences in the mean scatter of mental ability area means in categories of English. Inspection of the mental ability area mean scatter in good and poor pupil categories of English, as shown in Table 5, reveals mean scatter differences of deviation as follows: (1) the mean scatter of Mental Ability A is above the mean of the mental ability area means in the good pupil category, and (2) the mean scatter of Mental Ability A is below the mean of the mental ability area means in the poor pupil category.

TABLE 5

MENTAL ABILITY MEAN SCATTER IN GOOD AND POOR CATEGORIES OF ENGLISH

	Good Pupil Category			Poor Pupil Category		
Mental Ability	Total Score	Mean Score	Mean Scatter	Total Score	Mean Score	Mean Scatter
A	6103	51.72	2.34	6889	48.51	-1.94
B	8459	47.79	-1.59	11005	51.67	1.22
C	8609	48.64	-0.74	10900	51.17	0.72
Mean of Means		49.38			50.45	

Differences in the mean scatter of mental ability area means in categories of Mathematics. Inspection of the mental ability area mean scatter in good and poor pupil categories of Mathematics, as shown in Table 6, reveals mean scatter differences of deviation as follows: (1) the mean scatter of Mental Ability B is above the mean of the mental ability area mean in the good pupil category, and (2) the mean scatter of Mental Ability B is below the mean of the mental ability area mean in the poor pupil category.

TABLE 6

MENTAL ABILITY MEAN SCATTER IN GOOD AND POOR CATEGORIES OF MATHEMATICS

	Good Pupil Category			Poor Pupil Category		
Mental Ability	Total Score	Mean Score	Mean Scatter	Total Score	Mean Score	Mean Scatter
A	5483	48.96	-0.49	7509	50.74	0.38
B	8550	50.89	1.44	10914	49.16	-1.20
C	8146	48.49	-0.96	11363	51.18	0.82
Mean of Means		49.45			50.36	

Differences in the mean scatter of mental ability area means in categories of Social Science. Inspection of the mental ability area mean scatter in good and poor pupil categories of Social Science, as shown in Table 7, reveals mean scatter differences of deviation as follows: (1) the mean scatter of Mental Ability C is above the mean of the mental ability area means in the good pupil category, and (2) the mean scatter of Mental Ability C is below the mean of the mental ability area means in the poor pupil category.

TABLE 7

MENTAL ABILITY MEAN SCATTER IN GOOD AND POOR CATEGORIES OF SOCIAL SCIENCE

	Good Pupil Category			Poor Pupil Category		
Mental Ability	Total Score	Mean Score	Mean Scatter	Total Score	Mean Score	Mean Scatter
A	6262	49.70	-0.57	6730	50.22	0.54
B	9363	49.54	-0.73	10101	50.25	0.57
C	9744	51.56	1.29	9765	48.58	-1.10
Mean of Means		50.27			49.68	

Logical analysis. Since the mean score of Mental Ability A occurs above the mean of the mental ability area mean in the good pupil category of English and does not occur above the mean of the mental ability area means (being below the mean) in the poor pupil category of English, a causal comparative relationship is suggested between the mean scores of Mental Ability A and good and poor pupil categories of English. The same logic will apply to Mental Ability B with reference to Mathematics, and to Mental Ability C with reference to Social Science.

Summary and Rationale

Summary

The preceding mean scatter comparisons show relationships between intelligence sub-test scores or combinations of intelligence sub-test scores when the mean scatter of the scores in one category of pupils in a given mark area is compared to the mean scatter of the scores in another category of pupils in the same given mark area. These comparisons are called, in the literature, inter-test comparisons.

In relating sub-test data to mark area data, marks can be divided into populations (mark areas); and each population of marks can be subdivided into groups of pupils receiving the marks. Intra-individually divided, two groups of pupils could be called: (1) group A, which consists of pupils receiving good marks in a given mark population, and (2) group B, which consists of pupils receiving poor marks in the same mark population. Then, inter-test comparisons can be made between the mean scatter of intelligence test data in group A and the mean scatter of the intelligence test data in group B. These techniques were used in this study.

The first three mean scatter comparisons were between mean scores of each intelligence sub-test in one group of pupils and mean scores of each intelligence sub-test in another group of pupils. This technique located the intelligence sub-tests which could be grouped into sub-test combinations.

The second three mean scatter comparisons were between mean scores of each sub-test combination in one group of pupils and mean scores of each sub-test combination in another group of pupils. This technique confirmed the composite scatter postulate and justified the development of the sub-test combinations into mental ability areas. The mean of the sub-test means within each sub-test combination was called a mental ability score, and the composite ability represented was called a mental ability.

It should be pointed out that the actual comparisons were made between differences of deviation in the mean scatter of the intelligence sub-test data. However, the end purpose was to find each sub-test combination which shows relationships of agreement in mean scatter with a category of pupils having good marks and a category of pupils having poor marks in a given mark area. The end result was accomplished. Consequently, since the mental abilities represent the composite ability of each sub-test combination, and since the pupil categorization represents division of good and poor marks in mark areas, the mental abilities have been shown to be related to good and poor marks in mark areas.

The findings show that group means of mental ability scores of Mental Ability A, Mental Ability B, and Mental Ability C, respectively, are related to good and poor marks in English, Mathematics, and Social Science.

Rationale

Point 1. When individual scores are summated into one score for each of the variables to be considered, the number of cases being considered is reduced to one case for each variable. Although no objection may be made against this technique, it does not constitute comparison of intra-individual scatter patterns of marks and intelligence. Various cases of intra-individual scatter patterns will be compared in the next chapter.

Point 2. Group comparisons were made from two-dimensional comparison methods, i.e., deviations above or below a mean. Two dimensions were deemed adequate for relating the data. Measurement in degrees of deviation will be made in the next chapter.

Point 3. The logic was used to support the steps of the statistical computations, not to prove them.

Point 4. In view of the number of variables to be considered, this chapter held to a minimum the number of techniques which were used to relate the data. The next chapter will reorganize the data, develop the intra-individual scatter patterns, equate the variables, and test the hypothesis by computing the statistical significance of the data.

CHAPTER V

STATISTICAL ANALYSIS OF THE SCATTER PATTERNS

This chapter reports the statistical analysis of mean scatter patterns of marks in mark areas and scatter patterns of mental ability scores in mental ability areas. Before the statistical relationships between scatter patterns could be calculated, three preliminary steps were necessary: Recalculation of Some Distributions of the Data; Development of Intra-Individual Mean Scatter; and Equating the Distributions of Mean Scatter. These three steps were necessary in order to have distributions of intra-individual mean scatter in each mark area of English, Mathematics, and Social Science which were directly comparable to distributions of intra-individual mean scatter in each mental ability area of Mental Ability A, Mental Ability B, and Mental Ability C. From these distributions, inter-trait[1] comparisons were made between each individual's pattern of mark area deviation and the same individual's pattern of mental ability area deviation. The relationships between scatter patterns were tested by the statistical methods of chi square[2] and contingency coefficients.[3]

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[1]In this study, mark abilities and mental abilities are each considered as traits. Inter-trait is defined as being between traits.

[2]Henry E. Garrett, Statistics in Education and Psychology, pp. 251-53.

[3]*Ibid.*, pp. 359-65.

Recalculation of Some Distributions of the Data

Orientation. In the original development of the data, raw mark scores and weighted intelligence sub-test scores of each member of the population were quantified so as to be expressed in two-digit standard scores. Then the three distributions of mark area scores and the eleven distributions of intelligence sub-test scores were converted into "T" scores. The original steps were deemed to be sound enough. However, because comparisons were to be made between each individual's scores rather than between group scores, and since the comparison of each individual's scores demanded more exact data, it was decided to use the significant three-digit[4] scores of the mark area data rather than the two-digit scores of the preceding analysis. The intelligence sub-test data were also developed in three-digit standard scores relative to the research population.[5]

Intelligence sub-test data. In order to prepare for the recalculation of the intelligence sub-test data, the weighted sub-test scores of each intelligence sub-test were tabulated. The mean, standard deviation, and the standard errors of each intelligence sub-test distribution were obtained. The results are shown in Table 8.

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[4]Three digits were the significant number of digits to be used to have significant figures. Ibid., pp. 23-26. Also, three-digit scores were needed to have smooth distribution curves. Normalized distributions of two-digit scores with a frequency of 130 are not large enough to be free from score clusters which were not symmetrical and from distribution gaps which were uneven in the original distribution.

[5]Although the distributions of the weighted intelligence sub-test scores of the research population resembled the distributions of the standardized population, the distribution scores do not necessarily stand in the same relationships with each other in the two populations.

TABLE 8

INTELLIGENCE SUB-TEST MEANS AND STANDARD DEVIATIONS
OF THE RESEARCH POPULATION

Sub-Test	Mean	SE of Mean*	S.D.**	SE of S.D.***
Information	10.31	.16	1.78	.11
Comprehension	10.74	.18	2.00	.12
Digit Span	7.84	.23	2.61	.16
Arithmetic	8.77	.25	2.82	.17
Similarities	10.34	.17	1.97	.12
Vocabulary	9.21	.15	1.72	.11
Picture Arrangement . .	9.59	.23	2.64	.16
Picture Completion . .	10.16	.22	2.54	.16
Block Design	11.13	.20	2.23	.14
Object Assembly	10.71	.25	2.80	.17
Digit Symbol	11.48	.19	2.18	.14

*Standard error of the mean
**Standard deviation
***Standard error of the standard deviation

Each individual's weighted sub-test score, within each sub-test distribution, was next converted into a standard score in terms of its standard deviational value relative to the research population. The standard scores represented the standard deviational value of each individual's ability in each of the sub-tests relative to the research population as a whole. Then the standard scores were recorded in the appropriate place on prepared four-by-six cards.

Mental ability area data. In order to obtain each individual's score in each of the three mental ability areas, the standard scores of his sub-test within each given sub-test combination were averaged to give one mental ability score for each given sub-test combination. This reduced the intelligence sub-test scores to three mental ability scores for each member of the population, and formed three new distributions of scores. Each mental ability score was designated as X of a given mental ability, and is used to denote the individual's raw score of a given mental ability. Each individual's three mental ability scores were also recorded in an appropriate place on the four-by-six cards.

Mark area data. The original development of the mark area data was in relation to the research population. The redevelopment of the data was merely to restore the average mark area scores of the sub-populations to three-digit scores. Each mark area score was designated as X of a given mark area, and is used to denote the individual's raw score of a given mark area.

Development of Intra-Individual Mean Scatter

At this point, the data were prepared for a development of intra-individual mean scatter in each of the three mark areas and in each of the three mental ability areas. In developing the intra-individual mean scatter, the distributions of X scores in each mark area and in each mental ability area were equated between individuals, and then the intra-individual mean scatter was found by computing differences within the individuals. The following steps were taken.

Step 1. The means and the standard deviations of the X distributions were computed for each mark area, and for each mental ability area. The results are shown in Tables 9 and 10.

TABLE 9

MEANS AND STANDARD DEVIATIONS OF X SCORES
IN MARK AREAS

Mark Area	N	Mean	SE of Mean	S.D.	SE of S.D.
English	130	49.939	.818	9.329	.579
Mathematics	130	49.389	.728	8.306	.515
Social Science	130	50.001	.665	7.581	.470

The means and the standard deviations were computed preparatory to equating each of the means and each of the standard deviations in each trait distribution, and for converting the distributions of X scores into "Z" scores.

TABLE 10

MEANS AND STANDARD DEVIATIONS OF X SCORES IN MENTAL ABILITY AREAS

Mental Ability	N	Mean	SE of Mean	S.D.	SE of S.D.
A	130	49.959	.680	7.755	.481
B	130	50.012	.651	7.426	.461
C	130	50.068	.637	7.261	.450

Step 2. The scores of each mark area distribution and each mental ability area distribution were converted into distributions of "Z" scores[6] having a mean of 50 and a standard deviation of 10.

Step 3. For each individual, "Z" scores of X were computed in each of the three mark area distributions, and in each of the three mental ability area distributions.[7] This procedure equated the means and standard deviations of the X distributions.[8]

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[6]It should be noted that "Z" scores do not change the original form of the distributions. Ibid., p. 157.

[7]This technique established the standard deviational value of the position of X for each individual relative to the position of other individuals of the research population in any given trait area.

[8]Also, since each "Z" score represents a standard deviational value, the position of the scores in each trait area were comparable to the position of the scores in any other trait area.

Step 4. All of the "Z" scores of X in English, Mathematics, and Social Science were combined into one distribution; and all of the "Z" scores of X in Mental Ability A, Mental Ability B, and Mental Ability C were combined into another distribution. Each distribution was normalized[9] by the use of prepared probits.[10] This process reduced the data to two distributions and produced a smooth distribution curve of equivalent scores in each distribution.[11]

Step 5. Each individual's "Z" score of X in English, Mathematics, and Social Science was replaced by a normalized "Z" score of X; and each normalized score was recorded in a table.

Step 6. The mean of each individual's three normalized scores of English, Mathematics, and Social Science was computed and entered in a table to the left of the normalized scores.

Step 7. The mean of each individual's three normalized scores was subtracted from each of the individual's normalized scores in English, Mathematics, and Social Science and entered in a table to the right of his three normalized scores.

Step 8. The technique of steps 5, 6, and 7 was used to record tables of each individual's normalized "Z" scores of X, the mean of his

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[9]Although the positions of the scores in each distribution of "Z" scores were comparable, differences between the positions of various scores within one trait distribution and differences between the positions of various scores within another trait distribution could not necessarily be construed as being comparable differences of ability. Therefore, in order to obtain comparable ability units, the distributions of each trait area were combined and normalized.

[10]Palmer O. Johnson, Statistical Methods in Research, (New York, 1949), pp. 160-62.

[11]Since now all of the scores within each trait are in one distribution, the intra-individual differences can be obtained precisely from comparisons of the same distribution curve.

three normalized scores, and the mean scatter of his three normalized scores in Mental Ability A, Mental Ability B, and Mental Ability C.

The foregoing procedure found the intra-individual mean scatter of normalized scores within each trait distribution for each individual of the research population. Step 7 found the individual's raw mean scatter in English, Mathematics, and Social Science; and step 8 found the individual's raw mean scatter in Mental Ability A, Mental Ability B, and Mental Ability C. An example of the tables used for recording intra-individual mean scatter in each trait distribution is Table 11.

TABLE 11

EXAMPLE OF TABLES OF RAW INTRA-INDIVIDUAL MEAN SCATTER OF NORMALIZED SCORES IN TRAIT DISTRIBUTIONS

		Normalized scores* of mental abilities			Mean scatter** of mental abilities		
Individual	Mean	A	B	C	a	b	c
1	60.8	65.0	56.3	61.1	4.2	-4.5	0.3
2	54.3	65.0	58.5	39.4	10.7	4.2	-14.9
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
n							

*The distributions of normalized scores were recorded in three-digit scores. The mean of each distribution was 50 and the standard deviation of each distribution was 10.

**Mean scatter was recorded in positive or negative scores. To lessen the possibility of mistake, the positive scatter was originally recorded in blue and the negative scatter was originally recorded in red.

Equating the Distributions of Mean Scatter

A result of obtaining intra-individual mean scatter of normalized scores in each trait was to find six new distributions of raw mean scatter, three distributions within each trait; i.e., distributions of each individual's mean scatter in English, Mathematics, and Social Science, and distributions of each individual's mean scatter in Mental Ability A, Mental Ability B, and Mental Ability C. Each individual's mean scatter score in the six distributions was designated as x, and is used to denote his raw mean scatter score in any given mark area, and in any given mental ability area.

Mean scatter comparisons between component parts of intra-individual scatter patterns can be made at this point. However, before comparisons between configurations of intra-individual scatter patterns can be adequately tested, there is the problem of variance relationships[12] in the scores of each mean scatter distribution to be considered.

Now, variance relationships of two variables being compared (e.g., marks in English being compared to test scores of Mental Ability A) can be taken care of by statistical computations which compare the two variables. However, one statistical computation will not take care of the variance relationships of three variables when the three variables are compared to three other variables.[13] For instance, a comparison between

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[12]The concern of variance here was the probable overlapping of factors of the x distributions. The variance relationships considered were the variance relationships between the means, spread, and the general shape of the x distributions.

[13]A given mean scatter distribution within a mark area may not necessarily stand in the same variance relationship to another given mean scatter distribution. The same principle will apply to mean scatter distributions in mental ability areas.

the intra-individual mean scatter of English and the intra-individual mean scatter of Mental Ability A was made at this point, and chi square computations from contingency tables took care of the variance differences in the two distributions. However, a comparison between the intra-individual mean scatter patterns of English, Mathematics, and Social Science and the intra-individual mean scatter patterns of Mental Ability A, Mental Ability B, and Mental Ability C could not be made at this point because chi square computations from contingency tables would not simultaneously take care of variance differences in six distributions. Therefore, before the scatter patterns could be adequately tested, and before the three variables in the mark trait could be compared to the three variables in the mental ability trait, the variance relationships of the six variables being considered had to be reduced to one variance relationship within each trait. Consequently, in order to equate the variance of the mean scatter variables so as to satisfy the preceding considerations, the following steps were taken:

<u>Step 1</u>. The means, the mean deviations,[14] the mean of the means, and the mean of the mean deviations of the x distributions of mean scatter were computed for each mark area. The results are shown in Table 12.

<u>Step 2</u>. The means, the mean deviation, the mean of the means, and the mean of the mean deviations of the x distributions of mean scatter were computed for each mental ability area. The results[15] are shown in Table 13.

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[14]"The mean deviation . . . is the mean of the deviations of all the separate measures in a series taken from their central tendency . . ." Garrett, <u>Statistics in Education and Psychology</u>, p. 55.

[15]Although the means are virtually the same, an inspection of the

TABLE 12

MEANS AND MEAN DEVIATIONS OF INTRA-INDIVIDUAL
MEAN SCATTER IN MARK AREAS

Mark Area	N	Mean	Mean** Deviation
English	130	.025128	2.429743
Mathematics	130	-.048718	3.630256
Social Science	130	.023590	3.124102
Mean of the means		.000000*	
Mean of the mean deviations			3.061367

*Decimals were carried to the number of places which were needed to show that the mean of the means equaled zero.

**To be consistent, decimals in mean deviation were carried to the same number of places as the decimals in the mean.

TABLE 13

MEANS AND MEAN DEVIATIONS OF INTRA-INDIVIDUAL
MEAN SCATTER IN MENTAL ABILITY AREAS

Mental Ability Area	N	Mean	Mean Deviation
A	130	-.019744	7.043846
B	130	.033333	5.368205
C	130	-.013590	5.440256
Mean of the Means		.000000	
Mean of the Mean Deviations			5.950769

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mean deviations indicated that the mean scatter of mental abilities is greater than the mean scatter of mark areas. This would suggest that teacher measurement of marks in secondary schools allows for less score variation than do scientifically constructed tests such as the Wechsler-Bellevue Scale. The greater mean deviation of Mental Ability A is most likely due, at least in part, to the fact that the scores of this mental ability area were derived from only two intelligence sub-tests, while the other mental ability areas were derived from three intelligence sub-tests.

Step 3. Algebraic equations were made and solved for converting the mean scatter of each x distribution of mark areas into distributions of mean deviational values[16] ("Z" scores of x)[17] having a mean of zero and a mean deviation equal to the mean of the mean deviations, i.e., a mean of .000000 and a mean deviation of 3.061367.

Step 4. Algebraic equations were made and solved for converting the mean scatter of each x distribution of mental ability areas into distributions of mean deviational values ("Z" scores of x) having a mean of zero and a mean deviation equal to the mean of the mean deviations, i.e., a mean of .000000 and a mean deviation of 5.950769.

Step 5. For each individual, "Z" scores of x were computed in each of the three mark area mean scatter distributions;[18] and each "Z" score of x was recorded in tables.

Step 6. In order to obtain equivalent ability units, all of the "Z" scores of x in the mark areas of English, Mathematics, and Social Science were combined into one distribution; and the distribution was normalized by the use of prepared probits.[19]

Step 7. Each individual's normalized "Z" score of x in English,

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[16]Since computations of mean scatter were derived from a mean, the deviational values of mean scatter were computed from mean deviation statistics. A mean deviational value as used here is the ordinal relationship of an x score in a given mean scatter distribution relative to other x scores in the same distribution.

[17]The computations of mean deviational values were as "Z" scores of x. Ibid., p. 157.

[18]This procedure equated the mean and the mean deviations of the x distributions. Also, it placed each individual's mean and mean deviational score into a position comparable to the positions of the mean and the mean deviation of all of the other scores within each trait distribution.

[19]Palmer O. Johnson, Statistical Methods in Research, pp. 160-62.

Mathematics, and Social Science was found and entered in tables to the right of the scores indicated in step 5.

Step 8. The techniques of steps 5, 6, and 7 were used to record tables of each individual's normalized "Z" score of x in Mental Ability A, Mental Ability B, and Mental Ability C.

An example of the tables used for recording "Z" scores of x and normalized "Z" scores of x is Table 14.

TABLE 14

EXAMPLE OF TABLES OF EQUATED DISTRIBUTIONS OF INTRA-INDIVIDUAL MEAN SCATTER (Mental Ability Areas)

	Mean Deviational Values* of Mean Scatter Scores ("Z" Scores of x)			Normalized Mean Deviational Values** of Mean Scatter Scores (Normalized "Z" Scores of x)		
Pupil	a	b	c	a	b	c
1	-3.0	2.2	1.7	46.0	53.4	52.2
2	12.4	-5.3	-10.8	67.0	43.5	34.7
3	-	-	-	-	-	-
4	-	-	-	-	-	-
n						

*Mean deviational values were recorded in positive or negative scores. To lessen the possibility of mistake, the positive scatter was originally recorded in blue and the negative scatter was originally recorded in red.

**The distributions of normalized mean deviational values were recorded in three-digit scores. The mean of each distribution was 50 and the standard deviation of each distribution was 10.

At this point, the development of the data was completed. The variance of each x distribution had been equated and normalized; and since the distribution scores were in equal ability units, each intra-individual scatter pattern of mark areas was directly comparable to each intra-individual scatter pattern of mental ability areas.

Statistical Significance of Scatter Relationships

Each individual's scatter pattern of marks in English, Mathematics, and Social Science was compared to the same individual's scatter pattern of scores in Mental Ability A, Mental Ability B, and Mental Ability C. Then, each individual's mean scatter of English was compared to his raw mean scatter in Mental Ability A; each individual's mean scatter in Mathematics was compared to his mean scatter in Mental Ability B; and each individual's mean scatter in Social Science was compared to his mean scatter in Mental Ability C.

The comparisons were made by the use of the statistical methods of chi square of independence in contingency tables, and by coefficients of contingency. Differences were tested by computing chi square and the significance of the difference, and agreement was tested by computing the coefficient of contingency.

Scatter pattern comparisons. Contingency tables were constructed with rows and columns of spaces bounded by equidistant standard deviational values of normalized mean scatter. As a check against atypical concentrations of the data, two tables were made: one table was six-fold with the cell spaces bounded by one (1.00) standard deviation (i.e., 3.00 to 2.00, 2.00 to 1.00, 1.00 to 0.00, 0.00 to -1.00, -1.00 to -2.00, and -2.00 to -3.00 standard deviations); the other table was seven-fold with the cell spaces bounded by nine tenths (0.90) of one standard deviation (i.e., 3.15 to 2.25, 2.25 to 1.35, 1.35 to 0.45, 0.45 to -0.45, -0.45 to -1.35, -1.35 to -2.25, and -2.25 to -3.15 standard deviations). The distribution of scores in each scatter pattern covered approximately six standard deviations.

Comparisons of each individual's mean scatter pattern were plotted in the contingency tables as follows: (1) from a table (such as Table 14) a given individual's equated mean scatter in English was found; (2) from Table 14 the same individual's equated mean scatter in Mental Ability A was found; (3) the row in which the mean scatter value of English fell was located in the contingency table, the row was followed until the row intersected the cell space of the column in which the mean scatter value of Mental Ability A fell, and a tally mark was plotted in the cell space; (4) the three techniques above were used to plot a tally mark for the same individual in Mathematics and Mental Ability B, and for the same individual in Social Science and Mental Ability C, respectively; (5) the same techniques were continued until each individual's scatter pattern of marks was compared with his scatter pattern of mental abilities; and (6) the tally marks in the contingency tables were tabulated, and the total of tally marks in each cell space were recorded within each cell space. The data of each contingency table were tested by chi square of independence and by contingency coefficients.

The null hypothesis to be tested was, namely, that the intra-individual scatter patterns of marks in English, Mathematics, and Social Science are essentially unrelated or independent of the intra-individual scatter patterns of scores in Mental Ability A, Mental Ability B, and Mental Ability C.

The results are shown in Table 15. Chi square reveals a wide divergence of difference from what is expected on the null hypothesis. Since chi square is large, and the significance of the difference (.001) is highly significant, the null hypothesis was rejected. Therefore, it

TABLE 15

COMPARISONS BETWEEN INTRA-INDIVIDUAL SCATTER PATTERNS OF MARK AREAS AND MENTAL ABILITY AREAS

Table Size	N	Chi Square	Sig.	C	SE* of C
Six by six	390	53.841	.001	.381	.051
Seven by seven	390	66.072	.001	.411	.051

*Standard error of the contingency coefficient

may be concluded that the intra-individual scatter patterns of mark areas are essentially related and dependent on the intra-individual scatter patterns of mental ability areas. Since the scatter patterns are tested in contingency tables of positive and negative achievement, positive achievement in one trait may be said to be related to positive achievement in the other trait, and negative achievement in one trait may be said to be related to negative achievement in the other trait; furthermore, the patterns in this respect will differentiate positive and negative levels of achievement in the two trait areas. The coefficient of contingency, although not high in the ratio of its relationship, is nevertheless statistically significant. Therefore, it can be stated with confidence that intra-individual scatter patterns of mark areas are related to intra-individual scatter patterns of mental ability areas.

Mean scatter comparisons. Comparisons between intra-individual mean scatter of English and Mental Ability A, Mathematics and Mental Ability B, and Social Science and Mental Ability C were made to test the scatter sub-hypotheses, and to determine the extent to which the component mean scatter relationships exist. In order to free the x distributions of mean scatter from the equated variance of the scatter pattern distributions, and since only two variables were involved, the mean scatter comparisons were made from the x distributions of raw mean scatter.

Three four-by-four contingency tables[20] were constructed with rows and columns of cell spaces in each contingency table bounded by mean deviation values consistent with the mean deviation of the mean scatter with respect to plus and minus scores being above or below the mean deviation. The cell spaces of each side of the tables were labeled as follows: 2, 1, -1, and -2; 2 was for positive scatter above the mean deviation, 1 was for positive scatter bounded by the mean and the mean deviation, -1 was for minus scatter bounded by the mean and the mean deviation, and -2 was for minus scatter below the mean deviation.

Comparisons of each individual's raw mean scatter were plotted in contingency tables as follows: (1) from a table (such as Table 11) a given individual's raw mean scatter in English was found; (2) from Table 11 the same individual's raw mean scatter in Mental Ability A was found; (3) the row in which the mean scatter of English fell was located in the contingency table, the row was followed until the row intersected the cell space of the column in which the mean scatter of Mental Ability A fell, and a tally mark was plotted in the cell space; (4) the three preceding steps were continued until each individual's raw mean scatter of English was compared with his raw mean scatter of Mental Ability A; (5) the tally marks in the contingency table were tabulated and the

[20]With the frequency of the scores in each mean scatter comparison being 130, the number of classes in the contingency tables was reduced to four; i.e., a four-by-four table with four rows and four columns. This made scores in the cell spaces more reliable.

total of tally marks in each cell space was recorded within each cell space.

Using the techniques of the preceding paragraph, comparisons of each individual's raw mean scatter were tabulated in a second contingency table for Mathematics and Mental Ability B, and comparisons of each individual's raw mean scatter were tabulated in a third contingency table for Social Science and Mental Ability C.

The null hypotheses to be tested were: (1) that the intra-individual mean scatter of English is essentially unrelated or independent of the intra-individual mean scatter of Mental Ability A, (2) that the intra-individual mean scatter of Mathematics is essentially unrelated or independent of the intra-individual mean scatter of Mental Ability B, and (3) that the intra-individual mean scatter of Social Science is essentially unrelated or independent of the intra-individual mean scatter of Mental Ability C.

The results of the statistical computations are shown in Table 16.

TABLE 16

COMPARISONS BETWEEN MEAN SCATTER OF HYPOTHESIZED RELATIONSHIPS

Table Size	N	Chi Square	Sig.	C	SE * of C
English and Mental Ability A					
Four by four	130	28.935	.001	.493	.088
Mathematics and Mental Ability B					
Four by four	130	19.953	.02	.421	.088
Social Science and Mental Ability C					
Four by four	130	18.483	.04	.408	.088

*Standard error of the contingency coefficient

The results show that the chi square scores are large, and that the significance of the differences is sufficient to warrant the rejection of the null hypothesis in each comparison. Therefore, it is concluded that the differences are real, and that intra-individual mean scatter of English, Mathematics, and Social Science, respectively, is related and dependent, in degree, on the intra-individual mean scatter of Mental Ability A, Mental Ability B, and Mental Ability C, respectively; also, that the hypothesized relationships of the scatter sub-hypotheses exist. Furthermore, each contingency coefficient is significant. An estimation of the standard error of C (by the formula of 1 over the square root of N) gives evidence that the true ratio of the relationships may vary considerably from what is found in the experimental results; however, since the observed ratios range from 4.6 to 5.6 times the estimated standard error, it may be stated with confidence that the existing relationships are statistically significant.

CHAPTER VI

CROSS VALIDATION

The cross validation was made in order to discover whether the results found from the investigation of the data in another research population would confirm the results found in the original study. No attempt was made to relate the intelligence sub-test data to the mark data, since this was done in the original study. The procedure was first to quantify the basic data and then proceed to the analysis of data from mark averages in English, Mathematics, and Social Science and mental ability scores in Mental Ability A, Mental Ability B, and Mental Ability C. The originally hypothesized relationships of marks and mental abilities were tested by the same statistical methods. A summary of the steps of cross validation is reported in the following pages.

The Research Population

The research population defined. The research population of the cross validation is defined as the 17 to 19 age group (inclusive) of the senior class of 1952-1953 and the senior class of 1953-1954, of La Joya High School in Hidalgo County, Texas. The research population consisted of 30 boys and 20 girls.

Background of the research population. The geographic area of the population is located in the southern extremity of Texas near the mouth of the Rio Grande River. The population consists of many Latin-American pupils with a bi-lingual background.

The economic structure is chiefly the result of agriculture. Much of the land is irrigated and produces grapefruit, oranges, cotton, and various vegetable crops. Incomes, in general, have a rather wide spread. The area is densely populated. There are many towns, but the background is fundamentally rural.

Sources of the data. As in the original investigation, the data were obtained from two sources. (1) The individual pupil marks of the high school study (grades 9 to 12, inclusive) were obtained from the school records for each member of the population. (2) Each member of the population had previously been given the Wechsler-Bellevue Intelligence Scale Form I, by the writer. Scores obtained by the writer furnished the second source of the data.

Techniques of Quantification

Mark Data

Division of the mark data. In as much as the population consisted of two senior classes, the population of marks was divided such that the marks from each senior class became, at first, a sub-population. This was done in order to have a better comparison of marks, since in this way pupils would be compared in standard scores with pupils with whom they had actually competed for marks; furthermore, it virtually eliminated the differences in the teacher element since most of each class had the same teacher. For each senior class, all of the recorded high school marks in English, Mathematics, and Social Science were translated from letter marks into numerical marks appropriate to the marking system of the school. The numerical marks that each pupil had obtained in English were summated, and each pupil was given an average numerical mark of his work in English; the same procedure was followed relative to Mathematics and Social Science.

Basic techniques of quantification. For each senior class, the mean and the standard deviation were computed from the distribution of average scores of each pupil in English. The same procedure was used relative to Mathematics and Social Science. The means and standard deviations are shown in Tables 17 and 18. Senior class I is the 17 to 19 age group of seniors who graduated in 1954, while senior class II is the 17 to 19 age group of seniors who graduated in 1953. The age group denotes the age of the pupils at the time of the administration of the Wechsler-Bellevue Scale.

TABLE 17

MEANS AND STANDARD DEVIATIONS OF RAW SCORES IN MARK AREAS OF SENIOR CLASS I

Mark Area	N	Mean	SE of Mean	S. D.	SE of S. D.
English	23	75.630	1.293	6.202	1.194
Mathematics	23	77.696	1.330	6.377	1.227
Social Science	23	76.848	1.329	6.372	1.226

Each mark area distribution, within each senior class, was converted into standard scores having a mean of 50 and a standard deviation of 10. Thus, each pupil's average numerical mark of his work in English, Mathematics, and Social Science, respectively, was converted into a standard score with respect to the mark area distribution of his senior class.

Next, the standard scores of each mark area, regardless of class, were combined into one distribution. Since all of the marks were in standard scores, the positions of the scores between each mark area were comparable. The mean and standard deviation of each combined mark

TABLE 18

MEANS AND STANDARD DEVIATIONS OF RAW SCORES IN MARK AREAS OF SENIOR CLASS II

Mark Area	N	Mean	SE of Mean	S. D.	SE of S. D.
English	27	82.989	.845	5.733	.780
Mathematics	27	79.396	1.266	8.587	1.169
Social Science	27	82.378	.994	6.739	.917

area distribution were computed and converted into a distribution with a mean of 50 and a standard deviation of 10. These statistics are shown in Table 19.

TABLE 19

MEANS AND STANDARD DEVIATIONS OF COMBINED SCORES IN MARK AREAS

Mark Area	N	Mean	SE of Mean	S. D.	SE of S. D.
English	50	50.020	1.413	9.993	.999
Mathematics	50	49.996	1.503	10.063	1.006
Social Science	50	49.936	1.416	10.013	1.001

Then, each individual's standard scores were converted into "Z" scores. At this point, the standard scores of each mark area were equated. The mark area data were ready for intra-individual comparisons.

Intelligence Sub-test Data

Development of the intelligence sub-test data. Since the Wechsler-Bellevue Scale was administered by the same person, namely, the writer, and since each sub-test was scored in terms of the standardized population, division of the classes into sub-populations was not necessary.

The weighted sub-test scores of each intelligence sub-test were recorded for each pupil. Then the mean and standard deviation of each intelligence sub-test to be considered were obtained. These statistics are shown in Table 20.

TABLE 20

INTELLIGENCE SUB-TEST MEANS AND STANDARD DEVIATIONS OF THE CROSS VALIDATION POPULATION

Sub-Test	Mean	SE of Mean	S. D.	SE of S. D.
Information	5.96	.330	2.33	.233
Digit Span	6.74	.302	2.14	.214
Arithmetic	6.62	.421	2.98	.298
Similarities	6.36	.354	2.50	.250
Picture Arrangement	7.20	.382	2.70	.270
Picture Completion	7.38	.363	2.57	.257
Block Design	9.06	.342	2.42	.242
Digit Symbol	9.96	.308	2.18	.218

Next, each individual's weighted sub-test score, within each sub-test distribution, was converted into a standard score in terms of its standard deviational value relative to the research population. The standard scores were computed in terms of a mean of 50 and a standard deviation of 10. Then, each individual's standard score was recorded in tables.

Development of the mental ability area data. In order to obtain a score in each of the three mental ability areas for each member of the population, the standard scores of each sub-test combination were averaged so as to give one mental ability score for each of the sub-test combinations. Each individual's standard score in Digit Span and Digit Symbol, when averaged, gave his raw score in Mental Ability A. The same procedure was used for Arithmetic, Picture Completion, and Block Design relative to Mental Ability B, and for Information, Similarities, and Picture Arrangement relative to Mental Ability C.

In order to convert the raw scores of each mental ability into standard scores, the mean and standard deviation of each mental ability distribution were obtained. The scores are shown in Table 21.

TABLE 21

MEANS AND STANDARD DEVIATIONS OF RAW SCORES IN MENTAL ABILITY AREAS

Mental Ability	N	Mean	SE of Mean	S. D.	SE of S. D.
A	50	49.688	1.028	7.272	.727
B	50	49.824	1.177	8.325	.832
C	50	50.000	1.170	8.273	.827

Finally, each mental ability raw score, within each mental ability distribution, was converted into a standard score in terms of its standard deviational value relative to the research population. The standard scores were computed in terms of a mean of 50 and a standard deviation of 10. Each individual obtained a standard score for each mental ability.

Analysis of the Data

Development of Equated Intra-Individual Mean Scatter

Step 1. Each individual's mental ability scores were recorded in tables.[1] The mean of the mental ability area scores for each individual was computed and recorded to the left of the other three scores. Then, the mean of the three mental ability scores was subtracted from each of

[1]Table 1, page 28, illustrates the form of the tables.

his three mental ability scores, and the differences were recorded in the appropriate place to the right of the three scores. This gave the raw mean scatter scores for each individual; these scores were recorded in positive or negative values, as the case might be. Table 22 gives an illustration of the mean scatter scores. The same treatment was applied to the mark area standard scores.

TABLE 22

ILLUSTRATION OF MEAN SCATTER SCORES

Pupil	Mean	Mental Ability			Mental Ability Scatter		
		A	B	C	a	b	c
1	60.0	60.7	61.9	57.4	0.7	1.9	-2.6
2	41.1	44.9	37.7	40.7	3.8	-3.4	-0.4
3	50.2	48.1	51.7	50.8	-2.1	1.5	.6
4	42.1	29.1	51.3	45.9	-13.0	9.2	3.8
5	59.7	64.0	67.2	47.9	4.3	7.5	-11.8
n	-	-	-	-	-	-	-

Step 2. A result of obtaining intra-individual mean scatter in each trait was to find six new distributions of raw mean scatter, three distributions within each trait; i.e., distributions of each individual's mean scatter in English, Mathematics, and Social Science, and distributions of each individual's mean scatter in Mental Ability A, Mental Ability B, and Mental Ability C. In order to equate the variance of the mean scatter for each of the six distributions of mean scatter, the summation of the mean scatter for each of the six new distributions was obtained, and the mean and the mean deviation were computed for each distribution. The results are shown in Tables 23 and 24. The mean deviations within the two traits stand in the same relation as in the original population with the exception that the mean deviation of the English scores is larger.

TABLE 23

MEANS AND MEAN DEVIATIONS OF INTRA-INDIVIDUAL MEAN SCATTER IN MARK AREAS

Mark Area	N	Mean	Mean Deviation
English	50	.693400	4.054660
Mathematics	50	.453400	4.129340
Social Science	50	-1.146600	3.332000
Trait Area	150	.000000	3.838667

<u>Step 3</u>. Each of the mark area mean scatter distributions and each of the mental ability area mean scatter distributions was converted into mean deviational values in terms of the respective mean and mean deviation of each trait. The mark area mean scatter has a mean of zero and a mean deviation of 3.838667, while the mental ability trait area has a mean of zero and a mean deviation of 4.917778. The mean deviational value of each individual's score was recorded for each individual of the population.

TABLE 24

MEANS AND MEAN DEVIATIONS OF INTRA-INDIVIDUAL MEAN SCATTER IN MENTAL ABILITY AREAS

Mental Ability Area	N	Mean	Mean Deviation
A	50	-.540000	5.580660
B	50	.940000	4.223340
C	50	.400000	4.994934
Trait Area	150	.000000	4.917778

Step 4. As was done in the original study,[2] in order to normalize the mean deviational values of each trait area, the mean deviational values of each individual's scores in English, Mathematics, and Social Science were combined into one distribution; and the distribution was normalized by the use of probits. The same procedure was applied to the mental ability trait areas.

Step 5. The normalized mean deviational values of each individual's scores were recorded in tables.[3]

Inter-Trait Comparisons

Scatter pattern comparisons. Scatter pattern comparisons were tested by chi square of independence in contingency tables, and by contingency coefficients. In as much as the cross validation has a reduced number of cases, it was deemed advisable to use no more than a four-by-four contingency table; fifty cases do not lend themselves to reliable computations beyond a fourfold table. Since a four-by-four table adapts nicely to mean deviational values, the cell spaces of the contingency table were labeled as follows: 2, 1, -1, and -2. 2 is a positive scatter above the mean deviation, 1 is a positive scatter bounded by the mean and the mean deviation, -1 is a negative scatter bounded by the mean and the mean deviation, and -2 is a negative scatter below the mean deviation. The mean deviation of the normalized distributions of the mark trait areas and the mental ability trait areas was set at the points which found the middle 57.5 per cent of the distributions.

The two trait patterns of each individual were compared and plotted

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[2]See "Equating the Distributions of Mean Scatter," Chapter V.

[3]See Table 14, Chapter V.

according to previous hypothesized relationships of intra-individual mean scatter.[4] The method of comparison of scatter patterns is illustrated in the following hypothetical example. Let case number one have a trait pattern in marks as follows: -2 in English, plus 1 in Mathematics, and plus 1 in Social Science. Let him have a trait pattern in mental abilities as follows: -2 in Mental Ability A, plus 1 in Mental Ability B, and plus 1 in Mental Ability C. According to the hypothesized relationships, English is plotted against Mental Ability A, Mathematics is plotted against Mental Ability B, and Social Science is plotted against Mental Ability C. In this instance, case number one has a trait pattern in marks which is identical to, and agrees with, the trait pattern of mental abilities. The extent to which the mean scatter patterns tend to agree is measured by tabulating the plots in the cell spaces of the contingency table, computing chi square, and solving for the contingency coefficient. Chi square indicates the significance of the difference between the observed relationship and the expected relationship, and the confidence with which one can expect the scores in one trait to differentiate success or failure in the achievement of scores in another trait.

The results of comparing the two trait patterns are shown in Table 25.

TABLE 25

COMPARISON OF SCATTER PATTERNS OF MARKS WITH SCATTER PATTERNS OF MENTAL ABILITIES

Table Size	N	Square	Sig.	C	SE of C
Four by four	150	27.489	.001	.455	.082

[4]See "Development of the Mental Abilities," Chapter IV.

The null hypothesis to be tested is, namely, that the intra-individual scatter patterns of marks are essentially unrelated or independent of the intra-individual scatter patterns of mental abilities. Chi square reveals a wide divergence of difference from what is expected on the null hypothesis. The significance of the difference (.001) is highly significant; therefore, the null hypothesis must be rejected. The contingency coefficient, which is almost nine times its estimated standard error, is also significant. This confirms the original study and suggests that the relationships exist as hypothesized.

Mean scatter comparisons. Mean scatter comparisons were also tested by chi square of independence in contingency tables, and by contingency coefficients. The component parts of the scatter patterns were tested in the manner as stated before. Inter-test comparisons of each individual's raw mean scatter were made as follows: English with Mental Ability A, Mathematics with Mental Ability B, and Social Science with Mental Ability C. The comparisons were plotted in two-by-two contingency tables, with the mean scatter being either above or below the mean of the raw mean scatter scores of each individual. The results are shown in Table 26.

TABLE 26

COMPARISONS BETWEEN MEAN SCATTER OF HYPOTHESIZED RELATIONSHIPS

Table size	N	Chi Square	Sig.	C	SE of C*
		English and Mental Ability A			
Four by four	50	7.218	.01	.502	.141
		Mathematics and Mental Ability B			
Four by four	50	11.768	.001	.617	.141
		Social Science and Mental Ability C			
Four by four	50	3.498	.07	.362	.141

*Standard error of the contingency coefficient

The hypotheses to be tested are: namely, (1) that the intra-individual mean scatter of English is essentially unrelated to or independent of the intra-individual mean scatter of Mental Ability A, (2) that the intra-individual mean scatter of Mathematics is essentially unrelated to or independent of the intra-individual mean scatter of Mental Ability B, and (3) that the intra-individual mean scatter of Social Science is essentially unrelated to or independent of the intra-individual mean scatter of Mental Ability C.

The results reveal that the statistical significance of the chi square score in the Social Science and Mental Ability C comparison fell slightly above the level of confidence sufficient to reject the null hypothesis (.07). The contingency coefficient is estimated to be significant at the .05 level. The interpretation is inconclusive. The other two areas of comparison show a large chi square and are highly significant; therefore, the null hypothesis must be rejected.

Conclusions

The methods and techniques of analysis used in the cross validation are the same as used in the original study. However, the steps of normalizing the distributions of standard scores along the way were omitted. These steps of omission, with fifty cases, would seem to be not only justifiable, but necessary. The purpose of normalizing the data was to get the scores into equal ability units which were comparable; however, standard scores in a frequency distribution of fifty will be expected to have score clusters, uneven gaps in the distribution, uneven spread of extreme scores, and different shapes. Normalized scores of these distributions would tend to be forced into unnatural positions of comparison, and would not be very representative of a normalized function.

Under the circumstances, standard scores were considered to be more representative.

In general, the cross validation of the original study confirms what was found before. With the exception of the Social Science-Mental Ability C relationships, the results were statistically more significant than results of the original study. If it could be assumed that the trend of the cross validation data would continue in the same porportion for 130 cases, the results would indicate that the differences of the Social Science-Mental Ability C relationship were statistically significant. For example, chi square of the Social Science-Mental Ability C relationship would be 9.095 in a twofold contingency table, and the significance of the difference would be .02. Of course one cannot conclude from assumptions; therefore, it is concluded that, from the data at hand, the relationship of this particular comparison is inconclusive. The comparisons of English and Mental Ability A, Mathematics and Mental Ability B, and the trait patterns of the whole configuration confirm the findings of the original study. This suggests that the basic hypothesized relationship of these comparisons does exist, and that it is characteristic within the research population.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

Foreword. This study seeks to discover whether patterns of marks which pupils receive in school studies are related to patterns of sub-test scores which pupils receive in the Wechsler-Bellevue Intelligence Scale; and if so, what characteristic relationships exist. The original data were collected from a research population of 130 high school seniors, and the cross-validation data were collected from a research population of 50 high school seniors. The data consist of: (1) pupil marks in English, Mathematics, and Social Science as obtained from school records, and (2) pupil intelligence sub-test scores resulting from the administrating and scoring of the Wechsler-Bellevue Intelligence Scale by the writer.

Development of the Problem

Quantification of the data. In as much as the marking systems of the schools represented in the original population were not the same, the population of marks was divided so that the marks from each school became, at first, a sub-population. All of the recorded high school marks of each sub-population were translated into equivalent numerical values appropriate to the particular marking system of each school concerned. For example, a mark of "B" might receive a numerical value of eighty-five. The numerical values of the marks for each class of subject matter were then recorded separately for each sub-population. The mean and sigma statistics were computed for each mark area within each sub-population. Then, standard or "Z" scores were computed for each individual's mark area average within each sub-population. The "Z" scores for each mark area were grouped together with the "Z" scores of like mark areas in the other sub-populations in such a manner as to normalize, within limitations, the whole population of each mark area, by converting the "Z" scores into "T" scores. This was done for the purpose of transforming like mark area data into equivalent scores of equal ability units, which could be combined into one distribution, and which would be directly comparable to other distributions likewise transformed. Finally, the normalized mark area scores, for each individual of the research population, were recorded in tables; and the mean of his three normalized mark area scores was recorded to the right of his other three scores. This process revealed the variability of each individual's scores.

The weighted intelligence sub-test scores of each pupil were recorded on Wechsler-Bellevue forms. This gave each pupil a score for each of the eleven Wechsler-Bellevue sub-tests. Then, in order to make the sub-test scores comparable to the mark area scores, the distribution of scores in each sub-test was normalized by converting the originally recorded scores into "T" scores. Four-by-six cards were used to record each individual's normalized sub-test scores.

Relating the intelligence sub-test data to the mark area data. In relating the sub-test data to mark data, each area of marks was divided into two categories of variation within the individual; one category consisted of pupils with good marks in a given mark area, and the other category consisted of pupils with poor marks in the same mark area. Then, comparisons were made between the mean scatter of intelligence sub-test mean scores in the good pupil category and the mean scatter of intelligence sub-test mean scores in the poor pupil category. The same technique was used for each mark area.

The comparisons which were made yielded mean scatter differences of deviation between the intelligence sub-test means in good and poor categories of a given mark area. A sub-test which had a mean scatter deviation markedly above the sub-test mean in a good pupil category and had a mean scatter deviation markedly below the sub-test mean in a poor pupil category was considered to be related to achievement in the mark area from which the good and poor pupil categories were derived.

The sub-tests which were associated in deviational agreement relative to the mean scatter of the intelligence sub-tests in mark area categories were combined so as to form composite patterns of sub-test combinations. The composite abilities which represent each sub-test combination were called: Mental Ability A, Mental Ability B, and Mental Ability C. The same techniques of relating the intelligence sub-tests to the mark areas were used to relate Mental Ability A to marks in English, Mental Ability B to marks in Mathematics, and Mental Ability C to marks in Social Science.

Statistical analysis of intra-individual mean scatter data. After the mental ability areas were related to the mark areas, the investigation proceeded to the development of intra-individual differences in each individual's ability to achieve in the three mark areas and his ability to achieve in the three mental ability areas. Since intra-individual measurement of each individual demanded more exact data, the initial step was to recalculate some of the original distributions of the data so as to obtain new raw scores for each individual of the population. Then, the means and standard deviations of the three mark area distributions were equated, and means and standard deviations of the three mental ability area distributions were equated. "Z" scores were computed for each individual in each of the three mark area distributions and in each of the three mental ability distributions. Next, all of the "Z" scores within each trait were normalized, and the normalized scores were recorded in tables. Also, the mean of each individual's three normalized mark area scores was computed and entered in the table to the left of the three normalized scores; and the mean of the three normalized scores was subtracted from each normalized score and the differences entered in the table to the right of the three normalized scores to find the intra-individual mean scatter of each individual in the mark areas of English, Mathematics, and Social Science. The same technique of recording scores was used to find the intra-individual mean scatter of each individual in the mental ability areas of Mental Ability A, Mental Ability B, and Mental Ability C. This procedure formed six new distributions of intra-individual mean scatter, one distribution for each of the three mark areas and one distribution for each of the three mental ability areas.

Next, the means and the mean deviations of each mark area mean scatter distribution were equated, and the means and the mean deviations of each mental ability area mean scatter distribution were equated. Then, mean deviational values of mean scatter scores were computed for each individual in each of the three mark area mean scatter distributions and in each of the three mental ability area mean scatter distributions. Then, all of the mean deviational values of mean scatter scores within each trait were normalized.

Finally, each individual's mean deviational value of mean scatter in English, Mathematics, and Social Science, and his normalized mean deviational value of mean scatter in English, Mathematics, and Social Science were recorded in the same table. Likewise, another table was made to record each individual's mean deviational value of mean scatter in Mental Ability A, Mental Ability B, and Mental Ability C, and his normalized mean deviational value of mean scatter in Mental Ability A, Mental Ability B, and Mental Ability C. At this point, the intra-individual scatter patterns of mark data were ready for comparisons with the intra-individual scatter patterns of the intelligence test data.

Inter-trait comparisons were made by comparing the pattern formed by each individual's normalized mean deviational values of mean scatter in English, Mathematics, and Social Science with the pattern formed by the same individual's normalized mean deviational values of mean scatter in Mental Ability A, Mental Ability B, and Mental Ability C. The statistical significance of the patterns was tested by chi square of independence in contingency tables, and by contingency coefficients.

Cross validation. The cross validation study was made in order to discover whether the results of the original investigation would hold in another research population. With one exception, the methods and techniques of analysis used in the cross validation study are the same as those used in the original study; the method of normalizing distributions of standard scores was omitted.[1] The findings essentially confirmed what was found in the original data.

Results and Interpretation

The results of this investigation were obtained from testing intra-individual relationships between mark areas and mental ability areas on

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[1]See Chapter VI.

the null hypothesis. In each comparison between mark data and mental ability data, the statistical significance of the relationship was found as follows: chi square was computed from the tabulation of scores in contingency tables; degrees of freedom[2] for the data in each contingency table were computed, and the significance of the difference was found by reference to statistical tables;[3] then, the contingency coefficient was computed, and the significance of the contingency coefficient was estimated by reference to the computation of its standard error.[4]

In reporting the results, each reference to the significance of the difference denotes the level of significance between degrees of difference in the intra-individual ability of pupils to achieve in mark area scores and the intra-individual ability of pupils to achieve in mental ability scores. The contingency coefficient measures the extent to which the differences found in chi square computations tend to be in agreement. Each reference to the contingency coefficient denotes the ratio of relationship between degrees of difference in the intra-individual ability of pupils to achieve in mark area scores and the intra-individual ability of pupils to achieve in mental ability scores. A summary of the results follows.

Results. The results were obtained from investigation of data in two separate populations, the original population and the cross validation population. The results consist of findings in terms of the basic hypotheses, and findings in terms of the three sub-hypotheses.

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[2]Henry E. Garrett, Statistics in Psychology and Education, p. 241.

[3]Ibid., p. 242.

[4]Ibid., p. 360.

The intra-individual scatter patterns of marks in English, Mathematics, and Social Science are essentially related to and dependent on the intra-individual scatter patterns of scores in Mental Ability A, Mental Ability B, and Mental Ability C; the significance of the difference is .001 in the original population and .001 in the cross validation population; the contingency coefficients are .381 and .411 in the original population and .455 in the cross validation population.

The component intra-individual mean scatter of marks in English is essentially related to and dependent on the component intra-individual mean scatter of the scores in Mental Ability A; the significance of the difference is .001 in the original population and .01 in the cross validation population; the contingency coefficient is .493 in the original population and .502 in the cross validation population.

The component intra-individual mean scatter of marks in Mathematics is essentially related to and dependent on the component intra-individual mean scatter of the scores in Mental Ability B; the significance of the difference is .02 in the original population and .001 in the cross validation population; the contingency coefficient is .421 in the original population and .617 in the cross validation population.

The component intra-individual mean scatter of marks in Social Science is essentially related to and dependent on the component intra-individual mean scatter of the scores in Mental Ability C in the original population, but the relationship is inconclusive in the cross validation population; the significance of the difference is .04 in the original population and .07 in the cross validation population; the contingency coefficient is .408 in the original population and .362 in the cross validation population.

Interpretation. With one exception,[5] all of the chi square scores are statistically significant. This means that the differences between the scatter patterns of marks and the scatter patterns of mental abilities are not random[6] (i.e., not by chance), but are true differences and that the mean scatter of marks tends to be in agreement with the differences in the mean scatter of mental abilities. The level of significance in chi square indicates the confidence with which one can expect achievement in one trait to differentiate success or failure of achievement in another trait.

All of the contingency coefficients are statistically significant; therefore, it can be stated with confidence that relationships of agreement between the scatter patterns of marks and the scatter patterns of mental abilities were not found by chance. Contingency coefficients show that intra-individual ability to achieve in mark areas is related to intra-individual ability to achieve in mental ability areas.

Although the analysis of the data suggests cause and effect relationships between marks in mark areas and mental abilities, the question of which is cause and which is effect stands as an apriori one,

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[5]The exception is the significance of the difference between marks in Social Science and scores in Mental Ability C of the cross validation. This relationship is inconclusive in the cross validation and does not confirm the relationship found in the original study; however, this finding does not necessarily negate the relationship found in the original population. See "Conclusions" in Chapter VI.

[6]If the differences were random, a comparison between a given mark area distribution of plus and minus mean scatter and a given mental ability area distribution of plus and minus mean scatter would tend to cancel the differences between the two mean scatter distributions. If the differences were not random, but were in agreement, the plus mean scatter of one distribution would tend to agree with the plus mean scatter of the other distribution, and the minus mean scatter in one distribution would tend to agree with the minus mean scatter in the other distribution in a positive relationship of agreement; or conversely, would tend to agree in a negative relationship of agreement.

independent of statistical methods. If these relationships exist, marks cannot be construed as being the cause of mental abilities; marks must necessarily be the effect and the mental abilities the cause.

The relationships between marks in mark areas and mental abilities suggest that within the research populations, patterns of intra-individual deviation in mark areas are, in part, the result of patterns of intra-individual deviation in mental ability areas, and that intra-individual scatter patterns of marks in English, Mathematics, and Social Science can be predicted from intra-individual scatter patterns of scores in Mental Ability A, Mental Ability B, and Mental Ability C. However, the value of the predictions would depend on the reliability of the sub-test combinations of the Wechsler-Bellevue from which the mental abilities were derived.

A crude estimation of the reliability of the mental abilities was made from the following tabulation:[7]

Test-Retest Correlation and Standard Errors of Measurement for the Bellevue Scale

Subtests	Correlations	S.E. meas.
Information	.86	.68
Digit Span	.67	1.68
Arithmetic	.62	2.06
Similarities	.71	1.22
Vocabulary	.88	.73
Picture Arrangement	.64	1.82
Picture Completion	.83	.95
Block Design	.84	1.10
Object Assembly	.69	1.31
Digit Symbol	.80	1.06
Verbal IQ	.84	3.96
Nonverbal IQ	.86	4.49
Full Scale IQ	.90	3.29

(Source: G. F. Derner, M. Aborn, and A. H. Canter, "The Reliability of the Wechsler-Bellevue Sub-test Scales," Journal of Consulting Psychology, (Vol. 14, 1950), pp. 172-79)

[7]Frank S. Freeman, Theory and Practice of Psychological Testing, (New York, 1955), pp. 175-77.

The average reliability of the sub-tests within each mental ability and the average reliability of the eleven sub-tests of the full scale were computed. The average reliabilities found were: Mental Ability A, .735; Mental Ability B, .763, Mental Ability C, .737; and the full scale, .753. If the average reliability of .753 for the full scale gave a test-retest correlation of .90, then by prorating the number of sub-tests in each mental ability area in relation to the eleven sub-tests of the full scale and by interpolating from the full scale reliability of .90, the estimated test-retest correlations of the mental abilities were found to range between .76 and .80. Although this estimate is not a high degree of reliability, it is nevertheless above the average reliability of the individual sub-tests; and since the cross validation essentially confirmed the results of the original study, the differential prediction of marks from mental abilities should yield reasonably reliable results.

Conclusions

Since intra-individual scatter patterns of mark area scores were found to be related to intra-individual scatter patterns of mental ability scores, and since mark area scores are measures of marks and mental ability scores are measures of intelligence, then intra-individual scatter patterns of marks are related to intra-individual scatter patterns of intelligence. Also, since the relationships between intra-individual scatter patterns of marks and intelligence were found to be statistically significant within the research populations, these relationships are considered characteristic of the research populations. Therefore, it is concluded that characteristic relationships exist between scatter patterns of marks and scatter patterns of intelligence. Furthermore, since all of the component intra-individual mean scatter relationships of mark areas and mental abilities are statistically significant in the original population and only one relationship was inconclusive (not negative) in the cross validation population, it is concluded that characteristic relationships exist between marks in English and Mental Ability A and between marks in Mathematics and Mental Ability B, and may exist between marks in Social Science and Mental Ability C.

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