PRIMARY MENTAL ABILITIES AND ACHIEVEMENT

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CURRICULUM STUDIORUM

The writer was born July 23, 1912, in Minneapolis, Minnesota, U.S.A. She received the Bachelor of Science degree in Education from De Sales College, Toledo, Ohio, U.S.A., in 1942; and the Master of Arts degree in Psychology from the University of Ottawa, Ottawa, Ontario, in 1961. The title of her thesis was A Comparison of Lower and Higher Achievers in Grades Five and Six On Certain Intellectual and Social Factors.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Effective education seeks to elicit the maximum development of every boy and girl in terms of his unique nature and needs. Teachers, dedicated to the education of each individual child regardless of the degree to which he may differ from others, are aware of the fact that it is no longer an acceptable practice to apply the same standards to all children. To this end, a general knowledge of how students think and learn is not sufficient. Rather, specific information as to the degree of difference in the individual child is necessary. Aside from the "exceptional" children, every classroom includes both those students whose differences make them unable to perform at the average level as well as those whose differences allow them to perform above the average. Thus, the realistic educator, admitting the fact of individual differences, is faced with two tasks: first, an adequate identification of the abilities of children, and second, the proper provision for educating these groups after they have been identified. It is the first task which is of interest to this study.

Many difficulties are encountered in the identification process. A major problem still is the nature and organization of intelligence. Volumes have been written on the subject but its nature remains a mystery. The oldest notion conceives intelligence as a unitary concept which regards it as the ability to integrate experiences into meaningful wholes,

or the adaptability to new situations. This has proven insufficient for practical purposes.

Another is the two-factor theory based on the elaborate statistical procedure of factor analysis as proposed by Spearman and Vernon. It theorizes that measurable variations in mental capacity could be accounted for only by the assumption of certain S factors or specific abilities in addition to the G factor or general ability. The latter is considered as a form of mental energy present but not equally operative in S factors which are operative in specific situations. Although acceptable, this theory seems to have been insufficiently explored for practical educators.

To date the most widely accepted explanation is the multiple-factor theory of which Thurstone is the principal spokesman. This theory postulates several "primary mental abilities" which include such factors as: spatial relations, perceptual speed, number ability, verbal meaning, word fluency, rote memory, and induction. Individual differences in intelligence may lie in any or all of these aspects of intelligence. Thus a total score which is obtained in a mental ability test leaves much that remains to be known before a correct assessment of a subject's real ability to perform can be made. Two individuals obtaining the same total score may prove to be very different when their performance is analyzed more specifically. So any attempt at measuring general intelligence

leaves some intellectual performance unaccounted for, and any attempt to measure narrower abilities separately points to something they have in common especially when scores are correlated positively. There is a growing realization that the question of variation in individual abilities deserves serious consideration and should be investigated in its own right. It is essential that inquiry be made as to the extent of variation within the individual if his best performance is to be elicited academically.

The basic assumption conceded generally is that due to rapid growth and differentiation, the nature and composition of mental functions changes continuously and rapidly at first. By six years of age, various mental processes are organized to the extent that some formal schooling can be attempted. Even as they become stable, they continue to grow steadily through childhood, with the result that a slight acceleration has been observed in mental growth between the eighth, ninth, and tenth years. At this time, the variability of intelligence scores increases. It decreases during the late teens and early twenties and current studies seem to indicate that thereafter the scores for many kinds of intelligence remain steady or increase slowly throughout adult life until senescence. The rate of decline varies with the kind of mental ability and the particular individual. Thus the nature of mental abilities differs at various phases of life, and

although the rates of change vary both with age and the specific mental functions of each individual, the over-all trends of increment and decrement are similar, and some periods of growth are characteristically more stable than others. In the face of these generalities the practical teacher has need for more specific facts concerning these trends if guidance and teaching are to be effective at particular phases of school life.

Since it is a fact that many abilities are involved in every learning experience and that several abilities come into play in each school subject, some abilities may be more important in one subject and less important in another. A specific knowledge of these abilities would help those engaged in the education of children to understand the learning process and thus aid in determining proper methods and procedures of teaching, the nature of textbooks, and the organization of a practical curriculum. Undeniably many intangible factors play a role in learning but the fact that it does depend on certain abilities also justifies attempts at evaluating them to some extent.

Accepting Thurstone's theory of intelligence, the purpose of the present study is to examine the stability of the pattern of abilities which boys and girls of the middle elementary grades utilize when faced with identical tasks. Approaching the problem with the variables of grade, sex, and

academic achievement held constant, it will explore the possibility of the emergence of a more definite picture of mental abilities operative in the intelligent behavior of overachievers, average achievers, and underachievers. Attempts will be made to answer such questions as: Do boys and girls use abilities to the same degree when faced with similar tests? Is there a greater variability in scores among boys at different grade levels? Among girls? Are the primary mental abilities being as effectively used by boys and girls within the underachieving group as they are within the average or overachieving groups? More simply stated, the problem resolves itself into the following question: Is there a difference in the primary mental abilities called into play in the performance of similar tasks by boys and girls of various levels of achievement in grades four, five and six?

The first chapter of this study attempts to give the background of the problem. It presents a terse review of the literature with respect to research relevant to the problem of mental organization as influenced by sex, grade, and achievement level. The basic hypothesis is presented.

Chapter two outlines the procedure used in the selection of the sample population. The description of the sample is followed by information with respect to the tools used, their administration, and the statistical method employed for the analysis of the data.

The results of the analysis of variance of the scores are presented in the third chapter. This is followed by a discussion of the data in chapter four. A summary and conclusions follow, with possible implications for an optimistic orientation toward developing the potential intellectual resources of children. Several suggestions for further research are made.

CHAPTER I

REVIEW OF LITERATURE

There is a growing need which is felt by educators conscious of individual differences, for a plan to effect the fullest development of the mental capacity of each child, to elicit his best mental performance. The common denominator underlying the failure to find a solution to this problem is the fact that mental organization is not yet fully understood. Measured I.Q. alone does not distinguish between those who can and those who do achieve to their capacity. Most educators are agreed that intelligence is not a unitary ability but rather a combination of various mental abilities which not only develop at different rates but are present in different degrees in individuals.

While much research has been directed toward this problem of individual differences in the growth and organization of mental abilities, the results are far from being conclusive. Not all human qualities related to the complex factors inherent in the learning process itself are really measurable. Yet evaluation or quantitative measurement is almost mandatory for an objective study of individual differences. Thus, in defying objective measurement, these factors have somewhat impeded the progress of research in this direction.

This study proposes to take a closer look at the question of the organization of mental abilities. By a comparison of the primary mental abilities operative in students at different stages of the learning process, possible variation in the use of mental abilities may appear as reflected in school achievement. A semblance of definite patterns of factors may emerge for various groups which could serve as guideposts to methods and content in order to produce maximum achievement for each individual. Since the variables of sex, grade, age and level of achievement necessarily will come into focus, a review of the related research found in literature is here presented in the following order: 1) Investigations regarding mental abilities as influenced by sex, age, and grade; 2) Studies concerning mental abilities and achievement; and 3) The summary and hypothesis.

1. Mental Abilities: Sex, Age, Grade.

Intelligence and the organization of its factors as related to differences in sex and increase in age and grade level, has been the goal of many investigations. While it has never been proven which sex is superior, there is evidence that males are superior in some respects and females in others and that intelligence develops from a general ability to specific abilities as age increases. Complete agreement by investigators is not always found. The following studies support

the hypothesis of developmental differentiation of mental abilities with increase in age and/or grade and have reported sex differences.

Bayley[1] contends that "Intelligence appears...to be a dynamic succession of developing functions with the more advanced and complex functions in the hierarchy depending on the prior maturing of earlier simpler ones." This hypothesis stems from her intensive studies on the growth of intelligence. Of interest here is her longitudinal study[2] of a group of forty children who had been tested at most or all of the thirty eight testing ages from one to eighteen years of age. Since the attention had been focused primarily on the age changes in variability of intelligence test scores and on the individual consistency in relative scores, the author reports finding some negative evidence which seems to indicate that there are no consistent trends in the variability of scores during growth. There appear to be some periods during which the abilities of children are homogeneous, and others in which great individual differences appear. These periods seem to be inherent in the process of mental development. Furthermore, it is postulated that the greatest homogeneity in scores occurs for a function

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1 Nancy Bayley, "On the Growth of Intelligence", in The American Psychologist, Vol. 10, No. 12, Dec. 1955, p. 807.

2 ———, "Consistency and Variability in the Growth of Intelligence from Birth to Eighteen Years", in the Journal of Genetic Psychology, Vol. 75, Sept. 1949, p. 165-196.

when it begins to develop. The scores seem to be most dispersed when a function is in the process of developing, but when those who are growing rapidly in that function are not yet mature. As the slower-growing individuals reach maturity in the same function, the differences again become somewhat restricted. If tests measure these abilities adequately, it may be assumed that the fluctuations in scores are caused by the progressive development and maturing of the various types of intellectual ability.

Jones[3] compared two hundred pupils at each of four age levels: seven, nine, eleven, and thirteen. His results conform to the trend expected on the basis of the hypothesis of developmental differentiation. He found that at the age of seven the verbal, reasoning, and memory factors are similar to those found at the age of nine. The absence of a spatial factor in the seven year old group is explained as being due to the absence of items logically dependent upon a subject's spatial ability in the age seven battery. At the age of nine, the memory factor, verbal and spatial factor are found to be similar to that at age eleven. The reasoning factor differs from that of age thirteen. At age eleven, the meaningful factors found were verbal, spatial, and memory. For the age

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3 Lyle V. Jones, "A Factor Analysis of the Stanford-Binet at Four Age Levels", in Psychometrika, Vol. 14, No. 4, Dec. 1949, p. 299-331.

thirteen group, six factors emerged--the verbal, memory, visualization, spatial and two reasoning factors. In this study the loss of a general ability with advancing age was indicated by the more clearly defined group factors at the higher ages. The author explains this thus:

> ...While it may be argued that the factorial solution depends upon the items included and does not necessarily reflect underlying patterns of mental abilities, it nevertheless seems reasonable that the nature of the items selected did depend upon the mental organization of subjects in the standardization groups. Thus we find more homogeneous items at the younger age levels, and appropriately less distinct group factors emerge.[4]

Bryan's[5] study supports this finding for she found a considerable degree of homogeneity in the mental abilities of one hundred five year old boys to whom she administered eleven tests of immediate memory. These tests were as closely related to the verbal factor as they were to each other.

Tyler[6] inquired into the possibility of similar patterns of primary mental abilities in the same subjects by means of equivalent Primary Mental Abilities Tests. These were given to eighty three fourth grade children who had taken the corresponding battery in the first grade, and to one hundred

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4 Jones, Ibid., p. 316.

5 Alice I. Bryan, "Organization of Memory in Young Children", in Archives of Psychology, Vol. 24, No. 162, 1934, 56 p.

6 Leona E. Tyler, "The Stability of Patterns of Primary Mental Abilities Among Grade School Children", in Educational Psychological Measurement, Vol. 18, No. 4, 1958, p. 769-774.

twenty-seven eighth graders who had been tested by this battery in the fourth grade. She reports finding no consistency over the three-year period between the first and fourth grade levels, although there was a considerable amount of change in individual cases. However, the relationship between the fourth and eighth grade patterns was significant, again suggesting the increasing stability of individual mental ability patterns as age progresses. The correlations between scores for the same special abilities were higher for older than for the younger age levels.

In a study of mental organization among school children Schiller[7] used twelve tests such as arithmetic computation and reasoning, vocabulary, sentence completion, mazes, analogies, reading, man-drawing, and cube manipulation to study intelligence in small children. These tests were administered to three hundred ninety-five nine year old boys and girls in grades three and four. The results showed no reliable sex differences in the ability to handle verbal concepts and the only numerical test which showed a reliable difference in favor of the boys was that of arithmetic reasoning. However, the boys had what was described as "differentiable" spatial factor in the verbal-spatial and the numerical-spatial tests while the

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7 B. Schiller, "Verbal, Numerical, and Spatial Abilities of Younger Children", in Archives of Psychology, Vol. 24, No. 161, 1934, 69 p.

girls had a "differentiable" verbal factor in these same tests. There was no spatial factor found for the girls.

Three years later Asch[8] retested as many of the original subjects as were available which Schiller used in the above study and found that with the same battery given to seventy-nine boys and eighty-two girls, the intercorrelation between tests was lower at the age of twelve than at nine, especially between verbal and numerical tests. The average of all correlations was .56 for boys at the age of nine and .57 for the girls. At twelve years of age the average for the boys was .41 and .51 for the girls. This drop in the correlation coefficients between the two ages was considered statistically significant, thus showing the increase of specific abilities with advancing age.

Upon investigating three groups of over seven hundred boys and girls of ages nine, twelve and fifteen, Garrett, Bryan and Perl[9] found that intercorrelations among ten mental tests (six memory and four non-memory) decreased for all tests for both boys and girls between the ages of twelve and fifteen as did the mean intercorrelation of each of their subgroups of tests for these age levels. However, the data shows a decrease

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8 S.W. Asch, "A Study of Change in Mental Organization", in Archives of Psychology, Vol. 28, No. 195, 1936, 30 p.

9 H.G. Garrett, A.I. Bryan and R.E. Perl, "The Age Factor in Mental Organization", in Archives of Psychology, Vol. 26, No. 176, 1935, 31 p.

between ages nine and twelve for girls but not for boys, and an increase of mean intercorrelation coefficients of all tests.

> ...Our inability to separate retentivity from general intelligence at the three age levels which we have investigated and the findings that the role of general abilities is minimized in favor of special abilities as age increases, are the most significant results of this study.[10]

Richards[11] verified these findings when he analyzed Garrett's data. His solution showed a consistent shift towards discreeteness with increase in age for girls and though the same was observed for the boys, he felt the picture was not as clear because of the low variance.

Clark[12] using Thurstone's test of Primary Mental Abilities studied the changes in the factor patterns of three hundred forty-six boys, ages eleven, thirteen and fifteen with an I.Q. range of 83-115, and from varying socio-economic levels. Grades four to twelve were sampled. There was a statistical significant increase with age in the mean scores of the six components (number, verbal, memory, space, word fluency, and reasoning) as also a consistent tendency for variability of scores in each component to increase with age. The greatest amount of change through these age levels was in word fluency.

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10 H.G. Garrett, et al, Ibid., p. 29.

11 T.W. Richards, "Genetic Emergence of Factor Specificity", in Psychometrika, Vol. 6, No. 37, 1941, p. 37-42.

12 M.P. Clark, "Changes in Mental Organization with Age", in Archives of Psychology, Vol. 41, No. 291, 1944, 30 p.

Reasoning and verbal meaning were next in order of magnitude of change, while memory, space and number exhibited the least amount of change. The memory factor was little related to the other factors at any age from eleven to fifteen and showed no consistent change within the age range. However, with this exception, there was found a consistent decrease in the intercorrelation among six abilities as age increased, and this trend was not influenced by the general intelligence of the subjects.

The relationship of reading and the primary mental factors was investigated by Bond and Clymer[13] with a group of eighty-seven fourth graders. They found a significant correlation of the reading ability with the measures of the Primary Mental Abilities Test with the exception of the space factor.

Reichard[14] administered eight tests designed to measure verbal, number, and spatial abilities to 542 boys and girls of ages nine, twelve, and fifteen in the schools of suburban New York. Intercorrelations dropped in the group of twelve to fifteen year old, but there was an increase from ages nine to twelve for both boys and girls. This apparent contradiction

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13 Guy L. Bond and Theodore Clymer, "Interrelationship of the SRA Primary Mental Abilities, Other Mental Characteristics, and Reading Ability", in Journal of Educational Research, Vol. 49, No. 2, Oct. 1955, p. 131-136.

14 Susanne Reichard, "Mental Organization and Age Levels", in Archives of Psychology, Vol. 41, No. 295, 1944, 30 p.

may have been due to the superior nine year old group.

That abilities become specialized with increasing age was attested by two studies of Thurstone. In the earlier study[15] when fifty-six tests were administered to two hundred forty students, ages sixteen to twenty-five, the correlations among primary factors were very low and the author concluded that they were essentially independent.

In a later study[16] in which Thurstone and Thurstone measured 1,154 eighth grade children with sixty tests, the authors extracted ten factors which they later reduced to six primaries and a second-order general factor which they identified as probably equivalent to the g of Spearman.

Using subjects from the nine to sixty year range, Balinsky[17] investigated the stability of mental factors. He found that the verbal and performance factors of the Wechsler test were most consistent; that the average of the subtest intercorrelations decreased from age nine to twenty-nine and then increased up to the age of fifty to fifty-nine; and that a g

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15 L.L. Thurstone, "Primary Mental Abilities", in Psychometric Monographs, No. 1, Chicago, University of Chicago Press, 1938, ix-121 p.

16 L.L. Thurstone and T.G. Thurstone, "Factorial Studies of Intelligence", in Psychometric Monographs, No. 2, Chicago, University of Chicago Press, 1941, v-94 p.

17 Benjamin Balinsky, "An Analysis of the Mental Factors of Various Age Groups from Nine to Sixty", in General Psychology Monographs, Vol. 23, Feb. 1941, p. 191-234.

factor seemed to be present at ages nine and fifty to fifty-nine but was not disclosed for other age groups. He concluded that it could be stated that the mental traits change and undergo reorganization over a span of years.

Hobson[18] employing the Primary Mental Abilities Test, found that the girls in grades eight and nine had a CR of 5.45 and 4.31 in word fluency as compared to the boys of the same grades. The means of the boys resulted in a CR of 8.86 and 4.99 for the spatial relations test. There was also indication that the girls at the same age and grade levels exceed boys slightly in numerical facility while the boys exceed the girls in verbal meaning. The ninth grade means for both boys and girls are higher than eighth grade means in all of the primary mental abilities except visual memory, thus indicating that these abilities increase between the age and grade levels represented.

The research of Havighurst and Breese[19] revealed similar results. Again, using the PMA tests they found thirteen year old boys in grade four to nine, to excel in spatial tests while the girls were superior in reasoning, numbers, word

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18 James H. Hobson, "Sex Differences in the Primary Mental Abilities", in Journal of Educational Research, Vol. 41, No. 2, Oct. 1947, p. 126-132.

19 R.J. Havighurst and F.H. Breese, "Relation Between Ability and Social Status in a Midwestern Community; III. Primary Mental Abilities", in Journal of Educational Psychology, Vol. 38, No. 4, April 1947, p. 241-247.

fluency, and visual memory. The sexes were equal in comprehension.

Emm[20] reports some differences in sexes after administering eighteen different tests among them the PMA to 736 fifth graders in the schools of New York. In this sample girls tend to be superior to boys in reading comprehension. Boys and girls do not use the same pattern of traits in arithmetic problem-solving. The girls seem to be able to carry out fundamental processes in arithmetic but the boys are superior in solving problems. She found a spatial factor for boys but not for girls.

Further evidence of the differentiation of abilities is also given on the adult level. Schneck[21] obtained a correlation of .26 between the verbal and numerical factors at the college level where he administered nine tests, five verbal and four numerical to 210 college men, eighteen to twenty-one years of age.

Anastasi[22] had similar results with college women. She found the correlation between verbal and memory to be -.085

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20 Sister M. Eloise Emm, A Factorial Study of the Problem-Solving Ability of Fifth Grade Boys, Wash. D.C., The Catholic University of America Press, Vol. 22, No. 1, 1959, vi-58 p.

21 M.R. Schneck, "The Measurement of Verbal and Numerical Abilities", in Archives of Psychology, Vol. 17, No. 107, 1929, 49 p.

22 Anne Anastasi, "Further Studies on the Memory Factor", in Archives of Psychology, Vol. 24 No. 142, 1932, 60 p.

and between numerical and memory to be .00, again pointing to the fact of a low correlation between verbal and numerical at this age.

So far studies have been cited which support the developmental differentiation of abilities from general ability to specific abilities with increase in age and some difference in sex. However, not all research which is reported in literature upholds these general trends. The following are some examples of investigations which fail to corroborate the general trend that with increasing age there appears to be a gradual breakdown of general ability into a group of special abilities, or that sex differences are evident. Conversely, they stress the importance of the general factor increasing with age, and find no significant sex differences.

One such research is that of Curtis[23] who, after studying the same group as Asch[24] did, disagrees with the results and postulates an increase with age of the importance of the general factor. This difference was accounted for by the fact that two different difficulty levels of tests were used. Thus the easy form may have produced a larger general factor than the difficult form did. This would exonerate the role of age

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23 Hazen A. Curtis, "A Study of the Relative Effect of Age and of Test Difficulty Upon Factor Patterns", in Genetic Psychology Monographs, Vol. 40, 1949, p. 99-148.

24 Asch, Op. Cit., 30 p.

in the Curtis study.

Chen and Chow[25] found in their study of a wide range of Chinese subjects from the fourth grade, junior high school, senior high school, and college freshman class, that this sampling manifested increasingly simpler factor patterns with increments in age and educational level. While in the primary grade four factors were identified as: general, verbal, numerical and spatial, those at the junior high level numbered three: general, verbal and spatial. At the senior level only the general ability and the spatial ability were evident. The college group displayed but one: the general factor. They concluded that mental functions seemed to be integrated with increase in age and educational level.

Swineford[26] found no systematic changes in the factor patterns of the two groups studied. She administered six different tests to seventh, eighth and ninth graders and then compared the seventh and ninth and the eighth and ninth. Her results encouraged the assumption that the specific factors became less important and the general factor increased with age. No sex differences appeared.

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25 T.L. Chen and E.H. Chow, "A Factor Study of a Test Battery at Different Educational Levels", in Journal of Genetic Psychology, Vol. 73, Sept. 1948, p. 187-199.

26 Frances Swineford, "Growth in General and Verbal Bi-Factors from Grade VII to Grade IX", in Journal of Educational Psychology, Vol. 38, No. 5, 1947, p. 257-272.

Burt[27] and Droppelt[28] postulated from the data resulting from their inquiries that the importance of the general factor was positively related to increment in age.

In his study of several researches, Wesman[29] attributes sex differences or lack of them to the method in which tests are constructed and to the fact that boys and girls acquire knowledge and skills selectively and thus differ in their performance as a result.

Kuznets and McNemar[30] compiled a table in which pertinent data of twelve studies of sex comparisons were reported. Of the fifty-six sex-age comparisons in this table, twenty-eight favored boys, twenty-five favored girls and three gave a zero difference. They found no startling differences between the sexes either in average tendency or in variation. They did concede that similar comparisons on specific types of performance may reveal differences between sexes.

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27 Cyril Burt, "The Structure of the Mind, A Review of the Results of Factor Analysis", in British Journal of Educational Psychology, Vol. 19, 1949, p. 176-199.

28 Jerome E. Droppelt, "The Organization of Mental Abilities in the Age Range Thirteen to Seventeen", in Teachers College Contributions to Education, Vol. 10, No. 962, New York, Columbia University, 1950, 86 p.

29 Alexander Wesman, "Separation of Sex Groups in Test Reporting", in Journal of Educational Psychology, Vol. 40, No. 4, April 1949, p. 223-229.

30 G.M. Kuznets and Olga McNemar, "Sex Differences In Intelligence-Test Scores", in National Society for the Study of Education, Yearbook 39, Part I, Intelligence: Its Nature and Nurture, Bloomington, Illinois, Public School Publishing Co., 1940, p. 211-220.

Two general conclusions which may be drawn from these studies are: first, that there is no significant sex difference between boys and girls as measured by present-day tests of intelligence; and second, that boys and girls differ significantly in specific abilities which seem to become more specialized with increasing age and grade. Boys were found to be superior in the use of mathematical reasoning, spatial relations and science, and girls in verbal fluency, memory, and perceptual speed. It is evident that studies do not always agree in their results and conclusions. More research on the problem of organization of mental abilities and the roles which age and sex play in this process is necessary before the maximum mental development of each child can be assured.

2. Mental Abilities and Achievement.

Studies were conducted with an interest in the possible relationship of the mental abilities and various levels of achievement. The following cite results, some of which show positive relationship, while others demonstrate negligible or no relationship.

Woodrow[31] used six mental ability tests in a study of mental unevenness and brightness of 1,572 subjects ranging in

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31 H. Woodrow, "Mental Unevenness and Brightness", in Journal of Educational Psychology, Vol. 19, No. 5, 1928, p. 289-302.

mental age from eight to sixteen years and eleven months. He reports finding the bright and dull showing greater variability than the normal when he compared the trait variability in the six intelligence subtests for the children.

Gray[32] attempted to discover the relationship which existed between the level of intelligence and individual variability in educational achievement. In the study involving six hundred sixth graders, she found achievement variability greater among the lower intelligence group than the middle and higher groups.

In a comparison of the variability in achievement of two hundred three bright, normal, and dull fifth grade pupils, Commins[33] found greater unevenness in scholastic proficiency among boys. Comparing the internal variability of this same group on the basis of intelligence, he found that children with intelligence quotients above one hundred five are more uneven in their scholastic achievement than are the average or inferior children.

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32 Susan Grey, "The Relation of Individual Variability to Intelligence", in Journal of Educational Psychology, Vol. 35, No. 4, 1944, p. 201-210.

33 W.D. Commins, Principles of Educational Psychology, New York, The Ronald Press Co., 1937, p. 557-561.

In a study[34] of two hundred lower and higher achievers in grades five and six, within a restricted I.Q. range of 90 to 119, there was evidence of differences between the groups in mental abilities. A significant difference was found between the means for the entire lower and higher achieving groups regardless of grade, for the spatial factor at the .02 level of confidence and for the numerical factor at the .05 level of confidence. Concerning each grade level, the lower and higher achievers in the fifth grade differed significantly in the numerical factor at the .01 level of confidence and in the verbal factor at the .05 level of confidence. The lower and higher achievers of the sixth grade varied significantly for the space factor at the .05 level of confidence.

Chase[35] explored intellectual differences between two extreme achievement groups in which the total mental age was held constant. Besides the Otis and Stanford Achievement Test he used the SRA Primary Mental Abilities Test. The results of the one hundred eighty-four students of the fifth grade who were tested, showed only one of the five factors of the PMA to

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34 Sister Mary Francis Lopata, A Comparison of Lower and Higher Achievers in Grades Five and Six on Certain Intellectual and Social Factors, unpublished Master's Thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, 1961, x-73 p.

35 Clinton I. Chase, "The Control of Ability to Learn in the Comparison of Extreme Groups", in The Journal of Educational Research, Vol. 57, No. 9, 1964, p. 495-497.

be significant at the .01 level of probability and that was the number factor. This evolved from the comparison of experimentally matched groups. However, when the entire group of good achievers was compared to the entire group of poor achievers, two significant differences between the means at the .01 level of confidence were found for two factors. The number factor produced an F result of 5.78 and the reasoning factor yielded an F of 5.13 . The method of selection of groups makes a difference in the results.

Research also reveals that no differences in mental abilities between students of various levels of achievement were found. Thus the hypothesis of no difference between bright and dull children in primary mental abilities was supported by the results of Kolstoe's[36] investigation. His sample consisted of twenty-nine third and fourth graders and twenty-nine eighth and ninth graders who had a mental age of ten years. Various tests were administered, among them the PMA test. He found no difference between the two groups in the primary mental abilities, and his results support the general ability concept.

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36 Oliver P. Kolstoe, "A Comparison of Mental Abilities of Bright and Dull Children of Comparable Mental Ages", in Journal of Educational Psychology, Vol. 45, March 1954, p. 161-168.

Burrall[37] found no statistically significant correlation between trait variabilities in a sample of more than two hundred boys and girls in the fifth grade. No sex differences were found. The more varying achievers tended to be more socially accepted.

With positive and negative results obtained by various investigators concerning the problem of the relationship of mental abilities and levels of achievement, more study is needed to clarify whether there is or is not a relation between academic performance and the kinds of abilities used in the performance.

3. Summary and Basic Hypothesis.

Postulating intelligence to be neither a summation of several unrelated traits nor a unitary quality, research studies of both internal and external types of analyses point to the fact that:

> ...Intelligence is both one thing and many things. When we attempt to measure its general component we always leave some portion of the intellectual performance of our subjects unaccounted for. When we attempt to measure narrower abilities separately - verbal, spatial, perceptual, - we always find something they have in common makes scores on the separate

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37 Lucille Burrall, "Variability in Achievement of Pupils at Fifth Grade Level", in California Journal of Educational Research, Vol. 5, 1954, p. 68-73.

traits correlate positively with one another. To describe an individual's mentality accurately we need to specify both level and pattern.[38]

Bayley[39] further explains that:

> It...seems likely that the test scores are reflecting actual changes in variability which are inherent in the process of development of any given function. During growth of a structure or function variability increases, in part because of increasing individual differences in capacity, and in part because of individual differences in the speed with which the maturing process takes place. These two factors are known to be operative in physical growth and it seems reasonable to expect that they may be characteristic of many growth processes. During the stage of development when both factors operate freely the variability of measures or scores will become greater with the general increments in the structure concerned. But as the increasing number of individuals stop growing, and the means level off to a constant value, the individual differences which remain become restricted to those of the achieved mature state. On this hypothesis, we should assume that in the present series of tests of mental growth we have scores on at least two types of function which develop successively, resulting in alternating periods of increasing and decreasing variability. These large general trends may well obscure similar tendencies, which are occurring more or less simultaneously in more specific functions which develop in various parts of the growth span.

The last statement suggested this study of making a comparison of specific factors in children at various stages of the learning process for possible significant differences between these stages or levels. This could be accomplished by observing through a statistical process the resulting variations

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38 Leona E. Tyler, The Psychology of Human Differences, New York, Appleton-Century-Crofts, Inc., 1956, p. 103.

39 Bayley, Op. Cit., p. 179.

in the functioning of mental abilities as reflected in school achievement. More specifically, an attempt would be made to answer questions which are pertinent to:

1. Sex Differences: Is there a significant difference between boys and girls in the performance on the PMA tests?

2. Grade Differences:

a. Is there any significant difference 'within' each grade between the scores on the PMA test obtained by boys and girls for each primary mental factor?

b. Is the performance on the PMA test significantly different among boys 'between' grade levels?

c. Is the performance on the PMA test significantly different among girls 'between' grade levels?

d. Is the performance on the PMA test significantly different for boys and girls 'between' grade levels?

3. Achievement Differences:

a. Do boys and girls differ significantly in the use of the primary mental factors 'within' specific levels of achievement?

b. Do boys differ significantly in the use of the primary mental abilities 'between' levels of achievement?

c. Do girls differ significantly in the use of the primary mental abilities 'between' levels of achievement?

d. Do boys and girls differ significantly in the use of the primary mental factors 'between' levels of

achievement?

4. Do the comparisons of the scores on the PMA for the boys and girls result in some definite pattern with relation to the variables of sex, grade, and level of achievement?

To attempt an answer to these questions a comparison between factor patterns of intelligence as operative in boys and girls of the same grades differentiated on their scholastic achievement, resolves itself into the following null hypothesis: The PMA factors do not differentiate between boys and girls classified according to achievement in grades four, five, and six.

The purpose is to investigate the function of the primary mental abilities at three levels of achievement. Because guidance is mandatory in early grades to eliminate maladjustment as early as possible, grades four, five, and six were the source of a sample of boys and girls. They were classified as overachievers, average achievers, and underachievers on the basis of the difference in each individual case, between the mental age grade-placement as measured by the California Short-Form Test of Mental Maturity and the achievement battery grade-placement as measured by the California Achievement Tests. Further, the scores of the Primary Mental Abilities test were to be subjected to an analysis of variance for significant differences between the performance of these three groups. Possibly some definite pattern of factors would emerge for the

various groups which could serve as guideposts to method and content of curriculum in order to produce maximum achievement for each individual.

CHAPTER II

METHODOLOGY AND PROCEDURE

The procedure employed to test the proposed hypothesis of no significant difference in mental abilities between sexes at three levels of grades and achievement is presented in this chapter. It includes: 1) a brief account of the chief characteristics of the tests used; 2) a statistical description of the sample population with reference to the criteria used in the selection and classification of subjects; and 3) the statistical method employed in the analysis of the test data obtained.

1. The Testing Program.

The California tests were used to provide the criterion for the differentiation of students for this study. Involved were the California Short-Form Test of Mental Maturity, Elementary, Grades 4-5-6-7-8, 1957 S-Form[1] devised by E.T. Sullivan, W.W. Clark and Ernest E. Tiegs, and the California Achievement Tests, Complete Battery, Elementary, Grades 4-5-6, Form Y,[2]

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1 Elizabeth T. Sullivan, Willis W. Clark, and Ernest W. Tiegs, Manual California Short-Form Test of Mental Maturity, California, California Test Bureau, 1957, 32 p.

2 Ernest W. Tiegs and Willis W. Clark, Manual California Achievement Tests Complete Battery, California, California Test Bureau, 1957, 62 p.

devised by E.W. Tiegs and W.W. Clark. Since the same sampling of the national school population provided normative data for both series of tests they were articulated statistically to within one raw score unit, from the first grade through the second year of college. This brought the scores on two adjacent levels to the closest possible equivalency providing directly comparable scores between various levels since these tests were standardized according to a research design systematically planned as a dual project. Thus longitudinal and developmental studies of achievement in relation to mental maturity can be undertaken with greater confidence with tests of achievement and mental maturity that have been simultaneously administered to identical standardization populations.

In this study, the individual's discrepancy between the grade-placement yielded by the achievement test and that resulting from the mental maturity test was used as the criterion for classifying him as an overachiever, an average achiever, or an underachiever.

To identify the mental abilities of these students the SRA Primary Mental Abilities for Grades 4-6, Revised 1962[3] tests were used. The norms for the revised edition of the PMA were based on a random sample of 32,708 students drawn from 73

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3 L.L. Thurstone and Thelma G. Thurstone, SRA, PMA Primary Mental Abilities, for Grades 4-6, Examiner's Manual, Revised 1962, Science Research Associates, 1963, 46 p.

schools in 39 school systems from eight regions throughout the country. Usable data were obtained from 31,919 pupils because of incomplete data in 789 cases.

These tests were designed to yield not only a general measure of intelligence but also multifactored measures. According to Thurstone[4] whose group-factor theory holds a position somewhere between Thorndike's "atomistic" theory and Spearman's general factor theory, these tests measure five factors of intelligence which appear to be very important in schoolwork. These include: 1) the verbal meaning factor: the ability to understand ideas which are expressed in words, and measured by two subtests consisting of a word test and a picture meaning test; 2) number facility: the ability to work with numbers in the basic mathematical operations with speed and accuracy, and to understand and recognize quantitative differences, also measured with two subtests consisting of a number sense test and an addition test; 3) spatial relations: the ability to visualize objects and figures rotated in space and the relations between them; 4) reasoning: the ability to solve problems, to foresee consequences, to plan and to profit from experience, also a composite measure of the two subtests of figure grouping and word grouping; and 5) perceptual speed: the ability to recognize similarities and differences between

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4 Thurstone and Thurstone, Ibid., 46 p.

symbols and objects quickly and accurately.

Separate scores for the primary mental abilities are provided thus preserving the picture of individual differences and providing a reliable estimate of individual intelligence.

2. The Sample.

The administrators of five elementary schools in Detroit, Michigan, which were under the jurisdiction of the Sisters of St. Francis of Sylvania, Ohio, were asked to participate in this study. On the basis of regional location within the city and the school size, the subjects were a representative cross-section of elementary grade students of economically average middle class families.

The teachers of the participating schools were requested to administer the California tests of intelligence and achievement to all pupils in grades four, five, and six in the Fall of 1962. Within the same period, after the above tests were given, the Primary Mental Abilities Test was administered by a Diocesan supervisor to the same sample consisting of 1,355 students. In order to have a reasonably sound basis for the generalization of the final results of this study for the average classroom, the range of the intelligence quotients was limited to those between eighty and one hundred twenty-nine. This delimited the sample to 1,200 students.

The administration of the California Achievement Tests yielded a grade-placement (ABGP) for each pupil. This score indicated the grade level of the individual's actual performance at the time of testing. The California Short-Form Test of Mental Maturity also resulted in a grade-placement level (MAGP) but this indicated the grade level at which the individual was capable of performing. The discrepancy between these two grade-placements for each individual was then duly noted, that is, the difference between his actual performance and his potential performance. This allowed for the formation of the following three arbitrary categories: the overachievers, performing nine months or more above individual mental-age grade-placement; the average achievers, functioning three months above, at, or below individual mental-age grade-placement; and the underachievers, performing nine months or more below the individual mental-age grade-placement. Since the statistical method of analysis to be used required dividing the sample into six cells with the same number of subjects in each cell of the computation, the sample was necessarily further delimited. After assigning a number to each student, a random selection of thirty-six subjects was made for each cell. This allowed for 216 subjects (108 boys and 108 girls) in each category, all on the basis of individual achievement.

A statistical description of the final sample of 648 students (324 boys and 324 girls) is presented in Table I.

Taken by grades regardless of achievement, the avera e intelligence quotient for grade four is 111.2; for grade five, 112.3; and for grade six 109.4 . The average I.Q. for the entire group regardless of grade is 110.97 . In regrouping the same sample according to achievement regardless of grade, the average intelligence quotient for the overachievers is 103.6; for the average achievers, 112.3; and for the underachievers, 117.2.

In this sample the individual overachievers function on an average of ten months above their individual mental ages; the average perform a little above, at, or below one month from their individual mental ages; and the underachievers show a discrepancy of little over nine months between their individual mental age and individual performance at the time of this study. Chronologically there is a difference of twelve months between grade four subjects, grade five and also grade six subjects.

3. The Statistical Method.

The procedure chosen for checking the hypothesis concerning the influence of several variables on a dependent variable in this sample, was the method of analysis of variance. The purpose was to design the experimental setup so as to make one set of data serve for testing the hypothesis regarding the separate influence of sex, grade and achievement on the use of primary mental abilities.

Table I.-Statistical Data Descriptive of the Sample (N:648).

Group	Gr[a]	n	Sex[b]	IQ	MA[c]	CA[d]	MAGP[e]	ABGP[f]	Diff[g]
Overachievers:									
	4	36	B	101.7	114.0	112.5	4.24	5.29	1.03
		36	G	105.9	121.0	111.6	4.82	5.82	.99
	5	36	B	104.9	130.3	123.3	5.50	6.57	.87
		36	G	106.7	132.8	124.5	5.77	6.72	.95
	6	36	B	99.2	135.1	136.6	5.93	6.99	1.05
		36	G	102.1	138.8	135.9	6.19	7.36	1.15
		Average		103.6	128.7	124.1	5.41	6.46	1.01
Average Achievers:									
	4	36	B	114.0	127.4	112.2	5.32	5.29	.19
		36	G	112.8	125.9	111.8	5.20	5.17	.18
	5	36	B	112.5	139.6	124.2	6.32	6.31	.17
		36	G	115.3	142.5	123.6	6.56	6.56	.22
	6	36	B	109.4	149.8	136.8	7.15	7.08	.19
		36	G	109.9	150.2	136.7	7.14	7.14	.00
		Average		112.3	139.2	124.2	6.28	6.26	.18
Underachievers:									
	4	36	B	115.3	130.8	113.8	5.63	4.67	.96
		36	G	117.6	130.4	112.0	5.64	4.78	.88
	5	36	B	114.8	145.0	126.5	6.74	5.83	.91
		36	G	119.6	148.1	124.0	7.09	6.17	.91
	6	36	B	115.8	159.1	137.3	7.90	6.90	1.02
		36	G	120.0	163.8	136.3	8.25	7.44	.81
		Average		117.2	146.2	124.9	6.88	5.97	.92

a Grades 4, 5, 6; b B = Boys; G = Girls; c Mental Age (Average of group); d Chronological Age (Average of group); e Mental Age Grade-Placement; f Achievement Battery Grade-Placement; g Difference between MAGP and ABGP.

The computational formuli which were used for calculating the variances were based on Dayhaw's[5] model of analysis of variance involving three or more dimensions. They are as follows:

a. The sums of squares (SS):

1) For the dimensions of:

a) Sex: $SS_S = (\Sigma(T_S)^2)/n_S - T^2/N$

b) Grade: $SS_{Gr} = (\Sigma(T_{Gr})^2)/n_{Gr} - T^2/N$

c) Achievement: $SS_A = (\Sigma(T_A)^2)/n_A - T^2/N$

2) For double interactions of:

a) Sex and Grade:

$$S \times Gr = [(\Sigma(T_{S\ Gr})^2)/n_{S\ Gr} - T^2/N] - (SS_S + SS_{Gr})$$

b) Sex and Achievement:

$$S \times A = [(\Sigma(T_{S\ A})^2)/n_{S\ A} - T^2/N] - (SS_S + SS_A)$$

c) Grade and Achievement:

$$Gr \times A = [(\Sigma(T_{Gr\ A})^2)/n_{Gr\ A} - T^2/N] - (SS_{Gr} + SS_A)$$

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5 Lawrence-T. Dayhaw, Ph.D., Manuel de Statistique, Editions de l'Université d'Ottawa, Canada, 1958, p. 450-466.

3) For triple interaction of Sex, Grade and Achievement:

$$S \times Gr \times A = [(\Sigma (T_{S\ Gr\ A})^2)/n_{S\ Gr\ A} - T^2/N]$$

$$- (SS_S + SS_{Gr} + SS_A + SS_{S \times Gr} + SS_{S \times A} + SS_{Gr \times A})$$

4) For all individual scores:

$$SS_{Total} = \Sigma X^2 - T^2/N$$

5) For variance within cells:

$$SS_{Within} = SS_{Total} - (SS_S + SS_{Gr} + SS_A + SS_{S \times Gr} + SS_{S \times A}$$

$$+ SS_{Gr \times A} + SS_{S \times Gr \times A})$$

b. The estimated variance of 'within' cells (630 df) was used as the error term for the F test.

c. $$t = \frac{\text{Difference}}{\text{Standard Error of Difference}}$$

The application of the above formuli was made separately for each factor and each subtest namely for:

1) Verbal meaning: word meaning and picture meaning.

2) Spatial Relations.

3) Reasoning: figure grouping and word grouping.

4) Perceptual Speed.

5) Number Facility: number sense and addition.

CHAPTER III

PRESENTATION OF RESULTS

The primary purpose of the present study was to determine whether a discrepancy exists in the performance of boys and girls with respect to the specific mental abilities as measured by the PMA Primary Mental Abilities tests. This was accomplished by investigating the relation of the PMA factors to the variables of sex, grade, and level of achievement, as possible sources of significant differences in performance.

This chapter attempts to give an empirical picture of statistical results of the study by presenting:

1) A resume of the problem;

2) The statistically significant F tests, resulting in differences within the dimensions of sex, grade, and level of achievement;

3) The 't' tests determining which groups are responsible for the statistically significant F results obtained for the variables of sex, grade, and level of achievement; and

4) The 't' tests ascertaining which subgroups may have affected the significance in the group 't' tests.

1. Resume of the Problem.

The sample used for this study consisted of 324 boys and 324 girls within an intelligence quotient range of 80-129,

and drawn from grades four, five and six. They were divided into overachievers, average achievers and underachievers on the basis of the criterion obtained from the administration of the California tests of Intelligence and achievement. The students in the sample were then subjected to the PMA Primary Mental Abilities tests. These yielded separate scores for five primary mental abilities and their six subtests. The raw scores of these tests were subjected in turn to an analysis of variance, the results of which are presented in this chapter.

To test the hypothesis that the primary mental factors do not differentiate between boys and girls classified according to three levels of achievement in grades four, five and six, the following analyses were made for the variance in each factor separately:

a. According to sex: to establish whether any significant difference exists between boys and girls in this sample for each factor;

b. According to grades: to establish for each ability

1) Whether any significant difference exists among boys and girls 'within' grade four, five and six;

2) Whether boys in grades four, five and six vary significantly in their performance;

3) Whether girls of grades four, five and six show any significant difference in their performance;

4) Whether any significant differences exist between the performance of boys and girls in grades four, five and six.

c. According to level of achievement: to establish

1) Whether the present functioning of each primary mental factor differs 'within' the overachieving, average achieving and underachieving groups:

2) Whether boys of different levels of achievement vary significantly in their performance;

3) Whether girls of different levels of achievement vary significantly in their performance;

4) Whether significant differences exist between boys and girls of varying levels of achievement.

The analysis was carried out for each factor separately, the preliminary calculations of which are to be found in Appendix 1 of this study. The presentation of the tests of significance follows:

2. *F* Tests for All Factors.

The *Fisher* test was repeated seven times for each primary mental ability. This involved a separate process for the estimate of variance of the principal effects of sex, grade and achievement on each primary mental ability; for the double interaction of these; and also for the possible triple interaction of the three variables. Since the preliminary calculations yielded two estimates of the universe for each factor,

the 'intra' and 'inter', they were compared for possible real differences or chance fluctuations. In the F tests which resulted in no significant difference, it was assumed that both estimates of the universe were equal within limits of chance fluctuations. These were not recorded in the table. The F tests which were found to be significant are presented in Table II. In each case the 'within' variance of the individual scores of the entire sample for each specific ability was used as the error term for that same ability. The F tests found to be significant are as follows:

a. For the variables of:

1) Sex: A significant difference was found for reasoning, word grouping and the perceptual speed factors at the .001 level of confidence and at the .01 level of confidence for spatial relations, figure grouping, and the number sense factors.

2) Grade: A significant difference at the .001 level of confidence was found for every factor.

3) Achievement: A significant difference resulted for the word meaning ability at the .05 level of confidence and for the spatial ability at the .001 level of confidence.

b. Double Interaction:

This appears to be significant in two instances. The word grouping factor shows a difference between means at the .05 level of confidence for the interaction of sex and grade;

Table II.--F Ratios for the Analysis of Variance of the Primary Mental Factors (N:648).

PMA Factor	Estimate of Variance[a]	Error Term	F Ratio	P
Verbal Meaning:				
Grade	9902.13	49.69	199.28	.001
SxGrxA	117.62	49.69	3.96	.01
Word Meaning				
Grade	2898.44	17.69	163.85	.001
Achievement	63.83	17.69	3.61	.05
Picture Meaning				
Grade	2078.25	13.69	151.81	.001
SxGrxA	33.89	13.69	2.48	.05
Spatial Relations:				
Sex	86.57	13.33	6.49	.01
Grade	514.77	13.33	38.62	.001
Achievement	219.94	13.33	16.50	.001
Reasoning:				
Sex	430.22	29.35	14.66	.001
Grade	1203.06	29.35	40.99	.001
Figure Grouping				
Sex	85.96	12.69	6.77	.01
Grade	261.90	12.69	20.64	.001
Word Grouping				
Sex	169.07	11.47	14.74	.001
Grade	376.00	11.47	32.78	.001
SxGr	34.22	11.47	2.98	.05
Perceptual Speed:				
Sex	404.54	31.85	12.70	.001
Grade	2372.50	31.85	74.49	.001
Number Facility:				
Grade	3548.32	25.79	137.58	.001
GrxA	63.26	25.79	2.45	.05
Number Sense				
Sex	62.35	8.66	7.20	.01
Grade	632.28	8.66	73.01	.001
Addition				
Grade	1177.81	11.08	106.30	.001

[a] Data compiled from the F series of tables found in Appendix 1.

and at the .05 level for the interaction of grade and achievement for the number facility factor.

c. Triple Interaction:

The interaction of sex, grade and achievement variables seems to be significant at the .01 level of confidence for the verbal meaning factor and at the .05 level for the picture meaning factor.

Even though these F tests appear to be significant, they are at best only generally indicative of real discrepancies. They fail to disclose, for example, which sex, which grade level, or which group of achievers is responsible for the significance of the F tests in each case.

3. 't' Tests for Groups.

Since an F test of significance points to a difference between the two estimates of the same universe for a specific ability, but fails to disclose wherein the difference lies, the 't' test was applied to find specifically which sex, which grade, or which achievement group affected the difference. This resulted in more specific information regarding group performance involving each primary mental ability.

a. 't' tests for the sex variable:

Only six of the eleven factors display significant differences as seen in Table III: the spatial relations factor at the .01 level of confidence in favor of the boys; reasoning at the .001 level with its subtests of figure grouping at .01

Table III.--Significant Differences Between the PMA Means for Boys (n=324) and Girls (n=324).

PMA Factor	Test Means		Difference in Means	P
	Boys	Girls		
Verbal Meaning	-	-	-	-
Word Meaning	-	-	-	-
Picture Meaning	-	-	-	-
Spatial Relations	13.55	12.82	.73	.01
Reasoning	34.68	36.31	1.63	.001
Figure Grouping	16.67	17.40	.73	.01
Word Grouping	17.89	18.91	1.02	.001
Perceptual Speed	17.47	19.05	1.58	.001
Number Facility	-	-	-	-
Number Sense	14.72	14.10	.62	.01
Addition	-	-	-	-

and the word grouping at the .001 level, all pointing to a higher mean for the girls; the perceptual speed at .001 level of confidence also in favor of the girls; and finally, the number sense factor at .01 level of confidence with the boys surpassing the girls. These figures indicate differences only in a general manner.

b. 't' tests for the grade variable:

A breakdown of the group was made for grade level. Table IV presents the results of applying the standard errors of differences (See Appendix 1, Table XXIII) to the differences in means for the grades (See Appendix 1, Table XXII). As can be expected because of maturation and experience, these differences between the means for the grades are significant at the .001 level of probability for all factors, except for the spatial relations factor for which the means of grades four and five differ at the .01 level of confidence. No significant difference was found for figure grouping between the means of the fourth and fifth grades.

c. The achievement variable:

The variability between the means for the three groups differing in the level of achievement is also presented in Table IV. The results display only four apparent significant differences. Calculation shows that in the word meaning factor a discrepancy exists at the .01 level of confidence between the means of the overachievers and underachievers. The

Table IV.--Differences in PMA Factor Means[a] by Grade Level[b] and Achievement Level[c] (n=216).

PMA Factor	Grade Level		Achievement Level	
	4 vs 5	5 vs 6		
Verbal Meaning	7.61	5.89	-	-
Word Meaning	4.46	2.81	Over. vs Under.	1.09[d]
Picture Meaning	3.11	3.09	-	-
Spatial Relations	1.04[d]	2.00	Over. vs Average Over. vs Under. Average vs Under.	.80[e] 2.08[f] 1.28[f]
Reasoning	2.22	2.49	-	-
Figure Grouping	-	1.50	-	-
Word Grouping	1.50	1.13	-	-
Perceptual Speed	2.37	4.17	-	-
Number Facility	3.58	4.51	-	-
Number Sense	1.55	1.87	-	-
Addition	2.00	2.67	-	-

a Comparisons based on means presented in Table XXII for grades 4,5,6 and achievement levels (See Appendix 1).

b All differences significant at .001 level unless otherwise indicated.

c Differences significant at indicated levels.

d Significant at the .01 level of probability.

e Significant at the .05 level of probability.

f Significant at the .001 level of probability.

means for the spatial relations factor seem to be different between: the overachievers and the average achievers at the .05 level of probability; between the over and underachievers at the .001 level of confidence in favor of the underachievers; and between the average and underachievers at the .001 level.

4. Subgroup 't' Tests.

To find out which subgroup may have affected the significant differences presented in Table III and IV, a further analysis was carried out in the following manner:

a. Subtests for Grade Level:
   1) Within each grade (See Table V).
   2) Between the three grades:
      a) For boys (See Table VI).
      b) For girls (See Table VI).
      c) For boys and girls (See Table VII).

b. Subtests for Achievement Level:
   1) Within each achievement level (See Table VIII).
   2) Between the three achievement levels:
      a) For boys (See Table IX).
      b) For girls (See Table IX).
      c) For boys and girls (See Table X).

An explanation follows.

a. Subtests for Grade Level:

1) Within each grade:

A more specific picture of the real differences between the sexes within grades is presented in Table V. Although the means for the boys and girls vary for each grade, it was found that not all of these are significant. Verbal meaning with its subtests of word meaning and picture meaning fail to display any real difference as does the number facility factor. In spatial relations, although the means for the boys in each grade exceed those for the girls, only one significant difference at the .05 level of confidence was found between the fifth grade boys and fifth grade girls. The means for the reasoning ability point to the girls surpassing the boys in the fifth grade at the .001 level and in the sixth grade at the .02 level of confidence. The subtests for this factor, namely, figure grouping and word grouping, confirm this difference at the .02 level between the fifth grade boys and the fifth grade girls in figure grouping, at the .001 level in word grouping between the fifth grade boys and the fifth grade girls, and at the .05 level of confidence between the sixth grade boys and the sixth grade girls. The perceptual speed factor shows the fourth grade boys and the fourth grade girls differing at the .02 level and the fifth grade boys and girls varying at the .05 level of probability. Here again, the girls received the higher scores. The number sense of the fourth grade boys

Table V.—Sex Differences[a] in PMA Factor Means[b] Within Grade Level[c] (n=198).

PMA Factor	Grade Level 4	5	6
Verbal Meaning	.54	.69	.05
Word Meaning	.41	.72	.42
Picture Meaning	.88	.00	.36
Spatial Relations	.69	1.11 (.05)	.39
Reasoning	.49	2.67 (.001)	1.73 (.02)
Figure Grouping	.57	1.12 (.02)	.79
Word Grouping	.28	1.86 (.001)	.93 (.05)
Perceptual Speed	1.91 (.02)	1.53 (.05)	1.45
Number Facility	.10	.10	.50
Number Sense	1.14 (.01)	.30	.42
Addition	.94 (.05)	.41	.13

a Various levels of significance listed in Table XXVI, (See Appendix 1).

b Comparisons based on Means presented in Table XXIV, (See Appendix 1).

c Differences not significant unless level is indicated.

differs with that of the fourth grade girls at the .01 level of probability while the addition factor shows a significant difference at the .05 level between the fourth grade boys and girls.

2) Between the three grades:

The variability of boys and girls 'between' grade levels was greater for all the factors than it was 'within' grades. The significant differences for boys and girls are presented separately in Table VI.

a) For Boys:

In grades four, five and six, the boys differed among themselves at the .001 level of probability for all the PMA factors except for the following: in spatial relations the fourth and fifth grade boys differed at the .02 level; in number sense the significant difference was reached at the .01 level of confidence for the same groups; the reasoning factor and its subtests of figure grouping and word grouping displayed no real difference between the means of the fourth and fifth grade boys.

b) For Girls:

The variability within the female sex showed marked significant differences between grades as did the boys in all but six comparisons of the PMA factors. Inspection of Table VI reveals a significant difference at the .001 level of probability between the girls for all factors except the following: no significant difference in spatial relations between the

Table VI.--Differences in PMA Factor Means[a] for Boys and Girls Separately by Grade Level (n=108).

PMA Factor	Boys		Girls	
	Grade 4 vs 5	Grade 5 vs 6	Grade 4 vs 5	Grade 5 vs 6
Verbal Meaning	6.99	6.22	8.22	5.58
Word Meaning	4.30	2.96	4.61	2.66
Picture Meaning	2.67	3.27	3.55	2.91
Spatial Relations	1.25(.02)	1.64	.83[b]	2.36
Reasoning	1.14[b]	2.96	3.32	2.02(.01)
Figure Grouping	.31[b]	1.67	1.06(.05)	1.34(.01)
Word Grouping	.71[b]	1.59	2.29	.66[b]
Perceptual Speed	2.63	4.22	2.25(.01)	4.14
Number Facility	3.49	4.81	3.69	4.21
Number Sense	1.13(.01)	1.93	1.97	1.81
Addition	2.24	2.95	1.71	2.41

a All significant at the .001 level of confidence unless otherwise indicated. Comparisons based on means presented in Table XXIV, (See Appendix 1).

b No significant difference found.

fourth and fifth grade girls; none between the fifth and sixth grade girls for the word grouping factor; at the .01 level of probability in reasoning between the means for the fifth and sixth grade girls, also for the figure grouping factor; at the .05 level of confidence for the fourth and fifth grade girls for the figure grouping factor; and in perceptual speed, a difference at the .01 level was found for the difference in means of the fourth and fifth grade girls.

c) For boys and girls:

Inspection of Table VII shows that in comparing the means of boys and girls in three grades, a significant difference at the .001 level of confidence was found for almost all factors. The exceptions were as follows: in spatial relations a difference at the level of .02 appeared between the fifth grade boys and sixth grade girls; at the .01 level between the fourth grade boys and fifth grade girls for figure grouping; and at the .05 level of confidence for the number sense factor between the fourth grade boys and fifth grade girls. Also, no real difference was found between the means for the fourth grade boys and fifth grade girls for the spatial relations and the addition factors; between the fourth grade girls and fifth grade boys, and also the fifth grade girls and sixth grade boys for reasoning and its subtests; and no significant difference for the fourth grade girls and the fifth grade boys for the perceptual speed factor.

Table VII.--Differences in the PMA Factor Means[a] of Boys (n:108) and Girls (n:108) by Grade Level.

PMA Factor	Boys in Grade	vs Girls in Grade 4	Girls in Grade 5	Girls in Grade 6
Verbal Meaning	4	-	7.68	13.26
	5	7.53	-	6.27
	6	13.75	5.53	-
Word Meaning	4	-	5.02	7.68
	5	3.89	-	3.38
	6	6.85	2.24	-
Picture Meaning	4	-	2.67	5.58
	5	3.55	-	2.91
	6	6.82	3.27	-
Spatial Relations	4	-	.14[b]	2.49
	5	1.94	-	1.24(.02)
	6	3.58	2.75	-
Reasoning	4	-	3.81	5.83
	5	.65[b]	-	4.69
	6	3.61	.29[b]	-
Figure Grouping	4	-	1.43(.01)	2.77
	5	.06[b]	-	2.46
	6	1.61	.55[b]	-
Word Grouping	4	-	2.57	3.23
	5	.43[b]	-	2.52
	6	2.02	.29[b]	-
Perceptual Speed	4	-	4.16	8.30
	5	.72[b]	-	5.67
	6	4.94	2.69	-
Number Facility	4	-	3.59	7.80
	5	3.59	-	4.31
	6	8.40	4.71	-
Number Sense	4	-	.83(.05)	2.64
	5	2.27	-	1.51
	6	4.20	2.23	-
Addition	4	-	.83[b]	2.64
	5	2.27	-	1.51
	6	4.20	2.23	-

a All differences significant at .001 level of confidence unless otherwise indicated. Comparisons based on means listed in Table XXIV (See Appendix 1).

b No significant difference found.

b. Subtests for Achievement Level:

1) Within Achievement Level:

Table VIII presents a summary of significant differences between the means for boys and girls within the three achievement groups, that is, the overachievers, average achievers, and underachievers. These are not as numerous as for the grade variable. Only eight discrepancies have been found for the eleven factors.

An apparent difference at the .01 level is seen between the means of boys and girls within the underachieving group for the spatial relations ability. The reasoning factor shows a difference within groups at the .01 level of probability between the means for the overachieving girls and boys, and at the .02 level between the means of the underachieving boys and girls. In word grouping, a difference exists within groups at the .01 level between the means for boys and girls in the overachieving group and in the underachieving group. The means for the perceptual speed factor show two discrepancies. Differing at the .05 level of probability are the means for the overachieving boys and girls, and at the .01 level between the average achieving boys and girls. Finally, the number sense factor seems to point to one difference between the means within the overachieving group at the .01 level of probability.

Table VIII.--Sex Differences in PMA Factor Means[a] Within Achievement Level[b] (n=108).

PMA Factor	Achievement Level		
	Over-achievers:	Average-achievers:	Under-achievers
Verbal Meaning	.56	.79	.44
Word Meaning	.75	.16	.96
Picture Meaning	.17	.54	.52
Spatial Relations	.19	.72	1.27(.01)
Reasoning	1.94(.01)	1.21	1.73(.02)
Figure Grouping	.87	.83	.47
Word Grouping	1.26(.01)	.58	1.23(.01)
Perceptual Speed	1.61(.05)	1.99(.01)	1.14
Number Facility	.09	.22	.61
Number Sense	1.18(.01)	.53	.15
Addition	.39	.07	.76

a Various levels of significance listed in Table XXVI, (See Appendix 1). Comparisons based on means presented in Table XXV, (See Appendix 1).

b Not significant unless otherwise indicated.

2) Between the Three Achievement Levels.

a) For Boys.

The variability for boys between the three achievement levels are found in Table IX. Only five significant differences have been found. In the word meaning factor, the mean for the overachieving boys differs from that of the underachieving boys at the .05 level of confidence with the latter having the smaller mean. These two groups also differed in the spatial relations factor at the .001 level of probability. The average achieving boys and the underachieving boys differed at the .05 level of confidence for the word meaning factor and at the .01 level of confidence in the spatial relations factor. The overachieving boys and the average achieving boys differed in the spatial relations factor at the .05 level of probability.

b) For Girls.

Table IX shows only two cases in which the girls differ. This occurs in the spatial relations variable where the overachievers vary with the underachievers at the .01 level of confidence, while the average achievers differ in their mean with that of the underachievers at the .05 level of probability.

c) For Boys and Girls.

Table X displays greater variability which exists in this sample between the sexes in the three levels of achievement than within each sex separately. In the word meaning factor, the overachieving girls differ in their use of this

Table IX.—Differences in PMA Factor Means for Boys and Girls[a] Separately by Level of Achievement[b] (n=108).

PMA Factor	Sex[c]	Achievement Level	Difference in Means	P
Verbal Meaning			-	-
Word Meaning	B	Over. vs Under.	1.19	.05
	B	Average vs Under.	1.16	.05
Picture Meaning			-	-
Spatial Relations	B	Over. vs Under.	2.53	.001
	B	Average vs Under.	1.56	.01
	B	Over. vs Average	.97	.05
	G	Over. vs Under.	1.45	.01
	G	Average vs Under.	1.01	.05
Reasoning			-	-
Figure Grouping			-	-
Word Grouping			-	-
Perceptual Speed			-	-
Number Facility			-	-
Number Sense			-	-
Addition			-	-

a Comparisons based on means listed in Table XXV, (See Appendix 1).

b Various levels of significance listed in Table XXVI, (See Appendix 1).

c B=Boys; G=Girls.

Table X.--Differences in PMA Factor Means[a] of Boys[b] and Girls[b] Between Levels of Achievement[c] (n=108).

PMA Factor	Groups Compared	Difference in Means	F
Verbal Meaning		-	-
Word Meaning	Under. B vs Over. G	1.94	.001
Picture Meaning		-	-
Spatial Relations	Over. B vs Under. G	1.26	.02
	Average B vs Over. G	1.20	.02
	Under. B vs Over. G	2.72	.001
	Under. B vs Average G	2.28	.001
Reasoning	Over. B vs Average G	1.44	.05
	Over. B vs Under. G	2.17	.01
	Average B vs Over. G	1.71	.02
	Average B vs Under. G	1.94	.01
	Under. B vs Over. G	1.50	.05
Figure Grouping	Over. B vs Average G	1.02	.05
	Over. B vs Under. G	1.13	.02
Word Grouping	Over. B vs Under. G	1.21	.01
	Average B vs Over. G	1.26	.01
	Average B vs Under. G	1.21	.01
	Under. B vs Over. G	1.28	.01
Perceptual Speed	Over. B vs Average G	2.64	.001
	Under. B vs Average G	2.49	.001
Number Facility		-	-
Number Sense	Over. B vs Average G	.92	.05
	Average B vs Over. G	.79	.05
	Under. B vs Over. G	.88	.05
Addition		-	-

a Comparisons based on means listed in Table XXV, (See Appendix 1).

b B=Boys; G=Girls.

c Various levels of significance listed in Table XXVI, (See Appendix 1).

ability with the underachieving boys at the .001 level of confidence. Four real differences with the boys having the larger mean in each case, are also evident between the groups for spatial ability: at the .02 level for the underachieving girls and overachieving boys; at the .02 level of probability between the means for the average achieving boys and the overachieving girls; at the .001 level for the underachieving boys and overachieving girls; and also at the .001 level for the underachieving boys and average girls.

The reasoning factor also seems to differentiate between the boys and girls in favor of the latter. The means differ at the .05 level of confidence between the overachieving boys and average girls; at the .01 level for the overachieving boys and underachieving girls; at the .02 level for the overachieving girls and average boys; at the .01 level for the average boys and underachieving girls; and at the .05 level between the overachieving girls and underachieving boys. The subtests for the reasoning factor display similar significant differences. In the figure grouping ability, the means for the average girls and the overachieving boys differ at the .05 level and for the underachieving girls and overachieving boys at the .02 level of probability. In word grouping all the following discrepancies were found between the means at the .01 level of probability: between the underachieving girls and overachieving boys; between the overachieving girls and average boys; between the

underachieving girls and average boys; and lastly between the overachieving girls and underachieving boys. Again, the means for the girls exceeded the means of the boys for this ability.

The performance on the perceptual speed factor showed variability between the average girls and the overachieving boys at the .001 level; and between the average girls and underachieving boys at the .001 level of probability. The girls seemed to take precedence in this ability both within and between groups.

The following differences were also evident for the number sense ability at the .05 level of probability; between the overachieving boys and average girls; between the average boys and overachieving girls; and between the underachieving boys and overachieving girls. The means for the boys in each case were greater than the means of the girls.

Thus from the results of the analysis of variance of the scores used in this s tudy, it would seem that there is some possibility of a real difference in the use of mental abilities by students within various levels of achievement and between sexes. Especially is this true of the reasoning, spatial relations, and the perceptual speed factors.

In the light of these findings, a general pattern of superior performance based on significant differences seems to evolve for sex, grade and achievement levels.

Regarding sex, the performance of the boys is superior to that of the girls in spatial relations and in number sense abilities. The performance of the girls as compared to the boys is better for reasoning, figure grouping, word grouping, and perceptual speed.

The pattern for the grade variable points to the results of the fifth grade boys as superior to the fifth grade girls in spatial relations; the fifth and sixth grade girls as performing better than the fifth and sixth grade boys in reasoning and in perceptual speed; and the fourth grade boys as exceeding that of the girls in the fourth grade in number sense. This is the pattern for the 'within' grade dimension but due to maturation and learning, the 'between' grade pattern shows a consistent increase in superior performance from the fourth to the sixth grades.

The possible pattern resulting from the analysis of the relation of the FMA factor means and the variable of achievement repeats some of the trends for the other two variables of sex and grade level. The results reveal the spatial ability to be superior in the boys, especially the underachieving boys whose scores exceeded those of all the other groups. The underachieving girls performed better in spatial ability than did the other girls, that is, the overachieving and average girls. The superior performance in reasoning ability is outstanding in this sample of girls especially where the overachievers and

underachievers are involved. While the boys seem to be equal in figure grouping, due perhaps to their superior spatial ability, they are superceded by the girls in the word grouping subtest of the reasoning factor. It could be that the word fluency attributed to the female sex is responsible in raising the scores for the girls.

The perceptual speed ability seems to be outstanding for the average achieving girls.

The boys show superior performance in number sense at the .01 level of probability within the overachieving group.

In this sample boys did not perform better in number sense than the underachieving girls but they were superior to the overachieving and average achieving girls at the .05 level of probability.

Thus through the method of analysis of variance it appears that there may be a definite discrepancy in boys and girls with respect to the use of primary mental abilities in relation to the sex, grade, and achievement level.

CHAPTER IV

DISCUSSION OF RESULTS

This investigation was concerned with the possibility of identifying differences in the primary mental abilities of students of various grades and levels of achievement in the ordinary classroom. Upon the administration of an intelligence and an achievement test, a sample of six hundred forty-eight students was chosen from the fourth, fifth, and sixth grades of five schools. The criterion for categorizing these pupils was obtained by finding the discrepancy for each child between his mental-age grade-placement and his achievement battery grade-placement. One third of the sample was found to be functioning nine months or more above the individual mental-age grade-placement, another third of the sample was performing two months above, at or below the individual mental-age grade-placement, and the final third of the sample was underachieving nine months or more below the individual mental-age grade-placement.

A test on the primary mental abilities was administered for the purpose of identifying any real differences in the specific abilities of these groups. The method of analysis of variance was used, the results of which will be discussed in light of the tests of significance for the variables of sex, grade, and achievement level, and the interaction of these.

1. The Sex Variable.

Through the analysis of variance significant differences for the sexes (See Table II) were found:

a. At the .001 level of confidence for reasoning, word grouping, and perceptual speed factors;

b. At the .01 level of confidence for spatial relations, figure grouping, and number sense abilities.

These results of the F tests indicate that significant differences exist between the two estimates of the same universe (the estimate resulting from group scores and that resulting from the individual scores) for each factor, but fail to indicate specifically where they are to be found.

To ascertain in which sex the difference lies, the 't' test was employed. The quantity 't' is the ratio of the obtained difference between the measures of two groups to the standard error of the difference and as related to the degrees of freedom resulting from the sizes of samples being compared. It is interpreted in terms of .001, .01, .02, and .05 levels of probability. An obtained 't' value equal to or greater than the critical value of 't' at any of these levels indicates that the obtained difference represents a real difference and cannot be attributed to chance fluctuations alone. Any 't' value below the .05 level of confidence is not considered statistically significant throughout this study.

Application of the 't' test (See Table III) to the means of three hundred twenty-four boys and the means of three hundred twenty-four girls regardless of grade and achievement level, revealed that the significant differences found at the .001 level of confidence in the factors of reasoning, word grouping and perceptual speed were due to the superior performance of the girls whose means were higher for each factor. The difference in figure grouping at the .01 level of probability was also caused by the more efficient performance of the girls in this factor in contrast to the performance of the boys. The other two significant differences at the .01 level of confidence in the spatial relations and number sense abilities were attributed to the superior performance by the boys.

These results are in agreement with the findings of Schiller[1] who found no reliable sex differences in the verbal factor but a significant difference in the arithmetic reasoning and spatial relations abilities of the boys. They are also in accord with the investigations of Kuhn[2] and of Havighurst and Breese[3] though the latter found the girls, not the boys, excelling in numbers. Burrell's[4] study resulting in no sex

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1 Schiller, Op. Cit., 69 p.

2 Kuhn, Op. Cit., vi-58 p.

3 Havighurst and Breese, Op. Cit., p. 241-247.

4 Burrell, Op. Cit., p. 68-73.

differences for the fifth grade is not upheld in this study (See Table V).

There is empirical evidence that even the school-age child has acquired the concepts male and female and although competence in intellectual and academic tasks is not as clearly a sex-typed trait as for example aggression or dependency, there appears to be some consistency in sex role identification and intellectual achievement. Problems requiring analysis and reasoning, primarily those involving spatial and mechanical reasoning, science and mathematics, are regarded as more appropriate for boys than for girls while the latter excel in linguistic achievements. The typical female regards the ability to solve problems involving geometry, logic, or arithmetic as a masculine skill and the question arises as to whether her unusual excellence on such tasks would be equated with a loss of femininity. Even developmentally, studies support the fact that preschool boys ask many more "how" and "why" questions than girls and that they have a tendency to analyze a situation rather than seek help or adopt a trial-and-error solution. Kagan[5] contends that the reason for the gradually increasing academic superiority of boys in adolescence is that there is a

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5 Jerome Kagan, "Acquisition and Significance of Sex Typing and Sex Role Identity", as quoted by Martin L. Hoffman and Lois W. Hoffman, Editors, in Review of Child Development Research, Russell Sage Foundation, New York, Vol. I, 1964, p. 137-167.

change in the perception of school and academic work. From the beginning to the fourth grade the average boy perceives the school as feminine since he is at this time striving to develop a masculine role identification. Thus, the preponderance of female teachers, their insistence on obedience and inhibition of aggressiveness and restlessness, plus the curriculum of reading, coloring and singing, all militate against his idea of achieving masculinity. Gradually an implicit association arises between subject matter and sex role standards. Academic success is linked to vocational preparation and as the boy's motivation grows, his academic achievement rises especially in the practical fields such as science, space relations and arithmetic.

2. The Grade Variable.

With reference to the grade variable and regardless of specific level of grade, achievement or sex, the F tests (See Table II) applied to the means of the two estimates of the entire group of six hundred forty-eight boys and girls reveal a significant difference at the .001 level of probability for every PMA factor. The greatest amount of change through these three grades was evidenced in word fluency with its F test value at 199.28 as compared to the critical value of 6.91 which is required for a difference at the .001 level of probability. Number facility (F 137.58) and perceptual speed

(F 74.49) were next in order of magnitude of change while reasoning (F 40.99) and spatial relations (F 38.62) exhibited the least amount of change. These findings are in accord with those of Clark[6] who found a statistical significant increase with age in the mean scores of all factors. However, he found the increase in reasoning greater than in the number factor, which is not true in this study.

More specific results (See Table IV) were derived from the application of the 't' test to the means of the specific grades regardless of sex and achievement. A significant difference at the .001 level of probability was found between most of the means of grades four, five, and six for every PMA factor. Thus the mean for grade four differed with the mean of grade five at the .001 level of probability for the verbal meaning factor. Likewise the mean for the fifth grade was significantly different from that of the sixth grade at the .001 level of confidence. With rise in grade, the mean increased. This trend was true of all the PMA factors except in two cases: In spatial relations the mean for the fifth grade differed with the mean of the fourth grade at the .01 level of confidence while the means for the figure grouping factor showed no significant difference for the fourth and fifth grades.

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6 Clark, On. Cit., 30 p.

Developmentally, this general trend is to be expected because of the gradual growth of concepts in depth and in number with an increase in age and in grade. Not only do maturation and experience account for this increase from grade to grade but it follows from the construction of tests where items increase in difficulty with a rise in age and grade level.

The 't' test which was applied separately to the means of boys and to the means of girls for the primary mental abilities presents a less consistent trend of parallel increase in mean score with increase in grade level. Three tables reveal differences in grades when the sex role in each grade is taken into consideration. Table V lists the mean score differences of boys and girls 'within' the same grade level. Table VI reveals the mean score differences in the same sex but at the various grade levels of four, five and six. Table VII presents the mean score differences between the boys and girls of grades four, five and six. All of these results are discussed separately for each factor.

a. Verbal Meaning:

This ability to understand ideas which are expressed in words is measured by two subtests, that of word meaning and that of picture meaning. Table V displays no significant differences for this ability of verbal meaning 'within' grade between sexes. Thus, no significant difference was found between the fourth grade boys and the fourth grade girls, nor between

the fifth grade boys and fifth grade girls. The same was true of the sixth grade.

Table VI reveals a developmental trend of parallel increase in mean score with increase in grade level. Thus:

1) The mean score of the boys in grade four was lower and differed at the .001 level of confidence with the mean of the boys in grade five. Also, the mean of the fifth grade boys was lower and differed with that of the sixth grade boys at the .001 level of confidence.

2) The mean score of the fourth grade girls was smaller than that of the fifth grade girls and significantly different at the .001 level. The same was true of the fifth grade girls whose mean was lower than and differed at the .001 level with the mean score of the sixth grade girls.

The figures of Table VII show that in verbal meaning and its subtests the fourth grade boys have a lower mean and vary significantly with the fifth and sixth grade girls at the .001 level of probability. Likewise, a discrepancy at the .001 level was reached between the fifth grade boys and the fourth and sixth grade girls; and between the sixth grade boys and the fourth and fifth grade girls. Again, this can be reasonably expected according to developmental differentiation of abilities.

These findings compare favorably with those of: Schiller[7] who found no reliable sex difference in the ability to handle verbal concepts; and with Balinsky[8] who found the verbal factor most consistent with increase in age. However, when the grade dimension is considered, these findings disagree with those of: Jones[9] who found the verbal ability at the age of nine (grade four) to be similar to that of age eleven (grade 6); and with Havighurst and Breese[10] whose results showed the girls to be superior in word fluency.

b. Spatial Relations:

The 'within' grade level (See Table V) revealed no significant difference in the spatial relations ability between the sexes in the fourth or sixth grades but the .05 level of confidence was evident between the girls and boys in the fifth grade with the better performance attributed to the boys.

A further breakdown in Table VI reveals that there were differences within the same sex at different grade levels. The boys in grade four differed in this ability at the .02 level of confidence with the fifth grade boys. The latter differed with the sixth grade boys at the .001 level of confidence.

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7 Schiller, Op. Cit., 69 p.

8 Balinsky, Op. Cit., p. 191-234.

9 Jones, Op. Cit., p. 299-331.

10 Havighurst and Breese, Op. Cit., p. 241-247.

There was no significant difference found between the girls in the fourth grade and the girls in the fifth grade but the significant difference at the .001 level of probability was reached between the means of the fifth grade girls and the sixth grade girls.

Table VII shows no significant difference in the spatial ability between the fourth grade boys and fifth grade girls, although the same fourth grade boys differed significantly with the sixth grade girls at the .001 level of probability, in favor of the latter. The fifth grade boys were superior to and differed with the fourth grade girls at the .001 level but they were less capable than the sixth grade girls who were better and differed at the .02 level of confidence. The sixth grade boys' superiority is clear for they differed significantly at the .001 level when compared to the fourth and fifth grade girls.

Thus in general, there is a corresponding increase in mean score with a rise in grade level even when the sexes are considered separately. However, there are some exceptions. Neither the fourth grade boys nor the fourth grade girls differ in their spatial ability with the fifth grade girls. A significant difference was found between the boys of the fifth grade and those of the fourth grade at the .02 level of confidence. 'Within' the fifth grade, the boys differed from the girls at the .05 level of confidence. Both differences can be attributed

to the superior performance of the fifth grade boys because of their higher mean. The sixth grade boys were superior to all boys and girls in the fourth, fifth and sixth grades. Throughout the thirteen comparisons made for the spatial ability within these three tables, even though only nine of them were statistically significant, the differences were all in favor of the boys, again bearing out the oft repeated fact in literature that boys are superior to girls in the spatial relations ability.

These results agree with those of Havighurst and Breese[11] who found boys in grades four to nine excelling in spatial tests. Clark[12] found that the space ability exhibited the least amount of change with increase in age. This was true of the present study also because the increase was less consistent than in the results for the verbal meaning ability.

The findings here are in contrast to those of Jones[13] who found the spatial factor at the age of nine similar to that of age eleven. In this study they were statistically different and significant. Schiller[14] found no spatial ability in girls in the fourth grade. In this study they performed as well as the boys in the fourth grade. Emm[15] using eighteen

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11 Havighurst and Breese, Op. Cit., p. 241-247.

12 Clark, Op. Cit., 30 p.

13 Jones, Op. Cit., p. 299-331.

14 Schiller, Op. Cit., 69 p.

15 Emm, Op. Cit., 58 p.

different tests found no spatial factor for the fifth grade girls. In this sample the girls in grade five performed as well as the fourth grade girls and boys in this ability but there is a statistically significant difference at the .05 level between the fifth grade boys and fifth grade girls in favor of the boys.

Developmentally, significant differences even within the same sex for the different grade levels can be expected. Although several theories concerning the development of space concepts are proposed, that of a stage-dependent process which is accepted by majority of educators seems to be supported in this study. The child is said to move through stages and substages. Thus he moves from the sensory-motor intelligence to preoperational thought, to concrete operation and into the period of formal operation. All these processes in the meantime involve transformation of concepts, substitutions and finally integrations. Thus, children at any given chronological age may function within different stages, and grade levels may be used as estimates of when certain kinds of functions may be expected. Developmentally a gradual increase in this ability results. That boys excel, may be a function of sex role identification and the seemingly innate desire to analyze.

c. Reasoning:

This ability is measured with two subtests, that of figure grouping and word grouping which involve the ability to

solve problems in the light of past experiences, to plan, and to foresee consequences. All higher learning demands this ability. The test items require the testee to be able to see differences in figures and in words.

The grade dimension plays a definite role with regard to the reasoning ability because of maturation and learning. However, the pattern is not consistent. The results of the 't' tests in Table V recount the 'within' grade differences which point to the superiority of girls over boys even though calculations show only five out of nine comparisons as statistically significant. In the total reasoning ability the following results were evident: no difference within the fourth grade; a significant difference at the .001 level of confidence within the fifth grade; and a difference at the .02 level within the sixth grade. For the subtest of figure grouping no difference was found within grades four and six but the .02 level of confidence was reached within the fifth grade. The comparison of mean scores within grades for the subtest of word grouping resulted in: no significant difference within the fourth grade; a difference at the .001 level of probability within the fifth grade; and at the .05 level within the sixth grade.

A further breakdown in the mean scores (See Table VI) shows the differences in reasoning within the same sex at the three grade levels. Regarding the boys: no statistically significant difference evolved between the mean scores of the

fourth grade boys and fifth grade boys for the total reasoning ability nor for the subtests of figure grouping and word grouping. However, the .001 level of confidence was reached by difference in the means of the fifth grade boys and the sixth grade boys. The trend for the girls was more consistent developmentally because each succeeding grade displayed better reasoning ability although not at the same level. The fifth grade girls were superior to the fourth grade girls in total reasoning and word grouping at the .001 level of confidence, but they were superior to them in figure grouping at only the .05 level of probability. The sixth grade girls excelled the fifth grade girls in total reasoning and figure grouping but the difference reached the statistical significance at the .01 level of probability. Even though the difference in word grouping was not significant between the fifth and sixth grade girls, the latter had the higher mean score.

In Table VII the 't' tests show a statistically significant difference at the .001 level of confidence in favor of the sixth grade girls over the fourth and fifth grade boys for the reasoning ability. The fifth grade girls differed at the .001 level of confidence with the fourth grade boys and were superior to them. The sixth grade boys were better and differed significantly at the .001 level of confidence with the fourth grade girls in reasoning but there was no significant difference between them and the fifth grade girls. The fourth

grade girls and fifth grade boys displayed equal reasoning ability.

Regarding the subtests of figure grouping and word grouping the picture remains the same essentially as in the total reasoning scores except that for the figure grouping factor the significant difference between the fourth grade boys and fifth grade girls reaches only the .01 level of probability instead of the .001 level.

Thus the results of all these mean score comparisons seem to emphasize the superiority of the girls in the reasoning ability not only when compared to the performance of the boys but also tend to show a consistent increase in the ability within the female sex with rise in grade level. Their scores in word grouping seem to account for the better performance in this study. Since girls are generally found to surpass boys in word fluency[16], this gave them the advantage over the boys. Havighurst and Breese[17] had similar results and found the girls to be superior in reasoning. Jones[18] however, found that the reasoning factor did not differ at ages nine and eleven. This is not in agreement with the present study, for consistent differences with higher mean scores were found for the girls

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16 Tyler, Op. Cit., p. 249.

17 Havighurst and Breese, Op. Cit., p. 241-247.

18 Jones, Op. Cit., p. 299-331.

with advancement in age level.

d. Perceptual Speed:

This factor requires the ability to recognize similarities and differences between objects or symbols quickly and accurately. Again, this ability to distinguish, for example, between b's and d's, m's and n's, p's and q's, is vital in learning to read, in speed reading, scanning a page and proof reading.

The developmental trend is quite consistent with the growth of this ability as age progresses. The 'within' grade differences for perceptual speed (See Table V) favor the girls with superior performance: in the fourth grade at the .02 level of confidence; in the fifth grade at the .05 level; and while in the sixth grade the difference is not statistically significant, it points to the superiority of the girls.

The same picture (See Table VI) unfolds when the means of the same sex are compared at different grade levels. The statistical difference shows a definite improvement in performance with progressive grade level for both boys and girls at the .001 level of confidence with only one exception at the .01 level between the fourth and fifth grade girls.

In all comparisons but one (See Table VII), the means rise with increase in grade level and are significantly different at the .001 level of probability. The one exception is the difference between the means of the fifth grade boys and the

fourth grade girls. Although the difference is not statistically significant it is in favor of the fifth grade boys. Again all this evidence supports the fact that this ability increases between the age and grade levels represented in this study.

e. Number Facility:

The last factor measured was that of number facility which is a composite of two subtests: one testing the ability to carry out several basic but simple arithmetical processes, and the other measuring the ability to add. These were independent of reasoning because they involved simply the fundamental mathematical processes.

The 'within' grade (See Table V) trend, as a result of 't' tests shows no significant differences in the performance of boys and girls within any grade for the total number ability. However, in the subtest of number sense, the fourth grade boys differed significantly with the fourth grade girls at the .01 level of confidence with superior performance attributed to boys, while in the addition subtest the fourth grade boys again differed significantly with the fourth grade girls at the .05 level but in the latter's favor. The other differences though not statistically significant tend to point to superior performance by the boys.

Table VI shows an increase in the ability within the same sex with rise in grade level both for boys and girls at the .001 level of confidence in each comparison except between the

fourth and fifth grade boys in number sense, which reached the .01 level of probability.

The grade and sex dimensions as analyzed (See Table VII) for this ability further support the fact that numerical ability increases with progress in grade level. The variability at the .001 level of confidence between the grades was consistent with the exception of the fourth grade boys differing with the fifth grade girls at the .05 level of probability in number sense and not showing any significant difference in addition.

The findings are in accord: with Schiller[19] who found a reliable difference in favor of the boys in grade three and four in arithmetic reasoning; with Clark[20] whose results showed a statistically significant increase with age in the mean scores for numerical ability; and partly with Havighurst and Breese[21] who found girls superior in numbers, whereas in this study they excelled only the boys in the fourth grade in addition. The boys in turn showed superiority in number sense by a more realistic statistical difference. Emm[22] also found that girls seem to be able to carry out fundamental processes in arithmetic but boys are superior in solving problems.

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19 Schiller, Op. Cit., 69 p.

20 Clark, Op. Cit., 30 p.

21 Havighurst and Breese, Op. Cit., 241-247.

22 Emm, Op. Cit., 58 p.

3. The Achievement Variable.

The over-all F test (See Table II) for the achievement dimension regardless of level of achievement, grade and sex resulted in significant differences between the two estimates of the sample for two factors only: the word meaning ability and the spatial ability. The means for the word meaning subtest differed at the .05 level with the critical value being 2.90 and the resultant F value at 3.61 . While this indicates a real difference, it does not specify which level of achievement and grade was different. In the spatial relations factor the difference reached the .001 level of probability with the critical value at 6.91 and the resultant F test at 16.50 .

To find which specific achievement group regardless of grade or sex, reflected these differences the 't' test was applied to the means of the three achievement groups, the results of which are listed in Table IV. The overachievers differed with the underachievers in the word meaning factor at the .01 level of probability. Reference to Table XXII (See Appendix 1) shows the overachievers as possessing the higher mean. The breakdown for the spatial relations factor shows the overachievers showing inferior performance and varying significantly from the average achievers at the .05 level of confidence and also from the underachievers at the .001 level of confidence. The underachievers scored much higher and differed significantly with the average achievers at the .001

level of probability.

A further breakdown of this information as to what role sex plays in these significant differences regarding achievement levels appears in Tables VIII, IX, and X. These are now discussed separately for each factor.

a. Verbal Meaning:

This factor includes the abilities of word meaning and picture meaning. While no significant differences were found 'within' each achievement group (See Table VIII), a further comparison of mean scores within the same sex (See Table IX) shows the underachieving boys exhibiting inferior performance and varying with the average achieving and overachieving boys at the .05 level of probability.

Table X presents a significant difference for the word meaning subtest, in which the overachieving girls scored higher than the underachieving boys and at the .001 level of confidence. Although this is not surprising if the general finding is accepted that girls excel boys in verbal achievement, here another factor is worthy of note. These overachieving girls with an average I.Q. of 103.6 had a higher mean score in verbal meaning and differed at the .001 level of confidence with the underachieving boys whose average I.Q. was 117.2 . From Table IX, it was seen that these underachieving boys were also inferior to the boys of the average and overachieving groups whose I.Q.s were lower. Perhaps the increase of

parental and social pressure, as Barker[23] contends, causes the average student to aspire beyond his capacity in order to be accepted, and while success in the earlier stages is within reach, as learning becomes complex, the student experiences fewer successes and more failures. Thus through extra effort the overachieving girls and boys may have mastered the simpler basic linguistic concepts which later as they increase in difficulty, they find unable to master as efficiently. Yet, higher education is very dependent on this ability of understanding ideas expressed in word forms including similarities, differences and definitions. Thus the possibility of misclassifying the nonverbal student as inferior is unjust if he possesses a high degree of other mental abilities. Certainly further research regarding the lack of verbal ability in underachieving boys of better than average intelligence quotients is necessary. McCarthy[24] contends that even though the developmental differences in linguistic skills between the sexes are small, about six months, they seem to have a cumulative and important effect on later acquisition of more complex forms of language. A suggestion is made that the introduction of male

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23 Roger G. Barker, "Success and Failure in the Classroom", in Morris Haimowitz and Natalie Haimowitz, editors, Human Development, Thomas Y. Crowell Co., New York, 1960, p. 543-547.

24 Dorothea A. McCarthy, "Some Possible Explanations of Sex Differences in Language Development and Disorders", in Journal of Psychology, Vol. 35, 1953, p. 155-160.

teachers into primary grades may help to solve the problem by creating a more masculine atmosphere and thus, in aiding sex role identification, the frequency of reading and linguistic problems would be reduced. Gradually, the associational link between sex roles and certain areas of knowledge would be modified.

b. Spatial Relations:

With reference to the achievement levels, one significant difference in the spatial factor was found 'within' achievement level (See Table VIII) and that was in the underachieving group where the boys displayed a better performance than did the girls at the .01 level of probability. The differences within the overachieving and average achieving groups were not significant but at both levels the boys possessed the higher mean scores.

Table IX lists figures which give evidence of the overachievers within each sex as having a weakness in this ability. Concerning the boys: the overachievers were excelled by the average achieving boys at the .05 level of confidence and by the underachieving boys at the .001 level of confidence. The underachieving boys showed a superiority over the average boys at the .01 level of probability. With regard to the girls: the overachieving girls were superceded in their performance by the underachieving girls at the .01 level and although the difference between the former and the average achieving girls

did not reach a significant level, it was in favor of the average girls. The underachieving girls also displayed a better performance in the spatial factor than did the average girls with a mean difference at the .05 level of probability.

The differences were significant (See Table X) between the sexes at various levels of achievement. Only in one instance were the girls superior to the boys, and this was the difference between the means of the underachieving girls and the overachieving boys which was significant at the .02 level of probability. The average boys were better than and differed from the overachieving girls at the .02 level of confidence. The underachieving boys differed significantly with the overachieving girls and average girls at the .001 level of confidence.

Thus the spatial ability was found to exist to a higher degree in the same underachieving boys who lacked the verbal meaning ability. They differed because of superior performance in this ability with the other groups of this sample at both the .001 and .01 levels of probability. The underachieving girls also excelled the performance of the average and overachieving girls but not to such a high level. Students with high intelligence quotients and underachieving with respect to their individual capacity in this study, have greater ability in spatial relations than do the average or overachieving groups. The performance of the boys on the whole is far

superior to that of the girls. Can it be assumed that high intelligence correlates with superior performance in spatial relations? What gives the male sex this superiority in spatial ability remains an unsolved problem. Generalizing, one may assume that perhaps the intelligence quotient correlates highly with the formation of space concepts, for in this study the underachievers with an average I.Q. of 117.2 show superior performance in spatial relations when compared to the average achievers with an average I.Q. of 112.3 and to overachievers whose average I.Q. is 103.6 . However, one must keep in mind that these underachievers were not failing by academic standards. Actually, the fourth graders were performing a little better than at the required fourth grade level norms; the fifth grade boys were functioning scholastically about four months above the average norms; the fifth grade girls were doing work at the sixth grade level; the sixth grade boys were functioning at the 6.9 level; while the sixth grade girls were succeeding academically at the 7.4 grade level. Keeping these facts in mind, may provide a cue which could be effective in stimulating achievers at various levels by activities in school and at home which are within the range of their ability and yet challenging enough to motivate them to a fuller development of their potentialities. The space relations factor requires the subject to see objects in various perspectives, to analyze component parts visually and to manipulate a form mentally in

order to recognize its appearance after it has been moved in various ways. Although many of the formal school subjects in the regular school curriculum do not depend directly on this factor, geography, science, art and handcraft certainly do. Success along these lines of creative thinking and creative expression is a continuing need for the preadolescent. Further investigation into space concept formation would be of great value in guiding teachers to a more effective organization of curricula as Sigel[25] suggests.

c. Reasoning:

The total reasoning score is a combination of the two subtests in figure grouping and word grouping abilities. Table VIII gives some evidence that the girls were responsible for the differences through better performance within each level even though only four out of nine differences were statistically significant. The overachieving girls possess a better ability in reasoning than do the overachieving boys at the .01 level of probability in the total reasoning factor and the word grouping factor. Also, the performance of the underachieving girls excelled that of the underachieving boys at the .02 level in total reasoning and at the .01 level of confidence in word grouping. Again, it is the word grouping

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25 Irving E. Sigel, "The Attainment of Concepts", as quoted by Martin L. Hoffman and Lois W. Hoffman, editors, in Review of Child Development Research, Russell Sage Foundation, New York, Vol. 1, 1964, p. 242.

factor which accounts for the differences between all the boys and the over and underachieving girls. This may be the result of a lack of motivation in the boys during the primary grades due to the developmental processes when success in motor abilities and the exploration of environment seems more enticing than learning to read.

No significant differences were found for the reasoning ability (See Table IX) when each sex was considered separately at various levels. However, even the small differences were due to the superior performance of the average and underachieving boys and girls.

The eleven comparisons between the levels of achievement in Table X show the girls to be superior in every case. The total reasoning factor shows: the average girls (at .05 level) and the underachieving girls (at .01 level of confidence) as surpassing the overachieving boys; the average boys as being surpassed by the overachieving girls at the .02 level of probability and by the underachieving girls at the .01 level of confidence; and the underachieving boys as differing from the overachieving girls at the .05 level of confidence. In figure grouping, the overachieving boys were surpassed by the average girls at the .05 level and by the underachieving girls at the .02 level of probability. In word grouping the significant differences found at the .01 level of confidence revealed: the overachieving boys excelled by the underachieving girls; the

average boys surpassed by the overachieving and underachieving girls; and the underachieving boys excelled by the performance of the overachieving girls. The question worth investigating would be: Would improvement in the verbal meaning factor lead to a better performance in the reasoning factor by the boys? As discussed previously, the girls surpassed the boys in verbal meaning which may account for their higher scores in reasoning.

d. Perceptual Speed:

In this ability, few discrepancies were found among the achievement groups. 'Within' achievement levels (See Table VIII) the mean score of the girls was higher and differed from that of the boys in the overachieving group at the .05 level of probability, and at the .01 level of confidence in the average achieving group.

No significant differences were found among the boys at the three levels nor among the girls (See Table IX), indicating that this perceptual speed factor exists to the same degree in each sex regardless of level of achievement.

In comparing boys and girls of various levels (See Table X) the average girls were superior to and differed from the overachieving boys and the underachieving boys at the .001 level of probability. Thus, these results bear out the contention in literature that girls are superior to boys in perceptual speed.

e. Number Facility:

This factor was quite consistent developmentally for the three levels of achievement. Only in the subtest of number sense did the results show significant differences. One real discrepancy was found (See Table VIII) 'within' the overachieving group between boys and girls at the .01 level of probability in favor of the performance of the boys.

No significant differences were found (See Table IX) within each sex at different levels of achievement, indicating that they possess the numerical ability in an equal measure regardless of their achievement level.

Table X gives evidence of boys excelling the girls in three comparisons in the subtest of number sense: the overachieving boys performing at a higher level than the average girls at the .05 level of confidence; and the average and underachieving boys both exceeding the means of the overachieving girls at the .05 level of confidence. Thus the sex difference usually found in numerical ability in favor of the boys is upheld in these results.

With reference to the achievement dimension, the above findings both agree and disagree with other investigations reported in research literature. Woodrow[26] found the bright and dull students showing greater variability than the average

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26 Woodrow, Op. Cit., p. 289-302.

when he compared trait variability in six intelligence subtests for children ranging in mental age from eight to sixteen years. The over-all picture of the findings of this study also gives evidence of this variability, for of the thirty-six significant differences found for the primary mental abilities only in one instance was it due to a discrepancy in the average group, and that was in the perceptual speed factor where the mean score of the girls differed from that of the mean score of the boys at the .01 level of confidence. Lopata's[27] study is in partial agreement with these results. The spatial factor does discriminate between the under and overachievers and in the former's favor, but the numerical factor which was found to be significantly different in that study was not found to differ with these groups. Here the verbal word meaning ability was different at the .01 level of probability between the over and underachievers in favor of the former.

The results of Kolstoe's investigation[28] are only in partial agreement with the findings of this study. He hypothesized no difference between the bright and dull children of mental ages of ten years in primary mental abilities. The PMA test with other tests he utilized, showed no difference between the two groups.

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27 Lopata, On. Cit., 73 p.

28 Kolstoe, On. Cit., p. 161-168.

Gray's[29] investigation of the achievement variability being greater among lower intellectual groups than the middle and higher groups is not borne out here because both the over and underachievers varied to about the same degree.

The great unevenness in scholastic proficiency among boys which Commins[30] found are not true of this study. His conclusions that subjects with intelligense quotients above the 105 are more uneven in their scholastic achievement than are the average or inferior children is not true of this study. Here the overachievers had an average I.Q. of 103.6 and showed variability in eighteen comparisons with the over and underachievers.

Supported by this study are also Wesman's[31] conclusions based on achievement results that boys are generally superior in arithmetic, science and history, and girls in reading, language and arts.

4. Interaction.

While the F test for the triple interaction of sex, grade and achievement was significant at the .01 level of probability for the verbal meaning ability, it reached the .05

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29 Gray, Op. Cit., p. 201-210.

30 Commins, Op. Cit., p. 557-561.

31 Wesman, Op. Cit., p. 223-229.

level for the picture meaning, a subtest of this factor. As was seen, the grade and sex variables played significant roles in the differences found between girls and boys as grade level increased. There was only one instance in which the underachieving boys differed significantly with average boys and overachievers as a whole. To determine whether the contribution of one variable in the combination exceeds chance expectations a statistical procedure[32] was used by which the influence of one variable was held constant by a statistical correction. This evaluation showed the grade variable to be more influential than the achievement variable. It resulted in an F test significant at .01 level of probability for both boys and girls (Boys, F 48.46; Girls, F 57.28). The achievement variable in this correction procedure resulted in no significant F tests.

In summary, this study seems to bear out the general findings in research that as far as tested abilities are concerned, there are some sex, grade and achievement level differences in the mean scores but that there is also some overlapping.

Much variability was found in the sex dimension which came through even in the grade and achievement variables. Boys tended to be higher in spatial relations and number sense.

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32 Dayhaw, Op. Cit., p. 465.

The girls averaged higher in verbal meaning, reasoning (where word grouping was concerned), and perceptual speed abilities.

The grade dimension points to the greatest variability in factors because of consistent real differences between grades four, five and six not only within the same sex and within these grades, but also between sexes and between grades. This may, no doubt, be attributed not only to maturation and learning experiences but also to sex role identification especially in the primary grades. Admittedly, many influential factors in addition to scholastic aptitudes are represented in the scores of students, such as, cooperativeness, persistence, and willingness to work. Yet, since studies have shown that with high school students the relationship between the primary mental abilities and high school achievement is high, the search for more effective early identification of mental abilities is of utmost importance so that implementation by more effective teaching methods and techniques will become a reality.

The scores of the PMA factors in relation to achievement level reflect differences in only two factors: word meaning and spatial relations. In word meaning the significant differences were found between the underachievers and the overachievers and in the latter's favor. The spatial relations factor discriminated between all three groups of overachievers, average achievers, and underachievers. Calculations for the other factors failed to produce any real differences between

achievement groups. Perhaps Bayley's[33] explanation holds true in this situation. She contends that the variability in scores emerges when a function is in the process of developing and that homogeneity in scores occurs in the same function when maturity is reached by the slower-growing individuals in a particular phase. Since the factors of reasoning, perceptual speed and number facility failed to reveal any variability in the achievement groups, perhaps at these age and grade levels the trend of growth in these abilities has reached a temporary plateau, giving a picture of homogeneity in scores.

Regarding the influence of sex on achievement, the accepted sex differences hold true: the boys showing superiority in number sense and spatial relations; the girls excelling in reasoning, verbal meaning and perceptual speed. However, it was the group of underachieving boys who excelled the girls at all three levels in spatial relations. The average achieving boys also had higher scores than did the overachieving girls. In number sense the boys at all levels were superior only to the overachieving girls. Regarding the female sex, only the overachieving girls showed superior performance in verbal meaning when compared to the underachieving boys. The overachieving and underachieving girls scored higher in reasoning than did all the boys, while the average girls were found to be superior

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33 Bayley, Op. Cit., p. 165-196.

to the over and underachieving boys in perceptual speed.

With sex differences in the primary mental abilities emerging significantly and consistently in both the grade and achievement dimensions of this study, they may be exerting a greater influence on education than is generally admitted.

The problem here of observing differences in the way boys and girls perform when faced with similar tests raises the question of whether coeducation may be an important factor in the role it plays in the relationship of mental abilities and achievement. Results show that they do not use the same pattern of traits. Whether the content being studied is the same or not is of lesser importance than the fact that boys and girls do not always use the same combinations of abilities but tend to favor the use of certain combinations whether they are best suited for the problem at hand or not. They do not study in the same way and should not be taught in the same way. Educators have maintained this for years and almost thirty years ago educators, among them Erskine[34] and Fitzpatrick[35,36] advocated separate education of boys taught by men and girls taught by women.

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34 John Erskine, The Influence of Women - and Its Cure, New York, Bobbs-Merrill Co., 1936, p. 68.

35 Edward A. Fitzpatrick, "The Question of Coeducation", in The Catholic School Journal, Vol. 30, July 1930, p. 254-255.

36 ———, editor, Readings in the Philosophy of Education, D. Appleton-Century Co., New York, 1936, p. 321-339.

> ...When we admitted girls to the prevailing system, along with the boys, we were trying them out in a masculine discipline designed to train the male, and perhaps successful only if men administer and teach it...(women--sic.) having got in, they softened and spoiled it, until our educational system is now satisfactory neither for boys nor for girls.[37]

At about the same time Pius XI[38] referred to the differences in sexes: "Besides there is not in nature itself, which fashions the two quite different in organism, in temperament, in abilities, anything to suggest that there can be...equality in the training of the two sexes".

Cunningham[39] reiterates this:

> ...it is only reasonable to expect that obvious anatomical and physiological differences will be reflected in psychological differences. Just as boys do not play like girls, work like girls, nor act like girls, so neither do they feel and think like girls. Adequate provision should be made for this fact during their formative years...

Wesman[40] almost assumes this fact when he discusses the advisability of considering sex differences in test results.

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37 Erskine, Op. Cit., p. 68.

38 Pope Pius XI, Christian Education of Youth, New York, The American Press, 1936, p. 23.

39 William F. Cunningham, The Pivotal Problems of Education, New York, MacMillan Co., 1940, p. 186.

40 Wesman, Op. Cit., p. 223.

> ...The literature on sex differences in learning has long demonstrated that boys and girls acquire knowledge and skills selectively. One need not attribute these differences to biological predispositions, since our culture provides differential experiences to the two sexes, and consequently differential opportunity and motivation for learning in specific areas.

More recently new insights into the problem of coeducation are to be found in the results of a series of studies conducted in the Department of Education at the Catholic University of America. Findings of these studies indicate the wisdom of educating boys and girls separately from the point of view of intelligence and achievement. Houlahan[41] reporting at the National Catholic Educational Association summarizes it:

> A sampling of representative literature in the field demonstrates that boys and girls should be educated separately, not just because of moral problems which may demand such segregation, but primarily because of differences between the two sexes in: (1) structure; (2) developmental rates; (3) differences in cognitive abilities and their uses; (4) differences in personality traits and their organization; and (5) differences in roles in life.
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> It is suggested that if boys were educated as boys for the male role in life and girls as girls for the feminine role, many of the frustrations resulting in maladjustments, particularly of the boys, could be eliminated.

Maritain[42] asserts that "...the teaching of the same discipline is received in a different way by young women and

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41 F.J. Houlahan, "Education and Differential Developmental Rates of Students", in National Catholic Educational Association Bulletin, Vol. 55, No. 1, Aug. 1958, p. 314.

42 D. and I. Gallagher, editors, The Education of Man: The Educational Philosophy of Jacques Maritain, Doubleday and Co. Inc., Garden City, New York, 1962, p. 157.

young men..." and Kolesnik[43] says "...we have tended to overlook the one difference which underlies all the rest -- that of the pupil's sex." This may be the solution to the problem.

Whatever the implications for the classroom teacher stem from this study, it must be remembered that no research can be entirely effetive in determining the causes of some learning-teaching difficulties. The inferences made are necessarily bound and limited by the tests used and the sample population involved. The results place emphasis on the fact that perhaps if boys were taught as boys and girls as girls, the hoped for maximum individual achievement could be realized.

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43 Walter B. Kolesnik, "Sex Differences and Education", in America, Vol. 108, No. 16, 1963, p. 552.

SUMMARY AND CONCLUSIONS

The purpose of this study was to investigate whether or not any differences exist in the primary mental abilities of subjects classified according to achievement in grades four, five, and six. From an analysis of variance of the scores of the Primary Mental Abilities tests to which the sample was subjected, the following results evolved regarding the relationship of the mental abilities to the variables of sex, grade, and level of achievement:

1. The Sex Variable: Significant F tests were found for the sex groups in the spatial relations, reasoning, figure grouping, word grouping, perceptual speed, and number sense factors. A breakdown of these groups and the application of the 't' test revealed the following:

a. The boys were superior in the

1) Spatial Relations ability -- in the fifth grade and in the underachieving group. The underachieving boys were superior to all groups of boys and girls.

2) Number Sense factor -- in the fourth grade and in the overachieving group. The average and underachieving boys also surpassed the overachieving girls.

b. The girls were superior in the

1) Reasoning ability -- in the fifth and sixth grades, and in the overachieving, average, and underachieving groups.

2) Figure Grouping ability -- in the fifth grade. The average and underachieving girls superior to the overachieving boys.

3) Word Grouping ability -- in the fifth and sixth grades, and in the overachieving and underachieving groups.

4) Perceptual Speed ability -- in the fourth and fifth grades, and in the overachieving and average achieving groups.

The null hypothesis that the primary mental factors do not differentiate between boys and girls classified according to achievement in grades four, five and six, is therefore partially rejected.

2. The Grade Variable: The F tests resulted in significant differences for all factors and their subtests for the grade dimension. The application of the 't' test to subgroups shows:

a. A significant difference between the fourth and fifth grades, and between the fifth and sixth grades for every factor.

b. Significant differences among boys of different grade levels for every factor with the exception of the fourth and fifth grade boys showing no difference in reasoning and its subtests of word grouping and figure grouping.

c. Significant differences among girls of different grade levels with the exception of the fourth and fifth grade

girls not varying in spatial relations, and the fifth and sixth grade girls not differing in word grouping.

d. Fifty-seven of the sixty-six comparisons made between the mean scores of subgroups in grades four, five and six displaying significant differences.

The null hypothesis that the primary mental factors do not differentiate between boys and girls classified according to achievement in grades four, five and six is therefore partially rejected.

3. The Achievement Variable: The F tests resulted in significant differences for the word meaning and spatial relations factors. An application of the 't' test resulted in significant differences for the following:

a. Word Meaning ability -- between the overachieving and underachieving groups. A further breakdown shows significant differences between overachieving and underachieving boys; between average achieving and underachieving boys; and between the underachieving boys and overachieving girls.

b. Spatial Relations ability -- between the overachieving, average, and underachieving groups. A further breakdown of groups produced evidence of the overachieving boys being inferior to the underachieving and average boys; and of the overachieving and average girls being inferior to the underachieving girls.

The null hypothesis that the primary mental factors do not differentiate between boys and girls classified according to achievement in grades four, five and six, is therefore partially rejected.

The implications from these findings regarding the primary mental abilities are, that significant differences in sex, grade, and achievement variables do exist and must therefore be taken into consideration by educators. Since teachers must provide classroom instruction, guidance, and meaningful experience for students in all areas, the search for the most effective plan to meet individual needs must continue. A vital step toward attempting to insure the fullest intellectual development of each child would be the identification of his weak and strong mental abilities as early as possible in the educational process. This could be accomplished with a tool such as the Primary Mental Abilities test which yields not only a total intelligence quotient but also scores for separate mental abilities. On the basis of such specific knowledge, the needs of individuals in a class could be assessed which in turn would facilitate a systematic re-organization and better adjustment of the curriculum to meet these needs.

The evidence in this study indicates that the abilities in which superior achievers were significantly better may be useful in organizing an instructional program or a remedial program as the needs of the class dictate. Doing so on a

separate sex basis could prove more effective. Experimentation in actual classroom situations could serve to reconcile the findings based on statistical analysis and the actual performance of pupils following the use of an instructional and/or a remedial program. Moreover, the teacher of any or all grades must assume responsibility for the adequate use of fundamental skills already learned, and for the further development of new and special skills required for successful progress and development of mental abilities as differentiation from the general to specific occurs.

Such an integrated development of these abilities could best be accomplished in the elementary school where the same teacher is in charge of all activities. Having an understanding of the problems and needs of the class facilitates a follow through with techniques designed to strengthen and aid developing mental abilities, and a 'carry-over' from one situation to another would result. Further, if training in the growth of these abilities were made an integral part of the work from the time when a formal study of the subject is first begun, the effect of the instructional program would be more permanent because teaching would be more meaningful. Because of persistent sex differences in primary mental abilities, the separate education of boys and girls without doubt would be more effective in bringing about the fullest development of their respective capabilities.

If advancement along these lines is to be made, continuous research is mandatory. Suggestions for further investigations could possibly include the following: a study similar to the present one but using larger samples from different populations to obtain more data as to the relationship of mental abilities and achievement; studies involving each factor separately with different combinations of variables controlled, such as mental age and ability to read, or mental age and numerical ability, *etc.*; investigating the separate function of each ability at every grade level; studies of a remedial nature, such as the influence of the improvement of reading skills on the progress of other mental abilities; studies in concept formation and interpretation as related to, for example, the spatial relations ability; investigations on the function of the learning method and its influence on a specific ability; and studies of the development of the reasoning ability, studying boys and girls separately. Further research could include separate longitudinal investigations for each sex and in each ability through the elementary grades from which with the use of a large representative sample, growth trends for each ability may emerge. Investigating the reasons for sex differences in specific mental abilities would be advantageous in leading to more effective methods devised for training in these abilities. Individual responses to the items of the test itself could be studied to ascertain the method of attack used by boys

and by girls. Hopefully, light shed on the manner of responding could in turn stimulate proper techniques for teaching, better textbooks, and more practical curricula. These and similar studies are urgently needed for effective education and to bring about the maximum development of intellectual abilities in each child.

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Growth trends in intelligence of forty children tested at most or all of thirty-eight testing ages from one through eighteen years of age presented with focus primarily on age changes in variability of intelligence test scores and on individual consistency in relative scores.

--------, "Mental Development", in Encyclopedia of Educational Research, New York, Macmillan Co., 1960, p. 817-823.

A discussion of mental organization at all stages of life which includes environmental-hereditary interactions in mental development and sixty-three pertinent references.

--------, "On the Growth of Intelligence", in The American Psychologist, Vol. 10, No. 12, Dec. 1955, p. 805-818.

Assuming intelligence to be a dynamic succession of developing functions, differences should be expected in the steepness of increment and decrement in the growth curves of different functions at different ages.

Bischof, L.J., Intelligence, Statistical Conceptions of Its Nature, New York, Garden City, Doubleday and Co. Inc., 1954, vi-33 p.

A discussion of various theories of the nature of intelligence with emphasis on the importance and usefulness of the primary-mental-abilities approach.

Curtis, Hazen Alonzo, "A Study of the Relative Effect of Age and of Test Difficulty Upon Factor Patterns", in Genetic Psychological Monographs, Vol. 40, 1949, p. 99-148.

An investigation of Garrett's hypothesis of specific abilities developed with increase in age reveals that the general factor becomes more important than the specific abilities with increment in age.

Dayhaw, Lawrence-T., Manuel de Statistique, Editions de l'Université d'Ottawa, Canada, 1958, xxiii-530 p.

The basic principles of experimental designs applicable to psychological and educational research are considered. Analyses are presented with specific and meaningful conclusions which with the aid of concrete illustrations enables the student to select or devise for himself the appropriate designs for specific situations and to analyze and interpret the obtained results.

Garrett, H.E., "A Developmental Theory of Intelligence", in The American Psychologist, Vol. 1, No. 8, 1946, p. 373-378.

Defining intelligence as including all abilities used in the solving of problems, evidence is given for the differentiation hypothesis and its implications. A summary of the findings of a number of factor analyses of intellectual functions is included.

Hoffman, Martin L. and Lois Hoffman, Editors, Review of Child Development Research, New York, Russell Sage Foundation, 1964, ix-547 p.

A summary of the latest studies of child development with pertinent studies of significance regarding the sex role identity, attainment of concepts, and productive thinking.

Tyler, Leona E., The Psychology of Human Differences, New York, Appleton-Century-Crofts, Inc., 1956, viii-568 p.

Included is a fine resume of research and findings regarding individual differences in intelligence, sex, and achievement.

---------, "The Stability of Patterns of Primary Mental Abilities Among Grade School Children", in Educational Psychological Measurement, Vol. 18, No. 4, 1958, p. 769-774.

An inquiry into the possibility of similar patterns of primary mental abilities in the same subjects, yielded data which supported the increasing stability of individual mental ability pattern as age progresses. Suggested the grade level for the sample of this study.

APPENDIX 1

PRELIMINARY TABLES FOR THE ANALYSES OF VARIANCE

The data required for the analysis of variance are presented in a series of three consecutive tables for each PMA factor and subtest. Table a presents the raw score totals for the factor concerned; Table b presents the sums of squares of the raw scores for the three principal effects of sex, grade and achievement; double and triple interactions; and the sum of the individual scores squared. In each case the use of raw scores rather than their deviations from the mean necessitated the use of the correction formula T^2/N. The sums of squares for the dimensions concerned with interaction were also eliminated to find the residual which could be mere chance fluctuation or interaction between cells. Table c presents a summary of the results of Table a and Table b and includes the sources of variance, their sums of squares, and the final estimates of variance after the adjustment was made with regard to the degrees of freedom.

Table XIa.-Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Verbal Meaning Factor.

Grade	Achievement Level						$T_{S\ Gr}$[a]		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	1201	1301	1233	1138	1153	1089	3587	3528	
T_{GrA}	2502		2371		2242				7115
5	1497	1454	1470	1475	1375	1488	4342	4417	
T_{GrA}	2951		2945		2863				8759
6	1652	1656	1668	1672	1693	1691	5013	5019	
T_{GrA}	3308		3340		3384		T_S		10032
T_{SA}	4350	4411	4371	4285	4221	4268	12942	12964	
T_A	8761		8656		8489				T 25906

a T= Total; S = Sex; Gr = Grade; A = Achievement.

Table XIb.--Sums of Squares by Sex, Grade, and Achievement for the Analysis of Variance of the Verbal Meaning Factor.

Group(g)	n_g	$\Sigma T^2_g / n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	648	1035678.76				
$(T_S)^2$	324	1035681.05	2.29		2.29	S
$(T_{Gr})^2$	216	1055483.01	19804.25		19804.25	Gr
$(T_A)^2$	216	1035854.53	175.77		175.77	A
$(T_{S\ Gr})^2$	108	1055525.33	19846.57	S + Gr	40.03	S x Gr
$(T_{SA})^2$	108	1035916.22	237.46	S + A	59.40	S x A
$(T_{GrA})^2$	72	1056028.11	20349.35	Gr + A	369.33	Gr x A
					20451.07	
$(S,G)^2$	36	1056585.06	20906.30	20451.07	455.23	S x Gr x A
					20906.30	
Individual Scores^2	1	1087891.00	52212.24		52212.24	Total
Within			52212.24	20906.30	31305.94	W

Table XIe.--Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Verbal Meaning Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	2.29	1	2.29
Grade	19804.25	2	9902.13
Achievement	175.77	2	87.89
Double Interactions:			
S x Gr	40.03	2	20.02
S x A	59.40	2	29.70
Gr x A	369.33	4	92.34
Triple Interaction:			
S x Gr x A	455.23	4	117.62
Within Cells	31305.94	630	49.69
Total:	52212.24	647	

Table XIIa.-Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Word Meaning Factor.

Grade	Achievement Level						$T_{S\,Gr}$[a]		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	630	703	646	596	565	587	1841	1886	
T_{GrA}	1333		1242		1152				3727
5	799	793	776	794	731	797	2306	2384	
T_{GrA}	1592		1570		1528				4690
6	872	887	876	891	877	893	2625	2671	
T_{GrA}	1759		1767		1770		T_S		5296
T_{SA}	2301	2383	2298	2281	2173	2277	6772	6941	T
T_A	4684		4579		4450				13713

[a] T = Total; S = Sex; Gr = Grade; A = Achievement.

Table XIIb.--Sums of Squares by Sex, Grade, and Achievement for the Analysis of Variance of the Word Meaning Factor.

Group(g)	n_g	$\Sigma T^2_g/n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	648	290195.01				
$(T_S)^2$	324	290239.09	44.08		44.08	S
$(T_{Gr})^2$	216	295991.88	5796.87		5796.87	Gr
$(T_A)^2$	216	290322.67	127.66		127.66	A
$(T_{S\ Gr})^2$	108	296039.21	5844.20	S + Gr	3.25	S x Gr
$(T_{SA})^2$	108	290404.75	209.74	S + A	38.00	S x A
$(T_{GrA})^2$	72	296249.65	6054.64	Gr + A	130.11	Gr x A
					6139.97	
$(B,G)^2$	36	296440.42	6245.41	6139.97	105.44	S x Gr x A
					6245.41	
Individual Scores^2	1	307586.00	17390.99		17390.99	Total
Within			17390.99	6245.41	11145.58	W

Table XIIa.—Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Word Meaning Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	44.08	1	44.08
Grade	5796.87	2	2898.44
Achievement	127.66	2	63.83
Double Interactions:			
S x Gr	3.25	2	1.63
S x A	38.00	2	19.00
Gr x A	130.11	4	32.53
Triple Interaction:			
S x Gr x A	105.44	4	26.36
Within Cells	11145.58	630	17.69
Total:	17390.99	647	

Table XIIIa.--Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Picture Meaning Factor.

Grade	Achievement Level						$T_{S\ Gr}$[a]		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	571	598	587	551	588	502	1746	1651	
T_{GrA}	1169		1138		1090				3397
5	697	661	694	682	644	691	2035	2034	
T_{GrA}	1358		1376		1335				4069
6	780	770	792	781	816	798	2388	2349	
T_{GrA}	1550		1573		1614		T_S		4737
T_{SA}	2048	2029	2073	2014	2048	1991	6169	6034	
T_A	4077		4087		4039				T 12203

a T = Total; S = Sex; Gr = Grade; A = Achievement.

Table XIIIb.-Sums of Squares by Sex, Grade and Achievement for the Analysis of Variance of the Picture Meaning Factor.

Group(g)	n_g	$\Sigma T^2_g/n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	: 648	229804.33				
$(T_S)^2$	: 324	229832.46	28.13		28.13	S
$(T_{Gr})^2$	: 216	233960.83	4156.50		4156.50	Gr
$(T_A)^2$	: 216	229810.27	5.94		5.94	A
$(T_{SGr})^2$	: 108	234009.66	4205.33	S + Gr	20.70	S x Gr
$(T_{SA})^2$	: 108	229843.10	38.77	S + A	4.70	S x A
$(T_{GrA})^2$	: 72	234045.76	4241.43	Gr + A	78.99	Gr x A
					4294.96	
$(S,G)^2$	: 36	234234.86	4430.53	4294.96	135.57	S x Gr x A
					4430.53	
Individual Scores^2	: 1	242857.00	13052.67		13052.67	Total
Within			13052.67	4430.53	8622.14	W

Table XIIIc.--Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Picture Meaning Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	28.13	1	28.13
Grade	4156.50	2	2078.25
Achievement	5.94	2	2.97
Double Interactions:			
S x Gr	20.70	2	10.35
S x A	4.70	2	2.35
Gr x A	78.99	4	19.75
Triple Interaction:			
S x Gr x A	135.57	4	33.89
Within Cells	8622.14	630	13.69
Total:	13052.67	647	

Table XIVa.--Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Spatial Relations Factor.

Grade	Achievement Level						$T_{S\,Gr}$[a]		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	421	386	437	424	456	430	1314	1240	
T_{GrA}	807		861		886				2554
5	436	431	465	429	548	469	1449	1329	
T_{GrA}	867		894		1017				2778
6	480	499	540	511	606	574	1626	1584	
T_{GrA}	979		1051		1180		T_S		3210
T_{SA}	1337	1316	1442	1364	1610	1473	4389	4153	
T_A	2653		2806		3083				T 8542

a T = Total; S = Sex; Gr = Grade; A = Achievement.

Table XIVb.--Sums of Squares by Sex, Grade and Achievement for the Analysis of Variance of the Spatial Relations Factor.

Group(g)	n_g	$\Sigma T^2_g/n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	: 648	112601.49				
$(T_S)^2$	: 324	112688.06	86.57		86.57	S
$(T_{Gr})^2$	: 216	113631.02	1029.53		1029.53	Gr
$(T_A)^2$	: 216	113041.36	439.87		439.87	A
$(T_{SGr})^2$	: 108	113731.20	1129.71	S + Gr	13.61	S x Gr
$(T_{SA})^2$	: 108	113158.46	556.97	S + A	30.53	S x A
$(T_{GrA})^2$	: 72	114141.97	1540.48	Gr + A	71.08	Gr x A
					1671.19	
$(B_{SG})^2$	: 36	114306.66	1705.17	1671.19	33.98	S x Gr x A
					1705.17	
Individual Scores^2	: 1	122706.00	10104.51		10104.51	Total
Within			10104.51	1705.17	8399.34	W

Table XIVe.--Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Spatial Relations Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	86.57	1	86.57
Grade	1029.53	2	514.77
Achievement	439.87	2	219.94
Double Interactions:			
S x Gr	13.61	2	6.81
S x A	30.53	2	15.27
Gr x A	71.08	4	17.77
Triple Interaction:			
S x A x Gr	33.98	4	8.50
Within Cells:	8399.34	630	13.33
Total:	10104.51	647	

Table XVa.--Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Reasoning Factor.

Grade	Achievement Level						$T_{S\,Gr}$[a]		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	1201	1211	1177	1215	1179	1183	3557	3609	
T_{GrA}	2412		2392		2362				7166
5	1196	1341	1238	1288	1245	1339	3679	3968	
T_{GrA}	2537		2526		2584				7647
6	1324	1379	1331	1374	1344	1433	3999	4186	
T_{GrA}	2703		2705		2777		T_S		8185
T_{SA}	3721	3931	3746	3877	3768	3955	11235	11763	
T_A	7652		7623		7723				T 22998

[a] T = Total; S = Sex; Gr = Grade; A = Achievement.

Table XVb.--Sums of Squares by Sex, Grade, and Achievement for the Analysis of Variance of the Reasoning Factor.

Group(g)	n_g	$\Sigma T^2_g/n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	648	816216.06				
$(T_S)^2$	324	816646.28	430.22		430.22	S
$(T_{Gr})^2$	216	818622.18	2406.12		2406.12	Gr
$(T_A)^2$	216	816240.56	24.50		24.50	A
$(T_{SGr})^2$	108	819183.26	2967.20	S + Gr	130.86	S x Gr
$(T_{SA})^2$	108	816686.07	470.01	S + A	15.29	S x A
$(T_{GrA})^2$	72	818715.50	2499.44	Gr + A	68.82	Gr x A
					3075.81	
$(B,G)^2$	36	819364.33	3148.27	3075.81	72.46	S x Gr x A
					3148.27	
Individual Scores^2	1	837855.00	21638.94		21638.94	Total
Within			21638.94	3148.27	18490.67	W

Table XVc.-Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Reasoning Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	430.22	1	430.22
Grade	2406.12	2	1203.06
Achievement	24.50	2	12.25
Double Interactions:			
S x Gr	130.86	2	65.43
S x A	15.29	2	7.65
Gr x A	68.82	4	17.21
Triple Interaction:			
S x A x Gr	72.46	4	18.12
Within Cells:	18490.67	630	29.35
Total:	21638.94	647	

Table XVIa.--Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Figure Grouping Factor.

Grade	Achievement Level						$T_{S\ Gr}$[a]		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	577	563	566	613	582	579	1725	1755	
T_{GrA}	1140		1179		1161				3480
5	557	634	594	607	597	628	1748	1869	
T_{GrA}	1191		1201		1225				3617
6	636	667	631	662	662	685	1929	2014	
T_{GrA}	1303		1293		1347		T_S		3943
T_{SA}	1770	1864	1791	1882	1841	1892	5402	5638	
T_A	3634		3673		3733				T 11040

[a] T = Total; S = Sex; Gr = Grade; A = Achievement.

Table XVIb.--Sums of Squares by Sex, Grade, and Achievement for the Analysis of Variance of the Figure Grouping Factor.

Group(g)	n_g	$\Sigma T^2_g/n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	648	188088.88				
$(T_S)^2$	324	188174.84	85.96		85.96	S
$(T_{Gr})^2$	216	188612.67	523.79		523.79	Gr
$(T_A)^2$	216	188111.91	23.03		23.03	A
$(T_{SGr})^2$	108	188718.07	629.19	S + Gr	19.44	S x Gr
$(T_{SA})^2$	108	188203.20	114.32	S + A	5.33	S x A
$(T_{GrA})^2$	72	188654.66	565.78	Gr + A	18.96	Gr x A
					676.51	
$(S,G)^2$	36	188820.28	731.40	676.51	54.89	S x Gr x A
					731.40	
Individual Scores^2	1	196812.00	8723.12		8723.12	Total
Within			8723.12	731.40	7991.72	W

Table XVIe.-Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Figure Grouping Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	85.96	1	85.96
Grade	523.79	2	261.90
Achievement	23.03	2	11.52
Double Interactions:			
S x Gr	19.44	2	9.72
S x A	5.33	2	2.67
A x Gr	18.96	4	4.74
Triple Interaction:			
S x A x Gr	54.89	4	13.72
Within Cells:	7991.72	630	12.69
Total:	8723.12	647	

Table XVIIa.-Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Word Grouping Factor.

Grade	Achievement Level						$T_{S\ Gr}$[a]		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	615	648	611	601	597	604	1823	1853	
T_{GrA}	1263		1212		1201				3676
5	629	708	632	682	639	711	1900	2101	
T_{GrA}	1337		1314		1350				4001
6	688	712	690	712	694	748	2072	2172	
T_{GrA}	1400		1402		1442		T_S		4244
T_{SA}	1932	2068	1933	1995	1930	2063	5795	6126	
T_A	4000		3928		3993				T 11921

a T = Total; S = Sex; Gr = Grade; A = Achievement.

Table XVIIb.--Sums of Squares by Sex, Grade, and Achievement for the Analysis of Variance of the Word Grouping Factor.

Group(g)	n_g	$\Sigma T^2_g/n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	: 648	219305.93				
$(T_S)^2$	: 324	219475.00	169.07		169.07	S
$(T_{Gr})^2$	: 216	220057.93	752.00		752.00	Gr
$(T_A)^2$	: 216	219320.52	14.59		14.59	A
$(T_{SGr})^2$	: 108	220295.43	989.50	S + Gr	68.43	S x Gr
$(T_{SA})^2$	: 108	219505.84	199.91	S + A	16.25	S x A
$(T_{GrA})^2$	: 72	220113.18	807.25	Gr + A	40.66	Gr x A
					1061.00	
$(B,G)^2$	: 36	220378.97	1073.04	1061.00	12.04	S x Gr x A
					1073.04	
Individual Scores^2	: 1	227602.00	8296.07		8296.07	Total
Within			8296.07	1073.04	7223.03	W

Table XVIIc.-Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Word Grouping Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	169.07	1	169.07
Grade	752.00	2	376.00
Achievement	14.59	2	7.30
Double Interactions:			
S x Gr	68.43	2	34.22
S x A	16.25	2	8.13
A x Gr	40.66	4	10.17
Triple Interaction:			
S x A x Gr	12.04	4	3.01
Within Cells:	7223.03	630	11.47
Total:	8296.07	647	

Table XVIIIa.--Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Perceptual Speed Factor.

Grade	Achievement Level						$T_{S\ Gr}$[a]		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	524	624	514	605	518	517	1556	1746	
T_{GrA}	1148		1119		1035				3302
5	601	603	630	712	593	675	1824	1990	
T_{GrA}	1204		1342		1268				3814
6	733	805	784	826	763	805	2280	2436	
T_{GrA}	1538		1610		1568		T_S		4716
T_{SA}	1858	2032	1928	2143	1874	1997	5660	6172	
T_A	3890		4071		3871				T 11832

a T = Total; S = Sex; Gr = Grade; A = Achievement.

Table XVIIIb.--Sums of Squares by Sex, Grade, and Achievement for the Analysis of Variance of the Perceptual Speed Factor.

Group(g)	n_g	$\Sigma T^2_g/n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	648	216043.56				
$(T_S)^2$	324	216448.10	404.54		404.54	S
$(T_{Gr})^2$	216	220789.15	4745.59		4745.59	Gr
$(T_A)^2$	216	216156.40	112.84		112.84	A
$(T_{SGr})^2$	108	221196.52	5152.96	S + Gr	2.83	S x Gr
$(T_{SA})^2$	108	216580.61	537.05	S + A	19.67	S x A
$(T_{GrA})^2$	72	221053.64	5010.08	Gr + A	151.65	Gr x A
					5437.12	
$(B,S)^2$	36	221615.39	5571.83	5437.12	134.71	S x Gr x A
					5571.83	
Individual Scores	1	241680.00	25636.44		25636.44	Total
Within			25636.44	5571.83	20064.61	W

Table XVIIIc.-Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Perceptual Speed Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	404.54	1	404.54
Grade	4745.59	2	2372.50
Achievement	112.84	2	56.43
Double Interactions:			
S x Gr	2.83	2	1.42
S x A	19.67	2	9.84
A x Gr	151.65	4	37.91
Triple Interaction:			
S x A x Gr	134.71	4	33.68
Within Cells:	20064.61	630	31.85
Total:	25636.44	647	

Table XIXa.--Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Number Facility Factor.

Grade	Achievement Level						[a] $T_{S\,Gr}$		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	952	933	916	917	894	899	2762	2749	
T_{GrA}	1885		1833		1793				5511
5	1055	1039	1042	1063	1039	1045	3136	3147	
T_{GrA}	2094		2105		2084				6283
6	1221	1158	1226	1180	1209	1264	3656	3602	
T_{GrA}	2379		2406		2473		T_S		7258
T_{SA}	3228	3130	3184	3160	3142	3208	9554	9498	
T_A	6358		6344		6350				T 19052

[a] T = Total; S = Sex; Gr = Grade; A = Achievement.

Table XIXb.-Sums of Squares by Sex, Grade, and Achievement for the Analysis of Variance of the Number Facility Factor.

Group(g)	n_g	$\Sigma T^2_g/n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	: 648	560152.32				
$(T_S)^2$	: 324	560157.16	4.84		4.84	S
$(T_{Gr})^2$	: 216	567248.95	7096.63		7096.63	Gr
$(T_A)^2$	: 216	560152.78	.46		.46	A
$(T_{SGr})^2$	: 108	567263.79	7111.47	S + Gr	10.00	S x Gr
$(T_{SA})^2$	: 108	560220.07	67.75	S + A	62.45	S x A
$(T_{GrA})^2$	: 72	567502.44	7350.12	Gr + A	253.03	Gr x A
					7427.41	
$(B,G)^2$	: 36	567518.28	7365.96	7427.41	-61.45	S x Gr x A
					7365.96	
Individual Scores^2	: 1	583765.00	23612.68		23612.68	Total
Within			23612.68	7365.96	16246.72	W

Table XIXc.-Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Number Facility Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	4.84	1	4.84
Grade	7096.63	2	3548.32
Achievement	0.46	2	0.23
Double Interactions:			
S x Gr	10.00	2	5.00
S x A	62.45	2	31.23
A x Gr	253.03	4	63.26
Triple Interaction:			
S x A x Gr	-61.45	4	-15.36
Within Cells:	16246.72	630	25.79
Total:	23612.68	647	

Table XXa.--Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Number Sense Factor.

Grade	Achievement Level						$T_{S\,Gr}$[a]		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	494	452	479	427	466	437	1439	1316	
T_{GrA}	946		906		903				2755
5	526	505	517	506	518	517	1561	1528	
T_{GrA}	1031		1023		1035				3089
6	595	530	576	582	598	612	1769	1724	
T_{GrA}	1125		1158		1210		T_S		3493
T_{SA}	1615	1487	1572	1515	1582	1566	4769	4568	T
T_A	3102		3087		3148				9337

a T = Total; S = Sex; Gr = Grade; A = Achievement.

Table XXb.--Sums of Squares by Sex, Grade, and Achievement for the Analysis of Variance of the Number Sense Factor.

Group(g)	n_g	$\Sigma T^2_g/n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	: 648	134536.37				
$(T_S)^2$	: 324	134598.72	62.35		62.35	S
$(T_{Gr})^2$	: 216	135800.90	1264.53		1264.53	Gr
$(T_A)^2$	: 216	134545.73	9.36		9.36	A
$(T_{SGr})^2$	: 108	135885.36	1348.99	S + Gr	22.11	S x Gr
$(T_{SA})^2$	: 108	134637.81	101.44	S + A	29.73	S x A
$(T_{GrA})^2$	: 72	135868.96	1332.59	Gr + A	58.70	Gr x A
					1446.78	
$(B,0)^2$	: 36	136012.42	1476.05	1446.78	29.27	S x Gr x A
					1476.05	
Individual Scores^2	: 1	141467.00	6930.63		6930.63	Total
Within			6930.63	1476.05	5454.58	W

Table XXc.-Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Number Sense Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	62.35	1	62.35
Grade	1264.53	2	632.28
Achievement	9.36	2	4.68
Double Interactions:			
S x Gr	22.11	2	11.06
S x A	29.73	2	14.87
A x Gr	58.70	4	14.68
Triple Interaction:			
S x A x Gr	29.27	4	7.32
Within Cells:	5454.58	630	8.66
Total:	6930.63	647	

Table XXIa.--Raw Score Totals by Sex, Grade, and Achievement for the Analysis of Variance of the Addition Factor.

Grade	Achievement Level						$T_{S\,Gr}$[a]		T_{Gr}
	Overachieving		Average		Underachieving				
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
4	458	491	447	482	428	461	1333	1434	
T_{GrA}	949		929		889				2767
5	529	534	525	557	521	528	1575	1619	
T_{GrA}	1063		1082		1049				3194
6	624	628	658	598	611	653	1893	1879	
T_{GrA}	1252		1256		1264		T_S		3772
T_{SA}	1611	1653	1630	1637	1560	1642	4801	4932	T
T_A	3264		3267		3202				9733

[a] T = Total; S = Sex; Gr = Grade; A = Achievement.

Table XXIb.--Sums of Squares by Sex, Grade, and Achievement for the Analysis of Variance of the Addition Factor.

Group(g)	n_g	$\Sigma T^2_g/n_g$	$-T^2/N$	-SS	SS	Symbol
$(T)^2$	648	146190.26				
$(T_S)^2$	324	146216.74	26.48		26.48	S
$(T_{Gr})^2$	216	148545.88	2355.62		2355.62	Gr
$(T_A)^2$	216	146202.73	12.47		12.47	A
$(T_{SGr})^2$	108	148602.97	2412.71	S + Gr	30.61	S x Gr
$(T_{SA})^2$	108	146242.25	51.99	S + A	13.04	S x A
$(T_{GrA})^2$	72	148580.46	2390.20	Gr + A	22.11	Gr x A
					2460.33	
$(S,G)^2$	36	148717.69	2527.43	2460.33	67.10	S x Gr x A
					2527.43	
Individual Scores	1	155701.00	9510.74		9510.74	Total
Within			9510.74	2527.43	6983.31	W

Table XXIe.-Variance Estimates by Sex, Grade, and Achievement for the Analysis of Variance of the Addition Factor.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance
Principal Effects:			
Sex	26.48	1	26.48
Grade	2355.62	2	1177.81
Achievement	12.47	2	6.24
Double Interactions:			
S x Gr	30.61	2	15.31
S x A	13.04	2	6.52
A x Gr	22.11	4	5.53
Triple Interaction:			
S x A x Gr	67.10	4	16.78
Within Cells:	6983.31	630	11.08
Total:	9510.74	647	

Table XXII.-PMA Factor Means for Grade and Achievement Level (n=216).

PMA Factor	Grade Level			Achievement Level		
	4	5	6	Overachievers	Average	Underachievers
Verbal Meaning	32.94	40.55	46.44	40.56	40.07	39.30
Word Meaning	17.25	21.71	24.52	21.69	21.20	20.60
Picture Meaning	15.73	18.84	21.93	18.88	18.92	18.70
Spatial Relations	11.82	12.86	14.86	12.19	12.99	14.27
Reasoning	33.18	35.40	37.89	35.43	35.29	35.75
Figure Grouping	16.11	16.75	18.25	16.82	17.00	17.28
Word Grouping	17.02	18.52	19.65	18.52	18.19	18.49
Perceptual Speed	15.29	17.66	21.83	18.01	18.85	17.92
Number Facility	25.51	29.09	33.60	29.44	29.37	29.39
Number Sense	12.75	14.30	16.17	14.36	14.29	14.57
Addition	12.79	14.79	17.46	15.11	15.13	14.82

Table XXIII.-Various Levels for Determining Significance of Differences Between Means on the PMA Factors for Both Grade and Achievement Levels (n=216).

PMA Factor	Probability Level			
	.05	.02	.01	.001
Verbal Meaning	1.33	1.58	1.75	2.24
Word Meaning	.79	.94	1.04	1.33
Picture Meaning	.70	.83	.92	1.16
Spatial Relations	.69	.82	.90	1.16
Reasoning	1.02	1.21	1.34	1.72
Figure Grouping	.67	.80	.88	1.13
Word Grouping	.64	.76	.84	1.07
Perceptual Speed	1.06	1.26	1.40	1.79
Number Facility	.96	1.10	1.26	1.61
Number Sense	.56	.66	.73	.93
Addition	.63	.75	.83	1.05

Table XXIV.-PMA Factor Means by Sex for Grade Level (n:108)

PMA Factor	Grade 4		Grade 5		Grade 6	
	Boys	Girls	Boys	Girls	Boys	Girls
Verbal Meaning	33.21	32.67	40.20	40.89	46.42	46.47
Word Meaning	17.05	17.46	21.35	22.07	24.31	24.73
Picture Meaning	16.17	15.29	18.84	18.84	22.11	21.75
Spatial Relations	12.17	11.48	13.42	12.31	15.06	14.67
Reasoning	32.93	33.42	34.07	36.74	37.03	38.76
Figure Grouping	15.88	16.25	16.19	17.31	17.86	18.65
Word Grouping	16.88	17.16	17.59	19.45	19.18	20.11
Perceptual Speed	14.26	16.17	16.89	18.42	21.11	22.56
Number Facility	25.55	25.45	29.04	29.14	33.85	33.35
Number Sense	13.32	12.18	14.45	14.15	16.38	15.96
Addition	12.34	13.28	14.58	14.99	17.53	17.40

Table XXV.--PMA Factor Means by Sex for Achievement Level (n:100).

PMA Factor	Overachievers		Average Achievers		Underachievers	
	Boys	Girls	Boys	Girls	Boys	Girls
Verbal Meaning	40.28	40.84	40.47	39.68	39.08	39.52
Word Meaning	21.31	22.06	21.28	21.12	20.12	21.08
Picture Meaning	18.96	18.79	19.19	18.65	18.96	18.44
Spatial Relations	12.38	12.19	13.35	12.63	14.91	13.64
Reasoning	34.45	36.39	34.68	35.89	34.89	36.62
Figure Grouping	16.39	17.26	16.58	17.41	17.05	17.52
Word Grouping	17.89	19.15	17.89	18.47	17.87	19.10
Perceptual Speed	17.20	18.81	17.85	19.84	17.35	18.49
Number Facility	29.89	28.98	29.48	29.26	29.09	29.70
Number Sense	14.95	13.77	14.56	14.03	14.65	14.50
Addition	14.92	15.31	15.09	15.16	14.44	15.20

Table XXVI.--Various Levels for Determining Significance of Differences Between Means on the PMA Factors for Boys and Girls for Grade and Achievement Levels (n=109).

PMA Factor	Probability Level			
	.05	.02	.01	.001
Verbal Meaning	1.88	2.23	2.47	3.16
Word Meaning	1.12	1.33	1.47	1.88
Picture Meaning	.99	1.17	1.30	1.66
Spatial Relations	.97	1.16	1.28	1.64
Reasoning	1.44	1.71	1.90	2.43
Figure Grouping	.95	1.13	1.25	1.60
Word Grouping	.90	1.07	1.19	1.52
Perceptual Speed	1.51	1.78	1.98	2.53
Number Facility	1.35	1.61	1.78	2.27
Number Sense	.79	.93	1.03	1.32
Addition	.89	1.05	1.17	1.49

APPENDIX 2

ABSTRACT OF

Primary Mental Abilities And Achievement[1]

This study was undertaken to investigate the variability of the primary mental abilities with relation to achievement. A sample of six hundred forty-eight boys and girls was drawn from grades four, five, and six from five schools. On the basis of individual discrepancy between mental age grade-placement and achievement battery grade-placement as measured by the California tests, the subjects were classified as over-achievers, average achievers, and underachievers.

Upon the administration of the SRA Primary Mental Abilities test to this sample, the results were subjected to an analysis of variance. This process revealed the following statistically significant differences in primary mental abilities for the sexes, grade and achievement variables:

a. The Sex Variable:

1) Boys superior in spatial relations and number sense factors;

2) Girls significantly better in reasoning and perceptual speed.

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1 Sister Mary Francis Lopata, O.S.F., Doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, April 1965, vi-146 p.

b. The Grade Variable:

1) Between grades -- a consistent parallel rise in mean score with rise in grade level;

2) Excelling within grade level -- fourth grade boys in number sense, fourth grade girls in addition and perceptual speed; fifth grade boys in spatial relations, fifth grade girls in reasoning and perceptual speed; and the sixth grade girls in reasoning.

c. The Achievement Variable:

1) Total group differences -- overachievers superior to underachievers in word meaning ability; overachievers inferior to average achievers in spatial ability; underachievers superior in spatial relations to both average and overachievers.

2) Subgroup differences between levels of achievement -- underachieving boys superior in spatial relations to all other groups; the over and underachieving girls superior in reasoning to all groups of boys; underachieving girls superior in spatial relations to the over and average achieving girls; average girls excelling all groups of achievers in the male sex in perceptual speed.

3) Subgroup differences within levels of achievement -- girls in the overachieving group excelling in reasoning and perceptual speed; boys in the overachieving group superior in number sense; girls in the average group superior in perceptual speed; boys in the under-achieving group excelling in

spatial relations; girls in the underachieving group superior in reasoning.

The differences found in the performance of boys and girls within and between achievement levels, lead to a partial rejection of the null hypothesis of no difference in primary mental abilities of boys and girls classified according to achievement in grades four, five, and six.