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ABSTRACT

The present study was designed to (1) investigate the changes in the structure and organization of mental abilities during childhood and adolescence of 514 students as sampled by the Wechsler Intelligence Scale for Children (5 to 15 years) and the Wechsler Adult Intelligence Scale (16 to 18 Years) and (2) interpret, and possibly modify, the current theories of cognitive and psychomotor development. The findings of the study are summarized and an overview of intellectual developmental theories, with reference to the differentiation hypothesis, is presented. (Author/CK)

Cover Page

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The basic data subjected to a different line of analysis for the purposes of the present study were originally collected under Grants Nos. MH 08918-01 and MH 11115-01, -02 and -03 from the National Institute of Mental Health, during 1964-68. Funds for the present analyses, compilation and interpretation of results were mainly provided by the U.S. Office of Education under Grant No. OEG-5-70-0027 (509).

The following abbreviations designate the various WISC and WAIS subtests throughout this report: I (Information), C (Comprehension), A (Arithmetic), S (Similarities), V (Vocabulary), D (Digits), PC (Picture Completion), PA (Picture Arrangement), BD (Block Design), OA (Object Assembly), and Cod/DS (Coding or Digit Symbol).

SUMMARY

The present study was designed to (a) investigate the changes in the structure and organization of mental abilities during childhood and adolescence as sampled by the Wechsler Intelligence Scale for Children (between 5 and 15 years) and the Wechsler Adult Intelligence Scale (between 16 and 18 years) and (b) interpret, and possibly modify, the current theories of cognitive and psychomotor development in the light of the foregoing.

The subjects were 514 children, between the ages of 5 and 18 years, who were selected according to a two-stage probability sampling procedure from various elementary and secondary schools in metropolitan Milwaukee and were administered the Wechsler scales during 1965-66. The data were appropriately analyzed to ascertain the trends in the organization of the various cognitive and psychomotor functions tapped by the Wechsler scales and to determine the invariance of these functions. The results indicate that (a) the number and nature of factors (obtained by means of the principal axis analysis with varimax rotation) generally correspond with the results based on the original standardization data of the Wechsler scales as reported by Cohen (1959) and Gault (1954) and (b) the differentiation hypothesis, unlike the results of a previous study (Quereshi, 1967), is not borne out by the Wechsler scale data of the present study. An overview of the theories of intellectual development, with special reference to the "differentiation hypothesis," has been presented.

INTRODUCTION

Background and Significance

Several developmental theories attempt to account for the changes in the structure and organization of human characteristics during various stages of life. Most of these theories attribute age changes, with varying degrees of relative emphasis, to both the unfolding process of the biological factors and the molding influences of the socio-cultural forces. Since the development of intellectual abilities is an important aspect of the general psychophysiological growth of an organism, it is not surprising that each one of the currently well-known developmental theories (Gesell, 1954; Koffka, 1925; Lewin, 1935: Piaget, 1950; Werner, 1948) have put forth a rationale for intellectual development vis-a-vis their postulates about general personality development. While there are other equally (or even more) influential theories of child development (e.g., Freud, 1949; Freud, 1951), the present discussion is chiefly concerned with those developmental theories which have made specific assertions about the course of cognitive and psychomotor development. Furthermore, the comparative analysis presented here will also include theorists who, despite not having delved into developmental problems in any great length, have specifically committed themselves to a definite theoretical viewpoint regarding the changes in the structure and organization of intellect over various segments of the life span.

It should be possible to compare some of these theories, with respect to their stand on the developmental changes in intelligence, without delineating their historical genealogy. It is worthwhile to note that a number of them subscribe to the hypothesis that intellectual abilities become more differentiated with increasing age. For example, Piaget (1950), in his discussion of the "hierarchy of operations and their progressive differentiation," asserts that "each of the transitions from one of these levels to the next is ... characterized both by a new coordination and by a differentiation of the systems constituting the unit of the preceding level" (p. 152). Similarly, in defining the basic functional and developmental characteristics of a schema, he indicates that all schemas undergo the sequential processes of repetition, generalization, and differentiation (Flavell, 1963). In addition, this sequence (repetition, generalization, and differentiation) permeates not only the horizontal development (interlocking of schemas at the same age) but also the vertical (across age levels) development of schemas.

Another source of theoretical support for the differentiation hypothesis derives from Gestalt psychology which emphasizes a continuity of psychological development (perceptual, social, intellectual) from an initially organized structure toward an ever-increasing differentiation of the same. Accordingly, psychological growth is characterized by a differentiated elaboration of mental processes already present rather than by the accretion of new functions. Koffka's attempt to relate the principles of Gestalt psychology to child development was available in the psychological literature as early as 1925. Later on Lewin (1935) provided a topological view of psychological development by employing a different terminological and axiomatic system. He postulated that the gradual differentiation of the cognitive field is a basic function of psychological development, and that the rigidity of boundaries between or among the differentiated areas of the cognitive field (as well as between need systems) increases as a direct function of the ageing process. Thus, the younger child has not only fewer cognitive regions but also has boundaries which are rather ill-defined, fluid and flexible.

The appeal of the differentiation hypothesis, among other things, is perhaps due to the fact that it represents a parallelism between (a) the neurological development of the human brain and its psychological functions and (b) the evolution of the species and the ontogenetic development of the child. After reviewing several bits of neurophysiological evidence, Werner (1948) concludes: "Indeed it does appear that the development of biological forms is expressed in an increasing differentiation of parts and an increasing subordination, or hierarchization" (p. 41). Subsequently, Werner cannot help postulating that "since living organism is a psychophysical unit, one has to expect a correspondence in mental development and in physico-biological genesis" (p. 41). In this respect Werner's views are similar to Burt's (1954) whose review of the neurological evidence, as well as of a number of psychological studies, led him to a reassertion of the differentiation hypothesis. Gesell's (1954) description of the "principle of individuating maturation" and his generalization that "the sequential patterning expresses itself in progressive differentiations within a total action system" (p. 356) is another expression of the same viewpoint.

Although the differentiation hypothesis has been discussed in one form or another for generations, its prominence in American psychology is mainly attributable to Garrett's (1946, p. 373) statement that "abstract or symbol intelligence changes in its organization as age increases from a fairly unified and general ability to a loosely organized group of abilities or factors." His summary of the then existing evidence seemed to support the hypothesis. An examination of the investigations between 1946 and 1964 (see Anastasi, 1958; Werner, 1964), however, does not provide any conclusive evidence for or against the differentiation hypothesis even if it is modified to apply only to the first 18 years of life. Most of these studies, however, suffer from two or more of such methodological inadequacies as (a) non-comparability of tests at different age levels, (b) non-equivalence of reliability, even when the tests are the same, at different age levels, (c) group differences in heterogeneity (since most of these studies are cross-sectional), (d) inappropriate selection of subjects (inadequate sampling procedures), (e) lack of control over sex representation at various age levels, (f) differences in educational, cultural, occupational, ethnic, and socioeconomic backgrounds, (g) inappropriate method of analysis, and (h) inadequate representation of the spectrum of human abilities due to certain test selection procedures.

A recent study (Quereshi, 1967) in this area represented an attempt to overcome at least seven of the eight limitations listed above. The results clearly corroborated the differentiation hypothesis as elaborated into the following three implications: (a) the percentage of variance accounted for by the general factor should gradually decrease from age to age, with the highest percentage at the youngest and the lowest at the oldest age levels, (b) the percentage of variance contributed by each of the group factors involved should gradually increase with age, from the lowest for the youngest to the highest for the oldest age group, and (c) the average intercorrelation of the factors should decline as age increases, i.e., the factors should become more independent of each other with increasing age.

The critical reader at this stage may wonder whether it is justified to cite Koffka, Lewin, and Piaget on the topic of progressive cognitive differentiation and then imperceptibly drift into a psychometric (correlational) interpretation and verification of essentially non-summative theories of cognitive development. Further, he may question the representativeness of various standardized tests, even if they are as well-known and as carefully constructed as the Stanford-Binet or the Wechsler Scales, to gauge the totality of mental functions and capabilities. Further still, he may argue that it is more meaningful to inquire, whether by means of correlational analysis or other procedures, into the conditions that bring about or modify trait organization rather than perseverate in the static description of factor patterns. It is important that these criticisms be evaluated within the context of the tenets of the scientific method and the realities of the available investigative tools and techniques. If one were to follow the field theorists or Piaget literally, it would be extremely difficult, if not impossible, to solve the problem of constructing coordinating and operational definitions to satisfy the conceptual requirements of their models and, at the same time, meet the canons of the scientific method--this remark applies only in connection with the differentiation hypothesis. For example, Piaget, after discussing the sequential transformation (repetition, generalization, and differentiation) of schemas, comes to a poetic conclusion that "in the last analysis these three forms are but one" (Flavell, 1963, p. 56). Without for a moment devaluing Piaget's contribution to psychology, one may ask how one would distinguish among three operations (equivalent to the three corresponding Piagetian concepts) and still treat them as "one" experimentally. The concepts of "generalization," "differentiation," and "rigidity," etc. have ready-made equivalent operations in statistical analysis and, therefore, should be subjected to such investigation. If there are complex hierarchies of structure and organization, there are appropriate statistical analyses capable of detecting their existence and transformation.

The other two points raised above can be best answered in the following manner. Tests like Stanford Binet and Wechsler were designed to deal with certain practical problems; and they have, within reasonable limits, served those purposes adequately. It is practically impossible to construct a manageable test which would adequately encompass the total spectrum of human characteristics, especially of individuals nurtured in a complex ecological milieu. It is, therefore, of some consequence to know what some of the most commonly employed instruments are measuring and whether these psychological functions--and changes in their interrelations--can be adequately depicted by a few general principles. Although it may be more meaningful to know how these changes are caused, it is at the same time of some importance to know what the changes are and what course they take.

Statement of the Problem

The present study provided a valuable opportunity to investigate (a) functional regularities in the course of cognitive development as measured by the Wechsler Intelligence Scale for Children (WISC) between 5 and 16 years, and the Wechsler Adult Intelligence Scale (WAIS) between the ages of 16 and 18, by employing suitable statistical procedures (see Treatment of Data) and

(b) verifying the validity of the differentiation hypothesis with respect to its three possible deductions as mentioned previously. However, it is expected that the differentiation hypothesis, in terms of its three deductions, will have to be modified in the following fashion: (a) the percentage attributable to the general factor will decrease gradually until about the age of 10 to 12 and reach a plateau thereafter; (b) the percentage of variance contributed by various group factors will increase with age, but will taper off at about 10 to 12 years and reach an asymptote thereafter; and (c) the average intercorrelation of factors (general and group together) will decline gradually and reach an asymptotic level at about the age of 12.

Although there are now available, either in published or unpublished form, a total of five studies which have conducted a factor analysis of either WBI (Hammer, 1950) or WAIS (Cohen, 1957) or WISC (Cohen, 1959; Gault, 1954; Hagen, 1952) data, based on normal subjects, over three to five age levels of the age range encompassed by these instruments, none of these studies employed a factor analytic method suited to the purpose of extracting a general factor and, at the same time, allowing for the emergence of group factors. Hagen (1952) specifically attempted to investigate the differentiation hypothesis and went to great lengths in attenuating the effects of discrepant reliabilities at the various age levels, but she neither corrected for variable heterogeneity at the different age levels nor used a method that was suited to this type of problem (for a detailed discussion of this issue see Burt, 1950; Burt, 1954; Quereshi, 1967). The same criticisms apply, with equal or greater force, to the other four studies (Cohen, 1957; Cohen, 1959; Gault, 1954; Hammer, 1950). It may be pointed out parenthetically that all of these five studies utilized the standardization data for the various scales provided by Wechsler and their results have never been cross-validated over the given age ranges. Furthermore, in the present study, it would be possible to accomplish two additional tasks which cannot be performed by means of analyzing Wechsler standardization data or any other data known to have been collected so far with the Wechsler scales: (a) To verify the results of factor analysis secured from the WISC and WAIS scores on the first testing with comparable data obtained from the second testing of the same individuals with these scales. (b) To provide a conceptual and experimental link between the WISC and WAIS measures at the age of 16 years (see details which follow).

METHOD

The data for the present study were obtained by testing and retesting with the WISC and WAIS 514 subjects (Ss) between the ages of 5 and 18 years. The details about the procedures for selecting these Ss and collecting the needed data are given below.

Subjects

Selection of Ss. In order to secure a fairly representative sample of the urban population and in view of practical considerations, the City of Milwaukee was chosen as the source of selection. According to the 1960 U.S. census, metropolitan Milwaukee has a population of over one and a quarter million. The two largest school systems in the City of Milwaukee, comprising about 95% of the total school population from kindergarten through high school, had enrollments of approximately 123,000 and 50,000 at the end of the 1964-65 academic year. After carefully considering a number of practical factors, it was decided to choose the sample from the latter school system despite the fact that it was only about 41% of the former in size. Of 530 children originally selected, complete data (testing and retesting with the WISC and/or WAIS) were secured for 514 Ss between the ages of 5 and 18 years. The sample was chosen in the following manner:

a. The selected school system, constituting the population in this case, consisted of 71 elementary (66 covering grades 1 through 8 and 5, grades 1 through 9) and 12 high schools (grades 9 through 12), excluding 7 elementary schools and one high school which chiefly served certain special groups such as the deaf, blind, emotionally disturbed, etc.

b. Ten of the 71 elementary and one out of 12 high schools were selected at random.

c. A quota of Ss, roughly proportional to the enrollment of a school, was assigned to each of the 10 elementary schools for the Ss between 5 and 14 years, while all Ss between 14 and 18 years were drawn from one randomly-selected high school.

d. All the children within certain age brackets (described in detail later) in the respective elementary schools were counted and the quotas were filled by randomly selecting children from each age segment. Equal representation was given to both sexes at all of the age levels, and the numbers in each of the age groups, with the exception of 15-year-olds, were approximately the same. The number of Ss at the 15-year level was about twice as large as that in any other age group. A detailed description of the total sample (N = 514) by age, grade, sex, socioeconomic status, and other pertinent demographic characteristics is available elsewhere (Quereshi, 1968a).

Range of Intelligence. No attempt was made to impose any restrictions by excluding any of the extremely bright or dull Ss. The present sample, therefore, includes children at all levels of intelligence that may occur in the general school population. However, care was exercised to exclude children who had any sensory or physical handicap or who suffered from any behavioral or emotional disturbance.

Distribution by Age and Sex. Seven age groups were sampled, beginning at age 5 and continuing by two-year intervals, through 17 years. With the exception of the 5-year group, each S was tested so that he/she was neither older nor younger than his/her respective age level by more than 6 months. The 5-year-olds were all between the ages of 5-0 and 6-0. At each age level, the number of males was identical to that of females. The seven age groups, from the youngest (5-0 to 6-0) to the oldest (16-6 to 17-6), consisted of 62, 68, 66, 64, 68, 124, and 62 Ss, respectively.

Socioeconomic Status. A careful examination was made of the occupational and educational levels of the head of household for every child in this study in order to assign him/her a socioeconomic category. The total group was broken down into three socioeconomic classes, determined on the basis of parental occupation and education as explained previously (Quereshi, 1961, 1964).

Nationality of Descent and Racial Background. No attempt was made to control the nationality of descent or the ethnic background of the Ss included in the above sample. However, Ss in whose home a language other than English was regularly spoken were excluded from the study. Of 514 Ss, 491 were whites and 23 nonwhites.

Instruments and Procedure

The selected children, sampled in the manner described above, were tested individually in the rooms set aside for this purpose in the respective schools. The WISC was administered to children between 5 and 14 and the WAIS was given to the Ss between 16-6 and 17-6. The 14-6 to 15-6 group was given both WAIS and WISC in a counterbalanced order so that half of the group (62 Ss, 31 males and 31 females) were tested with WISC but retested with WAIS, while the other half (62 Ss, 31 males and 31 females) were originally tested with WAIS but were retested with the WISC. All of the 514 Ss were tested and retested in accordance with the following schedule.

The first testing with the WISC or WAIS, depending upon the age of the Ss and the design of the experiment as described above, was carried out during the first semester of the school year. The same 514 Ss were retested with the WISC or WAIS after an elapse of approximately three months from the date of initial testing. All the testing was done by five (two males and three females) trained graduate examiners who were native-born, white Americans between the ages of 21 and 55 years. In order to control the examiner effects, care was taken to have a child retested by the same person as long as it did not seriously affect the completion of all testing by a certain deadline. In all, about 80% of Ss were tested on both occasions by the same examiner and 90% were retested by the examiner of the same sex.

It may be appropriate to mention that data were collected on 11 of the 12 subtests comprising the WISC (Mazes subtest was excluded) and on all 11 subtests included in the WAIS. Furthermore, in the case of 7 subtests (Information, Comprehension, Arithmetic, Similarities, Vocabulary, Digit Span, and Picture Completion), testing was carried out to the point of 6 consecutive failures instead of the discontinuance limits recommended by Wechsler (1949, 1955, 1958). However, the data for this study have been obtained in complete conformity with the discontinuance procedures laid down by Wechsler and are comparable to scores that might have been obtained had the testing with these 7 subtests been discontinued exactly at the points set down by Wechsler. Otherwise, there was no modification of the cutoff procedures regarding the other four subtests nor of any other rule or dictum pertaining to the administration or scoring of any of the 11 WISC and/or WAIS subtests included in the present investigation.

Treatment of Data

In order to achieve the primary as well as the secondary objectives of this study, the data were subjected to the following treatment:

Reorganization of Data. In view of the nature of the statistical analysis selected for this study, it is essential that the groups should be appreciably large (i.e., not less than 100). For this purpose, the seven age groups were reconstituted into four separate groups as follows:

No.	New Age Group and its Designation	Composed of Age Groups	N
1.	7-year-olds	5-0 to 6-0 and 6-6 to 7-6	130
2.	10-year-olds	8-6 to 9-6 and 10-6 to 11-6	130
3.	14-year-olds	12-6 to 13-6 and half of 14-6 to 15-6 who were given WISC first	130
4.	17-year-olds	16-6 to 17-6 and half of 14-6 to 15-6 who were given WAIS first	124

In accordance with the procedure and rationale described in the succeeding paragraphs, four additional variables were introduced. The Pearson rs were then computed for these 15 variables for each of the four age groups separately.

Choice of an Appropriate Method of Factor Analysis. Factor analysis is a convenient device for summarizing the covariant information contained in a set of measurements. However, it is important to realize that any single factor-analytic method cannot be equally suitable for all types of problems. For example, general summational methods (e.g., principal component, centroid, etc.), accompanied by certain analytic rotational devices, provide satisfactory solutions when the purpose is either to summarize correlational data for the purpose of differential description and prediction or to explore the clustering of variables where no previous non-subjective information is available. But these methods are inappropriate when one has to allow for the emergence of group factors (hypothesized on the basis of previously available information about the character of the constituting variables and their role in a particular theory) whose variance, by fiat, is distributed among a multiple of factors simply designed to account for the maximum possible variance on each iteration. In studying developmental problems of the type indicated here, summational methods may be used as exploratory devices to identify clusters of variables that "hang together" but their usefulness ends right there. Burt (1950, 1954) was perhaps the first one to point out the unsuitability of the general summational methods and suggested an alternative procedure with an appropriate demonstration of its applicability. In the present study, a choice can be made between Burt's method or a procedure exemplified in a recent study (Quereshi, 1967) of developmental patterns in psycholinguistic functions. Since Burt's method presumably requires that the same hierarchical arrangement of the variables under scrutiny prevail at the different age levels, it seems defensible to employ a procedure which does not impose any such restriction on the data. Briefly, the suggested procedure is a modification of the square root method in which one general and any number of group factors (depending on the total number of variables and the nature of the theoretical problem involved) are constituted beforehand on the basis of the available empirical and/or theoretical knowledge about their nature and composition. Table 1 presents the five pivotal variables (hypothesized factors), the procedure by which they were defined, and the rationale that underlies their constitution. The correlation of the general factor, A, with each one of the other 14 variables, was corrected for spuriousness that results from part-whole correlation. Also all correlations, at each one of the four age levels, were corrected for (a) attenuation due to differences in reliability of the respective variables (using the usual correction for bivariate attenuation formula) and (b) correlational discrepancies due to age differences in group heterogeneity (Quereshi, 1968a). (The correlations, it may be added, were based on the scaled scores for the 11 subtests at the respective age levels.) The 15 x 15 correlation matrices thus constituted were subjected to a square root analysis (with unities in the diagonal) for each of the four age groups separately, pivoting on the reference variables A, B, C, and D, respectively.

Validation with the Retest Data. With appropriate adjustments in the partition of the 14-6 to 15-6 group, the same hypothesized factors were extracted from the matrices constituted in a manner identical to that outlined above but based on the retest data. Such a procedure was necessary for securing corroborative evidence within the confines of the same population in addition to the cross-population verification afforded by the analysis above.

Determination of the Plateau of Differentiation. It was indicated previously that the differentiation of abilities is expected to reach an asymptotic level during early teens (at about 12 or 13 years). In order to specifically verify this assertion, with respect to the WISC data, scores for the 12-6 to 13-6 group (N = 68) were analyzed separately in the same fashion as the four groups mentioned above. Although the N for this age group was less than 100, it was considered justifiable to carry out this analysis, as a special case, once the general trends based on larger groups had been established.

Table 1

Pivotal Variables in Factor Analysis Based on 15x15 Correlation Matrices

For the Various Age Groups

Label	Procedure for Forming	Rationale
A	Sum of scores on all 11 subtests	A general ability factor should have loadings on all variables comprising either the WISC or WAIS.
B	Sum of scores on Information, Comprehension, Similarities, and Vocabulary	These four subtests have been shown (Gault, 1954, p. 87; Hammer, 1950) to have high loadings on the same factor (factor III in Gault's).
C	Sum of scores on Arithmetic, Digit Span, Picture Arrangement, and Coding	The same as for B above. This is factor IV in Gault's analysis.
D	Sum of scores on Picture Completion, Block Design, and Object assembly	The same as for B above. This is factor II in Gault's analysis.

Cross-validation of Past Factor-analytic Findings. This was a secondary objective of the present study. In order to verify the results obtained with the Wechsler Scales, utilizing the general summational methods (see Cohen, 1957; Cohen, 1959; Gault, 1954; Hagen, 1952; Hammer, 1950), data of both testings, for each of the four age groups were factor-analyzed separately. For this purpose, the eight matrices were analyzed by means of the principal axis method, employing varimax rotation.

The reader may question the need for this analysis, especially after the analyses bearing on the main hypothesis have been completed. As already mentioned, this analysis represents a secondary consideration, but it would provide evidence for or against the interpretations of the WISC and WAIS based on past, traditional analyses. The choice here of the principal axis method, with varimax rotation, is due to the fact that it provides more satisfactory solutions than those yielded by Thurstone's centroid method.

The reason for carrying out these analyses subsequent to, instead of preceding, the verification of the main hypothesis chiefly resides in the strategy that, wherever possible, hypotheses should be formulated in the light of the past studies and verified before the tendency of "data snooping" leads to their instantaneous modification.

The Test of Invariance of Factors. The present investigator has elsewhere (1967b) identified four different meanings that can be assigned to factorial invariance in various contexts. In the present study, however, the main concern was to determine the consistency of factors A, B, C, and D for a fixed set of variables (11 WISC and/or WAIS subtests) across (a) the four age groups for each of the two testings separately, (b) the two testings (within the same age level) for each of the four age groups separately, and (c) the four age levels when performance for one of the compared groups is based on the first testing and for all others on the second testing. Cases (a) and (c) are clear-cut situations for the application of Tucker's (1951) coefficient of congruence, while case (b) is solvable by means of the usual tests for correlated factor loadings (analogous to correlated correlations). Appropriate coefficients, therefore, were computed and evaluated accordingly.

Extraction of the Postulated Factors

In accordance with the method and rationale specified previously, four factors were postulated and extracted from each of the correlation matrices, both before and after making corrections for attenuation and for differential variability, at the four reconstituted age levels of 6, 10, 14, and 17 years. The results of the factor analysis utilizing the uncorrected correlations are presented first, followed by a discussion of those based on the corrected intercorrelations. Tables 2, 3, 4, and 5 embody the factor loadings of the WISC/WAIS variables at the four age levels, both for the first (F) and second (S) testings, for factors A, B, C, and D, respectively. The percents of variance attributable to these factors across the age levels are also presented in the respective tables.

Examination of the percents of variance for the general factor A indicates no consistent trend with respect to age. Thus, the prediction that the general factor decreases in importance with increasing age is not borne out by the WISC/WAIS data for the given age levels. A derivative prediction that the group factors would account for increasingly larger amounts of variance as age increases is also not supported by the data of the present study, since the percents of variance for the three postulated group factors (B, C, and D) do not follow any such trend. The data of the second testing in Tables 2, 3, 4, and 5 generally seem to follow those of the first testing, and hence do not corroborate the differentiation hypothesis or any of the deductions therefrom.

The results of the factor analysis, based on the correlation matrices corrected for attenuation and for differential variability, are completely consonant with those based on uncorrected <u>r</u>s insofar as the general factor A, presented in Table 6, is concerned. The results of the group factors, however, are uninterpretable because a number of them turn out to be imaginary factors as indicated by the respective negative diagonal residuals. Errors of this sort occur when the off-diagonal entries of a postulated factor are larger than the diagonal values. Furthermore, it seems that the correction for attenuation unduly enhances the role of the general factor at the expense of everything else. Since corrections for attenuation in the present study (as well as in many others) have taken into consideration the internal consistency reliability, the obliteration of other factors and the magnification of the general factor seem to be the artifacts of the correction for attenuation formula. Hence, further studies concerned with investigating the postulated group factors should avoid the pitfalls of correcting for attenuation. In the present study, therefore, all subsequent analyses involving postulated factors are based on uncorrected <u>r</u> matrices and corrected <u>r</u>s are utilized only when a general summational method (i.e., principal axis) is employed to obtain data for comparison with some of the past studies (e.g., Hagen, 1952).

<u>Analysis Based on Eight Groups</u>. The same four postulated factors were extracted from the uncorrected <u>r</u> matrices for the eight age levels. Table 7 embodies the percents of variance attributable to these factors for both the first and second testings. The results, with respect to the differentiation hypothesis, are in accord with those based on the

Table 2

Loadings of the WISC/WAIS Subtests on Factor A (Uncorrected) at the Four Age Levels on the First (F) and Second (S) Testings

Subtests	7 F	7 S	10 F	10 S	14 F	14 S	17 F	17 S
I	55	58	66	72	60	61	56	52
C	55	33	43	53	42	34	61	50
A	44	51	63	63	37	55	56	55
S	39	59	50	52	61	60	48	57
V	58	51	71	66	66	65	71	60
D	57	46	12	24	22	34	38	28
PC	38	33	44	55	54	56	46	58
PA	59	47	46	39	35	24	44	44
BD	40	41	62	60	50	61	66	58
OA	46	46	59	57	48	42	44	45
Cod/DS	36	12	38	36	24	30	19	11
Percent of Variance	31	27	35	36	28	31	33	30

Note.--Decimals are omitted; all values are reported to two decimals.

Table 3

Loadings of the WISC/WAIS Subtests on Factor B (Uncorrected) at the Four Age Levels on the First (F) and Second (S) Testings

Subtests	7		10		14		17	
	F	S	F	S	F	S	F	S
I	40	50	51	48	57	59	51	59
C	57	60	61	56	68	56	57	66
A	12	20	19	26	21	27	28	31
S	53	53	51	49	52	54	56	47
V	62	66	55	52	62	60	53	61
D	21	21	02	08	10	09	05	11
PC	03	19	11	25	24	26	10	14
PA	14	08	17	13	11	02	14	12
BD	06	11	10	09	05	13	22	06
OA	14	10	14	04	11	02	03	02
Cod/DS	09	-10	07	04	03	-01	07	05
Percent of Variance	13	15	14	13	16	15	14	16

(Age Levels: 7, 10, 14, 17)

Note.--Decimals are omitted; all values are reported to two decimals.

Table 4

Loadings of the WISC/WAIS Subtests on Factor C (Uncorrected) at the Four Age Levels on the First (F) and Second (S) Testings

Subtests	Age Levels 7 F	7 S	10 F	10 S	14 F	14 S	17 F	17 S
I	07	09	-01	00	-05	-05	00	-10
C	-07	-15	-09	-06	-06	-08	-06	-10
A	45	43	42	32	40	42	39	37
S	-14	00	-08	-07	-03	-06	-18	06
V	-09	-16	-09	-05	-10	-05	05	-03
D	42	51	45	51	60	58	64	61
PC	21	01	11	-08	01	-01	06	01
PA	48	48	43	48	49	45	38	34
BD	13	11	14	10	15	14	02	11
OA	07	20	11	17	03	14	08	00
Cod/DS	55	66	57	58	57	62	50	58
Percent of Variance	11	13	11	10	13	13	11	11

Note.--Decimals are omitted; all values are reported to two decimals.

Table 5

Loadings of the WISC/WAIS Subtests on Factor D (Uncorrected) at the Four Age Levels on the First (F) and Second (S) Testings

Subtests	7 F	7 S	10 F	10 S	14 F	14 S	17 F	17 S
I	05	-09	-03	00	-01	-04	-09	-02
C	-05	-09	-22	-14	-25	-18	00	-04
A	01	-04	01	-02	-06	-12	-06	-03
S	01	00	02	-01	06	04	02	-01
V	-11	-03	02	-01	-02	-07	-10	-07
D	-05	-18	-07	-10	-17	-11	-01	-10
PC	54	48	56	52	46	51	52	57
PA	09	18	02	04	04	12	10	22
BD	60	61	57	58	68	58	50	63
OA	57	57	53	03	70	64	73	78
Cod/DS	-12	05	01	00	13	03	-06	-09
Percent of Variance	11	11	10	10	13	11	12	14

Note.--Decimals are omitted; all values are reported to two decimals.

Table 6

Loadings of the WISC/WAIS Subtests on Factor A (Corrected $\underline{r}$ Matrices) at the various Age Levels on the First (F) and Second (S) Testings

Subtests	Age Levels: 7		10		14		17	
	F	S	F	S	F	S	F	S
I	76	91	87	90	77	82	98	86
C	77	55	57	76	50	57	98	81
A	60	81	74	71	51	77	88	94
S	50	86	63	74	81	92	93	97
V	69	68	90	80	87	86	98	93
D	79	62	25	42	30	49	73	53
PC	52	52	58	76	71	74	98	95
PA	75	63	59	47	53	38	91	97
BD	58	59	78	70	54	76	98	87
OA	71	69	91	87	60	83	70	72
Cod/DS	51	16	50	45	29	41	37	17
Percent of Variance	54	51	55	58	43	56	81	71

Note.--Decimals are omitted; all loadings are reported to two decimals.

Table 7

Relative Prominence of the General and Group Factors at the Eight Age Levels

Factors	First Testing							
Age (Years)	5	7	9	11	13	15(1)	15(2)	17
A (General)	31	26	39	29	35	18	31	36
B (Group)	14	13	12	15	14	19	14	13
C (Group)	12	11	10	12	12	14	12	11
D (Group)	11	12	9	12	11	16	11	12
Total	68	62	70	68	72	67	68	72
Mean Inter-factor *r*	.532	.488	.640	.488	.539	.275	.522	.569
	Second Testing							
A (General)	32	23	38	35	35	26	21	33
B (Group)	13	17	12	13	14	16	19	13
C (Group)	12	14	10	11	13	12	13	11
D (Group)	8	14	11	9	11	12	17	14
Total	65	68	71	68	73	66	70	71
Mean Inter-factor *r*	.587	.349	.621	.582	.546	.460	.308	.518

Note.--The data reported are percents of variance attributable to each factor. Ns for the respective age groups are 62, 68, 66, 64, 68, 62, 62, and 62 respectively. The 15(1) group was administered WISC and 15(2), WAIS, as explained previously. The mean inter-factor *r* bears on the third deduction of the differentiation hypothesis (i.e., the mean inter-factor *r* decreases as the age increases) which, of course, is not corroborated by these data.

uncorrected r matrices for the four age groups, i.e., they do not support the hypothesis or any of its implications. Thus, one can conclude safely that the WISC/WAIS data sample abilities which remain at more or less the same level of differentiation at all age levels between 5 and 18 years, a finding in agreement with previous analyses (Cohen, 1959; Cohen, 1957; Hagen, 1952).

Results of the Principal Axis Analysis

A number of factor analyses employing the principal axis method, accompanied by varimax rotation, were conducted: (a) analysis of uncorrected r matrices based on the four reconstituted age groups (6, 10, 14, and 17 years) for the first and second testings, (b) analysis of corrected r matrices for the same groups and testings as in (a), and (c) analysis of uncorrected r matrices for the eight age groups (5, 7, 9, 11, 13, 15-1, 15-2, and 17 years) on both testings.

In each of the three aforementioned conditions first three, then four, and finally five factors were extracted and rotated. Examination of the data (factor loadings and percents of variance) indicated that three factors were too few (percent of variance accounted for was seldom over 60) and five factors were too many (at least one and in some cases two factors turned out to be specific. The four factor solution in general provided factors that could be meaningfully interpreted and compared with the results of the previous studies (Cohen, 1957; Cohen, 1959; Hagen, 1952).

The results of the analyses involving the extraction of four factors at each of the four reconstituted age levels, for the first testing, are presented in Table 8, while Table 9 incorporates the results of identical analyses utilizing the data of the second testing. Examination of the loadings of Factor I indicates that it is primarily a verbal factor since it has substantial loadings on Information, Comprehension, Arithmetic, Similarities, and Vocabulary subtests at almost all of the age levels. At the first age level, however, Arithmetic loading is essentially zero, but gradually this subtest loads more and more heavily until at age 17 it reaches .65. Another subtest, Information, shows the same developmental trend as does Arithmetic, but it seems to reach a plateau at about the age of 14 since the loadings of Information at ages 14 and 17 are about the same in magnitude. Thus the characteristics measured by Information and Arithmetic subtests of the Wechsler scales gradually become more important in their contribution to the overall verbal comprehension and expression between the ages of 7 and 17 years. The foregoing fact simply mirrors the increasing emphasis placed on the acquisition of general information and the development of arithmetical skills, both inside the school and outside, during childhood and adolescence. In the context of the previous findings, Factor I is roughly comparable to Factor A in Cohen's studies of the WISC (Cohen, 1959, p. 287) and WAIS (Cohen, 1957, p. 284) and may be named Verbal Comprehension and Expression.

Factor II in the present study is almost identical to Factor B in Cohen's 1959 study (p. 287) since it consistently loads significantly on Block Design and Object Assembly at all of the age levels, but loads substantially on Picture Completion at the older age levels only and on Picture

Table 8

Principal Axis Analysis with Varimax Rotation of Four Factors Based on the Data of First Testing at the Four Reconstituted Age Levels

	Factor I				Factor II				Factor III				Factor IV			
Subtest Age	7	10	14	17	7	10	14	17	7	10	14	17	7	10	14	17
I	30	67	80	75	16	39	21	12	70	11	05	14	08	17	06	01
C	74	88	77	72	09	-09	-15	25	19	06	13	11	22	10	14	09
A	05	31	49	65	15	41	11	08	82	19	36	36	00	60	-04	07
S	71	49	60	74	34	42	29	22	-04	-24	-05	-17	-11	16	41	-04
V	76	77	84	78	00	40	23	19	32	06	04	32	21	11	08	06
D	39	05	18	13	12	06	-06	10	56	94	84	84	25	04	06	18
PC	-12	09	43	21	34	70	43	70	46	28	-16	04	42	01	46	15
PA	30	40	11	23	52	45	06	39	17	05	17	55	49	03	89	-23
BD	04	14	21	48	74	77	82	61	13	-07	13	17	18	34	00	-01
OA	26	22	18	08	74	71	82	84	20	-08	-06	12	-10	23	14	-03
Cod/DS	16	08	-14	11	03	13	49	08	06	-05	52	08	88	92	17	94
Percent of Variance	19	22	26	27	15	22	18	18	18	10	11	12	13	13	11	9

Note.--Decimals are omitted; all loadings are reported to two decimals.

Table 9

Principal Axis Analysis with Varimax Rotation of Four Factors of the WISC/WAIS Data Based on the Second Testing at the Four Age Levels

	Factor I				Factor II				Factor III				Factor IV			
Subtests Age	7	10	14	17	7	10	14	17	7	10	14	17	7	10	14	17
I	63	79	75	83	22	23	32	16	33	17	13	-09	13	18	-18	-04
C	69	80	69	73	-02	-04	-34	14	-19	19	12	07	16	05	24	06
A	47	59	57	62	24	47	08	18	47	35	47	47	05	-20	08	-10
S	68	60	69	62	39	32	32	31	00	-08	-02	16	-03	02	22	08
V	77	73	84	81	10	21	19	13	-03	10	14	18	24	21	-07	07
D	55	13	21	14	20	07	04	02	44	89	80	92	-36	05	-13	12
PC	27	61	55	30	10	24	42	76	13	-17	-02	-05	80	35	28	05
PA	13	20	06	26	75	17	18	62	20	07	03	-08	04	88	89	10
BD	08	32	35	16	70	74	75	78	02	-06	16	32	38	18	16	-15
OA	20	28	08	03	79	80	78	84	03	00	18	05	-09	01	11	03
Cod/DS	-16	01	-03	04	05	62	24	05	85	27	73	08	12	21	16	97
Percent of Variance	24	28	28	26	18	19	16	22	12	10	14	11	9	10	10	9

Note.--Decimals are omitted; all values are reported to two decimals.

Arrangement at the younger age levels only. Although Cohen's (1959) factors are not orthogonal like those of the present study, the close correspondence in the pattern of significant loadings seems to justify its name as Perceptual Organization. The data in Table 9, based on the second testing, seem to corroborate the conclusions based on those of the first testing, especially with regard to Factor II.

The subtest with consistently high loadings across the age levels on Factor III, is Digit Span. Arithmetic and Picture Arrangement have substantial loadings on this factor only occasionally (i.e., Arithmetic has a loading of .82 at age 7 and Picture Arrangement has a loading of .55 at age 17). The data of second testing given in Table 9 follow the same pattern with regard to the loadings of Digit Span and Arithmetic, but Picture Arrangement seems to fall out of the picture. Factor III in this study seems to be congruent with Factor C in past studies (Cohen, 1957, p. 285; Cohen, 1959, p. 287). The loadings of Arithmetic on the second testing are in striking accord with the data on the adult population between 18 and 75 years (Cohen, 1957, p. 285). This factor, therefore, may be named Freedom from Distractability in order to facilitate the comparison of our findings with those of the past studies.

Factor IV in the data of the first testing (Table 8) seems to load consistently on Coding/Digit Symbol subtest in the Wechsler Scales. Picture Arrangement has substantial loadings on this factor at two age levels (7 and 14) years). If only the significant loadings (.40 or above) are taken into consideration, this factor is strikingly similar to Factor E in two past studies of the Wechsler scales (Cohen, 1959, p. 287; Cohen, 1957, p. 286). Thus this factor has emerged consistently in the present study comprising the ages 7 thru 17 and previous studies extending over the age of 7½ years to 75 years. However, this factor does not emerge with equal regularity in the data of the second testing (Table 9) indicating that it is more subject to practice effects than any other factor. This factor, on the average, accounts for about 10 percent of the total variance and hence cannot be dismissed as unimportant, especially since it has emerged consistently in three different studies with the Wechsler scales conducted with widely divergent age groups and populations. Also, occasionally other subtests which are timed load on Factor IV and, with practice (data of the second testing in Table 9), the variance may shift from Coding/Digit Symbol to Picture Arrangement or Picture Completion. It seems, therefore, justifiable to label this factor as Perceptual Speed in as much as it appears only on those subtests which are subject to speeding and include aspects of performance which are readily susceptible to practice effects.

<u>Analyses Based on Corrected r Matrices</u>. Results of the principal axis factor analyses of corrected <u>r</u> matrices are presented in Tables 10 and 11 which report the factor loadings, etc. for four factors based on the first (Table 10) and second (Table 11) testings, respectively. The relative contributions of various subtests to the factors involved are the same as those based on uncorrected matrices, and hence the interpretations of these factors (and the conclusions therefrom) remain the same. The only noteworthy change is in the percents of variance attributable to each factor as well as the total percents of variance accounted for by four factors together at any one age level. In general, the percentage of variance attributable to

Table 10

Principal Axis Analysis with Varimax Rotation of Four Factors Based on the Data of First Testing at the Four Age Levels (Corrected r Matrices)

	Factor I				Factor II				Factor III				Factor IV			
Subtests Age	7	10	14	17	7	10	14	17	7	10	14	17	7	10	14	17
I	37	66	80	90	26	41	12	18	74	26	07	43	14	29	39	06
C	79	94	84	88	20	06	-08	25	15	08	12	20	29	07	13	15
A	12	34	30	72	13	31	10	17	91	36	10	30	05	69	84	21
S	60	49	74	93	61	42	48	33	01	-25	04	-01	-21	38	09	01
V	85	80	85	74	04	41	30	16	28	18	06	51	16	18	19	07
D	41	12	19	20	31	02	-05	16	63	93	87	84	31	-02	16	30
PC	-09	07	50	55	31	54	64	70	54	51	14	39	46	29	07	14
PA	24	36	45	43	56	74	34	43	18	05	46	78	59	-06	-28	-18
BD	01	12	03	71	68	79	79	63	32	08	22	31	28	44	32	10
OA	19	28	14	21	85	84	88	98	29	06	08	15	09	32	-11	04
Cod/DS	27	09	-07	16	04	14	38	06	13	-05	67	12	88	89	04	96
Percent of Variance	20	23	29	42	20	26	22	21	22	13	14	20	15	17	10	10

Note.--Decimals are omitted; all loadings are reported to two decimals.

Table 11

Principal Axis Analysis with Varimax Rotation of Four Factors Based on the Data of Second Testing at the Four Age Levels (Corrected r Matrices)

Subtests	Factor I				Factor II				Factor III				Factor IV			
Age	7	10	14	17	7	10	14	17	7	10	14	17	7	10	14	17
I	68	84	76	96	31	23	47	31	40	35	16	00	22	18	-17	-06
C	84	86	89	88	03	02	-15	20	12	36	04	10	-09	07	13	11
A	38	51	69	75	36	43	15	29	61	56	50	57	23	-27	11	-09
S	61	73	77	74	37	38	45	51	46	06	03	40	-03	07	32	11
V	89	76	90	88	11	25	28	26	12	19	14	32	16	21	-04	14
D	24	21	33	22	13	08	11	04	91	86	82	98	10	11	-15	15
PC	37	78	59	46	18	34	53	87	-01	-10	-02	-01	[illegible]	28	37	09
PA	06	28	11	40	77	20	28	81	32	11	06	09	14	86	89	02
BD	26	37	23	17	84	82	90	87	-14	-03	19	31	15	14	15	-12
OA	09	44	11	08	77	85	87	92	35	17	36	-04	-01	06	30	12
Cod/DS	-16	-02	-05	07	06	64	22	03	21	42	81	11	96	27	19	97
Percent of Variance	25	35	35	37	21	22	23	32	17	14	16	15	17	10	11	10

Note.--Decimals are omitted; all loadings are reported to two decimals.

each factor increases at a given age level (when compared to the corresponding percentage due to a factor based on an uncorrected r matrix), while the percentage of variance accounted for by four factors together is invariably larger than the corresponding percentage based on the uncorrected r matrix. These trends are in line with what is expected. However, some factors gain substantially more variance than others at certain age levels (e.g., Factor I on the first testing data at age 17 and Factor II on the second testing data at age 17), and the reasons for such differential gains may deserve further analysis.

Analyses Based on Uncorrected r Matrices for Eight Groups. Perhaps the main function served by these analyses is to provide an empirical justification for the procedure of forming four age groups out of the original eight, a step designed to obtain more stable and dependable results. Examination of Tables 12 and 13 (which report the analyses based on the first and second testings, respectively, for the original eight groups) indicates that the strategy to reconstitute the eight groups into four (as specified previously) was amply justified. In general, the factors based on the eight age groups do not emerge as clearly and consistently as they do in the case of four reconstituted age groups. The irregularities in the case of some factors (e.g., Factor IV in Table 13) are so marked that it would have been very difficult to provide any succinct explanation for them had it not been for the analyses based on the reconstituted age groups.

Test of Invariance of Factors

To estimate the congruence of the postulated factors (A, B, C, and D), Tucker's (1951) coefficients of congruence were computed, for the given set of variables (11 WISC/WAIS subtests), across (a) the four age groups for each of the two testings separately, (b) the two testings, within the same age level, for each of the four age groups separately, and (c) the four age levels when performance for one of the compared groups is based on the first testing and for all others on the second testing. Table 14 embodies such coefficients, involving the aforementioned cases (a), (b), and (c), for factors A and B, while the same type of information for factors C and D is presented in Table 15. The results clearly indicate a high degree of congruence for each of the four factors for each of the three possible cases of congruence investigatable in the context of the present study. For example, the lowest coefficient of congruence for any factor is .910, representing substantial congruence between the two versions of Factor C, one based on the data of first testing for 7-year-olds and the other based on the data of second testing for 17-year-olds. In general, the congruence is highest if a factor is being compared with itself within the same age level, but one version of it based on the first and the other based on the second testing (i.e., the test-retest congruence is the highest), and it is lowest when the two compared versions of a factor are so constituted that one is based on one age level on the first testing and the other is based on a different age level on the second testing.

Coefficients of Congruence Based on Eight Age Levels. Tucker's (1951) coefficients of congruence were also computed for the same factors but for eight age levels instead of the four discussed above. In order to conserve

Table 12

Principal Axis Analysis with Varimax Rotation of Four Factors Based on the Data of First Testing at the Eight Age Levels (Uncorrected r Matrices)

	Factor I								Factor II							
Subtest Age	5	7	9	11	13	15-1	15-2	17	5	7	9	11	13	15-1	15-2	17
I	24	43	58	76	81	68	74	85	04	00	52	22	20	28	22	07
C	80	51	86	78	77	72	85	66	11	02	06	-12	-07	-32	02	29
A	00	11	14	47	59	23	09	71	21	28	39	63	23	24	24	06
S	67	80	44	64	64	71	37	75	35	09	10	36	31	22	-01	13
V	80	62	75	81	86	82	65	74	-08	-05	42	22	19	14	23	23
D	23	28	11	01	19	-07	-02	13	29	-08	12	05	05	-15	69	06
PC	-02	-11	06	31	33	48	13	26	38	-16	68	41	45	56	56	76
PA	22	35	31	18	12	25	39	49	55	25	70	12	07	10	73	51
BD	17	06	17	16	38	-01	56	47	67	93	76	83	79	85	43	51
OA	07	66	14	37	16	20	18	-01	85	08	72	64	80	74	64	79
Cod/DS	13	13	05	-06	-03	-16	18	-01	-07	01	28	64	67	14	00	01
Percent of Variance	18	20	18	25	28	23	22	30	17	10	25	21	20	18	19	17

Note.--Decimals are omitted; all loadings are reported to two decimals.

Table 12 (cont'd.)

Principal Axis Analysis with Varimax Rotation of Four Factors Based on the Data of First Testing at the Eight Age Levels (Uncorrected r Matrices)

	Factor III								Factor IV							
Subtest Age	5	7	9	11	13	15-1	15-2	17	5	7	9	11	13	15-1	15-2	17
I	80	09	05	16	06	16	16	-04	12	68	26	-08	11	-26	21	10
C	16	54	11	06	-04	33	11	40	09	22	04	23	16	07	06	02
A	81	04	31	13	21	68	64	47	15	51	67	-18	-02	-18	15	04
S	-06	13	-12	-21	11	-16	77	-01	-02	-11	61	04	32	25	-16	-12
V	32	43	07	-06	10	-01	45	30	17	17	29	18	14	01	16	08
D	69	63	94	91	87	78	15	85	20	00	-05	-02	18	21	10	23
PC	14	17	08	29	-22	03	42	-17	60	82	18	-09	56	02	31	20
PA	11	46	11	-03	26	08	26	01	58	39	04	94	87	57	-06	06
BD	15	-03	-03	-10	03	19	25	43	40	02	33	17	12	13	-08	-09
OA	29	-08	08	-32	-01	-23	25	35	-04	31	22	22	25	22	-09	-20
Cod/DS	16	81	-10	19	50	00	02	18	84	10	78	05	-15	77	93	93
Percent of Variance	19	16	10	10	11	12	15	14	15	16	16	10	12	11	11	9

Note.--Decimals are omitted; all loadings are reported to two decimals.

Table 13

Principal Axis Analysis with Varimax Rotation of Four Factors Based on the Data of Second Testing at the Eight Age Levels (Uncorrected r Matrices)

	Factor I								Factor II							
Subtest Age	5	7	9	11	13	15-1	15-2	17	5	7	9	11	13	15-1	15-2	17
I	24	72	62	82	73	84	82	80	01	28	24	17	46	11	11	13
C	79	73	62	75	80	14	72	66	03	-09	-04	-08	-04	-06	09	42
A	05	49	77	70	70	35	61	69	22	04	47	36	07	15	25	19
S	28	79	63	63	52	79	66	60	77	30	11	43	48	26	07	10
V	73	81	50	72	80	77	85	82	28	06	23	19	38	05	07	19
D	29	48	31	06	35	10	08	45	55	03	08	07	03	00	01	16
PC	54	30	12	67	44	21	41	12	35	03	22	22	64	46	71	81
PA	-11	09	-10	22	01	04	22	10	64	68	42	06	18	56	60	25
BD	14	06	13	50	26	23	00	33	36	69	74	64	76	78	80	75
OA	17	09	27	27	-03	20	-09	21	73	77	74	78	87	73	74	85
Cod/DS	-04	-25	16	-04	-07	-07	02	01	08	02	73	67	18	47	05	-09
Percent of Variance	16	27	20	31	27	20	27	27	20	16	20	17	22	18	20	21

Note.--Decimals are omitted; all loadings are reported to two decimals.

Table 13 (cont'd.)

Principal Axis Analysis with Varimax Rotation of Four Factors Based on the Data of Second Testing at the Eight Age Levels (Uncorrected r Matrices)

	Factor III								Factor IV							
Subtest Age	5	7	9	11	13	15-1	15-2	17	5	7	9	11	13	15-1	15-2	17
I	77	-13	15	07	12	19	-25	-10	07	34	52	20	-07	-12	-18	11
C	20	-01	15	00	01	13	19	08	-02	-18	55	12	-02	84	03	-07
A	82	-13	06	28	27	67	45	10	05	57	-02	-15	34	12	-17	16
S	06	13	23	-26	-01	-03	31	-02	03	-03	10	18	38	23	08	54
V	20	-14	10	05	08	25	-05	13	-13	-01	64	02	-02	31	11	11
D	18	64	87	95	78	80	90	46	25	35	03	04	-03	00	04	-27
PC	-01	-75	-10	-05	-02	01	-24	03	20	21	85	13	24	47	01	09
PA	57	-04	39	01	03	-25	12	-04	05	14	59	85	91	30	03	86
BD	59	-33	13	01	16	23	24	05	14	-14	26	05	28	-03	-21	28
OA	27	25	-05	06	18	27	-22	-14	01	02	32	-18	-03	-23	33	08
Cod/DS	13	05	07	09	84	51	07	91	96	84	01	38	06	18	94	02
Percent of Variance	19	11	10	10	13	15	13	10	10	13	20	09	11	12	10	11

Note.--Decimals are omitted; all loadings are reported to two decimals.

Table 14

Coefficients of Congruence Across the Four Age Levels for Factor A (above the Diagonal) and Factor B (below the Diagonal) for Both Testings

		First Testing				Second Testing			
	Age Level	7	10	14	17	7	10	14	17
First Testing	7	---	935	941	966	964	951	931	945
	10	974	---	976	970	948	992	971	970
	14	963	985	---	974	961	984	984	984
	17	957	984	970	---	966	981	972	989
Second Testing	7	972	968	988	963	---	959	960	968
	10	954	981	992	983	977	---	983	981
	14	941	967	987	976	981	990	---	977
	17	962	982	988	981	976	990	984	---

Note.--Decimals are omitted; all coefficients are reported to three decimals.

Table 15

Coefficients of Congruence Across the Four Age Levels for Factor C (above the Diagonal) and Factor D (below the Diagonal) for Both Testings

	Age Level	First Testing 7	10	14	17	Second Testing 7	10	14	17
First Testing	7	---	987	951	938	955	934	953	910
	10	962	---	980	952	981	968	986	953
	14	934	971	---	960	966	977	990	982
	17	969	939	929	---	928	953	970	950
Second Testing	7	968	963	959	958	---	977	978	942
	10	975	991	982	960	977	---	989	950
	14	964	975	982	968	982	987	---	977
	17	982	950	942	987	983	972	977	---

Note.--Decimals are omitted; all coefficients are reported to three decimals.

space, these coefficients are not reported here. In general, they corroborate the conclusions reported for the four age levels, but are consistently lower in magnitude.

Coefficients of Congruence for the Factors Based on the Principal Axis Analysis. Coefficients of congruence were also computed for the four factors extracted by means of principal axis method, first for four age groups (7, 10, 14, and 17) and subsequently for the eight (5, 7, 9, 11, 13, 15-1, 15-2, and 17) age levels. The results presented in Tables 16 and 17 concern the data based on the reconstituted four age groups only since the eight group data do not add anything particularly revealing to the overall understanding of the invariance of factors. It is apparent from the data of Tables 16 and 17 that factors I and II possess a reasonable degree of stability across the age levels as well as across the two testings. Although the coefficients are in general considerably lower than those for factors A and B (Table 14), most of them are still in the vicinity of .90 to justify considering factors I and II fairly stable. However, the picture is quite different in the case of factors III and IV. The coefficients for factor III range between .431 and .942, with a median of .739. Although this level of congruence does not inspire too much confidence, considering the fact this factor is a product of analytic rotation rather than pre-determined postulation, one may consider factor III to possess a satisfactory degree of stability. On the other hand, factor IV is quite unstable since the coefficients range between almost zero (.031) to almost unity (.904). The median, however, is .436 which indicates that factor IV definitely lacks stability.

One fact emerges clearly from the data of Tables 16 and 17 in contradistinction to the corresponding data in Tables 14 and 15: factors I, II, and III are more stable, across the two testings, at the older than at the younger age levels while factor IV does not exhibit any such trend.

Multivariate Analysis of Variance of Scaled Scores

The analyses based on the uncorrected *r* matrices as predicated on two main assumptions: (a) the variance-covariance differences between the two sexes at the given age levels are negligible and (b) the variance-covariance differences among the age groups, in terms of the scaled scores, are negligible. To some degree age and sex differences are negated by transformation into Wechsler scaled scores, but this cannot entirely be taken for granted. To verify these assumptions, multivariate analyses of variance (MANOVA) were conducted for six age groups (5, 7, 9, 11, 13, and 15-1) which were administered WISC as well as for eight age groups (5, 7, 9, 11, 13, 15-1, 15-2, and 17) in which the last two were administered WAIS. Employing the .01 level of significance for the *F* ratios for H_1 (hypothesis of the equality of variance-covariance matrices) the results do not approach the required level for the six group analysis, either for the first or for the second testing. However, when the older two age groups which were administered WAIS (15-2 and 17) are incorporated with the younger six age groups, the *F* ratios for H_1 for both the first and second testings become significant beyond the .01 level (*F* ratios with 990/141009 *dfs* equal 1.35 for first and 1.22 for the second testing, respectively). Examination of the variance-covariance

Table 16

Coefficients of Congruence across Four Age Levels for Factor I (above the Diagonal) and Factor II (below the Diagonal) for Both Testings (Principal Axis Analysis)

	Age Level	First Testing 7	10	14	17	Second Testing 7	10	14	17
First Testing	7	---	902	813	823	876	773	780	819
	10	904	---	936	932	898	922	899	951
	14	842	883	---	954	959	982	987	978
	17	929	910	847	---	916	956	966	976
Second Testing	7	961	863	771	833	---	925	943	941
	10	830	868	942	792	813	---	983	967
	14	877	919	964	846	832	891	---	973
	17	961	939	841	980	885	795	864	---

Note.--Decimals are omitted; all coefficients are reported to three decimals.

Table 17

Coefficients of Congruence across Four Age Levels for Factor III (above the Diagonal) and Factor IV (below the Diagonal) for Both Testings (Principal Axis Analysis)

		First Testing				Second Testing			
	Age Level	7	10	14	17	7	10	14	17
First Testing	7	---	624	548	721	607	631	646	594
	10	647	---	716	785	431	823	632	747
	14	596	221	---	797	772	941	942	830
	17	720	750	027	---	548	823	730	755
Second Testing	7	446	245	360	185	---	648	859	484
	10	700	182	883	048	425	---	875	837
	14	547	253	904	031	341	811	---	795
	17	787	675	304	904	065	301	236	---

Note.--Decimals are omitted; all coefficients are reported to three decimals.

matrices indicates that the significance of these F ratios is mainly due to the two oldest age levels (15-2 and 17) which were administered WAIS. The sex differences regarding variance-covariance estimates are generally negligible. However, the F ratios for H_2 (hypothesis of the equality of mean centroids) for the sex main effect are significant beyond .001 for both testings (F ratios of 7.10 and 9.44, respectively, with '1/488 dfs), indicating that there are definite differences between males and females on some or all of the variables at some or all of the age levels. The foregoing finding, however, has little bearing on the correlational analyses conducted in the present study, and thus the assumption of negligible sex differences in variances and covariances has been substantiated. The assumption regarding the homogeneity of variance-covariance matrices across the age levels is tenable only if the WISC or WAIS data are analyzed separately. In the light of the MANOVA results, therefore, it would have been advisable to correct for the differential variability at the two older age levels only.

CONCLUSIONS AND IMPLICATIONS

The main purposes of the present investigation were: (a) To verify the differentiation hypothesis as elaborated into the implications that (i) the percentage of variance accounted for by the general factor should gradually decrease as age increases (ii) the percentage of variance contributed by each of the group factors involved should increase with age, and (iii) the average intercorrelation of the factors should decline as age increases. (b) To compare the results of the factor analyses of the present WISC/WAIS data with the results of the previous studies (Cohen, 1957; Cohen, 1959; Gault, 1954; Hagen, 1952; Hammer, 1950) in this area. (c) To verify the results of factor analysis secured from the WISC and WAIS scores on the first testing with comparable data obtained from the second testing of the same persons with these scales. And (d) to provide a conceptual and experimental link between the WISC and WAIS measures at the age of 15-17 years.

The results and discussion in the foregoing pages leave little doubt that the data based on the Wechsler scales do not corroborate the differentiation hypothesis whether or not the correlations are corrected for differential reliability or variability at the various age levels.

Thus any modification of the extant theories of child development--if such modification were contingent upon the verification of the differentiation hypothesis--will have to be postponed. Since in a previous study (Quereshi, 1967a) the differentiation hypothesis was substantially validated, one may conclude that the type of test materials involved have definite bearing on the trends in the patterns of intellectual development. Thus one can state with a high degree of confidence--since none of the studies with WISC/WAIS scales have yielded data in support of the differentiation hypothesis--that Wechsler scales do not constitute those samples of the cognitive and psychomotor behavior domains which are suited for testing the differentiation hypothesis. What kinds of samples of behavior domain are suitable for verifying the differentiation hypothesis cannot be answered on the basis of available data and, hence, must await further research.

The factor analytic results of the present study generally agree with those of the previous studies (Cohen, 1957; Cohen, 1959; Gault, 1954; Hagen, 1952; Hammer, 1950) if appropriate allowances are made for differences in methods of factor analysis. In fact, even without such qualifications, the similarities are striking. Within the confines of the present study, results based on the first testing are generally verified by those of the second testing; and, in some cases, these results are further illuminated by a conjunctive examination of the data of both testings (e.g., the interpretation of factor IV in the light of Cohen's factor E).

The comparison between the WISC and WAIS loadings at ages 15 and 17 (see the factor loadings of WISC/WAIS subtests for ages 15-1, 15-2, and 17, for each of the four factors, in Tables 12 and 13, pp. 30-33) indicates that in general WISC and WAIS subtests are quite similar in their factorial structure. This result, in conjunction with the findings of a previous study (Quereshi, 1968b), provides adequate evidence for deciding whether or not the two scales are comparable.

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