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AUTHOR Hathaway, Walter Ennis, Jr.
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ABSTRACT

The nature of the relations between traditional psychometric and Piagetian instruments is analyzed, in order to provide information relevant to the question of which type of test or combination of them will provide the most useful information to those seeking to construct and maintain optimal learning environments. Four hypotheses are posed: (1) the degree of the relationship between performance on Piagetian tests of intelligence and traditional psychometric measures of intelligence is moderate and positive; (2) traditional psychometric and Piagetian measures of intelligence both assess "general intelligence"; (3) Piagetian measures assess some traits not assessed by traditional measures of general intelligence; and (4) Piagetian measures add significantly to the prediction of school achievement by traditional psychometric measures of intelligence. Directly related studies are discussed. In the present study, 41 variables from the WISC, Lorge-Thorndike, Lincoln-Oseretzsky, CA (Chronological Age), and CAT, on which data were collected previously in three annual testing periods, are subjected to a detailed analysis of the same data at the level of the subtests, using factor analysis and stepwise multiple regression along with descriptive statistics and simple correlation. The results are presented in seven tables and discussed. The four hypotheses were accepted. A comprehensive bibliography is provided. (DB)

The Degree and Nature of the Relations Between Traditional Psychometric and Piagetian Developmental Measures of Mental Development

Walter Ennis Hathaway, Jr.

I. Introduction

For theoretical, practical, and political reasons Piaget-inspired tests are increasingly being constructed and used to assess levels of mental development. There is theoretical and empirical evidence which indicates that what is assessed by such Piagetian instruments bears at least some relationship to what is assessed by the traditional psychometric measures of intelligence.

This article reports a further analysis of the same data analyzed in an earlier study whose stated purpose was "to analyze the relationship between measures of the child's intellectual powers as evaluated by Piagetian methods and conventional measures in children ages five to eight.[1]" That study's major conclusion was that, in spite of theoretical differences in construction, the two types of tests measure overlapping but nonidentical aspects of mental development.

The 41 variables on which data for that study was collected for each of three annual testing periods are given in List 1. Descriptions of the less

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[1] S. Z. Dudek, E. P. Lester, J. S. Goldberg, and G. B. Dyer, "Relationship of Piaget Measures to Standard Intelligence and Motor Scales," Perceptual and Motor Skills, 1969, 28, 351-362.

List 1 - Variables Analyzed

1	WISC	1	Performance IQ
2		2	Verbal IQ
3		3	Full Scale IQ
4		4	Information
5		5	Comprehension
6		6	Arithmetic
7		7	Similarities
8		8	Vocabulary
9		9	Sum Verbal
10		10	Picture Completion
11		11	Picture Arrangement
12		12	Block Design
13		13	Mazes
14		14	Object Assembly
15		15	Sum Performance
16	Lorge-Thorndike	1	Subtest I Oral Vocabulary
17		2	Subtest II Cross-Out
18		3	Subtest III Pairing
19		4	Total Lorge-Thorndike
20	Lincoln-Oseretzsky	1	Motor Development
21		1	Space
22		2	Time
23		3	Night
24		4	Dream
25		5	Conservation of Quantity
26		6	Conservation of Surface
27		7	Inclusion
28		8	Movement
29		9	Seriation
30		10	Total Piaget
31	CA	1	Chronological Age (in months)
32	CAT	1	Reading Vocabulary
33		2	Reading Comprehension
34		3	Total Reading
35		4	Arithmetic Reasoning
36		5	Arithmetic Fundamentals
37		6	Total Arithmetic
38		7	Mechanics of English
39		8	Spelling
40		9	Total Language
41		10	Total CAT

common tests used and of the test procedures and subjects are to be found in the original report.[2]

The major results of the original study were, however, reported in terms of only the total scores (variables 1, 2, 4, 19, 20, 30, and 41). Thus, the significant but only moderately high correlations of the Piaget total (30) with the Lorge-Thorndike total (19) and the total WISC IQs (1, 2, 3) suggested that "while the WISC and Piaget tests are measuring a great deal in common each test is also accounting for different aspects not assessed by the other tests."

An examination of the simple and partial correlations of the same total scores with total achievement scores (41) and also of the simple and partial correlations of the individual Piagetian scores (21-29) with both the Piagetian total (30) and the total achievement scores (41) led to the inference, in accord with the previous suggestion, that "Piaget tests are accounting for aspects of IQ different from those which are accounted for by the WISC."

In the present study a more detailed analysis of the same data at the level of the subtests has been made using factor analysis and stepwise multiple regression along with descriptive statistics and simple correlation. The aim here was to discover the nature of the relationship between traditional psychometric and Piagetian developmental measures of mental development. In this way, it was hoped to provide more precise information that can aid the development, selection, and use of each type of measure and combinations of them for understanding the child's present behavior and for providing him an optimal developmental milieu. More specifically, from such research leading to more valid and comprehensive assessments of global intelligence and better

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[2] Ibid

assessment of specific intellectual functions, improvements can be hoped for in the areas if diagnosis and remediation of mental retardation, readiness assessment, ability grouping, curriculum development and scheduling, rate of learning diagnosis, achievement level assessment, and every area where the educational system attempts to assess and respond to individual differences in children's mental abilities.

II. Objectives and Hypotheses

It is the general goal of this study to analyze the nature of the relations between traditional psychometric and Piagetian instruments, with a view to providing information relevant to the question of which type of test or combination of them will provide the most useful information to those seeking to construct and maintain optimal learning environments. The objectives of this study led to the posing of the following four hypotheses:

Hypothesis I (Degree of relatedness of the two types of measures): The degree of the relationship between performance on Piagetian tests of intelligence and traditional psychometric measures of intelligence is moderate and positive.

Discussion: If the correlations between Piagetian and psychometric measures of intelligence do not significantly depart from zero and if subtests of each type of measure load on totally different orthogonal factors, the Piagetian tests would be judged to lack the situationally general and longitudinally stable sort of intelligence of known comprehensive predictive and practical value assessed by the traditional tests. Accordingly it would indicate that Piagetian tests are probably relatively useless as focusing points for education, related intellectual assessment or intervention.

On the other hand, if the correlations between Piagetian and psychometric measures of intelligence approach unity, and if all subtests of each type load on the same factor or randomly on several factors, the Piagetian tests would be judged to constitute just another assessment of what is already measured by traditional psychometric tests of intelligence, and accordingly Piagetian tests would be unnecessary as focusing points for education-related intellectual assessment or intervention.

Hypothesis II (Similarity of the two types of measures): Traditional psychometric and Piagetian measures of intelligence both assess "general intelligence."

Discussion: Since traditional psychometric measures have been designed as measures of general intelligence, factor analysis should reveal a first factor of general intelligence common to both types of measure but more heavily loaded on the psychometric tasks. Thus they should be found to be similar in that they both assess general intelligence.

Hypothesis III (Difference between the two types of measures): Piagetian measures assess some traits not assessed by traditional measures of general intelligence.

Discussion: Since traditional psychometric measures have been designed as measures of general intelligence, it is to be expected that traditional subtests will load mostly on a first, general intelligence factor. Piagetian measures, although they should load partially on the first general intelligence factor as Hypothesis III indicates, should also define one or more additional factors due to the uniquely interactional aspects of the theory from which they arise.

Hypothesis IV (Contribution of Piagetian measures to prediction of

achievement): Piagetian measures add significantly to the prediction of school achievement by traditional psychometric measures of intelligence.

Discussion: Since traditional psychometric measures of intelligence have been designed and revised using prediction of school achievement as the main criterion of the validity, it is to be expected that they would be good predictors of such achievement. If what Piagetian measures assess over and above what the traditional measures assess is to be of general predictive value, they must add significantly to this prediction of school achievement.

III. Directly Related Studies

In five recent studies factor analysis is used as the principal tool to investigate the relationship between Piagetian and traditional measures of mental development. An account of the first of these studies was made in 1966 when Kohlberg reported that he had been engaged for five years in a program of research designed to show that cognitive stages are real structures to be found in development. First he refined Piaget's concepts and measures of cognitive stages into about twenty tasks. Then he administered these tasks longitudinally to children aged four to eight and compared children's performance on these tasks to their performance on a battery of the usual psychometric tests of general and special intellectual abilities. In his 1966 article, however, Kohlberg gives the results for only two of the twenty tasks, Dreams and Reality-Constancy. He reported scale types which indicated an invariant order of sequence of development on these two tasks. A factor analysis of seven Reality-Constancy subtasks at two ages was also reported as indicating consistency in children's responses for various tasks involving reality-appearance differentiation.

In 1968 Kohlberg again appealed to tables of scale types to support his (Piagetian) interactional conception of stages. He also offered some

findings from the research program described in 1966. The chief finding was that, although Piaget tests correlate with the Binet, they "hang together" after Binet and other psychometric factors are removed. Kohlberg suggests that this intertask consistency of Piaget level represents a general Piagetian factor independent of any general intelligence factor entering into the Binet. He also draws upon this finding in concluding that Piagetian measures reflect general increments in cognitive development due to natural (indexed by chronological age) or educational experience better than do psychometric findings and that they should be valuable in assessing the effects of various types of cognitive stimulation programs, whether or not these programs have Piagetian cognitive development as an explicit objective.

In 1969 Kohlberg and Rheta DeVries reported on a factor analysis of psychometric and Piagetian tasks at age six. Their aim was to distinguish one or more Piagetian factors of intelligence and to show that the Piagetian factors are quantitatively more influenced by general physical and social experience (as represented by chronological age and social participation) and hence represent a more "interactional" component of cognitive maturity than psychometric general intelligence.

They studied 67 upper-middle class children of mental age six. The variables consisted of performance on 9 tests representing five psychometric "primary mental abilities" and 12 tests of Piagetian concrete operational thinking. The factor analysis indicated three oblique factors: a first factor of general intelligence common to both psychometric and Piagetian tasks but more heavily loaded on the psychometric tasks, a second general Piagetian concrete operations factor, and a third Piagetian conservation factor. The orthogonal rotation, which the authors found somewhat more difficult to interpret, also yielded a first psychometric factor, a second Piagetian verbal logical classification and reasoning factor, and a third Piagetian conservation

factor. From these factors the authors tentatively concluded that there is a consistency in Piagetian tasks that is relatively distinct from the consistencies found in psychometric tests and that there is a further component of consistency in Piagetian tasks that is related to psychometric performance and that helps to extend the concept of general intelligence.

The second of the relevant studies was Stevens' (1969) study of retardates and normals. She found significant correlations of WISC Verbal IQ, Performance IQ, and Full Scale IQ with Piagetian tasks of reasoning given to subjects ranging from 6 to 18 years of age, thus suggesting a general intelligence factor. The fact, however, that few correlations were .60 or higher although reliabilities were high, strongly suggested that Piagetian reasoning tasks generally assess intellectual processes different from those assessed by Wechsler's scales. This finding supported Freyberg, Dudek, et al., and Kohlberg. Stevens found two of five factors to be defined by scores from Wechsler's scales and a test of school achievement. Three factors were defined by Piagetian measures of operativity. Thus reasoning, as measured by Piagetian operational tasks, again appeared to be a multidimensional ability separate from that measured by standard tests of intelligence and achievement but somewhat related to them.

The third study employing factor analytic methods to examine the relationship between Piagetian and traditional measures was Longeot's (1969) study in which sex measures based on Piaget's theory were administered to 150 high school students aged 17, along with 3 ability tests (number, verbal, and spacial) and 2 achievement tests (arithmetic and French). The unrotated factor matrix displayed substantial loadings of all 6 Piagetian and 5 non-Piagetian measures on a general factor.

The fourth factor analytic study on the nature of the relationship of Piagetian and traditional measures of intelligence was performed by Ross (1971)

on children aged eight and nine. Using principal component analysis with varimax rotation, Ross found a clear dichotomy between the Piagetian and non-Piagetian measures. His first factor was defined by a test of reading comprehension, an IQ test (the Slosson), and a standardized test (SAT) of paragraph meaning. The second factor was defined by loadings from four Piagetian classification tasks.

The fifth and final factor analytic study relating Piagetian and non-Piagetian measures was that of Meyers and Orpet (1971). They administered 7 Piagetian tasks along with 26 ability tests to 70 middle-class children of about 5 1/2 years of age. Each of the 7 Piagetian measures had their highest loadings on a different factor. But two or more Piagetian tasks loaded heavily on three of the six factors identified respectively as "Mental manipulation or transformation," "Unnamed but Gestalt completion and ITPA analogies along with three Piagetian tasks," and "Also unnamed but characterized by WISC, Block Design, and Digets Forward as well as two Piagetian tasks."

Thus the meager factor analytic literature to date on the relationship between Piagetian and traditional measures suggests a variety of complementary hypothese. In the work of Kohlberg (1969) and Stevens (1969) we find the dual suggestion that 1) Piagetian tasks have an element of consistency related to the consistency among traditional tasks through general intelligence (similar to Hypothesis II in this study), but that 2) the Piagetian tasks also have other elements of consistency only slightly related to the aspects of consistency of traditional measures (similar to Hypothesis III of this study). Longeot's (1969) study with 17-year olds supported the first part of the inference from Kohlberg's and Steven's studies. Ross' (1971) study supported the second part of the earlier suggestion as did the study of Meyers and Orpet (1971).

IV. Analytical Procedures

Descriptive Statistics

Means and standard deviations are reported for all 41 variables. However, data are not given on the 10 CAT variables for Grade K (nor will they be given throughout the analyses) since it was not gathered for that test period.

Correlation

Correlations were computed among all variables for each of the testing periods (K, I, II). These correlations were tested for statistical significance. (See tables 2 to 4)

Factor Analysis

Factor analytic techniques were employed to determine whether selected subsets of the variables can be reduced to a smaller number of common factors and thereby to determine the basic dimensions or relationships among these variables and the aggregate variables constructed from them. Examination of which tests contribute to each component further revealed their relationships as formulated in the hypotheses.

The number of factors to be rotated was arrived at by following Cattell's and Harmon's suggestion of using a combination of Kaiser's criterion ("rotate as many factors as there are eigenvalues greater than or equal to unity") and the Scree test. Squared multiple correlations (SMCs) were used as the initial communality estimates instead of unity, thus involving principal factor rather than principal components analysis. This choice was directed by the goal of "best producing the observed correlations" rather than extracting the maximal variance. It was also in accord with Cattell's rejection of the components model for general scientific research because of the unlikelihood of n variables containing in themselves all sources of their variation. This

is certainly unlikely with either the set of variables with which we are dealing or with any of the subsets considered. Factor analyses were performed with both unity and SMC estimates of the communalities using the same representative set of variables and subjects to see whether differences in either the unrotated or rotated factors appear. Such difference did not occur. Varimax rotation was employed, as a variety of authors suggest, in order to approach simple structure. Oblique and oblimin transformations were employed, using the same representative set of variables and subjects, to see whether considerable departure is found from the varimax-rotated factors. Such departure was not found.

Aside from the factor analyses mentioned above, which were performed to guide the decisions regarding the number of factors to be rotated, the initial communality estimates, and the type of rotation, eight more analyses were performed on the same 56 subjects. For each of the 3 time periods--Kindergarten, Grade I, and Grade II--two, three and three combinations, respectively, were factor analyzed. Only two rather than three combinations were used in Kindergarten since the combination involving CAT variables was only available for Grade I and Grade II. The three variable combinations were selected with an eye to avoiding inclusion of obviously dependent measures and to having the logically most informative relationships available for study. The factors revealed by these eight analyses are reported in Tables 6a, 6b, and 6c.

Multiple Regression Analysis

Stepwise multiple regression was employed to explore the nature of the relationships between the traditional and the Piagetian measures and achievement by determining the order and degree of their contributions to prediction of the various achievement measures. Four analyses were made on the data for 56 subjects for both Grade I and Grade II, for a total of 8 analyses (see Table 7).

V. Results

n will be presented the results of the quantitative analysis performed in this study. The forms of analysis, as mentioned above, include descriptive statistics, correlations, factor analysis, and stepwise multiple regression. The results of these analyses for the appropriate variables and for the relevant test periods will be presented along with the technical explanation and immediate interpretation necessary for clarity. The bulk of the interpretation of these results will be, however, reserved for the following section.

Descriptive Statistics

Means and standard deviations for each variable for each test period are given in Table 1. The closeness of the WISC means to 100 is an indication of the general representativeness of the sample in this study, since the WISC was standardized in a sample selected to be representative of the geographic, urban-rural, and occupational distribution of white Americans.

Data are not given on the ten CAT variables for Grade K (and will not be given throughout this report on the results of the analysis) since they were not gathered for that test period.

Correlations

Intercorrelations for each variable for the test periods, K, I, and II are given in Tables 2, 3, and 4, respectively.

The WISC manual gives intercorrelations of the test scores for the standardization sample for age seven and one-half years (90 months). The age group closest to that in the present study is the group with average chronological age of 94.5 months in Grade II. A comparison of the intercorrelations of the verbal, performance, and full scale scores for the two samples is given below in Table 2. The similarity of the results is another indication of the representativeness of our sample.

TABLE 1

MEANS AND STANDARD DEVIATIONS

N	Variable	Highest Possible Score	N = 56					
			K		I		II	
			x	SD	x	SD	x	SD
1	WISC Performance IQ	156	108.6	12.8	112.3	10.9	115.4	11.9
2	" Verbal IQ	155	103.8	11.9	105.8	12.0	106.4	12.8
3	" Full Scale IQ	154	106.7	11.8	109.5	11.6	111.6	12.0
4	" Information	20	10.6	2.7	11.0	2.5	11.1	3.0
5	" Comprehenson	20	10.0	3.1	11.0	2.5	10.5	3.1
6	" Arithmetic	20	11.0	3.5	11.1	2.5	11.2	2.0
7	" Similarities	20	9.7	2.5	10.8	3.0	10.6	2.9
8	" Vocabulary	20	10.8	3.4	10.3	2.5	11.4	3.0
9	" Sum Verbal	100	52.3	10.3	54.3	9.3	55.1	10.2
10	" Picture Completion	20	10.6	2.2	11.8	2.4	11.5	2.6
11	" Geometric Design	20	11.8	3.0	12.4	2.8	12.4	2.6
12	" Block Design	20	12.0	2.4	12.3	2.6	12.1	3.0
13	" Mazes	20	10.9	3.2	12.2	2.7	12.4	2.6
14	" Animal Houses	20	10.5	2.8	10.2	2.9	12.7	3.0
15	" Sum Performance	100	56.1	8.9	58.9	7.8	61.0	8.6
16	Chronological Age	---	71.2	4.3	83.2	4.3	94.5	4.7
17	Piagetian Space	18	13.5	2.7	15.9	2.4	16.8	1.9
18	" Time	18	11.4	5.1	14.1	3.8	16.4	2.8
19	" Night	18	9.9	5.8	13.1	4.3	14.8	3.4
20	" Dreams	18	10.6	5.3	13.9	3.2	14.6	2.8
21	" Conservation of Quantity	18	9.3	3.4	12.1	4.5	15.0	4.3
22	" Conservation of Surface	18	6.4	5.3	10.4	5.8	14.5	5.1

TABLE 1--continued

N	Variable	Highest Possible Score	N - 56					
			K		I		II	
			x	SD	x	SD	x	SD
23	Piagetian Inclusion	18	8.2	4.0	12.4	5.1	13.9	5.2
24	" Movement	18	9.7	2.5	11.4	3.0	12.4	2.9
25	" Seriation	18	8.1	3.9	11.1	3.9	12.5	3.4
26	" Total	162	87.6	22.4	114.7	23.7	131.3	19.9
27	CAT Reading Vocabulary	50	----	----	23.7	5.9	40.2	6.4
28	" Reading Comprehension	50	----	----	22.8	7.8	36.5	5.0
29	" Total Reading	50	----	----	23.7	6.2	37.9	5.1
30	" Arithmetic Reasoning	50	----	----	23.0	5.3	37.6	5.9
31	" Arithmetic Fundamentals	50	----	----	20.0	4.5	32.1	5.9
32	" Total Arithmetic	50	----	----	21.2	4.6	33.8	5.8
33	" Mechanics of English	50	----	----	21.7	4.5	36.4	7.2
34	" Spelling	50	----	----	24.0	7.9	39.1	6.7
35	" Total Language	50	----	----	22.6	5.2	37.3	6.4
36	" Total CAT	50	----	----	22.3	4.9	35.5	5.2
37	Lorge Thorndike Oral Vocabulary	K I II 25 25 25	12.3	3.8	17.8	1.9	15.7	2.8
38	" " Cross-Out	20 20 25	10.2	4.6	17.6	1.8	17.0	2.6
39	" " Pairing	20 20 25	7.6	4.7	15.4	2.3	15.9	3.0
40	" " Total IQ	152 152 152	91.9	13.1	114.6	11.5	108.6	12.4
41	Lincoln-Oseretzsky Motor Development	60	36.7	10.5	40.4	11.9	52.8	16.6

TABLE 2

INTERCORRELATIONS ON WISC FOR
STANDARDIZATION AND STUDY SAMPLES

		Sample					
		This Study N = 56 Mean CA = 94.5			WISC Standardization N = 200 CA = 90		
Test	Verbal						
	Performance	.54			.60		
	Full Scale	.89	.85		.90	.89	
		Verbal	Performance	Full Scale	Verbal	Performance	Full Scale

For the sample size of this study, correlations with absolute values of .26 and .35 are significant at the .05 and .01 levels, respectively. Inspection of Table 3 shows that 30 percent of the values attain significance at least at the .05 level. (The increase in the percentage in Tables 4 and 5 over Table 3 is due largely to the inclusion of the 10 CAT variables in the intercorrelations for Grade I and II in Tables 4 and 5, respectively.)

Guilford (1965) notes, moreover, that when one is investigating a theoretical problem (such as the question of the relationship between two types of mental measures) even very small correlations, if statistically significant, are often indicative of a psychological law or relation. For whenever a relationship between two variables is established beyond reasonable doubt, the fact that the correlation coefficient is small may mean that the measurement situation is influenced by some factors uncontrolled or not held constant. Common experience also shows that correlations between two types of mental measures may be expected to range from .00 to .60, with most indices in the lower part of that range.

Notice that the Total Piaget score (variable #30) is correlated significantly ($p < .01$) with all three WISC total IQ scores and with the Lorge-Thorndike

INTERCORRELATION MATRIX Grade K TABLE 3

	1 WISC Perform. I Q	2 WISC Verbal I Q	3 WISC Full Scale I Q	4 WISC Information	5 WISC Comprehension	6 WISC Arithmetic	7 WISC Similarities	8 WISC Vocabulary	9 WISC Sum Verbal	10 WISC Pic. Complet'n.	11 WISC Pic. Arrangem't.	12 WISC Block Design	13 WISC Mazes	14 WISC Object Assembly	15 WISC Sum Perform.	16 Lorge-Thorndike Oral Vocabulary	17 Lorge-Thorndike Cross-Out	18 Lorge-Thorndike Pairing	19 Lorge Thorndike Total	20 Lincoln-Oseretzsky Motor Development	21 Piaget Space	22 Piaget Time	23 Piaget Night	24 Piaget Dream	25 Piaget Conserv. of Quantity	26 Piaget Conserv. of Surface	27 Piaget Inclusion	28 Piaget Movement	29 Piaget Seriation	30 Piaget Total	31 Chronological Age (in months)
1 WISC Performance I Q																														
2 WISC Verbal I Q	.51																													
3 WISC Full Scale I Q	.86	.87																												
4 WISC Information	.34	.68	.60																											
5 WISC Comprehension	.03	.53	.33	.11																										
6 WISC Arithmetic	.14	.26	.22	.20	.08																									
7 WISC Similarities	.45	.66	.65	.35	.20	.28																								
8 WISC Vocabulary	.46	.68	.65	.36	.27	.03	.28																							
9 WISC Sum Verbal	.47	.90	.80	.61	.56	.23	.61	.65																						
10 WISC Picture Completion	.33	.36	.52	.26	.05	.01	.27	.30	.35																					
11 WISC Picture Arrangement	.70	.49	.68	.32	.07	.17	.44	.40	.52	.33																				
12 WISC Block Design	.65	.43	.62	.32	.14	.09	.41	.28	.43	.11	.40																			
13 WISC Mazes	.63	.23	.49	.12	.11	.05	.25	.24	.23	.14	.18	.35																		
14 WISC Object Assembly	.65	.12	.42	.05	.22	.10	.14	.28	.09	.25	.35	.24	.24																	
15 WISC Sum Performance	.99	.50	.85	.33	.04	.14	.46	.47	.48	.52	.72	.64	.62	.66																
16 Lorge-Thorndike Oral Vocab.	.58	.35	.53	.32	.03	.05	.24	.40	.29	.10	.31	.55	.44	.43	.58															
17 Lorge-Thorndike Cross-Out	.47	.26	.43	.22	.03	.12	.27	.18	.33	.07	.37	.53	.26	.23	.44	.42														
18 Lorge-Thorndike Pairing	.46	.09	.32	.00	.06	.02	.14	.25	.16	.20	.20	.40	.40	.30	.45	.54	.53													
19 Lorge-Thorndike Total	.65	.34	.57	.30	.05	.17	.32	.32	.37	.14	.30	.60	.34	.49	.64	.77	.74	.79												
20 Lincoln-Oseret. Motor Develop.	.25	.06	.18	.16	.01	.08	.10	.05	.10	.00	.10	.27	.21	.22	.26	.44	.23	.26	.34											
21 Piaget Space	.40	.33	.43	.32	.11	.20	.25	.24	.33	.10	.38	.42	.28	.11	.41	.27	.17	.23	.27	.26										
22 Piaget Time	.43	.41	.48	.31	.08	.12	.34	.29	.43	.13	.34	.41	.16	.32	.43	.42	.34	.14	.36	.35	.30									
23 Piaget Night	.36	.32	.40	.25	.03	.02	.36	.35	.33	.22	.13	.35	.32	.13	.35	.36	.37	.35	.39	.09	.34	.19								
24 Piaget Dream	.31	.36	.39	.15	.37	.11	.26	.28	.43	.26	.17	.10	.35	.15	.31	.11	.20	.27	.18	.15	.25	.31	.31							
25 Piaget Conserv. of Quant.	.06	.19	.14	.09	.08	.17	.32	.08	.24	.10	.22	.07	.01	.02	.06	.12	.12	.11	.19	.25	.32	.32	.23	.33						
26 Piaget Conserv. of Surf.	.03	.17	.08	.06	.12	.10	.24	.02	.17	.04	.04	.03	.10	.17	.04	.01	.10	.10	.04	.19	.08	.28	.29	.17	.40					
27 Piaget Inclusion	.30	.32	.36	.21	.19	.08	.24	.19	.11	.03	.08	.27	.43	.02	.27	.32	.23	.26	.23	.06	.37	.05	.31	.15	.00	.01				
28 Piaget Movement	.22	.16	.22	.26	.02	.13	.07	.02	.18	.17	.23	.07	.09	.13	.23	.19	.10	.04	.20	.09	.28	.37	.03	.25	.22	.15	.10			
29 Piaget Seriation	.32	.33	.38	.24	.12	.13	.46	.12	.28	.16	.31	.24	.22	.10	.33	.30	.36	.34	.38	.20	.38	.29	.35	.27	.40	.30	.56	.11		
30 Piaget Total	.46	.51	.56	.36	.22	.09	.49	.33	.50	.22	.33	.38	.39	.15	.45	.39	.41	.33	.41	.30	.58	.62	.65	.60	.60	.56	.43	.37	.69	
31 Chronological Age (in months)	.05	.04	.07	.01	.03	.01	.19	.05	.05	.09	.07	.14	.26	.22	.04	.22	.32	.32	.08	.12	.11	.02	.21	.05	.00	.22	.32	.20	.33	.20

For r = .26, p = .05
For r = .35, p = .01

INTERCORRELATION MATRIX Grade I

TABLE 4

	1 WISC Perform. I Q	2 WISC Verbal I Q.	3 WISC Full Scale I Q	4 WISC Information	5 WISC Comprehension	6 WISC Arithmetic	7 WISC Similarities	8 WISC Vocabulary	9 WISC Sum Verbal	10 WISC Pic. Complet'n.	11 WISC Pic. Arrange-ment	12 WISC Block Design	13 WISC Mazes	14 WISC Object Assembly	15 WISC Sum Perform.	16 Lorge-Thorndike Oral Vocabulary	17 Lorge-Thorndike Cross-Out	18 Lorge-Thorndike Pairing	19 Lorge-Thorndike Total	20 Lincoln-Oseretsky Motor Development	21 Piaget Space	22 Piaget Time	23 Piaget Night	24 Piaget Dream	25 Piaget Conserv. of Quantity	26 Piaget Conserv. of Surface	27 Piaget Inclusion	28 Piaget Movement	29 Piaget Seriation	30 Piaget Total	31 Chronological Age (in months)	32 CAT Reading Vocabulary	33 CAT Reading Comprehension	34 CAT Total Reading	35 CAT Arithmetic Reasoning	36 CAT Arithmetic Fundamentals	37 CAT Total Arithmetic	38 CAT Mechanics of English	39 CAT Spelling	40 CAT Total Language	41 CAT Total
1. WISC Performance I Q																																									
2 WISC Verbal I Q	.50																																								
3 WISC Full Scale I Q	.53	.88																																							
4 WISC Information	.55	.81	.80																																						
5 WISC Comprehension	.19	.67	.50	.45																																					
6 WISC Arithmetic	.34	.61	.56	.54	.19																																				
7 WISC Similarities	.40	.66	.63	.46	.30	.19																																			
8 WISC Vocabulary	.32	.72	.61	.49	.42	.29	.35																																		
9 WISC Sum Verbal	.51	.99	.88	.83	.67	.61	.68	.71																																	
10 WISC Picture Completion	.62	.34	.53	.33	.09	.23	.29	.18	.32																																
11 WISC Picture Arrangement	.55	.56	.65	.59	.26	.39	.30	.33	.56	.24																															
12 WISC Block Design	.59	.30	.50	.32	.24	.27	.20	.04	.32	.23	.23																														
13 WISC Mazes	.75	.21	.53	.20	.00	.08	.27	.17	.23	.44	.28	.37																													
14 WISC Object Assembly	.23	.06	.19	-.02	.04	-.02	-.06	.21	.03	-.03	-.13	-.05	.03																												
15 WISC Sum Performance	.98	.52	.84	.55	.20	.35	.30	.33	.51	.64	.56	.58	.73	.32																											
16 Lorge-Thorndike Oral Vocab.	.24	.47	.43	.33	.23	.15	.38	.47	.46	.22	.16	.16	.16	.11	.28																										
17 Lorge-Thorndike Cross-Out	.39	.40	.44	.40	.18	.43	.26	.11	.39	.24	.41	.28	.11	.05	.40	.34																									
18 Lorge-Thorndike Pairing	.19	.34	.30	.41	.30	.29	.15	.11	.35	.01	.35	.18	.10	-.07	.18	.25	.41																								
19 Lorge-Thorndike Total	.42	.60	.59	.57	.37	.43	.46	.31	.61	.26	.41	.29	.22	.01	.42	.62	.70	.74																							
20 Lincoln-Oseretsky Motor Develop.	.23	.14	.23	.26	.04	.20	.09	.06	.16	-.15	.27	.08	.18	.19	.22	.14	.20	.02	.16																						
21 Piaget Space	.46	.44	.52	.50	.30	.33	.36	.13	.46	.23	.44	.40	.41	-.12	.45	.27	.27	.23	.36	.28																					
22 Piaget Time	.46	.49	.56	.40	.31	.40	.31	.34	.51	.43	.48	.35	.20	-.10	.44	.46	.41	.20	.41	.06	.54																				
23 Piaget Night	.24	.32	.33	.35	.07	.33	.20	.14	.32	.36	.29	.19	.13	-.05	.24	.37	.32	.22	.34	.10	.33	.41																			
24 Piaget Dream	.16	.29	.26	.32	.24	.22	.11	.21	.31	.04	.23	.30	.24	-.30	.15	.32	.25	.24	.30	.25	.32	.30	.28																		
25 Piaget Conserv. of Quant.	.19	.21	.25	.31	.02	.23	.20	.00	.22	.16	.27	.15	.20	-.24	.10	.28	.38	.21	.30	.22	.43	.46	.29	.20																	
26 Piaget Conserv. of Surf.	.22	.19	.26	.32	.02	.28	.12	-.05	.19	.18	.18	.36	.22	-.30	.22	.06	.09	.06	.05	.00	.39	.40	.27	.21	.47																
27 Piaget Inclusion	.26	.39	.40	.34	.09	.26	.42	.17	.37	.14	.37	.04	.32	.00	.29	.29	.41	.27	.39	.35	.24	.14	.58	.30	.35	.14															
28 Piaget Movement	.51	.46	.57	.52	.23	.40	.29	.22	.47	.30	.17	.56	.30	.01	.51	.32	.32	.43	.47	.02	.49	.38	.30	.21	.41	.40	.20														
29 Piaget Seriation	.33	.27	.41	.45	.12	.42	.25	.03	.37	.20	.36	.33	.37	-.29	.33	.23	.29	.29	.33	.23	.50	.26	.42	.32	.56	.26	.45	.52													
30 Piaget Total	.45	.52	.58	.59	.21	.48	.38	.19	.52	.32	.47	.43	.38	-.24	.46	.42	.45	.35	.48	.23	.07	.64	.68	.50	.73	.64	.61	.63	.71												
31 Chronological Age (in months)	-.09	-.01	-.03	-.01	.08	-.22	.00	.06	-.01	-.09	.07	-.06	.00	-.15	-.08	.19	.05	.10	-.06	.10	-.11	.11	.37	.25	.28	.04	.34	.03	.19	.29											
32 CAT Reading Vocabulary	.30	.39	.44	.37	-.05	.58	.24	.15	.36	.11	.45	.30	.30	-.08	.39	.16	.42	.22	.28	.35	.38	.36	.37	.38	.31	.37	.36	.38	.46	.57	.14										
33 CAT Reading Comprehension	.25	.34	.45	.34	-.04	.39	.35	.24	.33	.17	.45	.25	.39	.00	.46	.11	.30	.18	.17	.22	.24	.19	.28	.24	.10	.12	.33	.32	.26	.33	.20	.63									
34 CAT Total Reading	.33	.39	.48	.40	-.03	.53	.39	.20	.35	.13	.49	.33	.34	-.08	.43	.15	.40	.21	.26	.33	.36	.32	.37	.32	.27	.31	.38	.36	.43	.54	.17	.95	.81								
35 CAT Arithmetic Reasoning	.51	.50	.59	.62	.08	.61	.29	.16	.49	.29	.51	.45	.35	-.12	.52	.21	.43	.24	.34	.35	.54	.37	.38	.40	.42	.45	.42	.57	.61	.70	.09	.75	.54	.75							
36 CAT Arithmetic Fundamentals	.41	.21	.37	.32	-.02	.61	.04	-.06	.22	.15	.37	.28	.24	-.01	.41	.00	.44	.21	.23	.33	.38	.38	.27	.27	.36	.45	.25	.44	.41	.54	-.02	.62	.24	.57	.66						
37 CAT Total Arithmetic	.48	.49	.53	.33	.01	.68	.19	.07	.41	.21	.51	.46	.29	-.11	.49	.08	.46	.27	.30	.31	.50	.40	.35	.34	.44	.50	.36	.56	.55	.68	.04	.79	.45	.72	.92	.89					
38 CAT Mechanics of English	.43	.59	.59	.51	.21	.55	.43	.34	.48	.21	.44	.35	.34	-.10	.45	.26	.33	.25	.36	.23	.37	.40	.36	.41	.35	.31	.46	.41	.48	.60	.28	.66	.57	.70	.63	.45	.59				
39 CAT Spelling	.32	.28	.35	.27	.00	.49	.21	.08	.29	.01	.30	.28	.24	.03	.32	.08	.39	.21	.24	.48	.29	.25	.20	.25	.26	.20	.22	.31	.41	.40	.01	.75	.52	.72	.57	.56	.63	.59			
40 CAT Total Language	.40	.54	.54	.46	.15	.59	.41	.36	.54	.12	.42	.32	.31	-.09	.40	.17	.42	.31	.36	.33	.39	.36	.28	.38	.38	.33	.39	.45	.51	.58	.16	.75	.56	.70	.69	.59	.68	.83	.74		
41 CAT Total	.47	.50	.57	.50	.07	.56	.33	.21	.50	.16	.52	.41	.34	-.09	.48	.17	.47	.27	.34	.39	.45	.43	.39	.43	.30	.38	.41	.47	.55	.66	.17	.92	.68	.92	.83	.72	.86	.84	.77	.89	

INTERCORRELATION MATRIX — Grade II

TABLE 5

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
1	WISC Performance I.Q.																																									
2	WISC Verbal I.Q.	.54																																								
3	WISC Full Scale I.Q.	.85	.89																																							
4	WISC Information	.58	.80	.79																																						
5	WISC Comprehension	.21	.70	.54	.45																																				
6	WISC Arithmetic	.24	.54	.51	.35	.12																																			
7	WISC Similarities	.39	.69	.62	.46	.33	.31																																		
8	WISC Vocabulary	.39	.77	.68	.52	.47	.36	.35																																	
9	WISC Sum Verbal	.53	.99	.89	.80	.70	.54	.70	.77																																
10	WISC Picture Completion	.65	.48	.63	.47	.23	.27	.39	.31	.47																															
11	WISC Picture Arrangement	.56	.45	.57	.50	.27	.06	.25	.44	.45	.45																														
12	WISC Block Design	.79	.42	.68	.44	.17	.34	.34	.24	.43	.36	.39																													
13	WISC Mazes	.64	.28	.50	.24	.06	.39	.08	.27	.28	.22	.08	.49																												
14	WISC Object Assembly	.41	.02	.23	.16	-.04	-.01	-.01	-.01	.02	.02	-.16	.14	.32																											
15	WISC Sum Performance	.99	.53	.85	.57	.22	.34	.37	.39	.53	.65	.56	.79	.64	.42																											
16	Large-Thorndike Oral Vocab.	.40	.45	.49	.40	.24	.17	.30	.46	.45	.20	.34	.29	.22	.17	.41																										
17	Large-Thorndike Cross-Out	.35	.43	.45	.49	.26	.25	.12	.39	.43	.35	.49	.18	.16	.00	.35	.44																									
18	Large-Thorndike Pairing	.32	.30	.41	.51	.25	.15	.20	.25	.39	.28	.18	.26	.09	.16	.32	.23	.35																								
19	Large-Thorndike Total	.45	.61	.61	.58	.38	.32	.37	.50	.61	.42	.49	.28	.18	.03	.45	.72	.71	.62																							
20	Lincoln-Oseretsky Motor Development	.26	.20	.27	.20	.10	.13	.00	.29	.20	.16	.00	.03	.19	.45	.26	.29	.36	.22	.25																					
21	Piaget Space	.33	.28	.34	.33	.17	.12	.25	.11	.28	.12	.15	.30	.18	.27	.32	.40	.24	.34	.39	.22																				
22	Piaget Time	.23	.21	.25	.25	.17	.00	.29	.01	.21	.01	.13	.23	.10	.10	.23	.45	.15	.40	.43	.03	.49																			
23	Piaget Night	.32	.30	.35	.27	.27	.15	.04	.31	.30	.24	.29	.24	.06	.09	.32	.30	.21	.11	.20	.29	.19	.17																		
24	Piaget Dream	.33	.32	.36	.32	.17	.24	.20	.18	.31	.37	.27	.20	.17	.09	.33	.27	.43	.29	.35	.33	.38	.24	.49																	
25	Piaget Conserv. of Quant.	.28	.47	.44	.53	.10	.26	.48	.29	.47	.19	.17	.28	.13	.09	.27	.40	.21	.36	.40	.10	.44	.27	.22	.50																
26	Piaget Conserv. of Surf.	.40	.33	.40	.39	.02	.41	.21	.20	.33	.31	.17	.33	.18	.17	.39	.14	.01	.26	.21	.01	.21	.28	.35	.24	.58															
27	Piaget Inclusion	.33	.37	.39	.40	.15	.24	.26	.24	.37	.10	.15	.25	.27	.26	.33	.42	.31	.45	.44	.27	.32	.32	.15	.34	.36	.21														
28	Piaget Movement	.38	.42	.45	.38	.29	.31	.21	.29	.42	.16	.32	.40	.14	.13	.38	.39	.36	.21	.33	.14	.31	.23	.33	.35	.27	.33	.22													
29	Piaget Seriation	.39	.27	.37	.30	.18	.35	.04	.14	.27	.18	.21	.37	.35	.19	.39	.06	.33	.31	.28	.15	.39	.15	.04	.26	.20	.24	.26	.08												
30	Piaget Total	.54	.55	.62	.59	.29	.40	.37	.34	.55	.31	.32	.46	.30	.27	.54	.50	.38	.49	.54	.30	.40	.55	.55	.04	.77	.69	.62	.53	.46											
31	Chronological Age (in months)	.02	-.21	-.11	-.04	-.24	-.16	-.21	-.11	-.21	-.14	-.24	.05	.03	.38	.02	.08	.01	.06	-.23	.20	.05	.00	.18	.13	.11	-.02	.26	-.08	.03	.13										
32	CAT Reading Vocabulary	.49	.38	.48	.41	.17	.30	.23	.24	.38	.26	.20	.40	.30	.27	.48	.37	.36	.38	.46	.38	.50	.46	.16	.31	.26	.35	.22	.39	.40	.51	-.01									
33	CAT Reading Comprehension	.56	.33	.52	.47	.21	.28	.15	.25	.38	.34	.39	.38	.28	.20	.55	.46	.54	.40	.60	.33	.44	.38	.30	.42	.27	.30	.20	.44	.37	.52	-.02	.93								
34	CAT Total Reading	.54	.41	.53	.48	.22	.31	.18	.28	.41	.32	.32	.40	.34	.25	.54	.44	.51	.42	.57	.41	.51	.45	.31	.43	.30	.36	.23	.47	.40	.57	.00	.97	.80	.86						
35	CAT Arithmetic Reasoning	.44	.49	.62	.55	.28	.32	.27	.31	.49	.38	.39	.51	.43	.44	.56	.25	.42	.42	.40	.40	.49	.32	.35	.37	.30	.38	.37	.40	.47	.60	.01	.66	.62	.70	.75					
36	CAT Arithmetic Fundamentals	.56	.45	.57	.55	.22	.37	.19	.27	.45	.27	.19	.43	.44	.36	.56	.25	.43	.46	.47	.38	.50	.39	.38	.42	.37	.44	.37	.44	.44	.56	.00	.71	.72	.76	.85	.97				
37	CAT Total Arithmetic	.61	.48	.61	.58	.22	.36	.24	.30	.48	.32	.27	.47	.45	.34	.61	.33	.45	.46	.47	.38	.50	.39	.38	.42	.37	.44	.37	.44	.44	.57	.00	.82	.68	.82	.91	.97				
38	CAT Mechanics of English	.43	.33	.42	.39	.12	.26	.19	.22	.33	.29	.25	.28	.28	.15	.42	.32	.56	.39	.48	.20	.37	.28	.12	.32	.25	.24	.23	.29	.40	.42	.19	.58	.68	.82	.76	.84	.89	.86		
39	CAT Spelling	.42	.32	.42	.40	.17	.15	.17	.23	.32	.22	.13	.29	.28	.30	.41	.23	.37	.45	.41	.38	.38	.47	.15	.35	.27	.37	.19	.32	.35	.46	.24	.64	.68	.82	.76	.84	.89	.86		
40	CAT Total Language	.46	.37	.47	.44	.17	.26	.21	.24	.37	.28	.24	.32	.31	.21	.46	.32	.56	.42	.49	.26	.42	.37	.15	.36	.28	.30	.23	.53	.44	.48	.14	.79	.78	.66	.66	.96	.75			
41	CAT Total	.62	.50	.63	.59	.24	.37	.26	.31	.49	.33	.29	.47	.43	.33	.62	.40	.53	.50	.56	.41	.53	.43	.33	.44	.36	.41	.35	.47	.47	.65	.04	.95	.90	.89	.91	.94	.73	.81	.83	

total. It is also correlated significantly ($p < .05$) with the Lincoln-Oseretzsky total. The Piaget Total is also correlated significantly ($p < .01$) with the CAT Total (for Grades I and II), and it is more highly correlated with these achievement scores than the WISC, Lorge-Thorndike, or Lincoln-Oseretzsky totals. Discussion of the other relationships contained in the results of the correlational analysis shall await the presentation of the results of the other forms of analysis so that they may all be drawn upon together in the discussion and interpretation in the following section.

Factor Analysis

A summary of the results of the factor analyses for all three testing periods (K, I, II) for 3 combinations of variables are given in Tables 6a to 6c. The number of factors was three, as determined by Kaiser's criterion ("rotate as many factors as there are eigen values greater than or equal to unity") and Cattell's Scree Test. Squared multiple correlations were used as the initial communality estimates, thus making these analyses principal factor analyses aimed at best reproducing the observed correlations.

Although varimax rotation was selected in a quest for simple structure, several authors, notably Burt (1955), Kohlberg (1969), and Stevens (1969), have suggested that additional (and possibly more valid) information for interpretation may be obtained by investigating unrotated or obliquely rotated factors. Also, C. Harris (1967) suggested using several different computational schemes for the initial solution, obtaining desired solutions, both orthogonal and oblique, comparing the results, and regarding as substantative findings those factors that are robust with respect to method. The method or lack of rotation does not substantially alter the patterns of the factor coefficients or the interpretation of the factors for these data.

The major interpretation of the factor analyses (as for the other forms of analysis) will be reserved for the following section where all the results can be drawn upon simultaneously and related to the four hypotheses.

TABLE 6a

RESULTS OF FACTOR ANALYSIS--KINDERGARTEN TEST PERIOD

Variable Combinations	F1	F2	F3
	General-psychometric and verbally-mediated intelligence	Piagetian operational intelligence	Piagetian experiential, logical-classification, seriation and achievement intelligence
10 WISC and 9 Piagetian Subtests	All WISC Subtests have high loadings ($\geq .30$) except Comprehension, Arithmetic and Mazes. Piagetian Subtests have generally low loadings, and no Piagetian Subtest has its highest loading on this factor. But the verbal and early subtests (Space, Time, Night, Dream and Movement) have moderate loadings, and the two conservation subtests and Inclusion and Seriation have low or negative loadings.	Six Piagetian Subtests have high loadings ($\geq .30$). All Piagetian Subtests (except Inclusion) have at least moderate loadings. (Notice that the conservation subtests have especially high loadings.) No WISC Subtest has a high loading.	Three WISC Subtests have high loadings ($\geq .30$), i.e., Similarities, Block Design and Mazes. The Piagetian Night, Inclusion and Seriation Subtests have quite high loadings ($\geq .45$).

TABLE 6a--continued

Variable Combinations	F1	F2	F3
10 WISC, 3 Lorge-Thorndike, 1 Lincoln-Oseretzsky and 9 Piagetian Subtests and CA	Ditto;[1] the only changes of note are that the Piagetian Space, Time and Movement Subtests have increased loadings such that they are highest on this factor and Conservation of Quantity also has a higher loading. Additionally, the Lorge-Thorndike Subtests have at least moderate loadings (Oral Vocabulary is highest). The Lincoln-Oseretzsky has a moderate loading on this factor, and CA has a high negative loading.	Ditto; the only change of note is that the Piagetian Inclusion Subtest has a higher loading such that all Piagetian Subtests without exception have at least moderate loadings. Additionally, the Lorge-Thorndike and the Lincoln-Oseretzsky Subtests both have their lowest loadings on this factor; CA has a moderate loading.	Ditto. Additionally, all three of the Lorge-Thorndike Subtests have their highest loadings on this factor as does CA; the Lincoln-Oseretzsky has a moderate loading.
10 WISC, 9 Piagetian and 6 CAT Subtests	CAT data not available for Kindergarten Test Periods.		

[1]Here and in Tables 7b and 7c Ditto means, "Generally the same as above for WISC and Piagetian Subtests."

TABLE 6b

RESULTS OF FACTOR ANALYSIS--GRADE I TEST PERIOD

Variable Combinations	F1	F2	F3
	General-psychometric and verbally-mediated intelligence	Piagetian operational intelligence	Piagetian experiential, logical-classification, seriation and achievement intelligence
10 WISC and 9 Piagetian Subtests	All WISC Subtests (especially the verbal) have high loadings ($\geq$ .30) except Picture Arrangement, Block Design and Mazes. Piagetian Subtests have generally low loadings, and no Piagetian Subtest has its highest loading on this factor. But the verbal and earlier subtests (Space, Time, Night, Dream and Movement) have moderate loadings, and the two conservation subtests and Seriation have low or negative loadings.	Six Piagetian subtests (including the two conservation measures) have quite high ($\geq$ .45) loadings. All Piagetian Subtests (except Inclusion) have at least moderate loadings. The WISC Verbal Information and Arithmetic Subtests and all WISC Performance Subtests (except Object Assembly) have high loadings ($\geq$ .30).	Only four WISC Subtests have even moderate loadings, i.e., Information, Arithmetic, Similarities and Picture Arrangement. The Piagetian Night, Conservation of Quantity, Inclusion and Seriation have quite high loadings ($\geq$ .45).

TABLE 6b--continued

Variable Combinations	F1	F2	F3
10 WISC, 3 Lorge-Thorndike, 1 Lincoln-Oseretzsky and 9 Piagetian Subtests and CA	Ditto. Additionally, the Lorge-Thorndike Subtests have at least moderate loadings (Oral Vocabulary is highest on this factor); the Lincoln-Oseretzsky has a moderate leading on this factor; and CA has a negative loading.	Ditto; the only change of note is that the Piagetian Inclusion Subtest has a higher loading such that all of the Piagetian Subtests without exception have at least moderate loadings. Additionally, the Lorge-Thorndike and the Lincoln-Oseretzsky Subtests have their lowest loadings on this factor; CA has a negative loading.	Ditto. Additionally the Lorge-Thorndike Stubtests have at least moderate loadings (Cross-Out and Pairing are the highest on this factor); the Lincoln-Oseretzsky has its highest loading on this factor as does CA.
10 WISC, 9 Piagetian and 6 CAT Subtests	Ditto; the only change of note is that the WISC Object Assembly Subtest has a somewhat lower loading. Additionally, the six CAT Subtests have generally low loadings, with Reading Comprehension, Arithmetic, and Mechanics of English having the greatest of these low loadings.	Ditto; the only changes of note are that WISC Arithmetic and Picture Completion Subtests have somewhat lower loadings. Additionally, the six CAT Subtests have generally low loadings, with the two Arithmetic Subtests having the greatest of these low loadings.	Ditto; the only changes of note are that the WISC Arithmetic has a notably higher loading and the Piagetian Conservation has a notably lower loading. Additionally, all CAT Subtests have their highest loadings on this factor.

TABLE 6c
RESULTS OF FACTOR ANALYSIS--GRADE II TEST PERIOD

Variable Combinations	F1	F2	F3
	General-psychometric and Verbally-mediated intelligence	Piagetian operational intelligence	Piagetian experiential, logical-classification, seriation and achievement intelligence
10 WISC and 9 Piagetian Subtests	All WISC Subtests (especially the Verbal) have high loadings (≥ .30) except Mazes and Object Assembly. The Piagetian Subtests have generally moderate loadings. However, Night, Dream and Movement have high loadings (≥ .30) and Space and Time have low loadings.	All Piagetian Subtests except Night, Movement, and Seriation, have rather high loadings (≥ .40). The WISC Subtests have generally low loadings, except for Information and Similarities, which have high loadings (≥ .30).	Four WISC Subtests have high loadings (≥ .30) i.e., Arithmetic, Block Design, Mazes, and Object Assembly. The Piagetian Inclusion and Seriation Subtests have high loadings (≥ .30).

TABLE 6c--continued

Variable Combinations	F1	F2	F3
10 WISC, 3 Lorge-Thorndike, 1 Lincoln-Oseretzsky and 9 Piagetian Subtests and CA	Ditto. Additionally, the Lorge-Thorndike Subtests have at least moderate loadings (Oral Vocabulary and Pairing are highest on this factor); the Lincoln-Oseretsky has a moderate loading on this factor as does CA.	Ditto. Additionally, the Lorge-Thorndike Oral Vocabulary and Pairing Subtests have high loadings. The Lincoln Oseretzsky has quite a low loading on this factor as does CA.	Ditto; the only changes of note are that the WISC Arithmetic, Block Design and, to a lesser degree, Mazes, have lower loadings. Additionally, the Lorge-Thorndike Subtests all have moderately high loadings; the Lincoln-Oseretzsky has a high loading as does CA.
10 WISC, 9 Piagetian and 6 CAT Sub ests	Ditto. Additionally, the six CAT Subtests have generally low loadings, with Reading Comprehension, Arithmetic Reasoning, and Arithmetic Fundamentals having the greatest of these low loadings.	Ditto. Additionally, the six CAT Subtests have generally low loadings, with the two Arithmetic Subtests having the greatest of these low loadings.	Ditto; the only changes of note are that the WISC Arithmetic, Block Design and Mazes have loadings that are somewhat larger in magnitude. Additionally, the six CAT Subtests have their overwhelmingly greatest loadings on this factor.

Stepwise Multiple Regression

The results of the stepwise multiple regression for each of the test periods (I, II) for the total scores are given in Tables 7a and 7b, respectively. Unity was selected as the critical value of the F-ratio for a variable's inclusion in the regression. In Table 7 below is presented the relation of the following two tables to the test periods and the variables.

Recall that in stepwise multiple regression at each step one variable is added to the regression equation. The variable added is the one which makes the greatest reduction in the error sum of squares.

TABLE 7

MULTIPLE REGRESSION TABLES

Variable Combinations		Test Period	
Independent	Dependent	Grade I	Grade II
1. WISC Full Scale IQ Lorge-Thorndike IQ Lincoln-Oseretzsky Score Piaget Total Chronological Age	CAT Total	Table 8a	Table 8b
2. "	CAT Reading		
3. "	CAT Arithmetic		
4. "	CAT Language		

Equivalently it is the variable which has the highest partial correlation with the dependent variable partialed on the variables already added, and also equivalently it is the variable which, when added, has the highest F value.

Since this is the final set of results before the interpretation section, which follows, interpretation will be delayed until there where all the results will be discussed together and examined for interpretation and conclusions.

TABLE 7a

RESULTS OF MULTIPLE REGRESSION FOR TOTAL SCORES

GRADE I TEST PERIOD

Dependent Variable	Independent Variable Entered	Multiple R^2	Increase in R^2	F Value to Enter
CAT Total	Piaget Total	.43	.43	41.92
	WISC Full Scale IQ	.49	.06	5.61
CAT Reading	Piaget Total	.29	.29	22.64
	WISC Full Scale IQ	.33	.04	3.36
	Lorge-Thorndike IQ	.35	.02	1.12
CAT Arithmetic	Piaget Total	.46	.46	47.06
	WISC Full Scale IQ	.49	.03	2.82
	CA	.50	.01	1.54
CAT Language	Piaget Total	.34	.34	28.50
	WISC Full Scale IQ	.40	.06	5.75

TABLE 7b

RESULTS OF MULTIPLE REGRESSION FOR TOTAL SCORES

GRADE II TEST PERIOD

Dependent Variable	Independent Variable Entered	Multiple R^2	Increase in R^2	F Value to Enter
CAT Total	Piaget Total	.42	.42	40.66
	WISC Full Scale IQ	.51	.09	8.86
CAT Reading	Piaget Total	.32	.32	26.59
	WISC Full Scale IQ	.38	.06	4.39
	Lorge-Thorndike IQ	.39	.01	1.16
CAT Arithmetic	Piaget Total	.43	.43	42.28
	WISC Full Scale IQ	.50	.07	7.53
CAT Language	Piaget Total	.23	.23	16.76
	WISC Full Scale IQ	.28	.05	3.50
	CA	.30	.02	1.52

In this section we have set forth the results of the quantitative analysis performed in this study. In the succeeding section we will draw upon these results to see what evidence they provide for the acceptance or rejection of our four hypotheses. We will also examine the results to see what conclusions, beyond the hypotheses, they suggest.

VI. Discussion, Interpretation, and Conclusions

This section will be chiefly devoted to applying the results of the data analysis on the four hypotheses. Some additional ideas suggested by the results but extending beyond the framework established by the hypotheses will be presented at the end of this section.

Conclusions about the Hypotheses

The conclusions about the hypotheses can be presented as the response to three questions which are given and discussed below.

Does Performance on Piagetian Measures Bear a Moderate, Positive Degree of Relationship to Performance on Traditional Measures?

The results relevant to this question are directed toward Hypothesis I: (Degree of relatedness of the two types of measures.) "The degree of the relationship between performance on Piagetian tests of intelligence and traditional psychometric measures is moderate and positive." The results of two of the types of analysis (correlation and factor analysis) apply directly to this first hypothesis.

First of all, the correlational evidence set forth in Tables 3, 4, and 5 for Grades K, I, and II respectively, indicates that 30, 67, and 69 percent respectively of the correlations between Piagetian and psychometric measures are significantly different from zero, without however their approaching unity. Thus, one can conclude that there is a moderate, positive, and statistically significant degree of relationship between the two types of

measures. Let us examine the correlational evidence supporting this suggestion in greater detail by first considering the correlational evidence suggesting that the degree of the relationship between the two types of measures is positive and then considering the evidence suggesting that the degree of the relationship is moderate.

In Grade K the Piaget total has a correlation of .56 with the WISC Full Scale IQ and a correlation of .40 with the Lorge-Thorndike total, both of which are significant at the .01 level ($r \geq .35$).[3] Moreover, the Piaget total correlates significantly at the .01 level with all three of the Lorge-Thorndike subtests and with four of the ten WISC subtests (as well as with six of ten WISC subtests at the .05 level [$r \geq .36$]). Also, the WISC Full Scale IQ correlates significantly at the .01 level with six of the nine Piaget subtests, while the Lorge-Thorndike total correlates significantly at the .05 level with four of the nine Piaget subtests.

Table 9a gives (for each grade) the number of WISC subtests with which each Piaget subtest correlates significantly ($p < .05$). Similarly, Table 9b gives (for each grade) the number of Piaget subtests with which each WISC subtest correlates significantly ($p < .05$).

In Grade I the Piaget total has correlation of .58 with the WISC Full Scale IQ and a correlation of .48 with the Lorge-Thorndike total, both of which (as in Grade K) are significant at the .01 level. Moreover, the Piaget total correlates significantly at the .01 level with all three of the Lorge-Thorndike subtests and with six of the ten WISC subtests (as well as with seven of ten WISC subtests at the .05 level). Also, the WISC Full Scale IQ correlates significantly at the .01 level with five of the nine Piaget subtests (as well as with all nine at the .05 level), while the Lorge-Thorndike total correlates

[3]Read "positive and significant" for "significant" unless otherwise indicated.

significantly at the .05 level with all nine of the Piaget subtests.

In Grade II the Piaget total has a correlation of .62 with the WISC Full Scale IQ and a correlation of .54 with the Lorge-Thorndike total, both of which (as in Grades K and I) are significant beyond the .01 level. Moreover, the Piaget total correlates significantly at the .01 level with all three of the Lorge-Thorndike subtests and with four of the ten WISC subtests (as well as with nine of ten WISC subtests at the .05 level). Also, the WISC Full Scale IQ correlates significantly at the .01 level with seven of the nine Piaget subtests (as well as with eight out of nine at the .05 level [while the ninth misses significance at this level by only .01, i.e., it is .25 instead of .26]), while the Lorge-Thorndike total correlates significantly at the .05 level with seven of nine Piaget subtests.

Thus, the detailed correlational results highlighted above strongly suggest the acceptance of the first half of Hypothesis I since it is clear from the number and proportion of significant correlations between the two types of variables that they are not totally unrelated for any of the three test periods but instead have a positive degree of relationship.

Further evidence supporting the acceptance of the other half of Hypothesis I (that the degree of relationship is moderate as well as postive) is provided by the fact that, while many of our intercorrelations are indeed significantly greater than zero, the correlations between the two total scores are only .56, .58, and .62 for Grades K, I, and II respectively such that one type of variable provides only $(.56)^2 = .31$, $(.58)^2 = .34$, and $(.62)^2 = .38$ or only about one-third of the information required for perfect prediction of the other type of variable (the variance interpretation of correlation). Moreover, the largest intercorrelation among the subtests is .56 (between Block Design and Movement, Grade II). Thus each test provides at a maximum only $(.56)^2 = .31$,

or, again, only about one-third of the information required for perfect prediction of a test of the other type. Thus, the acceptance of Hypothesis I *in toto* is strongly suggested since it is clear from the correlational evidence that the two types of measures are neither totally unrelated nor do they assess identical abilities but instead bear a moderate, positive degree of relationship to each other.

The second of the three types of evidence directed toward the first hypothesis is the factorial evidence set forth in Tables 7a to 7c. By the nature of the factor analytic technique, it is not possible that a table of factor loadings should reveal any relationships not already contained in the tables of correlations. By reducing dimensionality, however, this technique may make such relationships "more highly visible." Analogously it may make it possible to see the forest in spite of the trees. As in the case of the correlational evidence attention here will be devoted first to the part of Hypothesis I that asserts that the degree of the relationsip between the two types of measures is positive and then to the part that asserts that the degree of relationship is moderate.

The factorial evidence suggesting the acceptance of the first half of Hypothesis I arises from the fact that although for all three grades the first factor is a basically psychometric factor and the other two factors are identifiable as Piagetian factors (as defined by high loadings on those types of tests) there are significant loadings of at least some of the "other" types of tests on each of the factors. For example, the first factor in Grade K has high loadings ($\geq .30$) on all the WISC tests, but the verbal and early Piagetian subtests also have significant loadings on this factor. This situation is generally reversed on the second factor where, although Piagetian tests dominate, WISC tests still contribute significantly. The third factor (although

identifiable as a Piagetian factor by virtue of the strength of the Piagetian Inclusion and Seriation tests over all of the three test periods) can be regarded as a "mixed" factor by virtue of its high loadings on both types of measures in Grades K and II. Thus the fact that subtests of each type do not load on completely different orthogonal factors provides strong factorial evidence in favor of the acceptance of the first half of Hypothesis I since it is clear that the two types of variables are not totally unrelated for any of the three test periods but instead have a positive degree of relationship.

Further evidence of supporting the acceptance of the other half of Hypothesis I (that the degree of the relationship is moderate as well as positive) is provided by the fact that the three factors (especially the first two) are clearly identifiable as predominantly WISC or Piagetian. The fact that the tests do not load evenly and randomly over the factors indicates that there is a significant difference in the traits assessed by each type of measure. Thus, the acceptance of Hypothesis I in toto is again strongly suggested since it is clear from the factorial evidence that the two types of measures are neither totally unrelated nor do they assess identical abilities but instead bear a moderate, positive degree of relationship to each other.

In the previous pages it has been seen that two bodies of the results of our analysis give strongly supporting evidence for the acceptance of Hypothesis I and for an affirmative answer to the question introducing this discussion. Thus, we are led to conclude from an examination of the evidence from simple correlation and factor analysis that performance on Piagetian measures is related to but not identical with performance on traditional measures of mental development and that the degree of the relationship between the two types of measures is moderate, positive, and significant.

The existance of such a relationship between these two types of

measures in which they measure related but also distinguishable aspects of mental functioning makes it legitimate and desirable to investigate the question:

What Do Piagetian Measures Assess That Traditional Measures Do Not (and How Do They Contribute to the Prediction of Achievement)?

The results relevant to this question are directed toward

Hypothesis II. (Similarity of the two types of measures): Traditional psychometric and Piagetian measures of intelligence both assess "general intelligence."

Hypothesis III. (Difference between the two types of measures): Piagetian measures assess some traits not assessed by traditional measures of general intelligence.

Hypothesis IV. (Contribution of the Piagetian measures to prediction of achievement): Piagetian measures add significantly to the prediction of school achievement by traditional psychometric measures of intelligence.

In the following pages the implications of the results of the analysis for each of these three hypotheses will be examined in the order stated.

The results of two of the types of analysis used in this study apply directly to Hypothesis III. First of all, the correlational evidence set forth for all three grades in Tables 3, 4, and 5 reveals few negative associations among these deliberately diverse tools for observing mental behavior. Secondly, there are generally moderate, positive, significant relationships exhibited by correlational analysis.

The factorial evidence points in the direction of the acceptance of this Hypothesis II since, for all three grades (Tables 7a to 7c), even the orthogonal factor loadings reveal a first factor with generally high loadings on the WISC, generally moderate loadings on the Piaget, the Lorge-Thorndike, and the Lincoln-Oseretzsky tasks, and generally low loadings on the WISC Mazes, CA, and the CAT tasks.

This factor seems similar to the first general intelligence factor found by Kohlberg and De Vries (1969), except that it appears in the orthogonally rotated as well as the unrotated loadings. It is also in general agreement with the first (general intelligence and school achievement) factor found by Stevens (1969), except that it does not include school achievement (low loadings on CAT), which is found here on the third factor instead.

That this factor is not a maturational one is indicated by its low loadings on CA. That it is not a school experience factor is indicated, as noted above, by its low loadings on CAT. That it may validly be interpreted as a "general intelligence" factor is suggested by its pervasiveness throughout all measures (except those that assess some quite specific aspect of total mental development) and its broad distribution over those measures involving a general ability to manipulate verbal symbols. Thus, the correlational and factorial evidence noted above strongly suggests the acceptance of Hypothesis II (Similarity of the two measures) and the conclusion that both types of measures draw upon a common "symbolic facility" which may be designated as "general intelligence."

The factorial evidence on the second and third factors applies particularly to Hypothesis III (Difference between what is assessed by the two types of measures). The second factor is clearly a Piagetian (operational) factor dominated (especially in Grades K and I) by the conservation tasks, and also involving the other Piagetian operational tasks. It has generally low loadings on the WISC tasks (except for the Performance tasks in Grade II) and on the Lorge-Thorndike and Lincoln-Oseretzsky tasks and on CA as well as on the CAT, except for the two arithmetic subtests.

This second factor seems similar to the third (conservation) factor found by Kohlberg and De Vries (1969) and the second (operational thought) factor found by Stevens (1969).

That this factor is not a purely maturational one is indicated by its low loadings on CA (especially in Grades I and II). That it is not a school experience factor is indicated by its low loadings on the CAT. The low loadings on the Lorge-Thorndike (and of course the WISC) indicate that this factor reflects a substratum of ability quite different from that commonly assessed by psychometric tests of mental functioning. This, of course, points to the acceptance of Hypothesis III.

Besides the Piagetian factor, described above (factor two) there is another Piagetian (experiential, logical-classification, seriation, and achievement) factor (factor three) which further suggests the acceptance of Hypothesis III. This factor is characterized by high loadings on the Piagetian Inclusion (classification) and Seriation (sequentiation) tasks, as well as on such sequential manipulative WISC tasks as Block Design and Mazes. The Lorge-Thorndike has high loadings, and while this set of measures purports to be an assessment of "general abstract intelligence," it deals basically with the class relationships among concepts and symbols.

This third factor seems similar to the second (classificatory-linguistic) factor of Kohlberg and De Vries (1969), except that the linguistic part of his factor properly belongs on the first factor of this study. The loadings which he got on language are probably (like our loading on oral vocabulary in Grade I) quite age specific. This factor is also in general agreement with Steven's third (classificatory thought) factor, except that it is broader and includes school achievement.

The consistently heavy loadings on CAT (school achievement) and CA of this factor over all three grade periods is quite provocative, especially in view of the clarity of the first two factors as broad WISC and Piagetian factors. The clear implication (to be taken up further in the discussion of Hypothesis IV)

is that the types of mental functioning represented by the first two factors here are far less fruitful for the prediction of achievement than the classificatory and sequential type of activity represented by this third factor, especially when general experience (as broadly represented here by CA) is taken into account.

Thus, the factorial evidence for the existence of two Piagetian factors (the second and third factors) clearly distinct from the (first) psychometric factor strongly suggests the acceptance of Hypothesis III (Difference between what is measured by the two types of measures) and the conclusion that while both types of measures do draw upon a common general intelligence factor (Hypothesis II), still (Hypothesis III) the Piagetian tasks assess some aspects of mental functioning not generally assessed by traditional psychometric tasks.

When Hypothesis IV (Contribution of the Piagetian measures to prediction of achievement) is examined in the light of our results, the factorial and stepwise multiple regression analysis furnish the chief evidence.

The factor analyses show overwhelming loadings of the CAT variates on the third factor (which is the Piagetian experiential, logical-classification, seriation, and achievement factor). Thus, this evidence favors the acceptance of Hypothesis IV, since some Piagetian measures do seem to be closely associated with achievement. What is most interesting, as noted previously, is that it is neither the (general intelligence) first factor nor the (broad Piagetian) second factor that shows this relationship with performance, but the third factor. Since this factor is clearly distinct from the other two and is overwhelmingly associated with performance, it seems most desirable, from a prediction viewpoint, to concentrate on its growth in children. The results of the stepwise multiple regression (Tables 8a and 8b) further dramatize the superiority of total Piaget over total WISC variables as predictors of CAT for both Grade I and Grade II. Thus, two bodies of evidence point toward the acceptance of the Hypothesis IV and toward the conclusion that exploration and development of what is measured

by the Piagetian tasks (especially Inclusion and Seriation) may lead to vastly superior prediction and development of achievement.

The foregoing conclusions may be summarized by noting that the evidence which has been discussed above indicates that the answer to the first part of the question with which this section was begun ("What do Piagetian measures assess that traditional measures do not?") is that Piagetian measures assess two dimensions of thought almost untapped by traditional psychometric measures. These are a dimension of operational (and conservational) thought represented by the second factor of the factor analysis and a dimension of classificatory and sequential thought represented by the third factor. (The Lorge-Thorndike test participates in both the WISC factor and the second of the Piaget factors, without, however, penetrating into Piagetian operational thought factor.)

The answer to the second part of the question with which this section was begun ("How do they (Piagetian tasks) contribute to the Prediction of Achievement?") is that Piagetian measures in general contribute more to the prediction of achievement than traditional psychometric tests (Tables 8a and 8b), and, among Piagetian tasks, Inclusion and Seriation tasks are those most highly associated with achievement.

VII. Summary and Recommendations for Future Research

The picture of the relationship between the traditional psychometric and the Piagetian measures of mental development revealed by this study can be summarized as follows: To this study's first question, "Does performance on Piagetian measures bear a moderate, positive degree of relationship to performance on traditional measures?" the answer is, yes, since the evidence makes it clear that the two types of measures are neither totally distinct nor totally identical.

The answer to the study's second question, "What do Piagetian measures assess that the traditional measures do not (and how do they contribute to the prediction of achievement?)," has several aspects. First it appears that while both types of measures contribute to a "general intelligence" factor, this aspect of mental functioning is largely defined by the psychometric measures, especially the WISC subtests. The existence of yet a second (orthogonal) Piagetian factor of operational thought suggests, however, the uniqueness of the Piagetian tasks and the aspects of mental development they reflect. The existence of a third (orthogonal) Piagetian largely experiential, logical-classification, seriation, and education factor suggests the richness as well as the uniqueness of the aspects of a child's thought processes that we may approach by Piagetian means. At the same time, it seems that psychomotor skills are not as closely related to all of the Piagetian measuring devices as the theory seems to suggest. As far as the last part of the second question is concerned, it seems that the overwhelming and dominant concurrent association of this third factor with measures of school achievement points the way to new and possibly more valid and reliable predictors and developmental aids to children's achievement.

The factors of mental structure identified in this study (general-psychometric and verbally-mediated intelligence; Piagetian operational intelligence; and Piagetian experiential, logical-classification, seriation, and achievement intelligence) are similar in broad outline to those obtained by Kohlberg and De Vries (1969) and by Stevens (1969). These may be "the three" fundamental or primary aspects of mental functioning, at least for normal members of the general age and cultural groups considered here. Moreover, the fact that the three primary mental abilities uncovered in this study remain generally recognizable over a three-year period from approximately 5 to 8 years of age and that the elimination of loadings appearing at only a single test period elimiates some of the vagueness and overlap from the Kohlberg and

De Vries' or the Stevens' factors suggests that a valid and reliable, new conceptual framework may exist both for (1) further theory development and model building in the area of human intelligence in the traditions of Spearman, Thurstone, and Guilford as well as of Piaget; and (2) construction of more reliable, valid, and efficient diagnostic, formative, summative, and predictive measures of children's mental lives.

The goal of immediate future research should be to further validate and refine these three basic factors by extending the number and types of tests and the number and types, ages, etc., of subjects in future studies of this type. For instance, clarification could result from the inclusion of tests such as Thurstone's Primary Mental Abilities tests, ETS's set of Cognitive Reference tests, and noncognitive tests (besides the psychomotor test employed here) of such traits as motivation, attitude, and self-concept.

At the same time, tests designed to measure the third factor discovered in this study in a pure manner should be constructed, given, and correlated with various criteria of performance to see if, indeed, a new, better, and shorter road to prediction of achievement has been discovered.

Another fruitful area of investigation would be to examine the relationship of the three factors of this study to Guilford's "Structure of Intellect" model to further refine and define them and to see if they are truly adequate to describe general mental functioning. This might lead to an answer to the question of what sorts of performance the first two factors of this study are related to in view of the fact that they have no apparent close tie to school achievement. Similarly the relationship of these three factors to the emergent "hierarchical" models of mental structure, such as those of Bloom, Gagne, Walbesser, Ebel, et al., should be explored for purposes of clarification, validation, and extension.

A more general recommendation for future research is that the quantitative, and especially the factorial methodology employed here be explored further as a tool for the refinement and validation of the Piagetian model of human development. A related and most important area of research is that of the susceptibility of the three factors identified here to influence by changes in the child's environment. A truly experimental set of studies should reveal whether especially the third factor can (and should) be expanded or accelerated.

Additions to the Bibliography

Longeot, F. Psychologie differentielle et théorie opératoire de l'intelligence (Differential Psychology and Piaget's Theory of Intelligence). Paris, Dunod, 1969.

Myeres, C. E. and Orpet, R. E. Ability factor location of some Piagetian tasks at 5 1/2 years. Proceedings of the 79th Annual Convention of the American Psychological Association, 1971.

Tuddenham, R. D. A Piagetian test of cognitive development. P. 49-70 in W. B. Dockrell (ed.) On Intelligence. Methuen, London, 1970.

Warburton, F. W. The British Intelligence Scale. P. 71-98 in W. B. Dockrell (ed.) On Intelligence. Methuen, London, 1970.

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BIBLIOGRAPHY

Achenbach, T. M. Conservation of illusion-distorted identity: its relation to MA and CA in normals and retardates. Child Development, September, 1969, 40, 3, pp. 663-674.

Adcock, Ugaire V. and Adcock, C. J. A factorial study of the ego reference system. The Journal of Genetic Psychology, 1967, 110, pp. 105-115.

Almy, M., Chittenden, E., and Miller, P. Young children's thinking. New York: Teachers College Press, Teachers College, Columbia University, 1966.

Almy, Millie, et al. Logical thinking in second grade. New York: Teachers College Press, Teachers College, Columbia University, 1970.

Anastasi, Anne. Psychological testing. Third edition, New York: The Macmillan Company, 1968.

Ausabel, David P. Learning theory and classroom practice. Toronto: The Ontario Institute for Studies in Education, Bulletin No. 1, 1967.

Baumeister, S. A. and Bartlett, C. J. A comparison of the factor structure of normals and retardates on the WISC. American Journal of Mental Deficiency. 66, 1962, pp. 641-646.

Bereiter, C. and Engelman, S. Teaching disadvantaged children in the pre-school. Englewood Cliffs, New Jersey: Prentice Hall, 1966.

Berlyne, D. E. Conflict, arousal, and curiosity. New York: McGraw Hill, 1960.

Berman, I. Wechsler scores vs. Piaget levels: a study of the cognitive efficiency of institutionalized retardates. Dissertation Abstracts, 25, (3), 2040, 1964.

Bertalanffy, Ludwig von. General systems theory. New York: George Braziller, 1969.

Bloom, B. S., Hastings, J. T., and Madans, G. F. Handbook on formative and summative evaluation of student learning. New York: McGraw Hill Book Company, 1971.

Braine, M.D.S. Piaget on reasoning: a methodological critique and alternative proposals. In W. Kessen and C. Kuhlman (eds) Thought in the Young Child. Monographs of the Society for Research in Child Development, 27, (2, Serial No. 83) pp. 41-63.

Braun, J. S. Relation between concept formation ability and reading achievement at three developmental levels. Child Development, 1963, 34, pp. 675-681.

Bruner, J. S. The course of cognitive development. American Psychologist, 1964, 19, pp. 1-16.

Bruner, J. S. et al. Studies in cognitive growth. New York: John Wiley and Sons, 1966.

Bybee, Rodger and McCormack, Alan. Applying Piaget's theory. Science and Children, 1970, Vol. 8, No. 4, pp. 14-17.

Campbell, D. T. and Fiske, D. W. Convergent and discriminant validation by the multitrait-multimethod matrix.. Psychological Bulletin, 56, 1959, pp. 81-105.

Campbell, Donald T. and Stanley, Julian C. Experimental and quasi-experimental designs for research. Rand McNally and Company, 1963.

Cattell, Raymond B. The meaning and strategic use of factor analysis. Handbook of Multivariate Experimental Psychology, Raymond B. Cattell, (ed), Chicago: Rand McNally and Co., 1966, pp. 174-243.

Charlesworth, William R. Development and assessment of cognitive structures. Journal of Research in Science Teaching, Vol. 2, 1964, pp. 215-219.

Cronbach, Lee J. Essentials of psychological testing. Second edition. New York: Harper and Row, 1960.

Davis, Frederick B. Educational measurements and their interpretation. Belmond, California: Wadsworth Publishing Co., Inc., 1964.

DeAvila, Edward A. and Randall, David L. A group measure of the Piagetian concepts of conservation and egocentricity. Canadian Journal of Behavioral Science, (1), 4, 1969, pp. 263-271.

Decarie, T. G. Intelligence and affectivity in early childhood. New York: International Universities Press, 1965.

Deese, James. General psychology. Boston: Allyn and Bacon, Inc., 1967.

Delorme, Andre and Pinard, Adrien. Le developpement de la notion de vitesse relative. Canadian Journal of Behavioral Science, 2, (2), 1970, pp. 91-103.

DeVries, R. and Kohlberg, L. The concept assessment kit-conservation. Journal of Educational Measurement, Vol. 6, No. 4, Winter, 1969, pp. 263-269.

Dodwell, P. C. Children's understanding of number and related concepts. Canadian Journal of Psychology, 14, 1960, pp. 191-205.

Dodwell, P. C. Children's understanding of number concepts: characteristics of an individual and a group test. Canadian Journal of Psychology, 15 (1), 1961, pp. 29-36.

Dodwell, P. C. Relations between the understanding of the logic of classes and of cardinal number in children. Canadian Journal of Psychology. Vol. 16, 1963, pp. 152-160.

Duckworth, Eleanor. Piaget rediscovered. Journal of Research in Science Teaching. Vol. 2, 1964, pp. 172-175.

Dudek, S. Z., Lester, E. P., Goldberg, J. S., and Dyer, G. B. Relationship of Piaget measures to standard intelligence and motor scales. Perceptual and Motor Skills, 28, 1969, pp. 351-362.

Dyer, Henry S. Is testing a menace to education? An address delivered at the 1961 NEA Convention, Atlantic City, N. J., 1961.

Elkind, D. Piaget and Montessori. Harvard Educational Review, 1967, Vol. 37, No. 4, Fall, 1967, pp. 535-546.

Elkind, David. The development of quantative thinking: a systematic replication of Piaget's studies. The Journal of Genetic Psychology, 98, 1961, pp. 37-46.

Elkind, David. Piaget's conservation problems. Child Development, 38, 1967, pp. 15-27.

Elkind, David. Piagetian and psychometric conceptions of intelligence. Harvard Educational Review, (2) 1969, pp. 319-337.

Elkind, David and Flavell, J. H. (eds) Studies in cognitive development: essays in honor of Jean Piaget. New York: Oxford University Press, 1969.

Erikson, Erik H. Childhood and society. New York: Morton Press, 1964.

Escalona, K. D. and Corman, H. M. The validation of Piaget's hypothesis concerning the development of sensorimotor intelligence: methodological issues. Paper presented at the meeting of the Society for Research in Child Development, New York, 1967.

Feigenbaum, K. Task complexity and intelligence as variables in Piaget's problems of conservation. Child Development, 34, 1963, pp. 423-432.

Ferguson, G. A. Learning and human ability: a theoretical approach. Factor analysis and related techniques in the study of learning. Edited by P. H. DuBois, W. H. Manning, and C. J. Spies. A report of a conference held at Washington University in St. Louis, Missouri, February, 1959. Technical Report No. 7, Office of Naval Research Contract No. Nona, 816 (02).

Festinger, Leon and Katz, Daniel, (eds). Research methods in the behavioral sciences. Holt, Rinehart and Winston, 1966.

Flavell, John H. The developmental psychology of Jean Piaget. Princeton, New Jersey: D. Van Nostrand Co., Inc., 1963.

Fowler, W. Dimensions and directions in the development of affecto-cognitive systems. Human Development, 9, 1966, pp. 18-29.

Freyberg, P. S. Concept development in Piagetian terms in relation to school attainment. Journal of Educational Psychology, Vol. 57, No. 3, 1966, pp. 164-168.

Fruchter, J. H. Introduction to factor analysis. New York: D. Van Nostrand Company, 1954.

Furth, Hans G. Piaget and knowledge. Englewood Cliffs, New Jersey: Prentice Hall, 1969.

Gagne, R. M. The conditions of learning. New York: Holt, Rinehart and Winston, 1965.

Ginsburg, H. and Opper, S. Piaget's theory of intellectual development. Englewood Cliffs, New Jersey: Prentice Hall, 1969.

Glass, Gene V. and Stanley, Julian C. Statistical methods in education and psychology. Englewood Cliffs, N. J.: Prentice Hall, Inc., 1970.

Golden, Mark and Birns, Beverly. Social class and cognitive development in infancy. Merrill Palmer Quarterly, 14 (2), 1968, pp. 139-149.

Goldman, Jacquelin. Factor(s) in child development. Paper presented at the 1970 meeting of the AERA. February, 1971.

Goldman, R. J. The application of Piaget's schema of operational thinking to religious story data by means of a Guttman scalogram. British Journal of Educational Psychology, 35, 1965, pp. 158-171.

Goldschmid, M. L. Different types of conservation and non-conservation and their relation to age, sex, I.Q., M.A., and vocabulary. Child Development, 38, 1967, pp. 1229-46.

Goodnow, J. J. and Bethon, G. Piaget's tasks: the effects of schooling and intelligence. Child Development, 37, 1966, pp. 573-582.

Green, B. F. A method of scalogram analysis using summary statistics. Psychometrica, 21, 1956, pp. 79-89.

Guilford, J. P. Factorial angles to psychology. Psychological Review, 68, 1961, pp. 1-20.

Guildford, J. P. The nature of human intelligence. New York: McGraw Hill Book Co., 1967.

Gulliksen, Harold. Methods for determining equivalence of measures. Psychological Bulletin, Vol. 70, No. 6, 1968, pp. 534-544.

Guttman, L. The basis for scalogram analysis. In S. A. Stouffer, et al, Measurement and Prediction, Princeton, New Jersey: Princeton University Press, 1950, pp. 60-90.

Hahn, Erich. Aktuelle entwicklungstendenzen der sociologischen theorie. Deutsche Z. Philos., 15, 1967, pp. 178-191.

Harman, Harry H. Modern factor analysis. Chicago: The University of Chicago Press, 1960.

Harris, Chester W. (ed) Problems in measuring change. Madison, Wisconsin: University of Wisconsin Press, 1963.

Hellmuth, J. (ed). Cognitive studies. New York: Brunner/Magel, 1970.

Helmstadter, G. C. Principles of psychological measurement. New York: Appleton-Century-Croft, 1964.

Henry, William E. and Sanford, Nevitt (eds). Tests and measurement in child development: a handbook. San Francisco: Jossey Bass, Inc., 1971.

Hilgard, E. R. Theories of learning. Second edition. New York: Appleton-Century-Crofts, 1956.

Hofstätter, Peter R. The changing composition of intelligence: a study in T-technique. The Journal of Genetic Psychology, 85, 1954, pp. 159-164.

Hood, H. B. An experimental study of Piaget's theory of the development of number in children. British Journal of Psychology, 53, 1962, pp. 273-286.

Horst, Paul. Factor analysis of data matrices. New York: Holt, Rinehart and Winston, Inc., 1965.

Hunt, J. McV. The challenge of incompetence and poverty: papers on the role of early education. Arbana, Illinois: University of Illinois Press, 1969.

Hunt, J. McV. Intelligence and experience. New York: The Ronald Press Co., 1961.

Inhelder, Barbel. Criteria of the stages of mental development, in J. M. Tanner and B. Inhelder, (eds), Discussions on child development. Proceedings of the first meeting of the World Health Organization study group on the psychobiological development of the child. Vol. I, New York: International Universities Press, 1953, pp. 75-96.

Inhelder, Barbel. Cognitive development and its contribution to the diagnosis of some phenomena of mental deficiency. Merrill Palmer Quarterly, Vol. 12, 1966, pp. 299-319.

Inhelder, Barbel. The diagnosis of reasoning in the mentally retarded. New York: John Day Company, 1968.

Inhelder, Barbel. The diagnosis of reasoning processes in the retarded. New York: John Day Company (original French edition, 1943), 1970.

Inhelder, Barbel, Bovet, M., Sinclair, H., and Smock, C. D. On cognitive development. American Psychologist, Vol. 21, 1966, pp. 160-165.

Inhelder, Barbel, and Piaget, Jean. The early growth of logic in the child: classification and seriation. London: Routledge and Kegan Paul, 1964.

Jensen, Arthur, et al. Environment, heredity, and intelligence. Cambridge, Mass.: Compiled from the Harvard Educational Review, 1969.

Jones, Dorothy L. Relationships between concept learning and selected ability test variables for an adult population. Wisconsin Research and Development Center for Cognitive Learning: Technical Report No. 51. University of Wisconsin, 1968.

Kaiser, Henry F. and Caffrey, John. Alpha factor analysis. Psychometrica, Vol. 30, No. 1, 1965, pp. 1-14.

Keasey, C. T. and Charles, D. C. Conservation of substance in normal and mentally retarded children. Journal of Genetic Psychology, 111, 1967, pp. 271-279.

Kofsky, E. A scalogram study of classificatory development. Child Development, 37, 1966, pp. 191-204.

Kohlberg, L. Cognitive states and preschool education. Human Development, 9, 1966, pp. 5-17.

Kohlberg, L. Early education: a cognitive-development view. Child Development, Vol. 39, No. 4, 1968, pp. 1013-1062.

Kohlberg, Lawrence. Early education: a cognitive-developmental view. Child Development, Vol. 39, No. 4, December, 1968.

Kohlberg, Lawrence and DeVries, Rheta. Relations between Piaget and Psychometric assessments of intelligence. Paper presented at the Conference on the Natural Curriculum of the Child, Urbana, Illinois, 1969.

Krause, Irl Brown, Jr. A comparison of the psychological views of Piaget and Gesell. Journal of Thought, 3 (3), 1968, pp. 168-176.

Kugelmass, Sol and Breznitz, Salomo. The Guttman scale as a means of testing Piaget's theory of development. The Journal of Genetic Psychology, 111, 1967, pp. 169-170.

Langer, Jonas. Theory of development. New York: Holt, Rinehart and Winston, Inc., 1969.

Laurendeau, Monique and Pinard, Adrien. Causal thinking in the child: a genetic and experimental approach. New York: International Universities Press, 1962.

LeFrancois, Guy R. Piaget's developmental model: equilibration--through adaptation. Alberta Journal of Educational Research, 13, (3), 1967, pp. 161-171.

Longstreth, Langdon E. Psychological development of the child. New York: The Ronald Press Company, 1968.

Lord, Frederic M. and Novick, Melvin R. Statistical theories of mental test scores. Reading, Massachusetts: Addison-Wesley Publishing Co., 1968.

Loretan, Joseph O., et al. From theory to the classroom. Princeton, New Jersey: Educational Testing Service, 1965 (a).

Loretan, Joseph O. Alternatives to intelligence testing. 1965 Invitational Conference on Testing Problems. Princeton, New Jersey: Educational Testing Service, 1965 (b), pp. 19-30.

Lunzer, F. A. Recent studies in Britain based on the work of Jean Piaget. London: National Foundation for Educational Research in England and Wales, 1960.

McLaughlin, Harry G. Psycho-logic: a possible alternative to Piaget's formulation. British Journal of Educational Psychology, 33, 1963, pp. 61-67.

McNemar, Quinn. Psychological statistics. Third edition. New York: John Wiley and Sons, Inc., 1966.

Mann, John. Intelligence and creativity, Chapter 5 of Frontiers of psychology. New York: The Macmillan Co., 1963, pp. 141-166.

Mann, John. Multidimensional analysis of human behavior, Chapter 7 of Frontiers of psychology. New York: The Macmillan Co., 1963, pp. 195-228.

Manley, Myron B. A factor analytic study of three types of concept attainment tasks. Princeton, New Jersey: Educational Testing Service Research Bulletin (RB-65-31) October, 1965.

Melton, Richard S., et al. Cognitive growth in preschool children. A symposium presented at the annual meeting of the American Educational Research Association, Chicago, Illinois: February, 1968.

Miller, G. A. The magical number seven plus or minus two: some limits on our capacity for processing information. Psychological Reviews, 1956, 63, pp. 81-97.

Morrison, Donald F. Multivariate statistical methods. New York: McGraw Hill Book Co., 1967.

Neisser, U. Cognitive Psychology. New York: Appleton-Century-Crofts, 1967.

Nelson, Martin J. Intelligence and special aptitude tests, in Robert L.Ebel (ed) Encyclopedia of educational research. New York: The Macmillan Co., 1967.

O'Bryan, K. G. and Macarthur, R. S. A factor analytic study of Piagetian reversibility. Alberta Journal of Educational Research, Vol. 13, 3, Sept., 1967, pp. 211-219.

Peel, E. A. Learning and thinking in the school situation. Journal of Research in Science Teaching, Vol. 2, 1964, pp. 227-229.

Peel, E. A. Experimental examination of some of Piaget's schemata concerning children's perception and thinking, and a discussion of their educational significance. British Journal of Educational Psychology, Vol. 29, June, 1959, pp. 89-103.

Phillips, John L., Jr. The origins of intellect: Piaget's theory. San Francisco: W. H. Freeman and Co., 1969.

Piaget, Jean. Psychology and intelligence. Ed.by C. K. Ogden, Totowa, New Jersey: The International Library of Psychology, Philosophy and Scientific Method, Littlefield, Adams and Co., 1966. (Original French Edition 1947)

Piaget, Jean. The psychology of intelligence. New York: Harcourt, Brace, 1950.

Piaget, Jean. The origins of intelligence in children. Translated by Margaret Cook, New York: International Universities Press, 1952.

Piaget, Jean. The construction of reality in the child. Translated by Margaret Cook, New York: Basic Books, Inc., 1954.

Piaget, Jean. Logic and psychology. New York: Basic Books, 1957.

Piaget, Jean. Six psychological studies. Translated by Anita Tenzer, New York: Vintage Books, 1968.

Piaget, Jean. Science of education and the psychology of the child. Translated from the French by Derek Coltman, New York: Orion Press, 1970.

Piaget, Jean, and Inhelder, Barbel. The psychology of the child. Translated by Helen Weaver, New York: Basic Books, Inc., 1969.

Pinard, Adrien and Laurendeau, Monique. A scale of mental development based on the theory of Piaget. Journal of Research in Science Teaching, Vol. 2, 1964, pp. 253-260.

Pine, Patricia. What's the I.Q. of the I.Q. test? American Education, November, 1969, pp. 30-32.

Reiss, P. R. Implications of Piaget's developmental psychology for mental retardation. American Journal of Mental Deficiency, 72, 1968, pp. 361-369.

Ross, Elliott. An investigation of verbal and non-verbal expression of reading comprehension skills and classification abilities at the concrete operations stage. Unpublished dissertation, Philadelphia, Pennsylvania: Temple University, 1971.

Schwartz, Marilyn Miller and Scholnick, E. Scalogram analysis of logical and perceptual components of conservation of discontinuous quantity. Child Development, 41, 1970, pp. 695-705.

Scriven, Michael. Perspectives of curriculum evaluation. New York: Rand McNally, 1967.

Shipman, Virginia, et al. Disadvantaged children and their first school experiences. ETS-Head Start longitudinal study. Vol. 1, Princeton, New Jersey: Educational Testing Service, August, 1970.

Siegelman, Ellen and Block, Jack. Two parallel sets of Piagetian tasks. Child Development, 40 (3), 1969, pp. 951-956.

Sigel, Irving E. and Hooper, Frank H. (eds). Logical thinking in children: research based on Piaget's theory. New York: Holt, Rinehart and Winston, Inc. 1968.

Smedslund, J. Concrete reasoning: a study of intellectual development. Monographs of the Society for Research in Child Development, 29 (2, Serial No. 93), 1964.

Spearman, Charles E. An autobiography, in Carl Murchinson (ed) A history of psychology in autobiography. Worcester, Massachusetts: Clark University Press, 1930, pp. 299-333.

Standards for educational and psychological tests and manuals. American Psychological Assn., 1966.

Stevens, W. B., Miller, C. K., and McLaughlin, J. A. The development of reasoning, moral judgment, and moral conduct in retardates and normals. Report on Project No. RD-2382 - P, Philadelphia, Pennsylvania: Temple University, May, 1969.

Sullivan, Edmund V. Piaget and the school curriculum: a critical appraisal. Toronto: The Ontario Institute for Studies in Education, Bulletin No. 2, 1967.

Sullivan, Edmund V. Piagetian theory in the educational milieu: a critical appraisal. Canadian Journal of Behavioral Science, (3), 1969, pp. 129-155.

Sullivan, Edmund. Piagetian theory in the educational milieu. Canadian Journal of Behavioral Science, 1, (3), 1969, pp. 129-155.

Thorndike, Robert L. and Hagen, Elizabeth. Measurement and evaluation in psychology and education. Third edition. New York: John Wiley and Sons, Inc., 1969.

Thurstone, L. L. Multiple-factor analysis. Chicago: University of Chicago Press, 1947.

Torgerson, Warren S. Theory and methods of scaling. New York: John Wiley and Sons, Inc., 1958.

Tucker, Ledyard R. An inter-battery method of factor analysis. Psychometrica, Vol. 23, No. 2, 1958, pp. 111-136.

Tuddenham, Read D. Jean Piaget and the world of the child. American Psychologist, 21, 1966, pp. 207-217.

Tuddenham, Read D. Psychometricizing Piaget's methode clinque. Paper presented at the meeting of the American Educational Research Association, Chicago, Illinois: February, 1968.

Tyler, Leona E. Tests and measurement. Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1963.

Uzgiris, I. and Hunt, J. McV. An instrument for assessing infant psychological development. Paper presented at the International Congress of Psychology, New York, March 29-April 1, 1967.

Vinh-Bang, N. P. Une échelle de dévelopment du raisonnement. (In preparation)

Werner, H. Comparative psychology of mental development. New York: International University Press, 1957.

White, Sheldon. Evidence for a hierarchical arrangement of learning processes. In L. P. Lipsitt and C. C. Spiker (eds) Advances in child development and behavior, Vol. 2, New York: Academic Press, 1965, pp. 187-220.

Wohlwill, J. F. Responses to class-inclusion questions for verbally and pictorially presented items. Child Development, 39, 1968, pp. 449-466.

Wohlwill, Joachim F. A study of the development of the number concept by scalogram analysis. The Journal of Genetic Psychology, 97, 1960, pp. 345-377.

Wohlwill, Joachim F. Comments in discussion on the developmental approach of Jean Piaget. American Journal of Mental Deficiency, Monograph Supplement, 70, 1966, pp. 84-105.

Zern, David. Some trends in the development of concrete reasoning in children: a note to Jan Smedslund's 'Concrete reasoning: a study in intellectual development.' The Journal of Genetic Psychology, 115, 1969, pp. 3-5.

Zigler, E. Methatheoretical issues in developmental psychology, in M. H. Marx (ed) Theories in contemporary psychology. New York: Macmillan, 1963, pp. 341-369.