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A total of 125 white children from three counties in Georgia (selected as representative of small rural and medium and large industrial urban populations) were administered a battery of tests in three phases of their schooling: (1) during the summer preceding their admission to the first grade, (2) near the end of the first grade, and (3) near the end of the third grade. The two objectives of this longitudinal testing were to describe the factorial organization of intelligence at the age levels tested and to observe changes in this organization as they occurred when the same subjects were measured repeatedly. The test battery included the Wechsler Intelligence Scale for Children, the Peabody Picture Vocabulary Test, and the Ammons Full Range Picture Vocabulary Test. Twelve factors were discovered, overall. The overlapping appearance of some factors in two or more phases confirmed the idea of the existence of stable mental factors at the preschool level. Identification of two emergent factors supported the idea that intelligence tends to differentiate with increasing age and experience. (WD)

A Longitudinal Investigation of Change in the Factorial Composition of Intelligence with Age in Young School Children

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While most theorizers assent to Wechsler's description of intelligence as a complex constellation of interacting factors, attempts to identify and define these factors have failed to result in unanimity. The dissenting conclusions found in the literature have been explained as functions of variables such as differences in statistical technique, varying philosophical orientations which affect decisions about rotation, and the nature of the sampled population. The question of the parameters of the sampled population assumes major proportion when one recognizes that one of the integral problems in the factorial description of intelligence involves the relationship between age and factorial structure. While there are important dissenters to the thesis, it appears that changes in the factorial organization of intelligence occur as functions of increasing age and experience. In reference to this change, one of the most recently published factor analytic investigators concludes that, "The problem is no longer whether it happens, but why it happens." The most comprehensive objective of this investigation is the description of the factorial organization of intelligence at the age levels tested. A second important objective is to observe changes in this organization as they occur when the same subjects are measured repeatedly.

The original experimental group consisted of 163 white children selected from three counties in Georgia representative of small rural, medium, and large industrial urban populations. At the time of the initial testing during the summer preceding their admission to the first grade in 1961 their mean age was 6 years, 2 months and the mean Wechsler Intelligence Scale for Children Full Scale I. Q. was 103. The subjects still available were retested near the end of the first grade in 1962 and again near the end of the third grade in 1964. A total of 125 subjects completed the three phases of the program. One important argument for selecting this age range inheres in the fact that there are no other known factor analytic WISC studies at the pre-school level. Also it seems reasonable to expect pronounced developmental changes psychologically in an age range in which profound physical changes occur.

The test battery administered in each phase included the Wechsler Intelligence Scale for Children, the Peabody Picture Vocabulary Test, the Ammons Full Range Picture Vocabulary Test and two reference tests. Prior to statistical analysis each WISC subtest except Coding was split into two, three or four parts to which individual subtest items were assigned by simple rotation. This operation resulted in 26 WISC variables which combined with the four tests mentioned previously to form a 30 variable intercorrelation matrix. The creation of additional variables by the modification provided the design with the capability of establishing more than the traditional number of dimensions

identified in most Wechsler analyses but it does not force this result. The resulting data were factor analyzed and rotated to Kaiser's varimax criterion. Tucker's congruence coefficients were computed between all factors, thereby facilitating the matching of factors.

Results

Eight factors were extracted from the 1961 testing. Ten factors were extracted for the 1962 data and nine for the 1964 data. In 1961, one of the factors was identified by its high loading on Manipulation of Areas and in 1962 one of the factors was identified by its high loading on Number Concepts. Since each of these is a "non-Wechsler" reference-variable factor and since each appears in only one of the three analyses they are not treated in this paper nor do they appear in the table. A factor loading of .40 is accepted as the significance criterion. However factor loadings of greater than .30 are accepted as significant when other splits from the same subtest also load significantly on a given factor. The presence of the stronger loading constitutes evidence that a somewhat weaker loading on another split of the same subtest may be more than an artifact. Note that five factors are "continuous," i. e. they are identifiable in the pre-school analysis and persist in each succeeding analysis. Obviously these lend themselves most easily to interpretation.

Factor A: Expressive Psycholinguistic. This is clearly the "Verbal" factor inevitably found in Wechsler analyses. The designation is borrowed from C. E. Meyers who uses it to discriminate between the receptive and the expressive use of language. The consistent Information and Vocabulary loadings suggest verbal facility or fluency rather than the application of judgment to new situations. The relation of the Comprehension subtest to Factor A is enigmatic. In 1961 and 1964 it forms the nucleus of a separate factor while it combines with factor A in 1962. This question will receive more extensive treatment when factors H, I, J and K are discussed. Factor A appears to place a premium on verbally retained knowledge. The increased loading of Information on Factor A in 1964 may be a reflection of the impact of formal education.

Factor B: Perceptual Organization. This factor is most readily identified by its consistently high loadings for Block Design. It is like Factor A in that a similar factor is systematically identified in Wechsler Analyses. Wechsler states that its main determinant involves the capacity to organize discrete spatially perceived units into larger wholes or configurations. Both in the visualization of outcome and in the manipulation of test material, speed is rewarded. It may be noted that the loadings for Object Assembly tend to reduce with increasing age. As a matter of fact, Object Assembly I does not load significantly on Factor B in 1964. More will be said about this trend in the treatment of Factor K.

Factor C: Numerical Ability. This factor has appeared repeatedly in previous factorial studies. In his factor analysis of the WISC standardization data Cohen identified a similar factor at the 13 - 6 age-level by its significant loadings on the Arithmetic and Digit Span subtests. The factor has frequently been identified as a "Memory" or "Freedom from distractibility" factor and certainly with good reason. "Numerical Ability" was selected in the present study because of the relationship of the Information subtest to Factor C. Note that in both 1961 and 1962 Information I loaded strongly on this factor. The items assigned to the Information I split are: (1) How many ears have you? (4) From what animal do we get milk? (7) How many pennies make a nickel? (10) How many things make a dozen? It seems likely that the common element running through each of the tests loading on this factor is content involving numbers. We are also confronted with a demonstration that item content, as well as item form, had considerable explanatory value in Wechsler tests.

Factor D: Perception of Incongruity. This factor derives its identity from its consistent Picture Completion loadings. In his analysis of the WAIS performance at four adult age levels, Cohen found that most of the Picture Completion variance was accounted for by a quasi-specific factor which he declined to interpret. Certainly its authenticity is attested by this study. The basic task of Picture Completion is the differentiation of essential from non-essential details. Since failure on Picture Completion is frequently a result of inappropriateness rather than lack of response, Wechsler provisionally describes this factor as a relevance factor. Thus Factor D can be identified in the pre-school analysis and seems to be well stabilized in the nine-year-old subject.

Factor E: Eduction of Conceptual Relations. Cohen found that Picture Arrangement loaded on a factor which he declined to interpret at ages 10 - 6 and 13 - 6. The present study reinforces his findings that Picture Arrangement cannot be accounted for in terms of a general "Perceptual Organization" or "Performance" factor. While Digit Span-Backwards disappears from this factor in 1964, its presence in two out of three analyses may contribute to the psychological meaningfulness of the factor. It may well be that the common element is sequence. Certainly the ability to give order to a series of discrete events is an important element in reasoning.

While factors A through E are not free of interpretive difficulty, it is fair to point out that the interpretation of the remaining factors is considerably more perplexing. The remaining factors are non-continuous in the sense that they failed to appear in all three analyses. Some of them are suggestive and induce one to generate hypotheses. Others are bewildering.

Factor F: Verbal Concept Formation. This factor is identified by its strong Similarities loading in 1961 which becomes exclusive in 1962. Both splits load decisively on the Expressive Psycholinguistics factor in 1964. The only other substantial loadings for this subtest are on the Picture Completion factor where Similarities I has a loading of .27 and Similarities II of .41. While what these tests have in common is not apparent, it is interesting that

Cohen observed a tendency for the two to load on common factors in his WAIS analysis. It could be said of Factor F that the 1964 results tend to confirm the findings of numerous factorial studies but not those of our own. Further theorizing with the data at hand would probably not prove helpful. The behavior of the Similarities subtest in the 1966 analysis will be viewed with genuine interest.

Factor G: Perceptual Speed. After the 1962 analysis in which Coding loaded exclusively and heavily on a unique factor, it was felt that a new factor might be emerging. The 1964 results confirm this prediction. The fact that the increase in the age of the subjects resulted in the administration of a non-familiar more advanced form in 1964 strengthens the interpretation. The basic task involves the association of certain symbols with certain other symbols. The score is a function of the speed with which the subject is able to do this. The identification of a Coding factor concurs with the findings of Cohen who observed that the Digit Symbol subtest loaded exclusively on a specific factor at all four adult-age-levels. The inverse relationship between Coding and Arithmetic I is perplexing. In that there is no frame of reference for interpretation the most expedient recourse is to dismiss it as a statistical artifact.

Factors H, I. J and K: We propose to discuss these factors collectively because they all share some relationship, albeit obscure, to the Comprehension subtest. Factor H is relatively straightforward and can be identified as a Comprehension factor. The main operation seems to be the evaluation of past experience in making judgment about new situations. The chief interpretive problem presented by Factor H stems from its absence in 1962 when Comprehension loads on the Linguistic factor. In his WISC analysis Cohen also observed the motility of the Comprehension subtest between the clear cut Verbal factor and a second factor identified by its loading on Comprehension, Vocabulary and Picture Completion. This factor and the 1964 Factor H are almost identical. This constitutes a strong argument for the authenticity of the factor in spite of the divergent results in 1962.

Factors I, J and K are even more difficult. Viewed comprehensively they do point up the independent, if not capricious, behavior of Comprehension III. Note that both Factor I in 1962 and Factor K in 1964 have strong inverse loadings for Comprehension III and Manipulation of Areas. This result, while consistent, does not yield to attempts at explanation. In 1962, Comprehension loads on still another factor, J, and again its bedfellows fail to contribute to its meaningfulness. The behavior of the Comprehension subtest supports two conclusions: (1) Comprehension is among the most factorially complex subtests; (2) Item content may be more important than item form in accounting for its variability. The fact that Comprehension III separates from the other Comprehension splits in 1964 provides an example of this. Comprehension III items involve the proper course of behavior if the grocer runs out of bread, the advantages in building a house of brick rather than wood, the advantages of paying bills by check rather than cash and the merits of cotton fiber in making cloth. While the items in each split were assigned by simple rotation, it appears that these particular items have a unique element. They are uniformly devoid of the interpersonal quality which is apparent in most of the remaining

items. The interpersonal content is exemplified by items like, "What is the thing to do if a fellow much smaller than yourself starts to fight with you?" or "Why should a promise be kept?" A quote from Wechsler's Adult Intelligence seems appropriate. In writing of the Comprehension test he observes, "Even more suggestive are certain capacities which, though as yet not actually demonstrated factorially, seem on the basis of clinical experience to influence performance on this test. One of these is a 'factor' that might be termed 'social sterotypy'; another, 'common sense judgment.' But here again one must await further analysis to substantiate these clinical hunches." The behavior of Comprehension in the present investigation may well constitute a substantiation of his informed hunch.

Factor L: Visualization. While this is a complex factor, it may derive its identity from its loading of both Object Assembly splits. The observation has already been made that Object Assembly tends to reduce its loadings on the Perceptual Organization factor with increasing age. In 1964, one of the Object Assembly splits leaves this factor entirely. The tentative interpretation is that Factor L represents an emerging factor which may increase in strength and definition with age. Perhaps the most basic difference between Block Design and Object Assembly is that Block Design requires the reproduction of a geometrical pattern provided by the examiner, while Object Assembly requires that the subject visualizes the finished product using only the cues supplied by inductive process.

Summary and Conclusions

1. The results of the present study are generally consistent with prior factor studies of the Wechsler. The greater number of factors identified is the function of methodology which permits, but doesn't force, this outcome. This investigation is important in that it confirms the existence of stable mental factors at the pre-school level.

2. The investigation resulted in the tentative identification of two emergent factors. This is interpreted as qualified support for the hypothesis that intelligence tends to differentiate with increasing age and experience. The ambiguous nature of the evidence is characterized by the Concept Formation Factor which appears to have undergone a process of consolidation.

3. The results suggest greater factorial specificity than has frequently been imputed to the Wechsler subtests. It would appear that the criticism of the clinical interpretation of the Wechsler psychogram on the basis of the factorial complexity of the subtests may be overestimated.

4. The results suggest that item content is an important determinant in factorial structure of the Wechsler. To the extent that the factorial complexity of a given subtest is determined by content, attempts to rank subtest items in terms of "absolute level of difficulty" will yield dissenting results as a function of the population sampled. The independent behavior of the Comprehension III split and the loading of the Information I split on a numerical ability factor provide good illustrations of the importance of item content.

In summary, an investigation of this nature leaves many questions unanswered and results in many conclusions which must be regarded as tentative. To any of you who experience a strong need for closure, I can only remind you that a fourth testing of the same group is scheduled for the Spring of 1966.

S.E.P.A.
April 2, 1965
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Table I

Significant Factor Loadings for WISC Performance at Three Age-levels:
A Longitudinal Analysis

1961		1962		1964	
Factor A: Expressive Psycholinquistics					
Information II	45	Information II	45	Information I	65
Information III	32	Comprehension I	61	Information II	74
Vocabulary I	69	Comprehension II	61	Information III	64
Vocabulary II	41	Comprehension III	47	Similarities I	69
Vocabulary III	64	Vocabulary I	61	Similarities II	60
Vocabulary IV	66	Vocabulary II	70	Vocabulary I	59
Peabody Picture Vocabulary	61	Vocabulary III	63	Vocabulary II	69
Ammons Full-Range Picture Vocab.	71	Vocabulary IV	63	Vocabulary III	39
		Peabody Picture Vocabulary	53	Vocabulary IV	63
		Ammons Full-Range Picture Vocab.	59	Peabody Picture Vocabulary	67
				Ammons Full-Range Picture Vocab.	57
Factor B: Perceptual Organization					
Digit Span-Backward	42	Block Design I	82	Arithmetic I	38
Block Design I	79	Block Design II	77	Arithmetic II	52
Block Design II	78	Object Assembly I	46	Block Design I	80
Object Assembly I	68	Object Assembly II	58	Block Design II	83
Object Assembly II	57			Object Assembly II	44
				Number Concepts	58
Factor C: Numerical Ability					
Information I	59	Information I	74	Arithmetic I	41
Arithmetic I	39	Information II	42	Arithmetic II	39
Arithmetic II	61	Arithmetic I	68	Digit Span-Forward	46
Digit Span-Forward	73	Arithmetic II	56	Digit Span-Backward	77
Digit Span-Backward	42				
Factor D: Perception of Incongruity					
Picture Completion I	55	Picture Completion I	60	Similarities II	41
Picture Completion II	60	Picture Completion II	56	Picture Comp. I	73
Picture Completion III	75	Picture Completion III	73	Picture Comp. II	59
Object Assembly II	41			Picture Comp. III	38
Number Concepts	45				

1961		1962		1964	
Factor E: Eduction of Conceptual Relations					
Digit Span-Backward	43	Digit Span-Backward	68	Picture ArrangementI	83
Picture Arrangement I	80	Picture Arrangement I	61	Picture ArrangementII	57
Picture Arrangement II	78	Picture Arrangement II	57		
Factor F: Verbal Concept Formation					
Information III	62	Similarities I	80		
Arithmetic I	51	Similarities II	74		
Similarities I	65				
Similarities II	63				
Coding A	58				
Factor G: Perceptual Speed					
		Coding A	83	Arithmetic I	48
				Coding B	82
Factor H: Evaluation of Past Experience					
Information I	30			Comprehension I	60
Information II	44			Comprehension II	68
Comprehension I	57			Vocabulary I	37
Comprehension II	50			Vocabulary II	30
Comprehension III	59			Vocabulary III	32
Picture Completion II	48			Picture Completion II	41
Factor I: Unnamed					
		Information III	-72		
		(Comprehension III	34)		
		Manipulation of Areas	-61		
Factor J: Unnamed					
		Comprehension III	60		
		Digit Span-Forward	74		
		Object Assembly I	-37		
Factor K: Unnamed				Comprehension III	78
				Manipulation of Areas	-53
Factor L: Visualization					
				Picture Completion III	54
				Vocabulary III	55
				Object Assembly I	68
				Object Assembly II	34

Note: Decimals are omitted.