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THE HIERARCHICAL FACTOR STRUCTURE OF THE WISC-R FOR READING DISABLED CHILDREN[1]

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ABSTRACT

A Wherry and Wherry (1969) hierarchical factor solution was obtained on WISC-R subtest intercorrelations for a sample comprised of 112 reading disabled children. A hierarchical ability arrangement congruent with Vernon's (1950) structural paradigm was obtained. The hierarchy included a general (*g*) factor, two subgeneral factors corresponding to the verbal-educational (*v:ed*) and spatial-perceptual-mechanical (*k:m*) dimensions from Vernon's paradigm, and four primary factors corresponding to those obtained by Cohen (1959) in his classical analysis of the WISC.

INTRODUCTION

There are a substantial number of studies which suggest that the structural paradigm proposed by Vernon (1950) provides a parsimonious account of the subtest variance in the Wechsler (1949, 1955, 1967, 1974) scales. Hierarchical factor analyses of the standardization data for the Wechsler Intelligence Scale for Children (WISC; Wechsler, 1955), Wechsler Preschool and Primary Scale of intelligence (WPPSI; Wechsler, 1967), and Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974) have all shown an ability arrangement congruent with Vernon's (1950) paradigm (Blaha, Wallbrown & Wherry, 1974; Wallbrown, Blaha & Wherry, 1974; Wallbrown, Blaha & Wherry, 1973; Wallbrown, Blaha, Wallbrown & Engin, 1975). In all four of these studies, the ability hierarchy included a strong general intelligence (*g*) factor and two major group factors corresponding to the verbal-educational (*v:ed*) and spatial-perceptual (*k:m*) parameters from Vernon's model.

The Wherry and Wherry (1969) method was used in all four of these studies cited above since it is especially suited for examining the structural relationships among ability dimensions such as those included in Vernon's (1950) model. That is, the Wherry and Wherry (1969) solution provides an objective procedure for obtaining a hierarchical ability arrangement if, in fact, such an ability arrangement is congruent with the data. As noted by Wallbrown, Blaha, and Wherry (1974), the Wherry and Wherry (1969) computer solution eliminates the subjectivity of the original Wherry (1959) solution by using a principal factor analysis along with a Minres cleanup to estimate communalities and a Varimax rotation for assigning variables to clusters. The essential steps in the Wherry and Wherry (1969) solution include first factoring the variable matrix and then rotating the factors thus obtained to Varimax criterion. The second step involves setting up clusters for each so they consist of those variables whose higher absolute loading falls on that factor. The third step consists of establishing a theoretical R matrix (from the relationship R = FF') and using the clusters from step two (with correct communalities in the diagonals) in performing a Thurstone multiple-group centroid analysis through obtaining the cluster intercorrelation matrix. The fourth step consists of obtaining a factor solution on the cluster intercorrelation matrix and extending this matrix by appending uniqueness factor loadings for each of the original clusters. The fifth step consists of changing the extended factor matrix into a transformation matrix by a modified Newton-Raphson process which modifies it so that its transpose is its inverse thus assuring that the rotations will be orthogonal. The transformation matrix thus obtained is then multiplied by the original Varimax loadings used to construct the theoretical R matrix. This procedure ($H = F \bullet T'$) provides the hierarchical factor loadings.

When more than one higher-order factor is obtained, the loadings for the unique cluster factors are dropped and the loadings for the new higher-order factors are retained to form a new theoretical R matrix. The entire process described above is then repeated. This process is either continued until only one general factor appears or terminated if the criteria for further higher-order factorization are not met.

The Wherry and Wherry (1969) solution offers several advantages for researchers but the most important one is that it provides an objective procedure for examining structural relations among abilities. Factor extraction can be controlled through specifying minimum eigenvalues and/or maximum residuals for both primary and higher order factors, as well as indicating the number of factors to be extracted at the primary level. Also, the proportion of variable variance attributable to factors at different hierarchical levels can be ascertained since the solution maintains orthogonality among factors at all levels in the hierarchy. Since variable variance can be apportioned between the general factor, group factors and primary factors, then one can ascertain the relative strength of factors at different levels in the ability hierarchy. Finally, the Wherry and Wherry (1969) solution has the potential advantage of eliminating the interpretational problems associated with oblique solutions where one must cope with inferred second-order and even third-order factors.

The factor structure of the WISC-R has not been investigated for reading disabled children using an objective method which shows the relative strength of factors at different hierarchical levels, as well as how the factors are arranged with respect to one another. Consequently, the present study was designed to determine the extent to which Vernon's (1950) structural model is applicable to the ability structure of reading disabled children. The work of Wallbrown, Blaha, Wherry and Counts (1974) with the WISC, suggests that the ability structure for reading disabled children may be somewhat more complex than the structure for normals. However, the extent to which these preliminary findings for the WISC can be generalized to the WISC-R must be determined empirically.

METHOD

SUBJECTS

The sample for the present study consisted of 112 children (82 boys and 30 girls) referred to the Reading Clinic of the Columbus (Ohio) Public Schools for psychological assessment. The diagnosis of reading disability was based on information from the following sources which were available for all children: developmental history, educational history, medical records, classroom behavior ratings, educational assessment and psychological evaluation. All children with impaired hearing or vision were excluded from the sample along with those diagnosed as emotionally disturbed or neurologically impaired. A detailed analysis of each student's reading skills was conducted by the educational diagnostician assigned to the clinic. A wide range of diagnostic reading tests and informal skill inventories were included in this assessment. The amount of time required for this assessment ranged from one to four hours. The scope of the diagnostic battery was partially determined by the nature of the presenting problem as described by the parents, classroom teacher and reading improvement teacher from the referring school. Other considerations were the age and skill level of the student, as well as the amount of diagnostic test data already available.

For all students included in the sample, the diagnosis of reading disability was established in a clinic staffing on the basis of all of the information described above. The only reading test available for all students was the Wide Range Achievement Test (Jastack & Jastack, 1965) which was routinely administered by the clinic psychologist as part of his assessment battery. When scores from this test were used, a two-year discrepancy between reading expectancy and reading achievement (sight vocabulary) was obtained. Reading expectancy was computed by subtracting 5-3 from MA (WISC-R FSIQ X CA) and converting the resultant grade-score to decimal form so it was comparable to grade-equivalent scores from the Wide Range. The discrepancy score was computed by subtracting the reading grade equivalent score from the reading expectancy score described above.

The mean WISC-R Full Scale IQ score for the sample was 101.6 (SD = 12.8) and scores for *S*s ranged from 86 through 129. The median CA for the sample was 10-10 and the age range extended from 9-2 through 13-7. The racial composition of the sample was a follows: White, 77; Oriental, 3; and Black, 32. A total of 23 different elementary schools from diverse parts of the city were represented in the sample. All 112 children were enrolled in regular elementary school classes.

DATA ANALYSIS

A Wherry and Wherry (1969) hierarchical factor solution was obtained on intercorrelations among the 12 WISC-R subtests for the 112 *S*s in the sample. At the primary level, factorization was controlled by specifying a maximum residual value of $1/\sqrt{N}$. Higher-order factorization was controlled by specifying a maximum residual value of $1/2\sqrt{N}$.

RESULTS

The hierarchical factor solution obtained for the sample of reading disabled children on the WISC-R is summarized in Table 1. Examination of the factor structure suggests a hierarchical ability arrangement congruent with Vernon's (1950) structural paradigm. That is, the basic ability dimensions indicated by this structural paradigm were not only obtained but they were also arranged hierarchically in the manner indicated by the paradigm. The ability hierarchy included a *g*-factor defined by a pattern of positive loadings from all 12 WISC-R subtests, as well as two subgeneral factors and four primary factors. The two subgeneral factors correspond to the two major group factors, *v:ed* and *k:m* from Vernon's (1950) paradigm. That is, removal of the *g*-variance resulted in fairly complete bifurcation between the verbal and performance subtests with the former defining *v:ed* and the latter defining *k:m*. The hierarchical arrangement was clearly evident at the primary level where two verbal factors differentiated from the *v:ed* factor and two performance factors differentiated from the *k:m* factor.

TABLE 1

HIERARCHICAL FACTOR MATRIX FOR READING DISABLED CHILDREN

VARIABLE	FACTOR						
	GENERAL	GROUP		PRIMARY			
	g	v:ed	k:m	1	2	3	4
WISC-R SUBTESTS							
Verbal Subtests							
Information	59	36	16	32	14	03	11
Similarities	53	25	21	43	02	07	00
Arithmetic	43	47	-10	01	41	01	-05
Vocabulary	49	32	11	53	-01	-07	08
Comprehension	33	26	04	49	-03	-08	-03
Digit Span	37	43	-10	-09	42	02	-01
Mean Loading-Verbal	46	35	05	28	16	00	02
Performance Substest							
Picture Completion	19	-12	28	13	-11	22	-12
Picture Arrangement	31	-01	28	06	-12	-01	51
Block Design	42	02	35	-16	14	32	05
Object Assembly	47	-07	47	03	-01	35	04
Coding	23	25	-05	04	11	-15	32
Mazes	35	00	31	-26	11	21	29
Mean Loading-Performance	33	01	27	-03	02	15	18
Mean Loading-All Subtests	39	18	16	13	09	08	10

Note: Decimal points have been omitted. Definition of terms are as follows: g = general intelligence; v:ed = verbal educational ability; k:m = spatial-perceptual-mechanical ability.

Correspondence between the third-order factor in the first column of Table 1 and the construct *g* was established on the basis of its position within the ability hierarchy, as well as the pervasive configuration of positive loadings from the 12 WISC-R subtests. Specifically, the mean loading for all 12 subtests on the *g*-factor was .39 and the mean loading for the six verbal subtests was .46 whereas the mean loading was .33 for the six performance subtests. Loadings for individual subtests ranged from a low of .19 for Picture Completion up to as high as .59 for Information and .53 for Similarities. The mean of the squared loadings indicates that the *g*-factor accounted for approximately 17% of the total variance in the 12 WISC-R subtests.

Since, as noted by Wallbrown, Blaha and Wherry (1974, p. 50), "*g* is implicitly defined as the pervasive overlap among diverse intelligence assessors," then congruence was established between this factor and *g*, which is a construct proposed to explain individual differences in general intelligence/scholastic aptitude/academic aptitude or the ability to master the academic aspects of the school curriculum ("book learning"). Such an interpretation of *g* seems to be consistent with the work of hierarchical theorists such as Burt (1949), Vernon (1950) and Thomson (1951), who have modified and expanded Spearman's (1904) original interpretation of *g* and determined its relationship to other ability dimensions.

Likewise, congruence can be established between the *v:ed* parameter from Vernon's (1950) paradigm and the second-order factor which is summarized in the second column of Table 1. That is, the *v:ed* interpretation of this factor can be justified by its position just below *g* in the ability hierarchy, as well as the pattern of positive loadings from the six verbal subtests which serve to define it. The mean of the squared loadings on the *v:ed*-factor for the 12 WISC-R subtest indicates that it accounts for approximately 7% of their total variance. The mean loading on this factor was .35 for the six verbal subtests and loadings for individual subtests ranged from a low of .25 for Similarities up to a loading of .47 for Arithmetic. The square of the mean loading for the six verbal subtests indicates that the *v:ed* factor accounts for about 12% of their total variance. In contrast, the mean loading for the six performance subtests on the *v:ed*-factor was only .01. The only performance subtest which showed an appreciable tendency to load the *v:ed*-factor was Coding with a loading of .25. This loading on the *v:ed*-factor by Coding might conceivably reflect a tendency for some reading disabled children to give verbal labels to the visual symbols comprising that subtest rather than using their visual memory.

In a similar fashion, congruence can be established between the second-order factor from the third column of Table 1 and the *k:m* parameter from Vernon's (1950) hierarchical paradigm. Here again, this interpretation is indicated by the nature of the defining subtests, as well as the position within the ability hierarchy. The *k:m*-factor was defined by a pattern of positive loadings from five of the six performance subtests. The Coding subtest did not load the *k:m*-factor appreciably, but the loadings for the other five performance subtests ranged from .28 for Picture Completion and Picture Arrangement to .47 for Object Assembly. The mean loading on the *k:m*-factor was .27 for the six performance subtests but only .05 for the six verbal subtests. The mean of the squared loadings for the 12 WISC-R subtests on this factor indicated that it accounted for approximately 6% of their total variance.

Four factors were not only obtained at the primary level, but they also remained intact after the overlap among them was removed. Again, a hierarchical ability arrangement was indicated since two of the primaries were differentiated from the broader *v:ed*-factor and the other two were differentiated from the *k:m*-factor. Factor 1 was defined by substantial positive loadings from Vocabulary, Comprehension, Similarities and Information subtests. The mean of the squared loadings for factor 1 indicated that it accounted for about

8% of the total WISC-R subtest variance. This particular configuration of loadings shows considerable similarity to the verbal comprehension factors obtained by Cohen (1957, 1959) in his analysis of the WISC and WAIS. Consequently, the name Verbal Comprehension (VC) was adopted for factor 1 and Cohen's (1959, p. 285) definition for Verbal Comprehension I was modified so it clearly excludes arithmetic skills. Specifically, the following definition seems appropriate for factor 1: "verbally retained knowledge (exclusive of arithmetic skills) impressed by education" (*ibid.*). Similar factors were obtained by Wallbrown, Blaha, Wherry and Counts (1974) in their analysis of the WISC for reading disabled children.

Correspondence can be readily established between factor 2 and the Freedom from Distractibility (FD) factor obtained by Cohen (1957, 1959) in his analyses of the WB, WISC and WAIS. This correspondence can be established on the basis of the loadings from the Digit Span and Arithmetic subtests which Cohen (1952, 1957, 1959) originally used to define this factor. Factor 2 was defined by a loading of .42 from Digit Span and .41 from Arithmetic. Factor 2 accounted for about 4% of the total WISC-R subtest variance. None of the other subtests showed an appreciable tendency to load this factor. Thus, Cohen's (1959, p. 272) original definition seems adequate for the present factor: "A conative factor which makes it possible for problem elements to 'register' and be manipulated without loss in the course of manipulation, i.e., the ability to attend or concentrate." Again, a similar factor for reading disabled children was evident in the Wallbrown, Blaha, Wherry and Counts (1974) and Wallbrown, Blaha, Huelsman and Wallbrown (1975) studies.

The content of the subtests defining factor 3 suggests that it represents the differentiation of the spatial (*k*) component from the broader spatial-perceptual-mechanical (*k:m*) factor described by Vernon (1950). Factor 3 accounted for approximately 3% of the total WISC-R subtest variance. Cohen (1959) obtained a similar factor defined primarily by loadings from Block Design and Object Assembly, but also including loadings from Mazes and Picture Completion at different age levels. In terms of the defining subtests, factor 3 can be equated to the Perceptual Organization (PO) factor which Cohen (1959) defined as measuring the ability to interpret and/or organize visually perceived material against a time limit. Here again, factors with a similar configuration of subtest loadings were obtained in the two studies above where hierarchical analyses of the WISC were performed for reading disabled children.

Since factor 4 is loaded by both Picture Arrangement and Coding, it shows considerable similarity to the Quasi-Specific (QS) factor obtained by Cohen (1959) and replicated by Wallbrown, Blaha, Wherry and Counts (1974) in their analyses for reading disabled children. This factor accounted for approximately 4% of the total subtest variance. Factor 4 was also loaded positively by the Mazes subtest in the present study. Determining what elements are common to the Coding, Picture Arrangement and Mazes subtests is difficult without the presence of further information. Consequently, the most reasonable course of action seems to consist of following the precedent established by Cohen (1959) and simply acknowledge the reality of this factor without offering any psychological interpretation as to what it actually measures.

DISCUSSION

When the results of the present study are compared with those obtained for the standardization sample in the Wallbrown, Blaha, Wallbrown and Engin (1975) study, then there is an adequate basis for surmising that the factor structure of the WISC-R is more complex for reading disabled children than for normals. One finds support for this hypothesis since a two-factor solution at the primary level provides a parsimonious account (minimum residuals $< 1/\sqrt{N}$) for the common variance in the WISC-R subtests for normals. In contrast, it was necessary to extract four primary factors to obtain a parsimonious account of the WISC-R subtest variance for the present sample of reading disabled children.

If one is willing to consider hierarchical analyses of the WISC for normal and reading disabled children, then a stronger argument for a more complex factor structure for the latter can be developed. The results of the Blaha, Wallbrown and Wherry (1974) study indicated that a hierarchical solution with two primary factors provides a parsimonious account of the common variance in the WISC subtests for the standardization sample. For reading disabled children included in the Wallbrown, Blaha, Wherry and Counts (1974) study, however, a hierarchical solution consisting of four primary factors was necessary to account for the common variance in the WISC subtests. In the case of the severely reading disabled sample used in the Wallbrown, Blaha, Huelsman and Wallbrown (1975) study, four primary factors were necessary to explain the common WISC subtest variance, but a hierarchical ability arrangement could not be obtained from the data. That is, factors corresponding to the *g*, *v:d* and *k:m* parameters from Vernon's (1950) paradigm were not present in the factor structure. When the three studies cited above are considered together, one seems justified in suggesting the hypothesis that the more severe the reading disability, then the more the factor structure for that group may be expected to differ from the factor structure obtained for normals.

In conjunction with the studies noted above, the results of the present study suggest the usefulness of further research designed to examine the factor structure of the WISC-R for normal and reading disabled children. Such research should be designed so the reading disabled and normal groups are matched for sex, age, socio-economic status and FSIQ on the WISC-R. With such controls on sample heterogeneity, one should be able to obtain an effective test of cognitive structure hypotheses such as those proposed by Muklebust, Bannochie and Killen (1971) on the basis of their clinical experiences with a wide range of learning disabled children.

FOOTNOTES

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[2]Requests for reprints should be sent to Fred H. Wallbrown, Department of Counseling and Personnel Services, Graduate School of Education, Kent State University, Kent, OH 44242.

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