conceptual ability (CONCEPT) consisted of the mean of Comprehension, Similarities, and Vocabulary. Spatial ability (SPATIAL) was based on the mean of Picture Completion, Block Design, and Object Assembly. Finally for the profile analysis, the eleven subtest scores (excluding Mazes) were used in their standard scaled-score form.

Analysis

Hierarchical discriminant function analysis was used to determine whether the three groups were discriminable on the basis of the nine indices described above. In hierarachical discriminant analysis,variables enter in predetermined order, and no variable is allowed to enter the analysis unless it significantly adds to discriminability. Thus overfitting and inflation of Type 1 error is avoided. Based on previous findings, priority order for entry into the analysis was set as follows: (1) TOTLRANGE, (2) PERFRANG, (3) VERBRANG, (4) CODING, (5) SEQUENT, (6) ACQKNOWL, (7) CONCEPT, (8) SPATIAL, (9) DISCRFF. A separate profile analysis was also run on the 11 subtest scaled-scores for the three LD groups.

RESULTS

Discriminant Function Analysis

Evaluation of the assumptions and limitations underlying discriminant function analysis revealed the existence of four outlying cases among the original 100. Since all variables were reasonably well distributed and linearly related, the decision was made to delete the four cases rather than attempting to transform variables. Three of the cases were from the VISUAL group and one from the MEMORY group. Two of the VISUAL cases and the one MEMORY case were prototypical for their groups in terms of direction of discrepancy between Verbal and Performance IQ, so that their elimination, if anything, reduced the power of the analysis, resulting in more conservative tests. The fourth outlier showed an extremely low SEQUENT score along with average Full Scale IQ. All four outliers showed high total test scatter.

DOCUMENT RESUME

ED 215 506 EC 142 166

AUTHOR Tabachnick, Barbara G.; Turbey, Carolyn B.
TITLE WISC-R Scatter and Patterns in Three Types of Learning Disabled Children.
PUB DATE Apr 81
NOTE 16p.; Paper presented at the Western Psychological Association Conference (Los Angeles, CA, April 9-12, 1981).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Auditory Perception; Elementary Secondary Education; *Learning Disabilities; Memory; *Perceptual Handicaps; Profiles; Receptive Language; *Scores; Testing; Visual Perception
IDENTIFIERS Test Scatter; *Wechsler Intelligence Scale for Children (Revised)

ABSTRACT

Wechsler Intelligence Scale for Children-Revised (WISC-R) subtest scatter and Bannatyne recategorization scores were investigated with three types of learning disabilities in children 6 to 16 years old: visual-motor and visual-perceptual disability (N=66); auditory-perceptual and receptive language deficit (N=18); and memory deficit (N=12). Three indices of test scatter were computed for each S (verbal range, performance range, and total range), and four additional WISC-R measures were analyzed: sequencing, acquired knowledge, verbal-conceptual ability, and spatial ability. The "visual" group showed significantly more scatter over the 10 subtests than the "auditory" Ss, and more than that of the WISC-R standardization sample, but the magnitude of differences was small. Profile analysis revealed no significant differences among the three LD groups, nor did the groups differ in scaled average over subtests. Averaging over the three LD groups, however, there were significant differences among subtests, with low scores on coding and digit span. (Author/CL)

ED215506

WISC-R Scatter and Patterns in Three Types of Learning Disabled Children

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The WISC-R has frequently been used in the assessment of learning disabled children. Kaufman (1976) raised the question of diagnosis of learning disability on the basis of subtest scatter, and pointed out that amount of scatter can only be assessed in terms of a baseline produced by children without known pathology. He conveniently provided this baseline in the form of an index of scatter: the size of the difference between the highest and lowest scaled scores earned by the child.

Although Anderson, Kaufman, and Kaufman (1976) showed that children with identified pathology did not produce more test scatter than their baseline standardized sample, Tabachnick (1979) refuted their findings with a sample felt to be more stereotypically LD. That study showed that learning disabled children did show consistently more scatter within Performance subtests, and among Verbal and Performance subtests combined than did non-learning disabled children. However, we feel that diagnosis on the basis of subtest scatter alone is inappropriate since the overlap in subtest scatter between learning disabled and normal children is substantial.

As suggested by Tabachnick and Tabachnick (1976), a major problem with learning disabilities is with forming categories relevant to treatment within the learning disabilities diagnosis. If it could be determined that children with some types of disabilities produce more inter-subtest scatter than children with other types of learning disability, appropriate diagnosis of disability could occur and appropriate remedial procedures designed.

Paper presented at the Western Psychological Association Conference (Los Angeles, CA, April 9-12, 1981)

As another way of examining WISC-R patterns among LD children, Glasser and Zimmerman (1967) have stated that the subtest scores are of more diagnostic value when grouped rather than looked at individually. A popular model for recategorization of subtest scores is that of Bannatyne (1968). Bannatyne (1974) has stated that by recategorizing subtest scores, the WISC-R is of more practical diagnostic value and the format becomes more useful. Bannatyne's recategorization is as follows:

<u>Spatial Ability</u>
Picture Completion
Block Design
Object Assembly

<u>Verbal Conception</u>
Comprehension
Similarities
Vocabulary

<u>Acquired Knowledge</u>
Information
Vocabulary
Arithmetic

<u>Sequencing Ability</u>
Digit Span
Arithmetic
Coding

The purpose of this study was to investigate WISC-R subtest scatter and Bannatyne scores with three types of learning disability: visual-perceptual/motor deficit, auditory-perceptual/receptive language deficit, and memory deficit. It was hoped that if variations in subtest scatter and/or Bannatyne scores are effective in LD diagnosis, then WISC-R could aid in indicating categories of learning disability. Another goal was to investigate subtest profiles among our three LD samples.

METHOD

Subjects

One hundred children with identified learning disabilities were selected from a private non-profit agency to which suspected learning disabled children were referred. The children had been diagnosed as learning disabled on the basis of a variety of factors: difficulty in school, performance on an extensive battery of psychodiagnostic tests, and judgment of experienced psychodiagnosticians.

All children evaluated at the agency between the time the WISC-R became available and the end of the calendar year 1979, and administered the WISC-R as part of the psychodiagnostic battery at the agency, were considered for the sample. Those who deviated from the typical learning-disabled syndrome on the basis of mental retardation (IQ <.75) or severe physical disability or emotional disturbance were excluded. An additional requirement for this study was that the children be unambiguously categorized into one of the three major disability groups as defined below.

The final sample (after deletion of outliers, discussed below) consisted of 20 girls and 76 boys. The children ranged in age from 6 years 6 months to 16 years 5 months, with a median of 10 years. Full scale WISC-R IQ ranged from 75 to 135, with a mean of 101. Subgroups did not differ significantly on Full Scale IQ, age, or sex.

On the basis of diagnostic information described above, children were assigned by the agency director to one of the nine original categories describing area of primary disability. The original nine categories were: (1) visual-motor; (2) visual-perceptual, (3) auditory-perceptual, (4) receptive language, (5) expressive language, (6) hyperlexia, (7) conceptual, (8) memory, and (9) sensory-motor. Categories were developed prior to the onset of data collection in conference with the director, a psychometrician, and several learning disability specialists. Criteria for categories included potential utility for treatment programs as well as prior exposure to children exhibiting those areas of difficulty.

After several years of use, some of the categories were discovered to be too rare to be of practical utility, and others were found to be difficult to distinguish between. As a result, the set of categories was reduced to three for the current study: (1) a category combining visual-motor and visual-perceptual disability, abbreviated VISUAL, containing 66 of the children used in analysis, (2) a category combining auditory-perceptual and receptive language, abbreviated AUDLANG, containing 18 of the children, and (3) MEMORY, containing 12 children who showed difficulty in all types of sequential memory rather than visual or auditory memory deficits alone.

Variables

Three indices of test scatter were computed for each of the children in the manner described by Kaufman (1976). Verbal range, (VERBRANG), is defined as the difference between high and low scaled scores for each child on the five regular Verbal tests (Information, Similarities, Arithmetic, Vocabulary, Comprehension). Performance range (PERFRANG), is defined as the difference between high and low scaled scores on the five regular Performance tests (Picture Completion, Picture Arrangement, Block Design, Object Assembly, Coding). Total range, (TOTLRANG), is defined as difference between high and low scaled scores on all ten tests. Note that Digit Span and Mazes have been deleted from these indices in order to make the data comparable with that of Kaufman.

Four additional WISC-R measures were based on Bannatyne's (1974) recategorizaion of scores. For each child, a sequencing ability score (SEQUENT) was derived, based on the mean of Digit Span, Arithmetic, and Coding. An acquired knowledge score (ACQKNOWL) reflected the mean of Information, Arithmetic, and Vocabulary. Verbal conceptual ability (CONCEPT) consisted of the mean of Comprehension, Similarities, and Vocabulary. Spatial ability (SPATIAL) was based on the mean of Picture Completion, Block Design, and Object Assembly. Finally for the profile analysis, the eleven subtest scores (excluding Mazes) were used in their standard scaled-score form.

Analysis

Hierarchical discriminant function analysis was used to determine whether the three groups were discriminable on the basis of the nine indices described above. In hierarachical discriminant analysis,variables enter in predetermined order, and no variable is allowed to enter the analysis unless it significantly adds to discriminability. Thus overfitting and inflation of Type 1 error is avoided. Based on previous findings, priority order for entry into the analysis was set as follows: (1) TOTLRANGE, (2) PERFRANG, (3) VERBRANG, (4) CODING, (5) SEQUENT, (6) ACQKNOWL, (7) CONCEPT, (8) SPATIAL, (9) DISCRFP. A separate profile analysis was also run on the 11 subtest scaled-scores for the three LD groups.

RESULTS

Discriminant Function Analysis

Evaluation of the assumptions and limitations underlying discriminant function analysis revealed the existence of four outlying cases among the original 100. Since all variables were reasonably well distributed and linearly related, the decision was made to delete the four cases rather than attempting to transform variables. Three of the cases were from the VISUAL group and one from the MEMORY group. Two of the VISUAL cases and the one MEMORY case were prototypical for their groups in terms of direction of discrepancy between Verbal and Performance IQ, so that their elimination, if anything, reduced the power of the analysis, resulting in more conservative tests. The fourth outlier showed an extremely low SEQUENT score along with average Full Scale IQ. All four outliers showed high total test scatter.

Table 1 shows the univariate F values for each of the discriminating variables before beginning the discriminant analysis, and the pooled within-group correlations among the variables. As can be seen with 2 and 93 degrees of freedom for evaluating F, only two of the variables would reach statistical significance at the .05 level

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Insert Table 1 above here

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if used alone: total range of scaled scores (TOTLRANG) and discrepancy between Verbal and Performance IQ (DISCREP). Because of the priority order set for entry of variables into the analysis, TOTLRANG entered on step one, despite the slightly higher univariate F ratio for DISCREP. After the first step, none of the remaining variables met the statistical criteria for entering the analysis, and the procedure terminated. The three groups, then, are significantly discriminated on the basis of total range of WISC-R scaled scores, $F(2, 93) = 4.235$, $p < .05$, and no finer discrimination can be achieved by addition of any of the other variables. Greatest scatter is found for the VISUAL group (Mean TOTLRANG = 8.09), and least for the AUDLANG group (Mean = 6.26), with the MEMORY group falling between (Mean = 7.73). Canonical correlation of .30 reveals a relatively mild association between TOTLRANG and group separation. That is, less than 10% of the variance in total range of scaled scores is associated with differences among the groups.

Classification, although better than chance, was not impressive. Using a conservative classification scheme (chance rate = .33, jackknifed classification*) only 50% of the cases were correctly classified, as seen in Table 2a. With a jackknifed

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Insert Table 2 about here

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*Jackknifed classification reduces bias by classifying each case using equations developed from all data except the case being classified.

classification scheme using information about unequal estimated population sizes, the rate of correct classificaiton (cf. Table 2b) increased to 66.7%, however one could classify 69% correctly simply by categorizing all children as VISUAL.

Looking at <u>post hoc</u> (Scheffe) comparisons among the three groups, the VISUAL group was found to have significantly greater range of scaled scores than the AUDLANG group, $F(1, 93) = 8.47$, $p < .05$. None of the other pairwise comparisons approached statistical significance.

Had the discriminant analysis chosen DISCREP instead of TOTLRANG, the overall results would have been even worse. The AUDLANG and MEMORY groups showed virtually no difference in discrepancy between Verbal and Performance IQ. None of the pairwise comparisons would have survived a Scheffé test, and classification would have fared much worse. Under the most conservative conditions, only 40.6% of the cases would have been classified correctly, with the greatest loss in the AUDLANG group.

<u>Comparisons with Standardization Group</u>

In Kaufman's (1976) analysis of scatter in the standardization group of the WISC-R, the average difference between high and low scaled scores over the 10 regular subjects (corresponding to our TOTLRANG) was found to be 7.0 Scheffe tests were used to compare the average of each of our three disability groups against this baseline. Only the VISUAL group differed significantly, $F(1, 2264) = 16.75$, $p < .01$. Again, however, the association between TOTLRANG and separation of baseline and VISUAL groups is small, $\eta = .09$.

<u>Profile Analysis</u>

The initial, and for our purposes major, test in profile analysis is whether the profiles of the three groups on the WISC-R subtests differ . In our samples, there is no evidence of significant differences among the three groups, $F([illegible], 168) =$

1.21, $p = .25$. Nor were there significant differences among groups over all subtests combined, $F(2, 93) = 1.27$, $p = .29$.

The combined groups, however, did vary in their subtest scores, $F(10, 84) = 18.511$, $p < .01$. That is, the combined profile of scaled scores was not flat, as demonstrated in Table 3. The children show average scaled scores in Coding and

Insert Table 3 about here

Digit Span which are notably low, and suggestively high scores on object assembly and vocabulary. These generalizations hold across all groups with the exception of vocabulary, on which the AUDLANG scores were slightly below the mean of 10.

DISCUSSION

WISC-R subtest scatter does not appear to be of diagnostic value in the discrimination of three types of learning disabled children. Even when subtest scores are recategorized into Bannatyne groups, it is unlikely that the form of learning disability as defined by our criteria can be detected.

While there may be a frequent coexistence of perceptual dysfunctions and higher level disorders (Frostig 1975) WISC-R subtest profiles for learning disability were not found. Miller, Stoneburner, and Brecht (1978) have stated that the fact that a child has a learning process dysfunction in a particular mode does not imply that particular higher level disorders will develop. Conversely, the fact that a child has a particular cognitive level deficit, as measured by the WISC-R subtest score, does not indicate that the child first had a perceptual deficit. This study seems to support this conclusion. There is no evidence that patterns of WISC-R subtests are particularly useful in designing global treatment programs.

It is perhaps of value for diagnosticians to note when scaled subtest scores yield a wide range between the highest and lowest scores. Also, if the verbal score is markedly different from the performance score further investigation procedures should be employed to determine if a learning disability is present, and whether the primary area of deficit may lie in visual-motor/visual-perceptual skills. However, at present, type of disability as defined by our clinical criteria cannot be determined by subtest scatter or pattern.

Footnotes

We would like to thank the California Center for Educational Therapy, Woodland Hills, CA, and its director, Kenneth Tabachnick, for assisting in this project and providing access to the data. Ms. Rebecca Nunnalee aided us in preparing the data for analysis, under funds provided by the Federal Work-Study Program, administered through California State University, Northridge. Computer facilities were provided by CSUN and the central timesharing network (SUDC) of the California State Universities and Colleges.

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Table 1. Univariate F Ratio for Discriminating Among Three Groups and Pooled Within Group Correlations For Nine Discriminating Variables.

Variables	Univariate F df = 2,93	Pooled Within Group Correlations							
		PERFRANG	VERBRANG	CODING	SEQUENT	ACQKNOWL	CONCEPT	SPATIAL	DISCREP
TOTLRANG	4.235	.74	.52	-.33	-.09	.33	.42	.17	.35
PERFRANG	1.257		.21	-.42	-.14	.39	.39	.25	.35
VERBRANG	2.145			-.08	-.07	.03	.22	.09	.05
CODING	1.435				.69	-.01	.03	.17	-.43
SEQUENT	0.027					.50	.41	.38	.01
ACQKNOWL	2.003						.81	.42	65
CONCEPT	3.095							.59	.55
SPATIAL	2.313								-.20

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Table 2. Results of Jackknifed Classification of Three Groups on the Basis of TOTLRANG, Using (A) Equal Prior Probabilities, and (B) Prior Probabilities Based on Sample Sizes.

A. Prior Probabilities = .33 .33 .33

Group	Percent Correct	Number of Cases Classified into Group		
		VISUAL	AUDLANG	MEMORY
VISUAL	59.1	39	19	8
AUDLANG	47.4	2	9	8
MEMORY	0.0	5	6	0
TOTAL	50.0	46	34	16

B. Prior Probabilities = .69 .20 .11

Group	Percent Correct	Number of Cases Classified into Group		
		VISUAL	AUDLANG	MEMORY
VISUAL	97.0	64	2	0
AUDLANG	0.0	19	0	0
MEMORY	0.0	11	0	0
TOTAL	66.7	94	2	0

Table 3. Mean and Standard Deviation of Scaled Scores on 11 WISC-R Subtests, Averaged over Three LD Groups

Subtest	Mean	St. Dev.
Information	9.70	3.38
Comprehension	10.54	2.88
Arithmetic	9.33	2.60
Similarities	10.91	3.26
Vocabulary	11.19	3.04
Digit Span	8.66	2.63
Picture Completion	10.79	2.84
Picture Arrangement	10.66	2.58
Block Design	10.39	3.05
Object Assembly	11.27	2.61
Coding	7.79	2.63