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ABSTRACT

Factor analyses of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) was conducted. The random sample included 100 boys and 100 girls beginning at age four with increments of 6 months up to age 6 1/2. The intercorrelation matrix of the 11 WPPSI subtests at each of the age levels was factor analyzed, and the percent of common, specific, and error variance was calculated for each subtest. The two-factor solution, closely approximating Wechsler's a priori grouping into Verbal and Performance scales, was retained at each age level as the most psychologically and psychometrically sound solution to describe the 11 WPPSI subtests. Calculation of the coefficients of congruence confirmed the stability of the factor structure across all age levels. With the exception of subtests Information and Comprehension, there appears to be adequate test specificity to allow for individual interpretation in the determination of a child's cognitive strengths and weaknesses prior to developing and implementing an individual educational program. (RL)

Specific Variance of the WPPSI Subtests at Six Age Levels

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The Wechsler Preschool and Primary Scale of Intelligence (WPPSI) (Wechsler, 1967) is a widely used measure of intelligence for children ages 4 to 6½. The WPPSI has been subjected to numerous factor analytic studies since its publication in 1967. Researchers have examined the WPPSI factor structure across a variety of populations (Sattler, 1974) with several studies focusing on the WPPSI standardization sample. Silverstein (1969) collapsed the standardization sample into a single group. Two principal factors were found which closely approximated Wechsler's a priori grouping of the eleven subtests into Verbal and Performance IQ Scales. Hollenbeck and Kaufman (1972) combined the WPPSI standardization data into three age groups (4-4½, 5-5½, and 6-6½). Using several different factor analytic techniques, Hollenbeck and Kaufman obtained results similar to Silverstein's (1969), (i.e., factor structures closely resembling Wechsler's a priori grouping of the subtests into Verbal and Performance scales). Kaufman and Hollenbeck (1974) also found similar factor structures for Black and White children utilizing the same collapsed age groupings of the standardization data as in their previous study.

Boyd (1970) found slightly differing WPPSI factor structures utilizing a sample of Black children (52 females and 59

males, ages 5 to 7). Although a two factor solution also best described the battery for this sample (Sattler, 1974), the "Perceptual-Motor Memory Factor" encompassing the Information, Arithmetic, Mazes, and Block Design subtests indicated some factorial disharmony with Wechsler's a priori groupings of the subtests (i.e., Wechsler's grouping placed the Information and Arithmetic subtests in the Verbal Scale). The "Verbal Factor" was best described by the Vocabulary and Similarities subtests. Sattler suggested that these results may be indicative of "qualitative intellectual differences between Black and White children at the age levels studied." A conclusion partially supported by Reynolds, McBride, and Gibson (1979). However, this observation is restricted to the sample studied rather than inferring similar differences in the broader population due to the lack of replication with other samples (Sattler, 1974) and could reasonably be attributed to sampling error given the small N.

Woo-Sam and Zimmerman (1973) have summarized a number of WPPSI factor analyses as has Sattler (1974). With only two exceptions other than Boyd (1970), both involving special populations (Dokecki, Frede, & Gautney, 1969; Southern & Plant, 1969), the WPPSI factor structure corresponds strongly to Wechsler's Verbal and Performance IQ Scales. The only real exception has been the Arithmetic subtest, which tends to load highly on both factors (though typically highest on the Verbal

factor). Only a few studies have, however, reported on the specific variance of the individual WPPSI subtests.

As school psychologists now become more and more involved in the assessment of preschool children and in the development of individual educational programs for these youngsters (Reynolds, 1979a), it becomes important to have access to data regarding specific and error variance components of the WPPSI. The relationship between specific variance (the amount of variance not held in common with other subtests and not due to error) and error variance (the amount of variance that is essentially attributable to errors of measurement) for the most part determines one's ability to interpret the individual subtest scores of the instrument (Kaufman, 1979; Reynolds, 1979b). As a rule of thumb, specific variance should be required to exceed error variance prior to making individual interpretations of a subtest, even though the subtest in question may deviate significantly from the mean of all subtests (Reynolds & Gutkin, in press). Kaufman, Daramola, and DiCuio (1977) calculated the error and specific variances of the WPPSI subtests separately for males and females when the standardization sample was collapsed into three age groups (4-4½, 5-5½, and 6-6½). Kaufman et al. for the most part found the WPPSI subtests to have sufficient specific variance across sex at the three age levels studied to allow for individual subtest interpretation. The

factor structure of the WPPSI was also found to be invariant across sex at these three age groupings. However, to date these variance components have not been determined for each individual age level. Given the rapid developmental changes occurring during the 4 to 6½ year age span, refinement of the Kaufman et al. analysis by using briefer age groupings seems highly desirable.

In addition, separate factor analyses of the WPPSI standardization sample at each of the six age levels is still needed (Sattler, 1974). The present study was conducted to ascertain the factor structure of the WPPSI at each of the six age levels represented in the WPPSI standardization sample. The specific and error variance components of each WPPSI subtest by age level were calculated to provide more detailed information regarding the interpretability of the individual subtests. Coefficients of congruence were calculated between corresponding factors across all six age levels to determine the degree of invariance of the WPPSI factor structure across age. The coefficient of congruence is the most suitable statistic for examining factorial similarity across groups (Harman, 1976). A value of .90 or higher is taken to indicate factorial invariance.

Method

Subjects

The WPPSI standardization sample of 1200 children between

the ages of 4 and 6½ provided the subjects for the study. The sample includes 100 boys and 100 girls at each of six age levels beginning at 4 with increments of 6 months up to age 6½. The children were chosen through a random sampling of children in the U.S. with stratification on the basis of age, sex, race, geographic region of residence in the U.S., urban vs. rural residence, and SES as determined by father's occupation. The sample is described in greater detail elsewhere (Wechsler, 1967). Since no race (Kaufman & Hollenbeck, 1974) or sex (Kaufman et al., 1977) differences in factors have been found with the WPPSI sample, these groups were combined within each of the six age levels.

Procedure

The intercorrelation matrix of the 11 WPPSI subtests at each of six age levels (4, 4½, 5, 5½, 6, and 6½), from pages 26-31 of the WPPSI Manual, was factor analyzed through the method of principal factors with R^2 in the diagonal as initial communality estimates (h^2) with iteration until no significant increase occurred in the calculation of h^2. Two- and three-factor solutions were obtained at each age level. Factors obtained through this method were rotated orthogonally through the Varimax method.

Once an appropriate solution was obtained at each age level, the percent of common, specific, and error variance was calculated for each subtest as follows: h^2 was used to estimate the common

variance component for each subtest; error variance was calculated as $1-r_{xx}$; the percent of specific variance was calculated to be $r_{xx}-h^2$. Reliabilities were taken for the specific age level in question from Wechsler (1967, p. 22). Since the WPPSI is scaled to a common metric (i.e., equal standard deviations) across age groups, factor structures were compared based on the analyses of the correlation matrix at each age. Coefficients of congruence were calculated, via a formula provided by Harman (1976), for corresponding factors for each possible pair of age levels. Coefficients of congruence of .90 or higher are taken to indicate equivalence of factors or factorial invariance (Harman, 1976; Mulaik, 1972).

Results and Discussion

The two-factor solution was retained at each age level as the most psychologically and psychometrically sound solution to parsimoniously describe the 11 WPPSI subtests. The three-factor solution was quite weak at all ages, never approximating an Eigenvalue of one, and in no instance providing a more psychologically meaningful grouping of the subtests. The two-factor solution has Eigenvalues exceeding one at every level except age 6, where it was .97. The two-factor solution (presented in Table 1) closely approximated Wechsler's a priori grouping

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Insert Table 1 about here

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into Verbal and Performance scales with only minor exceptions. The Arithmetic and Animal House subtests tended to show substantive loadings on both the Verbal and Performance factors. However, these subtests did not group together on a third factor as might be suspicioned from the results of numerous analyses of the WISC-R (e.g., Kaufman, 1975; Gutkin & Reynolds, in press; Reynolds & Gutkin, 1980). Thus, at least with normal children, one may have considerable confidence in the WPPSI Verbal and Performance IQ's as coherent measures of distinct areas of intellectual function across all age ranges for which the test is normed (though it must be remembered that a large "g" factor pervades the entire scale). The two-factor solution is also very similar across the six age groups; the "g" factor is similar as well, accounting for from 86 to 91 percent of the common variance. Calculation of the coefficients of congruence confirmed the stability of the factor structure across all age levels. Coefficients of congruence across age level for the Verbal factor ranged from .97 to .99 while for the Performance factor comparisons across age yielded coefficients that ranged from .96 to .99. These results are highly consistent with the findings of Kaufman et al. (1977).

With regard to the interpretation of individual WPPSI subtests, with the exception of Information and Comprehension, there appears to be adequate test specificity to support the practice of interpretting subtests that deviate significantly

from the mean of all subtests in the same factor. For the most part, all other subtests have specific in excess of error variance and also contain more than 25% specific variance. Some exceptions to this occur with some subtests across the age ranges; however, the fluctuations show no pattern as the mean level of specific variance and mean level of error variance range only from 30 to 33% and 15 to 19%, respectively, across the six age levels studied. The cautious psychologist, however, may wish to consult Table 2 for the actual values of the common,

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Insert Table 2 about here

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specific, and error variance terms prior to attempting the individual interpretation of any WPPSI subtest.

The present results substantially support Wechsler's division of the WPPSI subtests into a Verbal and a Performance scale at all age levels. Additionally, the subtests, excluding Information and Comprehension, have sufficient specificity to allow for individual interpretation in the determination of a child's cognitive strengths and weaknesses prior to developing and implementing an individual educational program.

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Table One

WPPSI Subtest Factor Loadings on Factor One (Verbal) and Factor Two (Performance)

At Six Age Levels Following Varimax Rotation[a,b]

Subtest	4		4½		5		5½		6		6½	
	V.	P	V	P	V	P	V	P	V	P	V	P
Information	.71	.32	.74	.29	.66	.37	.74	.40	.69	.34	.74	.31
Vocabulary	.63	.31	.70	.18	.63	.31	.68	.31	.70	.32	.62	.35
Arithmetic	.50	.45	.56	.42	.54	.51	.61	.51	.54	.46	.55	.54
Similarities	.75	.17	.69	.26	.57	.13	.66	.17	.61	.31	.72	.23
Comprehension	.71	.29	.77	.17	.73	.28	.71	.31	.75	.25	.71	.22
Sentences	.66	.27	.66	.28	.53	.29	.61	.30	.55	.39	.65	.21
Animal House	.46	.29	.40	.43	.25	.60	.32	.56	.25	.63	.25	.42
Picture Completion	.43	.51	.49	.42	.37	.50	.37	.53	.42	.54	.31	.49
Mazes	.15	.77	.07	.65	.29	.57	.30	.61	.42	.58	.10	.65
Geometric Design	.27	.62	.27	.57	.24	.73	.17	.80	.25	.75	.20	.62
Block Design	.32	.50	.29	.56	.22	.72	.35	.68	.45	.55	.34	.61
Eigenvalue	5.23	1.13	5.13	1.23	5.13	1.19	5.71	1.16	5.74	0.97	5.03	1.27
%Variance	87.6	12.4	87.0	13.0	87.3	12.7	88.0	12.0	90.9	9.1	86.1	13.9

[a]Eigenvalues and variance accounted for are based on the unrotated principal factor matrix.

[b]V=Verbal factor; P=Performance factor

Table Two

Percent of Specific and Error Variance for each of the 11 WPPSI Subtests at Six Age Levels[a]

Subtest	Age Level 4			Age Level 4½			Age Level 5			Age Level 5½			Age Level 6			Age Level 6½			Mean Values		
	V_s[b]	h^2[c]	V_e[d]	V_s	h^2	V_e	V_s	h^2	V_e	V_s	h^2	V_e	V_s	h^2	V_e	V_s	h^2	V_e	V_s	h^2	V_e
Information	*24*	61	16	18	64	19	20	57	23	10	71	19	*25*	59	16	10	65	25	18	63	19
Vocabulary	*33*	49	18	*31*	53	16	*28*	50	22	*29*	56	15	*28*	59	13	*36*	50	14	*38*	53	16
Arithmetic	*36*	45	19	*29*	49	22	*29*	55	16	*22*	64	14	*32*	50	18	*23*	60	17	*29*	54	18
Similarities	*26*	60	15	*28*	54	18	*49*	34	17	*35*	47	18	*37*	47	16	*27*	57	16	*34*	50	17
Comprehension	20	58	22	*21*	62	17	17	61	22	*23*	61	16	*20*	62	18	*23*	55	22	*21*	60	20
Sentences	*37*	52	12	*36*	51	13	*47*	36	17	*41*	46	13	*36*	45	19	*37*	47	16	*39*	46	15
Animal House	32	30	38	*37*	34	29	*37*	42	21	*41*	41	18	*38*	46	16	*52*	24	24	*40*	36	24
Picture Completion	*41*	44	15	*42*	42	16	*43*	38	19	*45*	41	14	*36*	47	17	*47*	34	19	*42*	41	17
Mazes	*24*	61	15	*39*	43	18	*47*	41	12	*45*	46	09	*35*	52	13	*44*	44	12	*39*	48	13
Geometric Design	*34*	46	20	*42*	40	18	*23*	59	18	*18*	66	16	*25*	62	13	*35*	42	23	*29*	53	18
Block Design	*41*	35	24	*39*	39	22	*26*	57	17	*26*	59	15	*37*	51	12	*32*	49	19	*35*	48	18
Mean Values	*32*	49	19	*33*	48	19	*33*	48	19	*30*	54	15	*32*	53	16	*33*	48	19	*33*	50	18

[a]Italics are used to indicate each percent of specific variance that exceeds the percent of error variance for the subtest at that age. All decimals omitted. All signs are positive.

[b]V_s=percent of specific variance (r_{tt}-h^2)

[c]Communality Estimate

[d]V_e=percent of error variance (1-r_{tt})