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TWO- AND THREE-FACTOR SOLUTIONS OF THE WAIS-III

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The third edition of the Wechsler Adult Intelligence Scale manual reports four-factor solutions for the WAIS-III, and subsequent research has validated four-factor solutions for a variety of samples. These four factors consistently correspond to the four Factor Indexes that are yielded by the WAIS-III. However, the WAIS-III still provides Verbal and Performance IQs, in addition to the Indexes, making it desirable to examine two-factor solutions as well. In addition, because the Wechsler literature includes much interpretation of three-factor solutions, these solutions were likewise examined. Principal factor analysis followed by Varimax and Oblimin rotations of two and three factors were performed on data for the total WAIS-III sample ages 16 to 89 years ($N = 2{,}450$). The two-factor solutions were viewed as a construct validation of Wechsler's two separate IQs, although the Working Memory subtests tended to load higher on the Performance scale than on their intended scale (Verbal); three-factor solutions were interpreted within the context of Horn's expanded fluid-crystallized theory and research on working memory. Both the two- and three-factor Varimax-rotated solutions were related to similar factor analyses conducted previously for the Wechsler Adult Intelligence Scale–Revised and the Wechsler Intelligence Scale for Children–III. Coefficients of congruence between like-named factors consistently exceeded .90, and usually .98, across different Wechsler batteries.

Keywords: Intelligence, IQ, IQ tests, factor analysis, Horn's Theory

During the 1990s, the third editions of the Wechsler Intelligence Scale for Children (WISC-III; Wechsler, 1991) and the Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1997) departed from tradition. Instead of only yielding three global IQs like their predecessors (Wechsler, 1939, 1946, 1949, 1955, 1974, 1981), these new editions also yield four global standard scores called Factor Indexes. On the WAIS-III, for example, the Verbal (VIQ), Performance (PIQ), and Full Scale (FSIQ) IQs are joined by the following factor indexes: Verbal Comprehension Index (VCI), Perceptual Organization Index (POI), Working Memory Index (WMI), and Processing Speed Index (PSI). On the WISC-III, the WMI is called the Freedom From Distractibility

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Index (FDI). Although the subtest composition of three of the four Indexes differs for the WISC-III and WAIS-III (only PSI is identical), the four indexes are conceptually the same for the two Wechsler test batteries.

In the test manuals for the WISC-III (Wechsler, 1991) and WAIS-III (Psychological Corporation, 1997), the test publisher reported the results of rigorous exploratory and confirmatory factor analyses to support the construct validity of this new four-factor structure. Although some researchers (e. g., Sattler, 1992) dispute the meaningfulness of the FDI on the WISC-III and interpret only three factors, the evidence for four factors on the WISC-III has been provided for a large independent normal sample (Roid, Prifitera, & Weiss, 1993), for a variety of samples of exceptional children (Konold, Kush, & Canivez, 1997; Kush, 1996; Wechsler, 1991), and for a large normal Canadian population (Roid & Worall, 1997). Evidence for the WAIS-III's four-factor structure is less impressive, but nonetheless solid. Four factors corresponding closely to the four indexes emerged for normative ages 16-19 years, 20-34 years, 35-54 years, and 55-74 years (The Psychological Corporation, 1997, pp. 102-110) and for three normative subsamples: African Americans (n = 279), Hispanic Americans (n = 181), and Caucasian Americans (n = 1,925) (Tulsky, Zhu, & Prifitera, in press). The only sample that produced three meaningful factors was the oldest normative age group, 75-89 years (The Psychological Corporation, 1997, pp. 102-110). For elderly individuals, the POI was trivial, defined only by Matrix Reasoning (.42 loading) and, marginally, by Block Design (.39). In contrast, the PSI for ages 75-89 years included meaningful loadings not only by its designated subtests (i.e., Digit Symbol-Coding, Symbol Search), but also by three other Performance subtests.

If the four indexes were the only, or even the major, global scores interpreted by clinicians, then four-factor solutions of the WAIS-III and WISC-III would be ample. However, clinicians still feature the three IQs, focusing on the Verbal-Performance IQ discrepancy, when interpreting Wechsler profiles, either in addition to, or instead of, the four indexes. Therefore, it is essential to examine two-factor solutions of Wechsler's third edition instruments to ensure that they provide construct validation for the VIQ versus PIQ dichotomy. The WISC-III manual (Wechsler, 1991) provides these data, but the *WAIS-III Technical Manual* (The Psychological Corporation, 1997) does not. One goal of this study was to determine the two-factor structure of the WAIS-III and to evaluate (a) whether it supports the construct validity of the VIQ-PIQ distinction that has defined all Wechsler scales since the Wechsler-Bellevue (Wechsler, 1939), and (b) whether it is congruent with two-factor solutions identified for the WISC-III and WAIS-R (Wechsler, 1981). One two-factor WAIS-III solution has appeared in the literature (Caruso & Cliff, 1999), but these authors were primarily interested in studying equally and differentially weighted factor scores and presented the results of an uncommon (and largely unknown) approach called reliable-component analysis (RCA) that may or may not be comparable to more familiar exploratory techniques. Caruso and Cliff concluded from their two-factor solution that, "The most significant finding here is that the subtests do not group themselves as defined by the a priori subdivisions" (p. 200) of WAIS-III subtests. Will the same lack of construct validity be found by more common approaches?

Three-factor solutions of the WISC-III and WAIS-III are also of great interest to the researcher and clinician. As indicated, Sattler (1992) has reported three-factor solutions for the WISC-III (composed of VCI, POI, and PSI factors, with no evidence of FDI). No such solutions for the WAIS-III have been published. Such solutions are of interest, however, because of the prevalence of these solutions for earlier versions of Wechsler's scales and the importance often assigned to the third factor, variously referred to as attention-concentration, distractibility, sequencing ability, sequential processing, number ability, and short-term memory (Kaufman, 1979, 1990, 1994; Kaufman & Lichtenberger, 1999, 2000). A second goal of this study was to examine three-factor solutions of the WAIS-III to (a) permit comparison with Sattler's findings for the WISC-III, (b) allow comparisons with three-factor solutions identified for the WAIS-R (Kaufman, 1990, chapter 8), and (c) foster interpretation of the three dimensions from theoretical perspectives (e. g., Horn's, 1989, expansion and adaptation of the Horn-Cattell fluid-crystallized theory of intelligence or Richardson's, 1996, notion of working memory).

The aims of this study should not, however, be construed as implying, even implicitly, that a two-factor or three-factor WAIS-III solution is preferable to the four-factor solution. Indeed, the opposite is true: The featured role of the four Factor Indexes for the WAIS-III (and WISC-III) reflects a significant advance in Wechsler test development, has impressive exploratory and confirmatory factor-analytic support, and represents the key to competent profile interpretation from both clinical and theoretical standpoints (see, for example, the interpretive systems advocated by Kaufman & Lichtenberger, 1999, 2000). However, some clinicians (especially school psychologists; see Canivez & Watkins, 1998) choose not to administer supplementary subtests such as Symbol Search, preventing the computation of all four Indexes, and many cling to the two-factor or three-factor interpretations of Wechsler profiles that they may have found useful when interpreting previous editions of Wechsler's scales. It is, therefore, of interest to examine these alternate factor solutions.

Method

Instrument

The WAIS-III (The Psychological Corporation, 1997; Wechsler, 1997), for adults ages 16 to 89 years, was formatted to be similar to the WISC-III: It includes VIQ, PIQ, and FSIQ; Indexes on four factors (VCI, POI, WMI, PSI), all with a mean of 100 and a *SD* of 15; and scaled scores on seven verbal and seven performance subtests (M = 10, SD = 3). The WAIS-III, like its adult predecessors, includes six regular verbal subtests (Vocabulary, Similarities, Arithmetic, Digit Span, Information, and Comprehension) and five mandatory performance tasks (Picture Completion, Picture Arrangement, Block Design, Matrix Reasoning, and the renamed Digit Symbol-Coding). Matrix Reasoning, a new Wechsler subtest, replaces Object Assembly on the Performance Scale and POI; Object Assembly is included on the Performance scale as an alternate subtest for ages 16-74 years. Symbol Search, an analog of the WISC-III subtest of the same name, is a supplementary performance subtest that may serve as a substitute for Digit Symbol-Coding and that joins the latter subtest on the PSI. Letter-Number Sequencing is a new supplementary Verbal subtest that joins Arithmetic and Digit Span on the WMI.

The WAIS-III was standardized on 2,450 adult participants, selected according to 1995 U.S. Census data (U.S. Bureau of the Census, 1995) and stratified according to age, gender, race/ethnicity, geographic region, and education level. Participants were divided into 13 age groups between 16-17 years and 85-89 years, with each age group including 100 to 200 people. Average split-half reliability coefficients, across the 13 age groups, are as follows: .97 for VIQ, .94 for PIQ, and .98 for FSIQ. The average value for PSI was .87 (a test-retest coefficient because split-half is not applicable for highly speeded tasks), with the split-half coefficients averaging .93 to .96 for the other three indexes. The average individual subtest reliabilities ranged from .93 (Vocabulary) to .70 (Object Assembly), with a median coefficient of .85. Stability coefficients based on 394 adults from four broad age groups tested twice (interval averaging about 5 weeks) were as follows: VIQ (.94-.97), PIQ (.88-.92), FSIQ (.95-.97), VCI (.92-.96), POI (.83-.92), WMI (.87-.93), and PSI (.84-.90). Average test-retest coefficients for subtests ranged from .69 for Picture Arrangement to .94 for Information; median coefficients, across age groups, were .83 for the seven Verbal subtests and .79 for the seven performance subtests. As noted, the *WAIS-III technical manual* (The Psychological Corporation, 1997) reports data from numerous factor-analytic studies that support the underlying four-factor structure of the WAIS-III for ages 16 to 74 years, thereby offering evidence of construct validity for these ages.

Participants

The WAIS-III standardization sample of 2,450 individuals at ages 16 to 89 years comprised the sample. For the analyses presented in this paper, only data for the total sample were analyzed. The number of men and women was equal through age group 55-64 years, but matched U.S. Census proportions at ages 65+ years, when women are more numerous. As previously mentioned, the sample was stratified on the variables of race/ethnicity, geographic region, and educational attainment (The Psychological Corporation, 1997, pp. 19-39). When selecting the sample for testing, The Psychological Corporation (1997, Table 2.1) *excluded* three categories of adults: individuals with sensory or motor deficits that might compromise the validity of the obtained test scores (i.e., color-blindness, uncorrected hearing loss, uncorrected visual impairment, upper extremity motor disorder); individuals with concerns regarding alcohol, drugs, and medication use (those currently undergoing treatment for alcohol or drug dependency, those consuming four or more alcoholic beverages more than 2 nights per week, or currently taking antidepressant, antianxiety, or antipsychotic medication); and individuals with a known or possible neuropsychological disorder (those seeing a doctor or other professional for thought or memory problems, those experiencing any period of unconsciousness lasting at least 5 minutes, those suffering a head injury that required hospitalization for more than 24 hours, and those having a medical or psychiatric condition that could affect cognitive functioning such as stroke, epilepsy, Alzheimer's dementia, schizophrenia, or brain surgery). The standardization sample, therefore, excludes a variety of individuals who make up the adult population and is *normal* in a very restricted use of the term.

Procedure

The 14 x 14 subtest correlation matrix for the total WAIS-III standardization sample (N = 2,450), reported in the *WAIS-III technical manual* (The Psychological Corporation, 1997, Table 4.12), was subjected to principal factor analysis. Two-factor and three-factor solutions were specified in advance, even though the publisher of the WAIS-III has provided evidence that four meaningful, replicable factors define the WAIS-III's factor structure. In fact, however, examination of the scree plot of eigenvalues (Cattell, 1966b) for the total sample, after conducting principal factor analysis (R^2 in diagonals followed by iteration) suggests that there are only two, or at best three, significant factors that underlie the WAIS-III. Following extraction of two and three factors, both Varimax and Oblimin rotations were conducted.

The sample size for the Letter-Number Sequencing subtest is less than half the size of the total sample of 2,450. Although this limitation might affect the factor structure for analyses of separate age groups, the sample size for the Letter-Number Sequencing subtests is quite substantial for all ages combined, and, therefore, is not likely to affect the Varimax and Oblimin rotated factor structures reported here for ages 16 through 89 years.

In order to compare the factor structure of the WAIS-III with the structure of the WAIS-R the preceding Varimax-rotated analyses were repeated using an 11 x 11 subtest matrix, eliminating the three new WAIS-III subtests (Matrix Reasoning, Letter-Number Sequencing, Symbol Search). In this way the structure for the 11 subtests retained from the WAIS-R could be compared directly with the two-factor solution (Silverstein, 1982) and three-factor solution (Parker, 1983) for the WAIS-R total standardization sample. Similarly, the analyses were repeated with a 12 x 12 correlation matrix (excluding Matrix Reasoning and Letter-Number Sequencing) to permit direct comparisons with factor-analytic data reported for the WISC-III which includes the new Symbol Search subtest like the WAIS-III. Data for the WISC-III two-factor solutions were reported in the third edition of the *Manual for the Wechsler Intelligence Scale for Children* (Wechsler, 1991, Table 6.2); data for the three-factor solutions were reported by Sattler (1992, Table I-9).

Coefficients of congruence (Cattell, 1966a; Harman, 1976) for WAIS-III versus WAIS-R factors were computed between all like-named factors from the two- and three-factor solutions of each test using a program developed by Hebbler (1989). This exact computational procedure was then repeated for the WAIS-III versus WISC-III factors.

Results

Table 1 presents two- and three-factor Varimax-rotated solutions for the WAIS-III, and Table 2 shows the comparable results for the Oblimin rotation. In the two-factor solutions, easily identifiable Verbal and Performance factors emerged, of approximately equal size, with the Performance factor emerging first and the Verbal factor second each time. Four of the seven Verbal subtests loaded much higher on the Verbal than the Performance factor, the ones often associated with VCI factors on a variety of Wechsler batteries, starting with the Wechsler-Bellevue (Wechsler, 1939; see Kaufman, 1990, chapter 8). However, the three WMI subtests, though included on the Verbal scale, did not load as intended; Arithmetic loaded about equally on each factor; Digit Span and Letter-Number Sequencing loaded higher on the Performance factor, with the loadings decisively higher when correlated factors were permitted, as shown in Table 2. Construct validity support was far stronger for the Performance scale. With both the orthogonal and oblique rotations, all seven Performance subtests loaded higher on the Performance factor than the Verbal factor, especially with the Oblimin rotation, with only Picture Arrangement having a secondary loading as high as .30 in the oblique solution.

The three-factor solutions yielded a VCI factor (Factor I in Varimax solution, Factor II in Oblimin solution), a POI Factor (Factors II and I, respectively) and a third factor that was a blend of WMI and PSI. The VCI dimension had loadings above .70, with both rotations, by the three subtests included on the WAIS-III VCI (Information, Vocabulary, Similarities) and by Comprehension, which is part of the WISC-III VCI and has traditionally been associated with VCI factors. The POI dimension had its highest loadings (.53–.77), in both the Varimax and Oblimin solutions, by the three subtests categorized as measuring Spatial Ability by Bannatyne (1974) and as assessing Simultaneous Processing by Kaufman and McLean (1986, 1987): Picture Completion, Block Design, and Object Assembly. The WAIS-III POI is comprised of the first two of the aforementioned subtests plus Matrix Reasoning. Although Matrix Reasoning loaded higher on POI than the other two

Table 1
Two- and Three-Factor Varimax-Rotated Principal Factor Solutions for the 14 WAIS-III Subtests Ages 16 to 89 Years

	Two-factor solutions		Three-factor solutions		
Subtest	Factor I	Factor II	Factor I	Factor II	Factor III
Verbal					
Vocabulary	.35	**.82**	**.78**	.28	.33
Similarities	.39	**.74**	**.70**	.36	.27
Arithmetic	**.52**	**.53**	**.48**	.29	**.54**
Digit Span	**.45**	.34	.28	.12	**.61**
Information	.34	**.79**	**.75**	.27	.30
Comprehension	.34	**.76**	**.73**	.32	.25
Letter-Number Sequencing	**.53**	.38	.30	.19	**.67**
Performance					
Picture Completion	**.57**	.34	.29	**.57**	.26
Digit Symbol-Coding	**.61**	.22	.16	.37	**.52**
Block Design	**.66**	.35	.29	**.66**	.31
Matrix Reasoning	**.58**	**.44**	.39	**.49**	.38
Picture Arrangement	**.48**	**.45**	**.41**	**.47**	.25
Symbol Search	**.75**	.24	.18	**.51**	**.56**
Object Assembly	**.55**	.31	.25	**.72**	.11
% Total Variance	27.3	27.0	22.9	18.9	17.3

Note. Factor loadings ≥ .40 are in boldface. WAIS-III = Wechsler Adult Intelligence Scale–Third Edition, 1997. N = 2,450. Unrotated first-factor loadings were obtained from two-factor solution.

Table 2
Two- and Three-Factor Oblimin-Rotated Principal Factor Solutions for the 14 WAIS-III Subtests at Ages 16 to 89 Years

	Two-factor solutions		Three-factor solutions		
Subtest	Factor I	Factor II	Factor I	Factor II	Factor III
Verbal					
Vocabulary	.01	**.89**	–.02	**.86**	.06
Similarities	.11	**.75**	.13	**.74**	.09
Arithmetic	**.41**	.39	.05	.37	**.45**
Digit Span	**.42**	.18	–.10	.13	**.65**
Information	.00	**.85**	–.01	**.83**	.05
Comprehension	.03	**.81**	.08	**.80**	–.03
Letter-Number Sequencing	**.52**	.17	–.04	.12	**.71**
Performance					
Picture Completion	**.59**	.09	**.53**	.14	.10
Digit Symbol-Coding	**.72**	–.10	.26	–.07	**.53**
Block Design	**.71**	.05	**.62**	.10	.15
Matrix Reasoning	**.55**	.22	.36	.25	.24
Picture Arrangement	**.41**	.30	.37	.33	.07
Symbol Search	**.90**	–.16	**.42**	–.09	**.54**
Object Assembly	**.59**	.06	**.77**	.09	–.10

Note. Factor loadings ≥ .40 are in boldface. WAIS-III = Wechsler Adult Intelligence Scale–Third Edition, 1997. N = 2,450. Factors I and II in the two-factor solution correlated .75. In the three-factor solution, the following correlations emerged: I x II = .61; I x III = .55; II x III = .64.

factors with both rotations, its loadings on all three factors were nearly comparable in magnitude, ranging from .38 to .49 (Varimax) and from .24 to .36 (Oblimin). Picture Arrangement, sometimes associated with POI factors on other Wechsler subtests, loaded above .40 on both the VCI and POI factors with the Varimax rotation and loaded in the mid-.30s on both factors with the Oblimin rotation.

Factor III had loadings of .45 to .71 by both PSI subtests and all three WMI subtests, reflecting a merger of these two indexes. Arithmetic had a secondary loading of .48 on the VCI factor in the Varimax solution, but had a negligible VCI loading in the Oblimin solution. Symbol Search had secondary loadings above .40 on the POI factor with both rotations. This factor might simply be labeled WMI/PSI, although calling it simply WMI is also sensible because all five tasks require considerable use of a person's working memory for success. Multicomponent theorists (e.g., Baddeley, 1986; Logie, 1995) distinguish between the storage and processing of verbal and spatial systems, whereas other theorists (e. g., Richardson, 1996) minimize the distinction between verbal and visual working memory. In either case, Factor III is defined by subtests that stress either verbal or visual working memory, and is aptly named Working Memory. Alternatively, Factor III could be named Short-term Apprehension and Retrieval (SAR) from Horn's (1985, 1989, 1991) theory of intelligence; the WMI subtests demand auditory memory, whereas the PSI subtests require visual memory. Finally, the label assigned to the trio of WISC-III subtests that measure memory, and/or processing speed, FDI, could be given to the third factor in the WAIS-III analyses.

The WAIS-III factor structure was compared with the WAIS-R structure in Table 3, which shows Varimax rotations of only the 11 subtests they have in common. The two-factor structure for both the WAIS-III and WAIS-R reflects a nearly flawless split of the six Verbal subtests (Factor I) and the five Performance subtests (Factor II). The three-factor

Table 3
Two-Factor and Three-Factor Varimax-Rotated Principal Factor Solutions for the WAIS-III (Ages 16 to 89 Years) and WAIS-R (Ages 16 to 74 Years) Based on the 11 Subtests Included in Both Tests

Subtest	Two-factor solutions				Three-factor solutions					
	Factor I (VCI)		Factor II (POI)		Factor I (VCI)		Factor II (POI)		Factor III (WMI)	
	WAIS-III	WAIS-R	WAIS-III	WAIS-R	WAIS-III	WAIS-R	WAIS-III	WAIS-R	WAIS-III	WAIS-R
Verbal										
Vocabulary	**.84**	**.84**	.32	.32	**.79**	**.81**	.29	.26	.34	.34
Similarities	**.73**	**.69**	.39	.39	**.70**	**.67**	.37	.36	.28	.27
Arithmetic	**.61**	**.58**	**.40**	**.47**	**.41**	**.44**	.28	.34	**.64**	**.55**
Digit Span	**.44**	**.47**	.29	.37	.24	.30	.17	.22	**.58**	**.64**
Information	**.80**	**.79**	.31	.31	**.74**	**.75**	.27	.27	.34	.30
Comprehension	**.74**	**.73**	.35	.34	**.71**	**.71**	.33	.30	.27	.27
Performance										
Picture Completion	.33	**.44**	**.61**	**.55**	.30	**.44**	**.59**	**.56**	.21	.17
Digit Symbol-Coding	.36	.39	**.40**	**.46**	.23	.32	.34	.38	.36	.17
Block Design	.33	.33	**.72**	**.72**	.24	.27	**.66**	**.69**	.35	.33
Picture Arrangement	**.44**	**.45**	**.50**	**.45**	**.40**	**.42**	**.48**	**.42**	.25	.23
Object Assembly	.24	.22	**.71**	**.69**	.23	.19	**.73**	**.73**	.14	.17
Coefficient of Congruence	.998		.996		.994		.996		.984	

Note. Factor loadings ≥ .40 are in boldface. WAIS-III = The Wechsler Adult Intelligence Scale–Third Edition, 1997; WAIS-R = Wechsler Adult Intelligence Scale–Revised, 1981. VCI = Verbal Comprehension; POI = Perceptual Organization; WMI = Working Memory. Data for the WAIS-R two-factor solutions are mean values reported by Silverstein (1982) for the nine standardization age groups. Data for the WAIS-R three-factor solutions are from Parker's (1983) analysis of the correlation matrix for the entire standardization sample (N = 1,880).

solutions of the two Wechsler adult batteries produced crisp VCI (Factor I), POI (Factor II), and WMI (Factor III) dimensions. Digit Symbol-Coding, the one PSI subtest included in both tests, loaded below .40 on all factors for both the WAIS-R and WAIS-III. Indeed, the WAIS-III factors were nearly identical to their WAIS-R counterparts in both the two-factor and three-factor solutions, yielding coefficients of congruence of .984 to .998 with a median value of .996 (see Table 3).

The analogous comparison of factor solutions for the WAIS-III and WISC-III, based solely on the 12 subtests that they share, again produced highly congruent results (Table 4). Coefficients of congruence ranged from .945 to .998 with a median value of .982. This congruence is remarkable in view of the fact that the age ranges for the two tests are decidedly different (6 to 16 years for the WISC-III and 16 to 89 years for the WAIS-III). The only factor with a coefficient of congruence below .980 in either Table 3 or Table 4 was the value of .945 for the comparison of the third WAIS-III and WISC-III factor. This factor is labeled PSI for both tests, rather than the WMI, SAR, or FDI label given to the adult test batteries. When Symbol Search is included in the correlation matrix, as it is for the WAIS-III versus WISC-III analysis, then the third factor is primarily a speed dimension, with the highest loadings obtained by the two PSI subtests. For the WAIS-III, the WMI subtests of Arithmetic and Digit Span have meaningful loadings in the low .40s, but for the WISC-III, these loadings are trivial (low .20s). Nonetheless, a value of .945 reflects considerable congruence.

Discussion

The two-factor solutions of all 14 WAIS-III subtests shown in Table 1 (Varimax) and Table 2 (Oblimin) offer fairly good construct validity support for Wechsler's original armchair division of subtests into Verbal and Performance scales. The main exceptions are the loadings of two Verbal subtests: Digit Span (which loaded primarily on the performance dimension) and Arithmetic (which loaded about equally on the verbal and performance dimensions). Letter-Number Sequencing, placed on the Verbal scale by the test publisher about 15 years after Wechsler's death, was decidedly a performance subtest in its factor loadings, especially when correlated factors were permitted (see Table 2). However, Letter-Number Sequencing does not contribute to VIQ; its only scale placement is on WMI. According to the test manual (The Psychological Corporation, 1997), it can be used to replace Digit Span if that subtest is spoiled, but it cannot be used to replace any other Verbal subtest. Its failure to load on the Verbal scale as predicted is, therefore, of little practical consequence. Its substantial Performance factor loadings probably reflect the fact that this subtest presents a novel task to adults. They are presented with a series of alternating numbers and letters and are instructed to first repeat the numbers in ascending order, then repeat the letters in alphabetical order. Because of its novelty, this subtest probably measures not only immediate memory, but also fluid intelligence (Gf); other novel subtests on the Performance scale, such as Matrix Reasoning and Object Assembly, also measure abilities that Horn (1989; Horn & Hofer, 1992) associates with Gf. In addition, it is likely that visualization is a key strategy used by successful adults on this task, just as visualization has been inferred as an effective mediating technique on Digits Backward (Costa, 1975). Hence, Letter-Number Sequencing also probably depends to some extent on Broad Visualization (Gv; Horn, 1989, 1991; Horn & Hofer, 1992; Horn & Noll, 1997). Examination of the aging curve for Letter-Number Sequencing reveals that scores decline very rapidly with increasing age, mirroring the aging curves for the Performance subtests and consistent with the vulnerability displayed by Gf and Gv abilities (Kaufman, 2000; Kaufman & Lichtenberger, 1999, pp. 187-200; Kaufman, Kaufman, Chen, & Kaufman, 1996).

Apart from the three WMI subtests, other subtests behaved as predicted. All seven Performance subtests loaded higher on the Performance than Verbal factor, and in the Oblimin solution the differential loadings were clear-cut. The four Verbal subtests that are traditionally associated with VCI factors loaded much higher on the Verbal factor than Performance factor. As noted, however, Letter-Number Sequencing and Digit Span were more Performance tasks than Verbal tasks, and Arithmetic loaded about equally on both factors.

Table 4
Two-Factor and Three-Factor Varimax-Rotated Principal Factor Solutions for the WAIS-III (Ages 16 to 89 Years) and WISC-III (Ages 6 to 16 Years) Based on the 12 Subtests Included in Both Tests

	Two-factor solutions				Three-factor solutions					
	Factor I (VCI)		Factor II (POI)		Factor I (VCI)		Factor II (POI)		Factor III (WMI)	
Subtest	WAIS-III	WISC-III	WAIS-III	WISC-III	WAIS-III	WISC-III	WAIS-III	WISC-III	WAIS-III	WISC-III
Verbal										
Vocabulary	**.83**	**.81**	.34	.26	**.82**	**.82**	.26	.22	.27	.16
Similarities	**.74**	**.75**	.38	.29	**.72**	**.75**	.35	.30	.24	.10
Arithmetic	**.56**	**.56**	**.47**	**.42**	**.56**	**.55**	.25	.37	**.43**	.23
Digit Span	.38	.34	.38	.30	.38	.34	.13	.22	**.40**	.22
Information	**.80**	**.76**	.32	.30	**.78**	**.75**	.26	.29	.24	.11
Comprehension	**.76**	**.68**	.33	.24	**.74**	**.68**	.32	.19	.20	.19
Performance										
Picture Completion	.34	.39	**.58**	**.50**	.31	**.44**	**.55**	**.53**	.29	.09
Digit Symbol-Coding	.24	.17	**.60**	.39	.22	.32	.22	.12	**.67**	**.74**
Block Design	.36	.35	**.65**	**.72**	.32	.27	**.61**	**.73**	.33	.19
Picture Arrangement	**.45**	.34	**.48**	**.43**	**.43**	**.42**	**.44**	.36	.26	.25
Object Assembly	.30	.28	**.59**	**.66**	.23	.19	**.75**	**.67**	.18	.15
Symbol Search	.26	.26	**.76**	**.54**	.23	.19	.37	.35	**.74**	**.62**
Coefficient of Congruence	.998		.982		.994		.980		.945	

Note. Factor loadings ≥ .40 are in boldface. WAIS-III = Wechsler Adult Intelligence Scale–Third Edition, 1997. WISC-III = Wechsler Intelligence Scale for Children–Third Edition, 1991. VCI = Verbal Comprehension; POI = Perceptual Organization; PSI = Processing Speed. Data for the WISC-III two-factor solutions are from Maximum-Likelihood analysis of the correlation matrix for the entire standardization sample (N = 2,200) reported in the WISC-III test manual (Wechsler, 1991, Table 6.2). Data for the WISC-III three-factor solutions are median values for the 11 age groups reported by Sattler (1992, Table I-9).

Therefore, the six-subtest WAIS-III Verbal Scale includes only four subtests that are decisively Verbal, suggesting that the make-up of this scale is not optimal. In contrast, the results of the two-factor solutions support the placement of all seven Performance subtests on that scale.

Arithmetic's substantial loading on the Performance dimension is consistent with the fluid reasoning that Horn and Hofer (1992) consider to be integral to succeed on that task. The Performance loading of Digit Span is certainly not related to the need for fluid reasoning on this memory task. However, the Backwards portion of the task does require Broad Visualization, as mentioned previously, and Wechsler's Performance scale may legitimately be thought of as an *amalgam* of Gf and Gv. Additionally, like most Performance subtests, there is little crystallized thinking required for success on Digit Span (or Letter-Number Sequencing), therefore, neither formed education nor acculturation is likely to affect success on immediate memory tasks, unlike the subtests that have high loadings on the Verbal factor.

Interestingly, when the factor analysis is limited to the 11 subtests retained from the WAIS-R, the construct validity support is decisive (see Table 3), with all 11 subtests loading in the predicted direction. Thus, these data, in general, offer good construct validity support for the use of the VIQ versus PIQ dichotomy in clinical assessment. Note, however, that the best support for the VIQ distinction comes from the analysis of only the 11 "original" subtests. From a practical standpoint, clinicians will not be administering those 11 subtests; even if they elect not to give supplementary WAIS-III subtests, the standard battery of 11 subtests now includes the new Matrix Reasoning subtest instead of the old Object Assembly task.

Caruso and Cliff (1999) were less supportive of the agreement between their factor-analytic results and the scale placement of WAIS-III subtests. They used a procedure called reliable-component analysis (RCA) that they developed (Cliff & Caruso, 1998), which emphasizes the extraction of reliable orthogonal components and produces factor solutions that are a bit different from conventional techniques. In their RCA solution (which excluded Object Assembly), only 8 of the 13 subtests loaded decidedly on their predicted factor; Picture Arrangement loaded higher on the Verbal factor; Picture Completion loaded about equally on both factors; and the three WMI subtests, though included on the Verbal scale, loaded decisively on the Performance factor (Caruso & Cliff, 1999). Thus, the RCA solution does not offer good construct validity support to the WAIS-III's VPIQ split. Therefore, the combination of principal factor analyses with Varimax and Oblimin rotations presented in Tables 1 through 4 disputes the conclusions reached by Caruso and Cliff (1999).

Of special interest in Tables 1, 2, and 3 are differences in the way some subtests loaded based on the number of WAIS-III subtests that were factor analyzed. As noted, when only the original 11 subtests are analyzed, the two-factor solution (Table 3) produced clear-cut VPIQ splits, with each of the 11 subtests loading higher on the factor representing its designated scale. When all 14 WAIS-III subtests are analyzed (see Tables 1 and 2), it is evident that all three new subtests (Matrix Reasoning, Symbol Search, and Letter-Number Sequencing) loaded higher (usually substantially higher) on the Performance factors than the Verbal factors in the two-factor solutions. Furthermore, the inclusion of these new subtests exerted a "pull" on Digit Span, Arithmetic, and Digit Symbol-Coding toward the Performance factor. With only 11 subtests, the first two of these subtests were decidedly Verbal with the remaining subtests loading about equally on both factors (.40 Performance, .36 Verbal; see Table 3). With 14 subtests, Digit Span and Digit Symbol-Coding became unequivocally Performance subtests and Arithmetic loaded about equally on both factors (Tables 1 and 2). In the three-factor solutions, the most noteworthy change was in the third factor. With 11 subtests, the third factor on the WAIS-III is an Arithmetic-Digit Span dyad, with Digit Symbol failing to load meaningfully. This same third factor also characterized factor analyses of the WAIS-R standardization sample (see Table 3) as well as numerous clinical samples (Kaufman, 1990, chapter 8). With 14 subtests, the third factor is a robust dimension that comprises all five subtests that make up the WMI and PSI, including Digit Symbol-Coding.

The robustness of this third factor, especially in the correlated-factor solution (see Table 2), when coupled with the scree test that suggested no more than three meaningful factors, raises the question of whether the WAIS-III's publisher over-factored to produce its four-factor solution. That possibility was raised by Sattler (1992) for the WISC-III, who identified only three meaningful factors and did not believe that his factor analyses supported the existence of an FD dimension. However, the third factor identified by Sattler (1992) was purely a PSI factor, defined by only *two* subtests, with trivial loadings by the two FDI subtests (see loadings in parentheses; Table 4). That is quite different from the third factor for the WAIS-III, on which all *five* PSI and WMI subtests had their highest loadings, ranging from .45 to .71 (see Tables 1 and 2). The degree to which all five subtests loaded together on the third factor (with no other WAIS-III subtest loading higher than .24 on this dimension in the Oblimin solution) suggests that it denotes a meaningful psychological construct.

Indeed, all five subtests seem to reflect executive functioning, which is a popular construct in neuropsychological research and practice (e. g., Barkley, 1997) and therefore would be a defensible label for this WAIS-III third factor. Additionally, WMI would be an acceptable name for the robust third factor because the two PSI subtests certainly place heavy demands on an individual's working memory. In fact, executive functioning and working memory are interrelated concepts within the field of information processing (e.g., Logie, 1996). Some systems of working memory posit a central executive processor with two "slave systems," one that stores and processes verbal material (the phonological loop) and the other that is specialized for visual-spatial stimuli (the visuospatial sketch pad; Baddeley, 1986, 1992; Logie, 1996). This three-component model provides a strong theoretical basis for the third factor. Although other models, such as Richardson's (1996), deemphasize the verbal-visual distinction, these models are also suitable foundations for the third factor, which clearly includes tasks independent of auditory/verbal or visual/spatial processing. Regardless of the theoretical model, one commonality among working memory researchers is their definition of the construct, which, one way or the other, involves temporary storage of material that is in an active state (e. g., Woltz, 1988).

Even though one can argue in favor of the conceptual meaningfulness of a three-factor WAIS-III solution, the four-factor solution also has strong theoretical and clinical support. From Horn's (1985, 1989, 1991) theoretical model (also see McGrew, 1997), Factor 3 is too broad. Instead, it is composed of two distinct abilities, short-term memory (SAR) and speed (Gs), respectively. Further, these two Horn abilities have their own distinctive patterns across the adult age range, with Gs far more vulnerable to aging than SAR. In fact, these predictable and quite different patterns have been observed for the WAIS-III WMI versus PSI (Kaufman, 2000; Kaufman & Lichtenberger, 1999, Figure 6.2). Also, the confirmatory factor analyses conducted by the publisher of the WAIS-III provided empirical support for four- versus three-factor solutions for the total sample and most of the separate age groups (The Psychological Corporation, 1997, pp. 106-112). Overall, the replicability of the four factors across instruments (i.e., WISC-III and WAIS-III) and samples, along with the aforementioned reasons, suggest that the publisher was on solid ground to interpret four factors. Finally, many clinical samples tend to perform at decidedly different levels on the WMI and PSI factors. For example, groups of adults with traumatic brain injury, mild Alzheimer's disease, Huntington's disease, Parkinson's disease, chronic alcohol abuse, and Korsakoff's Syndrome each scored lower on PSI than WMI by 6.9 to 18.4 points (0.46 to 1.23 *SD*; The Psychological Corporation, 1997, pp. 144-165).

Nonetheless, the combination of WMI and PSI (FDI and PSI on the WISC-III) reflects a meaningful construct that might merit interpretation for individuals who perform consistently—whether high or low—on both factors. Some groups have consistently displayed low FDI and PSI scores on the WISC-III, notably samples of students diagnosed with learning disabilities or Attention-Deficit Hyperactivity Disorder (ADHD; Kaufman, 1994; Kaufman & Lichtenberger, 2000; Schwean & Saklofske, 1998).

Additionally, preliminary WAIS-III research with a small sample of ADHD adolescents likewise found lower mean indexes on WMI and PSI (The Psychological Corporation, 1997, chapter 4). When individuals with ADHD earn low standard scores on both WMI and PSI, one should usually hypothesize a common deficit, conceivably in executive functioning, that is likely responsible for both low scores (see, for example, Barkley, 1997).

Conclusions

1. The two-factor solutions of the WAIS-III are in general agreement with the WAIS-III Verbal-Performance dichotomy, offering empirical support for the VIQ versus PIQ discrepancy. The support is not unilateral though, because the three WMI subtests included on the Verbal scale tended to be associated either with the Performance scale (Digit Span, Letter-Number Sequencing) or with both scales about equally (Arithmetic).
2. The three-factor solutions of the WAIS-III provide empirical support for the VCI and POI and for an amalgam of the WMI and PSI.
3. The third factor may reflect an executive functioning or working memory dimension that should aid clinicians in the interpretation of WAIS-III profiles for individuals who perform either consistently low or consistently high on both the WMI and PSI factors. This third factor will be less important, however, for the many clinical groups that tend to perform differently on WMI and PSI. For example, patients with traumatic brain injury are more likely to have impairments in PSI than WMI (The Psychological Corporation, 1997, Table 4.41). Such clinical samples will be better understood by interpreting the four indexes rather than focusing on a three-factor solution that merges the PSI and the WMI into an aggregate dimension.
4. Although the two-factor and three-factor solutions of the WAIS-III presented here provide helpful interpretive guidelines for the WAIS-III, they are intended to supplement, not replace, the publisher's preferred four-factor solution.
5. Factor analysis of just the 11 WAIS-III subtests retained from the WAIS-R offers striking evidence of the continuity of the constructs measured by the WAIS-III and its direct predecessor with unusually high coefficients of congruence of .984 to .996. In the two-factor solutions, both coefficients exceeded .995. However, these results are of historical and psychometric interest only and are of no clinical consequence because of the continuity in the 11 subtests retained in the WAIS-III, the additional three subtests, and the new profile of four indexes all greatly enhance the information yielded by the battery as well as its clinical utility.
6. Factor analysis of the 12 subtests shared by the WAIS-III and WISC-III likewise supported the continuity of the Wechsler constructs measured by the children's and adults' scales with coefficients of congruence ranging from .945 to .998.
7. Previously published factor analyses of the WAIS-III (Caruso & Cliff, 1999; The Psychological Corporation, 1997; Tulsky et al., in press) have excluded Object Assembly from all analyses. This subtest is supplemental for ages 16-74 years and not advised for administration to older adults. The present analyses indicate that Object Assembly is a good measure of Performance ability in the two-factor solutions and the *best* measure of POI in the three-factor solutions. Nonetheless, the publishers of the WAIS-III were wise to replace this subtest with Matrix Reasoning. This new subtest is a well recognized measure of Gf, an important ability that has not been measured optimally in previous Wechsler scales. In contrast, the child-oriented puzzles used for Object Assembly probably make this task more suitable for assessing children than adults.

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