Please use the following citation when referencing this work:

Dombrowski, S. C., McGill, R. J., & Canivez, G. L. (in press). Hierarchical exploratory factor analyses of the Woodcock-Johnson IV full test battery: Implications for CHC application in school psychology. School Psychology Quarterly. Advance online publication. doi: 10.1037/spq0000221

Hierarchical Exploratory Factor Analyses of the Woodcock-Johnson IV Full Test Battery: Implications for CHC Application in School Psychology

Stefan C. Dombrowski

Rider University

Ryan J. McGill

College of William & Mary

Gary L. Canivez

Eastern Illinois

Author Note

Correspondence regarding this article should be addressed to Stefan C. Dombrowski, Ph.D., School Psychology Program, 2083 Lawrenceville Road, Lawrenceville, NJ 08648. E-mail: sdombrowski@rider.edu.

Abstract

The Woodcock-Johnson, Fourth Edition (WJ IV; Schrank, McGrew & Mather, 2014a) was recently redeveloped and retains its linkage to Cattell-Horn-Carroll theory (CHC). Independent reviews (e.g., Canivez, 2016) and investigations (Dombrowski, McGill & Canivez, 2016) of the structure of the WJ IV full test battery and WJ IV Cognitive have suggested the need for additional factor analytic exploration. Accordingly, the present study used principal axis factoring followed by the Schmid and Leiman (1957) procedure with the two school aged correlation matrices from the normative sample to determine the degree to which the WJ IV total battery structure could be replicated. Although seven factors emerged across the 9 to 19 age range, the pattern of subtests loadings did not fully cohere with the structure presented in the Technical Manual, most notably for the academic fluency subtests. Also, the fluid reasoning (Gf) and quantitative reasoning (Gq) subtests coalesced to form a combined factor rather than two separate factors and the long term retrieval (Gltr) subtests aligned with a variety of different factors. The results of this study indicated that the general intelligence factor variance far exceeded the variance attributed to the lower-order CHC factors. The combination of subtest migration and nominal total/common variance of the CHC lower-order factors suggests caution when interpreting the myriad CHC-related indices when making high stakes decisions. Implications for clinical practice are discussed.

Keywords: Exploratory Factor Analysis; Higher order Factor Analysis; Cattell-Horn-Carroll Theory; Schmid-Leiman Orthogonalization; General Intelligence

Statement

Results indicate that the WJ IV total battery may not measure some hypothesized CHC dimensions well and that the subtest composition of the CHC factors is different from what is indicated in the Technical Manual. Specifically, results did not locate distinct Gf, Gv and Gltr factors and the composition of the Gs, Gwm, and Gc factors is different than what is presented in the Technical Manual. As a result, users of the WJ IV are encouraged to interpret the WJ IV CHC-based indices carefully when using the WJ IV full battery of tests in clinical practice.

Hierarchical Exploratory Factor Analyses of the Woodcock-Johnson IV Full Test Battery: Implications for CHC Application in School Psychology

School psychologists devote a considerable portion of time administering and interpreting individually administered tests of intelligence and other related psychoeducational abilities (Dombrowski, 2015a; Sotelo-Dynega & Dixon, 2014). The Woodcock-Johnson battery of tests are likely among the more commonly used instruments to evaluate cognitive abilities and academic achievement (Schrank, Decker & Garruto, 2016). The WJ-IV was recently revised and comprises separate tests of cognitive ability, achievement, and oral language (Schrank, Mather & McGrew, 2014a, 2014b; Schrank, McGrew & Mather, 2014a, 2014b). Guided by Carroll's (1993) three-stratum theory of cognitive abilities, the work of Horn and Cattell (1966), and contemporary neuroscience research on memory (e.g., McGrew, LaForte & Schrank, 2014) the WJ IV was designed to measure several CHC factors including Comprehension-Knowledge (Gc), Fluid Reasoning (Gf), Short-Term Working Memory (Gwm), Cognitive Processing Speed (Gs), Auditory Processing (Ga), Long Term Retrieval (Gltr), Visual-Processing (Gv), Reading-Writing (Grw) and Quantitative-Numeric (Gq) (McGrew et al., 2014).

When analyzing the WJ IV full battery using principal axis factoring (PAF) with an oblique rotation, the test authors reported finding Heywood cases (i.e., communality >1.0), impermissible factors (i.e., less than two subtests saliently loading on a factor), and a lack of theoretical convergence (McGrew et al., 2014. The specific details of these findings were not presented in the Technical Manual. The test authors also conducted a principal components analysis (PCA) with varimax (orthogonal) rotation, arguing that these methods more readily yield an interpretable factor structure.

However, the use of these methods to disclose the latent structure of psychological tests is not without controversy (Fabrigar & Wegner, 2012; Gorsuch, 1983; Osborne, 2015). Although PCA falls under the general class of dimension reduction techniques, it does not consider the underlying latent structure of the variables, using all the variance in the manifest variables, and therefore does not does not distinguish between dimensions of variance (e.g., shared and unique variance). Because of this, the components derived from PCA should not be interpreted as a reflection of latent dimensions (i.e., general factor or group-specific factors; Bentler & Kano, 1990; Preacher & MacCallum, 2003; Widaman, 1993). Additionally, the use of varimax rotation following factor extraction has been questioned. Gorsuch (1983) explained that "varimax is inappropriate if the theoretical expectation suggests a general factor may occur" (p. 185). Also varimax rotation may be questioned for use when factors are highly correlated as is often the case with ability measures like the WJ IV.

Alternatively, an oblique rotation (e.g., promax) is considered by many researchers to be more appropriate under these conditions (e.g., Obsborne, 2015; Tabachnick & Fidell, 2007; Thompson, 2004). Although an oblique rotation for correlated traits may be preferred, it is not singularly sufficient and an additional step is often suggested when conducting exploratory factor analysis (EFA). Gorsuch (1983), Canivez (2016), Dombrowski, Beaujean, Canivez and Watkins (2015) and Thompson (2004) commented that higher-order factors are implicit in oblique rotations, particularly in the case of ability research, so it is recommended that these higher-order factors should be extracted and examined.

A commonly used approach to examining and extracting higher-order factors is through the Schmid and Leiman (SL; 1957) procedure (Canivez, 2016; Carretta & Ree, 2001; Carroll, 1993, 1995, 2003; Dombrowski, McGill & Canivez, 2017; Dombrowski, Canivez & Watkins,

2017). Carroll (1993) utilized this procedure exclusively to develop the three-stratum theory of cognitive abilities, which was a major influence on the development of the WJ IV. Thus, it may have been worthwhile to consider its use when exploring the factor structure of the WJ IV.

There are additional factor analytic results that are informative and have yet to be analyzed including the correlations among the first-order factors, the percentage of variance accounted for by higher- and lower-order factors, communality estimates, and model based reliability estimates (i.e., omega statistics). The body of literature on EFA methodology (e.g., Carroll, 1993, 1995, 1997, 2003; Gorsuch, 1983; McClain, 1996; Ree, Carretta, & Green, 2003; Thompson, 2004) has suggested that this information be included when presenting factor analytic results because it aids users in determining how an instrument should be interpreted. Unfortunately, this information was not included in the WJ IV Technical Manual, suggesting that the field's understanding of the measurement instrument is presently incomplete.

Purpose of the Current Study

To address this gap in the literature, the present study aimed to investigate the factor structure of the WJ IV full battery during school age (e.g., age 9 to 19) using principal axis factoring with an oblique rotation followed by the Schmid and Leiman (1957) orthogonalization procedure. Given the widespread use of the WJ family of instruments in clinical practice, it is believed that the results from the present investigation are important for establishing evidence-based assessment procedures for the WJ IV.

Method

Participants

Data for the WJ IV norms were collected from a nationally representative sample of 7,416 participants from age 2 through 90-plus. The WJ IV Technical Manual reports that the

normative data controlled for census region, sex, country of birth, race, community type, parent education, and occupational level. Detailed demographic characteristics are provided in the WJ IV Technical Manual. For this study, two school aged (9 to 13 years and 14 to 19 years) subtest correlation matrices (47 by 47) were obtained from the Technical Manual. The 9 to 13 age group contained an average of 1,572 participants whereas the 14 to 19 age group contained an average of 1,685 participants.

Measurement Instrument

The Woodcock-Johnson IV Total Battery (WJ IV; Schrank, McGrew, & Mather, 2014a) contains three batteries that allow for a comprehensive assessment of cognitive ability, achievement, and oral language: Woodcock-Johnson IV Tests of Cognitive Ability (Schrank, McGrew, & Mather, 2014d), Woodcock-Johnson IV Tests of Achievement (Schrank, Mather, & McGrew, 2014b) and Woodcock-Johnson IV Test of Oral Language (Schrank, Mather, & McGrew, 2014c. The Battery was designed to measure several Cattell-Horn-Carrol (CHC) factors including Comprehension-Knowledge (Gc), Fluid Reasoning (Gf), Short-Term Working Memory (Gwm), Cognitive Processing Speed (Gs), Auditory Processing (Ga), Long Term Retrieval (Gltr), Visual-Processing (Gv), Reading-Writing (Grw) and Quantitative-Numeric (Gq) (McGrew et al., 2014). The WJ IV also yields a general ability factor reflective of *g*. The Technical Manual provides correlation matrices for eight different age ranges (2 to 3; 4 to 5; 6 to 8; 9 to 13; 14 to 19; 20 to 39; 40 plus) to show the correlation among subtests (McGrew, LaForte, & Schrank, 2014). The Technical Manual presents the WJ IV subtests with their relationship to *g* and Cattell-Horn-Carroll (CHC) factors. Please see the instrument's examiner's manual for a synopsis of subtest demands.

Procedure

Subtest intercorrelation matrices for the WJ IV total battery configuration for ages 9-13 and 14-19 (47x47) were extracted from the Technical Manual. The two correlation matrices across the 9 to 19 age range were selected for several reasons. First, cognitive abilities have been shown to display a lack of invariance at younger age ranges (DiStefano & Dombrowski, 2006; Keith & Reynolds, 2010; Tusing & Ford, 2004). Second, the age period under investigation represents a range readily available in the schools for researchers and practitioners. Third, space limitations were also considered. Finally, this same age range was investigated in a prior EFA-SL study on the WJ III battery (e.g., Dombrowski & Watkins, 2013) so this may offer an element of comparison.

The correlation matrices were analyzed using several EFA methodologies. First, the intercorrelation matrices for the two age groups were evaluated using Bartlett's Test of Sphericity (Bartlett, 1954) and the Kaiser–Meyer–Olkin (KMO; Kaiser, 1974) statistic to ensure that the they were suitable for factor analysis. Second, the intercorrelation matrices were subjected to principal axis factoring (Cudeck, 2000; Fabrigar, Wegener, MacCallum, & Strahan, 1999; Tabachnick & Fidel, 2007) with promax rotation ($k = 4$; Tataryn, Wood, & Gorsuch, 1999) because of the assumption of correlated factors (Gorsuch, 1983; Schmitt, 2011; Tabachnik & Fidell, 2007). Pattern coefficients of .30 or higher were considered salient (Child, 2006; Schmitt, 2011). Next, multiple empirical factor extraction criteria were examined (Gorsuch, 1983) as well as factor interpretability and compliance with simple structure (Thurstone, 1947). Specifically, eigenvalues > 1 (Kaiser, 1974), the scree test (Cattell, 1966), Horn's parallel analysis (HPA; Horn, 1965), and minimum average partials (MAP; Velicer, 1976) were examined. These procedures were conducted using O'Conner's (2000) SPSS syntax. An additional step was to extract the nine factors posited in the Technical Manual. Additionally, a higher-order factor

analysis using the SL procedure was applied to the oblique first-order factors to elucidate the structure of the WJ IV using the SPSS syntax provided by Wolff and Preising (2005).

Results

Results from Bartlett's Test of Sphericity (Bartlett, 1950) for both age range analyses indicated that the correlation matrices were not random (9 to 13 age range $\chi^2 = 11{,}592.57$, $df = 153$, $p < .0001$; 14 to 19 age range $\chi^2 = 13{,}819.03$, $df = 153$, $p < .0001$). For the 9 to 13 and 14 to 19 age groups, the Kaiser–Meyer–Olkin (Kaiser, 1974) statistic was .867 and .894, respectively, well above the minimum standard of .60 for conducting a factor analysis suggested by Kline (1994). Measures of sampling adequacy for each variable were also within reasonable limits. Thus, the correlation matrices were judged to be appropriate for the factor analytic procedures that were employed.

Factor Extraction Criteria Comparison

Parallel analysis (Horn, 1965) suggested that seven factors be extracted for both the 9 to 13 and 14 to 19 age groups (See Figures 1 & 2). The MAP (Velicer, 1976) criterion also recommended extraction of seven factors for both age groups. The visual scree test indicated evidence for 7 to 9 factors for each age group. Factor extraction results are presented in Table 1. Seven factors were extracted in accord with factor extraction rules. Nine factors were extracted in accord with the test publisher's proposed theoretical structure reported in the Technical Manual. Eight factors were also extracted. A nine-factor extraction had the greatest linkage to theory –though only 7 interpretable factors were uncovered--and was deemed most interpretable across the two age group extractions.

Exploratory and Hierarchical Factor Analysis

Nine-Factor Extraction. The 9 to 13 and 14 to 19 school aged correlation matrices were subjected to principal axis factoring (PAF) with an oblique (promax) rotation. Tables 2 and 3 present the results of the PAF analyses for the age 9 to 13 and 14 to 19 correlation matrices in accord with a nine-factor extraction. These tables also include pattern and structure coefficients, eigenvalues for retained factors, percentage of variance accounted for by each factor, communality estimates, uniqueness, and the correlations among the extracted factors. This information was not included in the Technical Manual. The ages 9 to 13 analysis (Table 2) indicated that the first factor accounted for 38.94% of the variance. This exceeded the variance (6.84%) accounted for by the second factor for the 9 to 13 age group. Absolute value correlations among the extracted nine factors ranged from .04 to .60 (*Mdn* = .175). The age 14 to 19 analysis (Table 3) indicated that the first factor accounted for 42.48% of the variance. This exceeded the variance (5.92%) accounted for by the second factor. Absolute value correlations among the extracted nine factors ranged from .04 to .67 (*Mdn* = .20). Moderate to high correlation among factors, along with extant intelligence test theory, suggests the possible presence of a higher-order factor which needed to be extracted and examined (Gorsuch, 1983; Thompson, 2004).

Seven-Factor Extraction. The 9 to 13 and 14 to 19 school aged correlation matrices were subjected to principal axis factoring (PAF) with oblique (promax) rotation. Tables A1 and A2 (Online Supplement) presents the results of the PAF analyses for the age 9 to 13 and 14 to 19 correlation matrices in accord with a seven-factor extraction. Tables A1 and A2 include pattern and structure coefficients, eigenvalues for retained factors, percentage of variance accounted for by each factor, communality estimates, uniqueness, and correlations among the extracted factors. The age 9 to 13 analysis (Table A1) indicated that the first factor accounted for 38.94% of the variance. This surpassed the variance (6.78%) accounted for by the second factor for the 9 to 13

age group. Correlations among the nine extracted factors ranged from .04 to .60 (*Mdn* = .175). The age 14 to 19 analysis (Table A2) indicated that the first factor accounted for 42.48% of the variance. This surpassed the variance (5.92%) accounted for by the second factor. Absolute value correlations among the seven extracted factors ranged from .02 to .64 (*Mdn* = .46). Moderate to high correlations among the factors suggested the possible presence of a higher-order factor which needed to be extracted and examined (Gorsuch, 1983; Thompson, 2004).

SL Hierarchical Analyses: Nine First-Order Factors. Results from the SL procedure for ages 9 to 13 and 14 to 19 with the nine-factor solution are presented in Tables 4 and 5. For all analyses the results included the variance attributed to the general factor and group factors. These results are not included in the WJ IV Technical Manual and therefore serve to supplement analyses contained in the manual. In the 9 to 13 analysis, the general factor accounted for 32.6% of the total variance and 51.8% of the common variance, exceeding that accounted for by the lower-order group factors (Table 4; 1.9% to 5.4% total variance; 3.0% to 8.5% common variance). The general factor also accounted for between 10% and 53% (*Mdn* = 34.5%) of individual subtest variance. In the 14 to 19 analysis, the general factor accounted for 36.8% of the total variance and 55.6% of the common variance, exceeding that accounted for by the lower order factors (Table 5; 2.9% to 7.8% total variance; 1.9% to 5.1% common variance). The general factor also accounted for between 7% and 57% (*Mdn* = 37.5%) of individual subtest variance in the 14 to 19 analysis. The first- and second-order factors combined to measure 63.0% and 66.1% of the respective variance in the WJ IV, reflecting 37.0% and 33.9% unique variance in the 9 to 13 and 14 to 19 analyses. These results demonstrate a robust manifestation of general intelligence in the WJ IV where the combined influence of general intelligence and uniqueness exceeded the contributions made by the first-order group factors.

SL Hierarchical Analyses: Seven First-Order Factors. Results from the Schmid and Leiman (1957) procedure with the seven-factor solution are presented in Tables A3 and A4 (Online Supplement). In the 9 to 13 SL analysis (Table A3), the general factor accounted for 31.9% of the total variance and 53.1% of the common variance, exceeding that accounted for by the lower-order group factors (3.0% to 5.6% total variance; 5.0% to 9.3% common variance). The general factor also accounted for between 10% and 52% (*Mdn* = 36.5%) of individual subtest variance in the 9 to 13 analysis. In the age 14 to 19 analysis (Table A4), the general factor accounted for 36.4% of the total variance and 59.2% of the common variance, exceeding that accounted for by the lower-order group factors (2.7% to 5.0% total variance; 4.3% to 8.1% common variance). The general factor also accounted for between 7% and 56% (*Mdn* = 37.5%) of individual subtest variance in the 14 to 19 analysis. The first- and second-order factors combined to measure 60.1% and 61.5% of the respective variance in the WJ IV, reflecting 39.9% and 38.5% unique variance in the age 9 to 13 and 14 to 19 analyses. These results demonstrated a robust manifestation of general intelligence in the WJ IV where the combined influence of general intelligence and uniqueness exceeded the contributions made by the first-order group factors.

Eight-Factor EFA and SL Analysis: Ages 9 to 13 and 14 to 19: The correlation matrices for both age ranges were subjected to principal axis factoring with promax rotation followed by the Schmid-Leiman transformation. Results of an eight-factor extraction from these analyses yielded a theoretically plausible seven factor solution at age 9 to 13 and a 6 factor solution at age 14 to 19. These results are provided in Online Supplement Tables A5 to A8 but were deemed inferior to the nine-factor solution.

Discussion

The WJ IV represent the latest iteration of the WJ family of products and is poised to take the place of its predecessor as one of the preeminent CHC-based measurement instruments in school psychology practice and research. Within the professional literature, it has frequently been posited that the WJ IV full test battery measures nine distinct CHC-related cognitive-achievement factors (Gc, Gf, Ga, Gv, Gltr, Gwm, Gs, Grw, Gq) in addition to a higher-order general intelligence factor. In the present EFA study, the extraction of nine factors located only seven CHC-related dimensions including Gc, Grw, Gs, Gwm, Ga, combined Gq/Gf, and Gv across both age ranges (Ages 9-13, see Table 4; Ages 14-19, see Table 5). Additionally, across both age groups, the subtest alignment with several of the group factors displayed occasional migration away from theoretically posited factors and frequent cross-loadings with divergent factors (see Tables 6 and 7 for a factor structure summary detailing the pattern of subtest major loadings and cross-loadings via the SL analyses). The most notable were the academic fluency subtests (Math Fact Fluency, Word Reading Fluency, Sentence Reading Fluency and Sentence Writing Fluency). These subtests had higher loadings on the Gs group factor than on their respective academic factors although one subtest (e.g., Sentence Writing Fluency) at age 9 to 13 displayed a cross-loading with the Grw factor. Other examples included Reading Vocabulary which had a higher loading on the Gc (.36 for ages 9 to 13; .38 for ages 14 to 19) factor than on the Grw (.32 for ages 9 to 13; .23 for ages 14 to 19) factor.

The Gc, Grw, Ga, and the combined Gf/Gq factors generally contained theoretically consistent subtest alignment with occasional subtest migration (See Tables 6 and 7) for the nine-factor solution. For instance, Nonword Repetition (Ga) saliently loaded on the Gwm (.44 for ages 9 to 13, .43 for ages 14 to 19) factor, but failed to align with Ga in both age groups. Results did not locate distinct Gq and Gf group factors but instead found evidence for a combined Gf/Gq

factor. Results also did not locate a distinct Gltr factor for either age group. For ages 14 to 19, Retrieval Fluency and Rapid Picture Naming formed what appears to be a second Gs factor on the eighth factor.

When further reviewing the pattern of subtest loadings for the nine-factor solution, it was noted that several subtests for ages 9 to 13 aligned with, but failed to saliently load on, their respective group factors (e.g., Sound Awareness, .25 on Grw; Rapid Picture Naming, .29 on Gs), while still others did not display a salient loading or alignment with any group factor (e.g., Numbers Reversed; Story Recall). When reviewing the loadings for ages 14 to 19, several subtests aligned with, but failed to saliently load on, theoretically posited factors (e.g., Spelling, Oral Reading and Sound Awareness, .26, .24 and .23, respectively, on Grw; Understanding Directions and Numbers Reversed, .25 and .19, respectively, on Gwm), while other indicators did not display a salient loading or alignment with theoretically posited factors once the variance from the general factor was residualized (e.g., Visualization; Editing).

Extracting eight factors yielded a similar seven factor pattern for ages 9 to 13 as the nine-factor extraction (see Tables 6 & 7); however, for ages 14 to 19 an eight-factor extraction yielded six factors with the seventh having limited theoretical meaningfulness and the eighth being trivial (see Tables 6 & 7). Thus, the nine-factor solution was deemed more interpretable as it produced seven CHC-like factors.

Generally, extraction of seven factors as suggested by MAP and PA resulted in a solution that was less consistent with the theoretical structure posited in the Technical Manual. Although a seven factor extraction did not produce trivial factors (i.e., less than two subtests with salient loadings on a factor) as observed with the nine factor extraction, interpretability was deemed inferior. As a result, only five theoretically plausible factors could be identified across

both age ranges when seven factors were extracted. Given that it is better to overextract than underextract (Velicer, Eaton, & Fava, 2000) and considering that factorial consistency across both age groups and that linkage to theory was improved with a nine-factor extraction (resulting in seven plausible CHC factors), this was the solution that was deemed most appropriate.

When compared with Dombrowski and Watkins' (2013) EFA-SL analysis of the WJ III full test battery the results of this study indicate that the WJ IV full test battery more fully aligns with CHC theory. Dombrowski and Watkins (2013) analyses of the WJ III full test battery (Woodcock, McGrew & Mather, 2001) revealed Heywood cases (e.g., communalities >1.0), impermissible factors (e.g., no salient loading or only one loading on a factor), and a general lack of convergence of the full test battery's structure. Dombrowski and Watkins (2013) found that the WJ III full test battery did not reflect nine CHC factors as proposed in the Technical Manual. Instead, the instrument was deemed to measure six factors at ages 9 to 13 (Gc, Grw, Gs, Combined Gf/Gq, Ga and Glr) and five factors at ages 14 to 19 (Gc, Ga, Gs, Gq and Glr). More specifically, the academic fluency subtests displayed greater alignment with the Gs factor than with their respective academic factors. This is consistent with the present analysis. At ages 9 to 13 the Gq and Gf subtests fused together to form a combined factor consistent with the present analysis. Only the Gq factor, and not a Gf factor, was identified for ages 14 to 19. The Gc and Grw subtests often cross-loaded higher on alternate factors, and the Gsm and Ga factors did not reflect the subtest content proposed by the authors. These results raised concerns about the structural validity of the WJ III full test battery and its alignment with existing and later formulations of CHC theory (e.g., Schneider & McGrew, 2012). Subsequent research on the WJ III Cognitive and WJ III Achievement also found divergent factor structures from those proposed

in the Technical Manual (e.g., Dombrowski, 2013; Dombrowski, 2014a; Dombrowski, 2014b; Dombrowski, 2015b).

The results of this present study indicate that more factors appear to be measured by the WJ IV than its third edition counterpart. However, these results also suggest that the patterning of CHC-related variables on the WJ IV may be more complex than is presently described in much of the technical and professional literature.

Limitations and Future Directions

The present study is not without limitations. Most notably the use of correlation matrices produced from the Technical Manual's normative sample as a target for EFA analyses is a limitation. Although the current sample served as the normative reference for suggested WJ IV clinical interpretation, additional research is needed to determine if these results generalize to specific clinical populations such as those referred for specific learning disability evaluations and other related neurological impairments. Additionally, independent studies should also examine the structure of separate WJ IV tests of cognitive ability, achievement, and oral language to determine whether the structure of those instruments is consistent with that delineated in the Technical Manual as it is anticipated that most school psychologists will elect to employ large portions of the individual batteries in isolation.

Conclusion and Implications for Practice

The results of this study provided evidence that the WJ IV Total battery is a strong measure of *g* and seven smaller CHC factors (Gc, Ga, Gwm, Gv, Grw, Gs, and combined Gf/Gq). However, the subtest composition of many of the factors is different than what is posited in the Technical Manual. Results also indicated that the general intelligence factor accounts for anywhere from 6 to 18 times more variance than the lower order CHC factors. To help

understand this point, it may be useful to think metaphorically of the gravitational forces that influence the earth within our solar system. Certainly the moon and other planets exert a gravitational influence but it is smaller in size compared to the gravitational force exerted by the sun. It is the same with the general factor and the remaining CHC factors within this study. The lower order factors are indeed present but their influence may be less influential in comparison to that of the general factor.

What do the totality of findings mean for interpretation of the WJ IV battery of tests? The nominal lower-order factor explained common and total variance, the lack of alignment of subtests with theoretically posited factors, the inability to locate several CHC factors (i.e. Gf, Gq, Gltr), and the high degree of cross-loading of subtests on different factors impacts the utility of the WJ IV for direct index level interpretation, cross-battery assessment and other related interpretive procedures such as PSW analyses (e.g., Flanagan, Alfonso, & Mascolo, 2011; Flanagan, Ortiz, & Alfonoso, 2013; Niileksela, Reynolds, Keith & McGrew, 2016). The factors undergirding these approaches may be ephemeral, may lack sufficient unique variance for confident interpretation, and may reflect a different subtest composition from what is suggested in the Technical Manual. If a factor is non-existent or complexly determined, or if a subtest proposed to measure Grw instead measures Gs then the foundation for using either that factor or that subtest is simply not sufficiently strong for an interpretive heuristic such as XBA or PSW or even for straight-forward CHC index level interpretation. For example, Flanagan et al. (2012) have proposed a model for SLD identification which encourages practitioners to interpret group-factor scores as unidimensional indicators of cognitive-achievement abilities. The present results suggest that these practices may be difficult for practitioners to employ with confidence for several of the CHC-related indicators from the WJ-IV.

Although the present results suggest that the WJ IV has many laudable features, researchers and practitioners are encouraged to understand more fully the implications of the evidence offered by this study when interpreting the WJ IV CHC-related indices, and when engaging in complex diagnostic procedures such as XBA and PSW via the WJ IV (i.e, Kranzler et al., 2016; McGill, 2015; McGill & Busse, 2015; McGill & Busse, 2017).

References

Bartlett, M. S. (1954). A further note on the multiplying factors for various X^2 approximations in factor analysis. *Journal of the Royal Statistical Society, 16,* 296–298.

Beaujean, A. A. (2015). John Carroll's views on intelligence: Bi-factor vs. higher-order models. *Journal of Intelligence, 3,* 121-136. doi: 10.3390/jintelligence3040121

Bentler, P. M., & Kano, Y. (1990). On the equivalence of factors and components. *Multivariate BehavioralResearch*, *25*, 67-74. doi:10.1207/s15327906mbr2501_8

Canivez, G. L. (in press). Review of the Woodcock–Johnson IV. In J. F. Carlson, K. F. Geisinger, & J. L. Jonson (Eds.), *The twentieth mental measurements yearbook*. Lincoln, NE: Buros Center for Testing. Available for download at: http://marketplace.unl.edu/buros/

Canivez, G. L. (2016). Bifactor modeling in construct validation of multifactored tests: Implications for understanding multidimensional constructs and test interpretation. In K. Schweizer & C. DiStefano (Eds.), *Principles and methods of test construction: Standards and recent advancements* (pp. 247-271. Gottingen, Germany: Hogrefe.

Carretta, T. R., & Ree, J. J. (2001). Pitfalls of ability research. *International Journal of Selection and Assessment, 9,* 325–335. doi: 10.1111/1468-2389.00184

Carroll, J. B. (1993). *Human cognitive abilities.* Cambridge, United Kingdom: Cambridge University Press.

Carroll, J. B. (1995). On methodology in the study of cognitive abilities. *Multivariate Behavioral Research, 30,* 429 – 452. doi: 10 .1207/s15327906mbr3003_6

Carroll, J. B. (1997). The three-stratum theory of cognitive abilities. In D. P. Flanagan, J. L. Genshaft & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (pp. 183-208). New York: Guilford.

Carroll, J. B. (2003). The higher-stratum structure of cognitive abilities: Current evidence supports *g* and about ten broad factors. In H. Nyborg (Ed.), *The scientific study of general intelligence: Tribute to Arthur R. Jensen* (pp. 5–21). New York, NY: Pergamon Press.

Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research, 1,* 245–276.

Cattell, R. B., & Horn, J. L. (1978). A check on the theory of fluid and crystallized intelligence with description of new subtest designs. *Journal of Educational Measurement, 15,* 139 – 164. doi: 10.1111/j.1745-3984.1978.tb00065.x

Child, D. (2006). *The essentials of factor analysis* (2nd ed.). New York, NY: Continuum.

Cudeck, R. (2000). Exploratory factor analysis. In H. E. A. Tinsley & S. D. Brown (Eds.), *Handbook of multivariate statistics and mathematical modeling* (pp. 265–296). New York, NY: Academic Press.

Dombrowski, S. C. (2013). Investigating the structure of the WJ–III Cognitive at school age. *School Psychology Quarterly, 28,* 154–169. doi: 10.1037/spq0000010

Dombrowski, S. C. (2014a). Exploratory bifactor analysis of the WJ–III Cognitive in adulthood via the Schmid–Leiman procedure**.** *Journal of Psychoeducational Assessment***,** *32,* 330–341. doi: 10.1177/0734282913508243

Dombrowski, S. C. (2014b). Investigating the structure of the WJ–III Cognitive in early school age through two exploratory bifactor analysis procedures. *Journal of Psychoeducational Assessment, 32, 483–494*. doi: 10.1177/0734282914530838

Dombrowski, S. C. (2015a). *Psychoeducational assessment and reporting*. New York, NY: Springer Science.

Dombrowski, S. C. (2015b). Exploratory bifactor analysis of the WJ III Achievement at

school age via the Schmid-Leiman procedure. *Canadian Journal of School Psychology, 30, 34-50*.

Dombrowski, S. C., McGill, R. J., & Canivez, G. L. (2016). Exploratory and hierarchical factor analysis of the WJ IV Cognitive at school age. *Psychological Assessment*. Advance online publication. http://dx.doi.org/10.1037/pas0000350

Dombrowski, S. C., Canivez, G. L., Watkins, M. W., & Beaujean, A. (2015). Exploratory bifactor analysis of the Wechsler Intelligence Scale for Children—Fifth Edition with the 16 primary and secondary subtests. *Intelligence, 53*, 194-201. doi: 0.1016/j.intell.2015.10.009

Dombrowski, S. C., & Watkins, M. W. (2013). Exploratory and higher order factor analysis of the WJ–III full test battery: A school aged analysis. *Psychological Assessment, 25,* 442–455. doi: 10.1037/a0031335

Fabrigar, L. R., & Wegener, D. T. (2012). *Exploratory factor analysis*. New York, NY: Oxford University Press.

Fabrigar, L. R., Wegener, D. T., MacCallum, R. C., & Strahan, E. J. (1999). Evaluating the use of exploratory factor analysis in psychological research. *Psychological Methods, 4,* 272–299. doi: 10.1037/1082-989X.4.3.272

Flanagan, D. P., Alfonso, V. C., & Mascolo, J. T. (2011). A CHC-based operational definition of SLD: Integrating multiple data sources and multiple data-gathering methods. In D. P. Flanagan & V. C. Alfonso (Eds.), *Essentials of specific learning disability identification* (pp. 233-298). Hoboken, NJ: John Wiley.

Flanagan, D. P., Ortiz, S. O., & Alfonso, V. C. (2013). *Essentials of cross-battery assessment* (3rd ed.). Hoboken, NJ: John Wiley.

Gorsuch, R. L. (1983). *Factor analysis* (2nd ed.). Hillsdale, NJ: Erlbaum.

Horn, J. L. (1965). A rationale and test for the number of factors in factor analysis. *Psychometrika, 30,* 179 –185. doi: 10.1007/BF02289447

Horn, J. L., & Cattell, R. B. (1966). Refinement and test of the theory of fluid and crystallized general intelligence. *Journal of Educational Psychology, 57,* 253–270. doi: 10.1037/h0023816

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika,* 39, 31-36.

Kranzler, J. H., Floyd, R. G., Benson, N., Zaboski, B., & Thibodaux, L. (2016). Cross-battery assessment pattern of strengths and weaknesses approach to the identification of specific learning disorders: Evidence-based practice or pseudoscience? *International Journal of School & Educational Psychology*. Advance online publication. doi: 10.1080/21683603.2016.1192855

Mansolf, M., & Reise, S. P. (2016). Exploratory bifactor analysis: The Schmid-Leiman orthogonalization and Jennrich-Bentler analytic rotations. *Multivariate Behavioral Research, 0*, 1-20. doi: 10.1080/00273171.2016.1215898

Mansolf, M. & Reise, S. P. (2017). When and why the second-order and bifactor models are distinguishable. *Intelligence, 61*, 120-129. doi: 10.1016/j.intell.2017.01.012

McClain, A. L. (1996). Hierarchical analytic methods that yield different perspectives on dynamics: Aids to interpretation. *Advances in Social Science Methodology, 4*, 229-240.

McGill, R. J. (2015). Incremental criterion validity of the WJ–III COG clinical clusters: Marginal predictive effects beyond the general factor. *Canadian Journal of School Psychology, 30,* 51–63. doi: 10.1177/0829573514553926

McGill, R. J. (2017). Re(examining) relations between CHC broad and narrow cognitive abilities

and reading achievement. *Journal of Educational and Developmental Psychology, 7,* 265-282. doi: 10.5539/jedp.v7n1p265

McGill, R. J., & Busse, R. T. (2015). Incremental validity of the WJ III COG: Limited predictive effects beyond the GIA-E. *School Psychology Quarterly, 30,* 353-365 doi: 10.1037/spq0000094

McGill, R. J., & Busse, R. T. (2017). When theory trumps science: A critique of the PSW model for SLD identification. *Contemporary School Psychology, 21,* 10-18. doi: 10.1007/s40688-016-0094-x

McGrew, K. S. (2009). CHC theory and the human cognitive abilities project: Standing on the shoulders of the giants of psychometric intelligence research. *Intelligence, 37,* 1-10. doi: 10.1016/j.intell.2008.08.004

McGrew, K. S., LaForte, E. M., & Shrank, F. A. (2014). *Technical Manual: Woodcock–Johnson IV*. Rolling Meadows, IL: Riverside.

McGrew, K. S., & Woodcock, R. W. (2001). *Technical manual: Woodcock-Johnson III.* Itasca, IL: Riverside Publishing.

Niileksela, C. R., Reynolds, M. R., Keith, T. Z., & McGrew, K. S. (2016). A special validity study of the WJ IV: Acting on evidence for specific abilities. In D. P. Flanagan & V. C. Alfonso, WJ IV clinical use and interpretation: Scientist-Practitioner perspectives (pp. 65-102). New York: Academic Press.

O'Connor, B. P. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behavior Research Methods, Instruments, & Computers, 32,* 396 – 402. doi: 10.3758/BF03200807

Osborne, Jason W. (2015). What is Rotating in Exploratory Factor Analysis? *Practical Assessment, Research &Evaluation*, 20(2). Available online: http://pareonline.net/getvn.asp?v=20&n=2

Preacher, K. J., & MacCallum, R. C. (2003). Repairing Tom Swift's electric factor analysis machine. *Understanding Statistics*, *2*, 13-43. doi:10.1207/S15328031US0201_02

Ree, M. J., Carretta, T. R., & Green, M. T. (2003). The ubiquitous role of *g* in training. In H. Nyborg (Ed.), *The scientific study of general intelligence: Tribute to Arthur R. Jensen* (pp. 262–274). New York, NY: Pergamon Press.

Reise, S. P. (2012). The rediscovery of bifactor measurement models. *Multivariate Behavioral Research, 47,* 667–696. doi:10.1080/00273171.2012.715555

Reise, S. P., Bonifay, W. E., & Haviland, M. G. (2013). Scoring and modeling psychological measures in the presence of multidimensionality. *Journal of Personality Assessment, 95,* 129–140. doi:10.1080/00223891.2012.725437

Schmid, J., & Leiman, J. M. (1957). The development of hierarchical factor solutions. *Psychometrika, 22,* 53– 61. doi: 10.1007/BF02289209

Schmitt, T. A. (2011). Current methodological considerations in exploratory and confirmatory factor analysis. *Journal of Psychoeducational Assessment, 29,* 304-321.

Schneider, W. J., & McGrew, K. S. (2012). The Cattell-Horn-Carroll model of intelligence. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (3rd ed., pp. 99-144). New York: Guilford.

Schrank, F., Decker, S. L., & Garruto, J. M. (2016). *Essentials of WJ IV cognitive ability assessment.* New York: John Wiley and Sons.

Schrank, F. A., Mather, N., & McGrew, K. S. (2014a). *Woodcock–Johnson IV Tests of Achievement*. Rolling Meadows, IL: Riverside.

Schrank, F. A., Mather, N., & McGrew, K. S. (2014b). *Woodcock–Johnson IV Tests of Oral Language*. Rolling Meadows, IL: Riverside.

Schrank, F. A., McGrew, K. S., & Mather, N. (2014a). *Woodcock–Johnson IV*. Rolling Meadows, IL: Riverside.

Schrank, F. A., McGrew, K. S., & Mather, N. (2014b). *Woodcock–Johnson IV Tests of Cognitive Abilities*. Rolling Meadows, IL: Riverside.

Sotelo-Dynega, M., & Dixon, S. G. (2014). Cognitive assessment practices: A survey of school psychologists. *Psychology in the Schools, 51,* 1031-1045. doi: 10.1002/pits.21800

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston, MA: Pearson Education, Inc.

Tataryn, D. J., Wood, J. M., & Gorsuch, R. L. (1999). Setting the value of *k* in promax: A Monte Carlo study. *Educational and Psychological Measurement, 59*, 384–391.

Thompson, B. (2004). *Exploratory and confirmatory factor analysis: Understanding concepts and applications.* Washington, DC: American Psychological Association.

Thurstone, L. L. (1947). *Multiple-factor analysis*. Chicago, IL: University of Chicago Press.

Velicer, W. F. (1976). Determining the number of components form the matrix of partial correlations. *Psychometrika, 31,* 321–327. doi: 10.1007/BF02293557

Velicer, W. F., Eaton, C. A., & Fava, J. L. (2000). Construct explication through factor or component analysis: A view and evaluation of alternative procedures for determining the number of factors or components. In R. D. Goffin & E. Helmes (Eds.), *Problems and solutions in human assessment: A festschrift to Douglas Jackson at seventy* (pp. 41–71).

Norwell, MA: Kluwer Academic.

Widaman, K. F. (1993). Common factor analysis versus principal component analysis: Differential bias in representing model parameters? *Multivariate Behavioral Research*, *28*, 263-311. doi:10.1207/s15327906mbr2803_1

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson III*. Itasca, IL: Riverside Publishing.

Wolff, H.-G., & Preising, K. (2005). Exploring item and higher order factor structure with the Schmid-Leiman solution: Syntax codes for SPSS and SAS. *Behavior Research Methods, 37,* 48 –58. doi: 10.3758/BF03206397

Table 1

Number of WJ-IV Factors Suggested for Extractions via EFA across Standardization Age Groups

	Normative Age Groups	
Extractions Criteria	9-13	14-19
Eigenvalue > 1	8	8
Visual Scree Test	7-9	7-9
Horn's Parallel Analysis (HPA)	7	7
Minimum Average Partials (MAP)	7	7
Publisher Theory	9	9

Table 2

Age 9- to 13- WJ-IV Principal Axis Factor with Promax Rotation (Nine Factors)

	Pattern (Structure Coefficients)																			
Subtest	I		II		III		IV		V		VI		VII		VIII		IV		h^2	u^2
Writing Samples (Grw)	**.85**	(.73)	-.10	(.34)	.06	(.42)	-.20	(.32)	.06	(.43)	.07	(.26)	.19	(.13)	.10	(.13)	-.21	(-.06)	.63	.37
Reading Recall (Grw/Glr)	**.80**	(.69)	-.22	(.30)	-.24	(.36)	.05	(.38)	.28	(.54)	-.17	(.15)	.11	(.10)	.23	(.32)	.14	(.26)	.65	.35
Letter-Word Identification (Grw)	**.77**	(.88)	.20	(.61)	.08	(.57)	-.03	(.52)	-.07	(.49)	-.01	(.31)	-.01	(-.07)	-.03	(.04)	.06	(.21)	.80	.20
Passage Comprehension (Grw/Glr)	**.75**	(.81)	.20	(.59)	-.04	(.48)	-.10	(.49)	-.01	(.51)	.08	(.36)	.15	(.11)	.03	(.12)	.08	(.21)	.71	.29
Word Attack (Grw/Glr)	**.69**	(.75)	.01	(.48)	-.04	(.40)	.22	(.58)	-.15	(.38)	.17	(.47)	.06	(-.01)	-.11	(-.05)	-.04	(.06)	.66	.34
Oral Reading (Grw)	**.52**	(.70)	.17	(.51)	-.01	(.50)	.01	(.48)	-.08	(.43)	.11	(.35)	-.09	(-.12)	-.09	(.00)	**.51**	(.59)	.76	.24
Spelling (Grw)	**.50**	(.80)	.14	(.60)	.17	(.64)	.18	(.62)	.01	(.55)	-.03	(.35)	-.09	(-.10)	-.08	(.04)	.14	(.31)	.75	.25
Editing (Grw)	**.46**	(.77)	.21	(.62)	.02	(.56)	.17	(.61)	.10	(.57)	-.06	(.33)	-.20	(-.17)	.08	(.18)	.16	(.32)	.73	.27
Sentence Writing Fluency (Grw/Gs)	**.45**	(.69)	-.19	(.33)	**.44**	(.74)	.10	(.48)	.08	(.54)	-.09	(.21)	.02	(.01)	.03	(.15)	.14	(.36)	.69	.31
Sound Awareness (Grw/Ga)	**.37**	(.60)	-.05	(.42)	.06	(.43)	.20	(.59)	-.01	(.45)	**.35**	(.58)	.05	(.05)	-.09	(.01)	.02	(.14)	.54	.46
Picture Vocabulary (Gc)	.02	(.44)	**.88**	(.85)	-.06	(.32)	.02	(.50)	-.06	(.40)	-.05	(.27)	.06	(.12)	.09	(.22)	.06	(.16)	.74	.26
General Information (Gc)	-.08	(.38)	**.82**	(.77)	-.01	(.34)	-.10	(.42)	-.01	(.40)	.05	(.29)	.07	(.13)	-.07	(.08)	**.33**	(.41)	.70	.30
Social Studies (Gc)	.01	(.50)	**.78**	(.82)	.03	(.39)	-.07	(.48)	.20	(.53)	-.07	(.27)	-.08	(.01)	.06	(.19)	-.14	(.01)	.72	.28
Humanities (Gc)	-.13	(.41)	**.72**	(.77)	.01	(.35)	.01	(.52)	.12	(.48)	.13	(.41)	-.11	(.00)	.07	(.20)	.02	(.14)	.63	.37
Oral Vocabulary (Gc)	.11	(.55)	**.69**	(.82)	-.04	(.42)	.02	(.57)	.07	(.53)	.03	(.37)	.04	(.11)	.04	(.20)	.12	(.24)	.70	.30
Oral Comprehension (Gc)	.25	(.51)	**.64**	(.76)	-.08	(.31)	.10	(.54)	-.12	(.39)	-.01	(.33)	.26	(.29)	.07	(.20)	-.09	(.02)	.68	.32
Science (Gc)	.08	(.50)	**.57**	(.73)	-.11	(.30)	.11	(.53)	**.30**	(.54)	-.07	(.31)	-.08	(.01)	.08	(.19)	-.31	(-.17)	.69	.31
Reading Vocabulary (Grw/Gc)	**.46**	(.74)	**.51**	(.76)	-.03	(.48)	-.12	(.54)	-.01	(.54)	.11	(.40)	-.05	(-.02)	.15	(.24)	.17	(.30)	.76	.24
Pair Cancellation (Gs)	-.29	(.27)	.09	(.30)	**.92**	(.72)	-.04	(.34)	.02	(.38)	.08	(.20)	-.01	(.05)	.02	(.13)	-.26	(-.01)	.62	.38
Letter-Pattern Matching (Gs)	-.02	(.39)	-.10	(.25)	**.81**	(.77)	-.10	(.34)	.04	(.45)	.08	(.20)	.10	(.14)	.07	(.19)	.01	(.26)	.62	.38
Number-Pattern Matching (PerSpd)	.27	(.51)	-.21	(.22)	**.74**	(.76)	-.15	(.32)	.05	(.47)	.02	(.16)	.14	(.15)	.17	(.26)	-.11	(.15)	.67	.33
Word Reading Fluency (Grw/Gs)	.19	(.56)	.03	(.39)	**.68**	(.81)	-.03	(.42)	-.06	(.47)	-.09	(.13)	-.05	(-.01)	.20	(.30)	.17	(.41)	.74	.26
Math Fact Fluency (Gq/Gs)	.15	(.59)	.02	(.42)	**.57**	(.78)	.05	(.45)	.21	(.58)	-.16	(.15)	-.01	(.00)	-.13	(.04)	.10	(.33)	.68	.32
Sentence Reading Fluency (Grw/Gs)	**.37**	(.69)	.04	(.46)	**.54**	(.81)	.04	(.50)	-.06	(.52)	-.09	(.20)	.09	(.08)	-.01	(.13)	.23	(.45)	.78	.22
Rapid Picture Naming (Gs/Glr)	-.07	(.26)	.20	(.40)	**.39**	(.44)	**.30**	(.45)	-.20	(.26)	-.09	(.16)	.22	(.27)	.21	(.32)	-.16	(.01)	.42	.58
Nonword Repetition (Ga)	.10	(.37)	-.06	(.36)	-.10	(.27)	**.76**	(.68)	-.12	(.29)	.03	(.41)	.16	(.18)	-.12	(.03)	.06	(.13)	.51	.49
Sentence Repetition (Gwm)	.11	(.45)	.16	(.51)	-.05	(.33)	**.75**	(.71)	-.15	(.31)	-.13	(.32)	.02	(.05)	-.03	(.10)	-.03	(.07)	.55	.45
Verbal Attention (Gwm)	.09	(.46)	-.07	(.42)	-.08	(.37)	**.74**	(.73)	.13	(.47)	-.10	(.36)	-.07	(.01)	.08	(.23)	-.03	(.11)	.56	.44
Memory for Words (Aud Mem)	-.09	(.26)	-.07	(.34)	-.12	(.24)	**.58**	(.66)	.05	(.40)	.25	(.53)	-.01	(.12)	.27	(.39)	.05	(.15)	.56	.44
Object-Number Sequencing (Gwm)	**-.32**	(.24)	-.01	(.38)	.22	(.46)	**.56**	(.66)	.20	(.52)	.03	(.39)	.11	(.26)	.15	(.35)	-.01	(.17)	.58	.42

Understanding Directions (Gwm)	.06	(.41)	.08	(.46)	-.01	(.36)	**.51**	(.62)	.19	(.48)	-.08	(.34)	.25	(.29)	-.12	(.07)	-.11	(.03)	.49	.51
Number Series (Gf)	**.45**	(.72)	-.10	(.43)	.00	(.52)	-.02	(.46)	**.70**	(.78)	-.08	(.30)	-.11	(-.07)	-.06	(.08)	-.18	(.03)	.80	.20
Applied Problems (Gq)	.10	(.58)	.28	(.61)	.07	(.54)	-.11	(.48)	**.65**	(.80)	-.03	(.34)	.05	(.12)	-.12	(.09)	.03	(.22)	.72	.28
Calculation (Gq/Gs)	.28	(.67)	.02	(.47)	.21	(.63)	-.13	(.43)	**.63**	(.78)	-.07	(.27)	-.07	(-.03)	-.08	(.09)	-.06	(.17)	.73	.27
Analysis-Synthesis (Gf)	-.14	(.27)	.08	(.37)	.04	(.34)	-.11	(.38)	**.61**	(.67)	.23	(.42)	.17	(.30)	.12	(.30)	-.05	(.12)	.54	.46
Number Matrices (Gf)	.00	(.47)	.08	(.46)	.05	(.45)	.12	(.50)	**.56**	(.68)	.04	(.36)	-.22	(-.11)	.06	(.20)	-.05	(.13)	.53	.47
Concept Formation (Gf)	-.07	(.32)	.04	(.38)	-.05	(.33)	.11	(.47)	**.52**	(.64)	.15	(.43)	.18	(.28)	.00	(.20)	.05	(.19)	.48	.52
Story Recall (Glr)	.12	(.34)	.17	(.42)	-.07	(.26)	.11	(.40)	**.31**	(.49)	-.03	(.26)	.29	(.35)	.07	(.22)	-.17	(-.04)	.40	.60
Numbers Reversed (Gwm)	-.05	(.37)	.01	(.37)	.13	(.44)	.25	(.51)	.28	(.52)	.08	(.36)	-.03	(.06)	.01	(.16)	.10	(.24)	.36	.64
Sound Blending (Ga)	-.07	(.20)	.15	(.31)	-.02	(.15)	-.12	(.35)	-.02	(.29)	**.72**	(.69)	.07	(.13)	-.01	(.06)	.14	(.17)	.51	.49
Segmentation (Ga)	.21	(.36)	-.11	(.26)	-.03	(.20)	-.03	(.43)	.06	(.37)	**.69**	(.72)	.07	(.12)	.11	(.15)	-.15	(-.06)	.57	.43
Phonological Processing (Ga)	.17	(.51)	.06	(.47)	.07	(.41)	.13	(.62)	-.01	(.48)	**.51**	(.67)	-.19	(-.09)	**.32**	(.37)	-.02	(.13)	.68	.32
Spelling of Sounds (Ga/Grw)	**.38**	(.64)	-.13	(.37)	.10	(.45)	.13	(.56)	.07	(.47)	**.46**	(.65)	-.16	(-.17)	-.20	(-.13)	.02	(.13)	.70	.30
Visual-Auditory Learning (Glr)	-.02	(.20)	-.04	(.23)	-.03	(.21)	-.05	(.33)	.25	(.42)	**.42**	(.50)	.28	(.35)	-.01	(.13)	.16	(.23)	.40	.60
Picture Recognition (Gv)	.12	(.20)	.02	(.25)	.15	(.27)	.10	(.32)	-.08	(.27)	.07	(.23)	**.66**	(.67)	.03	(.18)	-.04	(.06)	.54	.46
Visualization (Gv)	-.03	(.28)	.01	(.33)	.01	(.30)	.08	(.42)	**.33**	(.51)	.26	(.47)	**.35**	(.41)	-.17	(.03)	.11	(.21)	.48	.52
Retrieval Fluency (Glr/Gs)	.03	(.33)	.25	(.45)	.25	(.42)	.01	(.41)	-.03	(.39)	.06	(.24)	.02	(.14)	**.54**	(.61)	-.13	(.05)	.55	.45
Eigenvalue	18.30		3.18		2.51		2.17		1.65		1.41		1.36		1.17		0.96			
Variance (%)	38.94		6.78		5.35		4.62		3.52		3.00		2.89		2.50		2.06			
Factor 1	1.0																			
Factor 2	.56	1.0																		
Factor 3	.58	.42	1.0																	
Factor 4	.56	.60	.51	1.0																
Factor 5	.56	.51	.56	.56	1.0															
Factor 6	.35	.37	.24	.57	.42	1.0														
Factor 7	-.08	.07	.03	.10	.15	.08	1.0													
Factor 8	.06	.15	.16	.21	.26	.07	.18	1.0												
Factor 9	.17	.13	.31	.17	.24	.07	.04	.13	1.0											

Note. h^2 = Communality coefficient. u^2 = Uniqueness. Pattern coefficients >.30 are ***bolded*** (Carroll, 1993, p. 108; Child, 2006). Note that alignment of subtests with respective CHC stratum I or II factors posited in the WJ-IV Technical Manual is indicted following each subtest name.

Table 3

Age 14- to 19- WJ-IV Principal Axis Factor with Promax Rotation (Nine Factors)

	Pattern (Structure Coefficients)																			
Subtest	I		II		III		IV		V		VI		VII		VIII		IV		h^2	u^2
General Information (Gc)	**.98**	(.82)	.05	(.46)	-.15	(.40)	-.09	(.48)	.11	(.44)	-.15	(.39)	.11	(.11)	-.15	-(.19)	-.09	(.15)	.74	.26
Picture Vocabulary (Gc)	**.94**	(.86)	-.05	(.42)	.04	(.49)	-.04	(.55)	.01	(.43)	-.11	(.43)	.08	(.09)	.14	(.06)	.08	(.21)	.76	.24
Social Studies (Gc)	**.79**	(.82)	-.03	(.44)	.01	(.51)	-.09	(.55)	-.07	(.42)	.27	(.63)	-.04	(.06)	.13	(.10)	-.04	(.03)	.74	.26
Humanities (Gc)	**.76**	(.80)	-.07	(.41)	-.13	(.44)	.11	(.60)	.06	(.49)	.10	(.53)	-.05	(.05)	.03	(.04)	-.05	(.07)	.67	.33
Oral Vocabulary (Gc)	**.75**	(.86)	.00	(.52)	.06	(.58)	.00	(.62)	.08	(.53)	.05	(.57)	.02	(.08)	.01	-(.04)	-.01	(.13)	.74	.26
Oral Comprehension (Gc)	**.75**	(.77)	-.13	(.35)	.24	(.56)	.07	(.58)	-.06	(.42)	-.07	(.48)	.17	(.18)	.19	(.17)	-.06	(.02)	.70	.30
Reading Vocabulary (Grw/Gc)	**.65**	(.85)	.02	(.57)	**.32**	(.72)	-.08	(.60)	.03	(.47)	.03	(.53)	-.03	-(.02)	-.02	-(.13)	.08	(.23)	.79	.21
Science (Gc)	**.57**	(.75)	-.20	(.36)	.14	(.55)	.06	(.59)	-.08	(.44)	**.38**	(.67)	-.03	(.09)	.14	(.15)	.01	(.01)	.70	.30
Word Reading Fluency (Grw/Gs)	.08	(.48)	**.91**	(.83)	.01	(.44)	-.08	(.41)	-.10	(.26)	-.04	(.35)	-.12	-(.06)	.23	-(.06)	.14	(.31)	.75	.25
Number-Pattern Matching (PerSpd)	-.16	(.32)	**.85**	(.73)	.21	(.47)	-.06	(.39)	-.11	(.26)	.05	(.48)	.14	(.20)	.10	(.00)	**-.31**	-(.16)	.71	.29
Letter-Patten Matching (Gs)	-.15	(.34)	**.83**	(.73)	-.02	(.36)	.01	(.44)	.14	(.41)	-.04	(.43)	.14	(.24)	.13	(.00)	-.09	(.06)	.62	.38
Pair Cancellation (Gs)	.03	(.36)	**.78**	(.63)	-.17	(.28)	-.08	(.39)	.18	(.41)	.04	(.43)	-.12	(.04)	.27	(.17)	-.21	-(.10)	.56	.44
Sentence Reading Fluency (Grw/Gs)	.10	(.58)	**.71**	(.84)	.23	(.60)	-.02	(.53)	-.06	(.36)	-.09	(.42)	.05	(.07)	.11	-(.16)	.20	(.38)	.78	.22
Math Fact Fluency (Gq/Gs)	-.01	(.48)	**.64**	(.76)	.01	(.46)	.02	(.46)	-.17	(.28)	**.30**	(.55)	-.01	(.09)	-.03	-(.19)	.06	(.20)	.63	.37
Sentence Writing Fluency (Grw/Gs)	-.15	(.46)	**.61**	(.77)	**.30**	(.61)	.07	(.50)	-.07	(.33)	.06	(.45)	.00	(.04)	.00	-(.20)	.10	(.25)	.65	.35
Writing Samples (Grw)	-.04	(.44)	.05	(.45)	**.76**	(.73)	-.16	(.43)	.04	(.39)	.14	(.53)	.27	(.27)	-.02	-(.06)	-.06	-(.03)	.65	.35
Word Attack (Grw/Glr)	-.01	(.54)	-.12	(.40)	**.71**	(.79)	.17	(.61)	.17	(.50)	-.04	(.44)	-.01	(.00)	.08	(.03)	.04	(.07)	.68	.32
Letter-Word Identification (Grw)	.27	(.70)	.12	(.60)	**.71**	(.88)	-.05	(.58)	-.02	(.41)	-.06	(.47)	-.02	-(.07)	-.02	-(.17)	.00	(.15)	.82	.18
Passage Comprehension (Grw/Glr)	.28	(.69)	.07	(.58)	**.61**	(.80)	-.15	(.56)	.12	(.51)	.04	(.55)	.13	(.13)	-.01	-(.12)	.05	(.16)	.74	.26
Reading Recall (Grw/Glr)	-.21	(.36)	.02	(.44)	**.61**	(.60)	-.06	(.37)	-.08	(.26)	**.31**	(.43)	.15	(.17)	.06	-(.11)	**.47**	(.43)	.60	.40
Spelling (Grw)	.24	(.71)	.22	(.68)	**.37**	(.76)	.22	(.67)	-.05	(.43)	-.01	(.50)	-.07	-(.06)	-.13	-(.24)	-.03	(.16)	.75	.25
Oral Reading (Grw)	.24	(.65)	.17	(.63)	**.34**	(.68)	.07	(.55)	.21	(.47)	-.16	(.32)	-.10	-(.13)	**-.33**	-(.47)	.12	(.37)	.78	.22
Sound Awareness (Grw/Ga)	-.03	(.51)	-.01	(.45)	**.33**	(.59)	.19	(.60)	**.30**	(.59)	.07	(.49)	.02	(.11)	.03	(.00)	.12	(.15)	.52	.48
Verbal Attention (Gwm)	.02	(.50)	.00	(.41)	.00	(.47)	**.80**	(.76)	-.16	(.38)	.10	(.50)	-.02	(.08)	-.03	(.05)	-.15	-(.08)	.61	.39
Nonword Repetition (Ga)	-.11	(.37)	-.12	(.28)	.07	(.37)	**.77**	(.67)	.12	(.45)	-.16	(.29)	.11	(.16)	-.01	(.04)	.06	(.10)	.49	.51
Sentence Repetition (Gwm)	.15	(.53)	-.09	(.34)	.13	(.47)	**.72**	(.71)	-.15	(.35)	-.10	(.34)	.01	(.04)	.19	(.15)	.14	(.16)	.58	.42
Memory for Words (Aud Mem)	-.02	(.40)	-.01	(.31)	-.10	(.31)	**.70**	(.68)	.15	(.51)	-.07	(.41)	.10	(.22)	.08	(.18)	-.10	-(.07)	.52	.48
Object-Number Sequencing (Gwm)	.01	(.46)	.27	(.51)	**-.30**	(.26)	**.55**	(.68)	.07	(.52)	.15	(.56)	.15	(.33)	.12	(.16)	-.02	(.02)	.62	.38
Understanding Directions (Gwm)	-.09	(.42)	-.06	(.36)	.12	(.41)	**.46**	(.61)	-.01	(.43)	.22	(.51)	.17	(.29)	.18	(.17)	.23	(.17)	.50	.50
Numbers Reversed (Gwm)	.03	(.48)	.15	(.49)	-.03	(.42)	**.34**	(.60)	.14	(.50)	.17	(.54)	.03	(.16)	-.11	-(.05)	-.13	-(.04)	.45	.55

Editing (Grw)	.28	(.73)	.13	(.63)	.27	(.73)	**.32**	(.70)	-.17	(.38)	.15	(.57)	-.13	-(.09)	-.18	-(.23)	-.10	(.08)	.77	.23
Sound Blending (Ga)	.14	(.44)	-.06	(.29)	.00	(.34)	.05	(.47)	**.68**	(.71)	-.06	(.37)	-.05	(.08)	-.06	(.01)	-.06	(.01)	.52	.48
Segmentation (Ga)	-.08	(.37)	-.10	(.27)	**.34**	(.49)	.01	(.49)	**.65**	(.72)	-.02	(.45)	.08	(.20)	.04	(.14)	-.16	-(.15)	.62	.38
Visual-Auditory Learning (Glr)	.08	(.35)	-.01	(.28)	-.01	(.23)	-.13	(.33)	**.61**	(.62)	.02	(.34)	.17	(.29)	.04	(.04)	.20	(.21)	.44	.56
Spelling of Sounds (Ga/Grw)	-.20	(.49)	.07	(.51)	**.41**	(.68)	.10	(.61)	**.52**	(.70)	.11	(.51)	-.19	-(.07)	-.06	-(.10)	.03	(.09)	.71	.29
Phonological Processing (Ga)	.16	(.62)	.07	(.47)	.14	(.57)	.14	(.65)	**.41**	(.68)	.09	(.54)	-.25	-(.09)	.19	(.16)	-.02	(.02)	.68	.32
Visualization (Gv)	.01	(.41)	-.01	(.39)	.00	(.33)	.11	(.48)	**.35**	(.58)	.19	(.51)	**.30**	(.41)	-.16	-(.10)	.10	(.15)	.50	.50
Number Series (Gf)	-.13	(.52)	-.02	(.53)	**.36**	(.65)	-.07	(.51)	-.08	(.41)	**.88**	(.84)	-.10	(.10)	-.06	-(.08)	.15	(.09)	.82	.18
Calculation (Gq/Gs)	.07	(.61)	.23	(.67)	.15	(.60)	-.13	(.53)	.00	(.47)	**.68**	(.80)	-.07	(.11)	-.14	-(.18)	.04	(.10)	.78	.22
Number Matrices (Gf)	.13	(.58)	.03	(.48)	-.08	(.44)	.10	(.55)	.06	(.47)	**.65**	(.71)	-.25	-(.02)	.00	(.01)	.08	(.07)	.61	.39
Applied Problems (Gq)	**.34**	(.72)	.10	(.61)	-.01	(.54)	-.09	(.57)	.08	(.54)	**.57**	(.78)	-.01	(.17)	-.14	-(.15)	.07	(.14)	.76	.24
Concept Formation (Gf)	.01	(.46)	-.03	(.40)	-.05	(.32)	-.04	(.48)	**.39**	(.62)	**.45**	(.61)	.07	(.28)	.14	(.11)	**.38**	(.30)	.61	.39
Analysis-Synthesis (Gf)	.10	(.42)	.07	(.37)	-.15	(.25)	-.01	(.43)	.25	(.53)	**.43**	(.65)	.22	(.42)	.00	(.10)	-.04	-(.05)	.53	.47
Picture Recognition (Gv)	.06	(.18)	.07	(.17)	.17	(.15)	.12	(.28)	.06	(.28)	-.27	(.20)	**.69**	(.67)	.20	(.22)	.06	(.05)	.55	.45
Story Recall (Glr)	.20	(.44)	-.11	(.31)	.07	(.33)	.17	(.46)	-.07	(.36)	.26	(.55)	**.45**	(.52)	-.07	(.01)	.02	(.03)	.51	.49
Rapid Picture Naming (Gs/Glr)	.09	(.30)	**.38**	(.34)	.00	(.21)	.16	(.40)	.02	(.30)	-.17	(.26)	.15	(.23)	**.56**	(.45)	.10	(.07)	.46	.54
Retrieval Fluency (Glr/Gs)	.29	(.47)	**.35**	(.43)	-.07	(.29)	.05	(.45)	.02	(.37)	.03	(.44)	.07	(.19)	**.41**	(.34)	-.04	-(.03)	.45	.55
Eigenvalue	19.96		2.76		2.47		1.89		1.65		1.42		1.29		1.03		0.97			
Variance (%)	42.48		5.92		5.26		4.02		3.51		3.03		2.75		2.20		2.07			
Factor 1	1.0																			
Factor 2	.57	1.0																		
Factor 3	.61	.55	1.0																	
Factor 4	.67	.56	.60	1.0																
Factor 5	.52	.42	.43	.61	1.0															
Factor 6	.58	.52	.50	.59	.54	1.0														
Factor 7	.04	.08	-.05	.12	.21	.29	1.0													
Factor 8	-.07	-.23	-.12	.05	.08	.09	.13	1.0												
Factor 9	.19	.25	.08	.09	.04	-.08	-.04	-.31	1.0											

Note. h^2 = Communality coefficient. u^2 = Uniqueness. Pattern coefficients >.30 are ***bolded*** (Carroll, 1993, p. 108; Child, 2006). Note that alignment of subtests with respective CHC stratum I or II factors posited in the WJ-IV Technical Manual is indicted following each subtest name.

Table 4

WJ IV Sources of Variance According to a Schmid-Leiman Orthogonalization (9 Factor) Ages 9 to 13

	Second-Order Factor		First-Order Factors																		
Subtest	*g*	S^2	F1	S^2	F2	S^2	F3	S^2	F4	S^2	F5	S^2	F6	S^2	F7	S^2	F8	S^2	F9	S^2	h^2	u^2
Writing Samples (Grw)	.50	.25	**.58**	**.33**	-.07	.00	.04	.00	-.12	.01	.04	.00	.06	.00	.19	.04	.10	.01	-.20	.04	.69	.31
Reading Recall (Grw/Glr)	.53	.28	**.54**	**.30**	-.16	.02	-.18	.03	.03	.00	.18	.03	-.15	.02	.11	.01	.23	.05	.14	.02	.77	.23
Letter-Word Identification (Grw)	.68	.47	**.53**	**.28**	.15	.02	.06	.00	-.02	.00	-.05	.00	-.01	.00	-.01	.00	-.03	.00	.06	.00	.77	.23
Passage Comprehension (Grw/Glr)	.65	.43	**.51**	**.26**	.15	.02	-.03	.00	-.06	.00	-.01	.00	.07	.00	.15	.02	.03	.00	.07	.01	.74	.26
Word Attack (Grw/Glr)	.60	.36	**.47**	**.22**	.01	.00	-.03	.00	.13	.02	-.10	.01	.15	.02	.06	.00	-.10	.01	-.04	.00	.65	.35
Oral Reading (Grw)	.61	.37	**.35**	**.13**	.12	.01	.00	.00	.01	.00	-.05	.00	.10	.01	-.09	.01	-.09	.01	**.49**	**.24**	.78	.22
Spelling (Grw)	.73	.53	**.34**	**.12**	.10	.01	.13	.02	.11	.01	.01	.00	-.02	.00	-.09	.01	-.08	.01	.13	.02	.72	.28
Editing (Grw)	.72	.52	**.31**	**.10**	.15	.02	.02	.00	.10	.01	.06	.00	-.05	.00	-.20	.04	.08	.01	.15	.02	.72	.28
Sentence Writing Fluency (Grw/Gs)	.63	.40	**.30**	**.09**	-.14	.02	**.32**	**.10**	.06	.00	.05	.00	-.07	.01	.02	.00	.03	.00	.14	.02	.64	.36
Sound Awareness (Grw/Ga)	.60	.36	.25	.06	-.04	.00	.04	.00	.12	.01	-.01	.00	.29	.09	.05	.00	-.09	.01	.02	.00	.54	.46
Picture Vocabulary (Gc)	.57	.32	.01	.00	**.63**	**.40**	-.05	.00	.01	.00	-.04	.00	-.04	.00	.06	.00	.09	.01	.06	.00	.74	.26
General Information (Gc)	.53	.28	-.05	.00	**.59**	**.35**	-.01	.00	-.06	.00	.00	.00	.04	.00	.07	.01	-.07	.01	**.32**	**.10**	.75	.25
Social Studies (Gc)	.61	.37	.01	.00	**.56**	**.31**	.02	.00	-.04	.00	.13	.02	-.06	.00	-.08	.01	.06	.00	-.13	.02	.73	.27
Humanities (Gc)	.59	.34	-.09	.01	**.52**	**.27**	.00	.00	.01	.00	.08	.01	.11	.01	-.11	.01	.07	.01	.02	.00	.65	.35
Oral Vocabulary (Gc)	.67	.44	.08	.01	**.49**	**.24**	-.03	.00	.01	.00	.05	.00	.03	.00	.04	.00	.04	.00	.11	.01	.71	.29
Oral Comprehension (Gc)	.58	.33	.17	.03	**.46**	**.21**	-.06	.00	.06	.00	-.08	.01	-.01	.00	.26	.07	.07	.00	-.09	.01	.66	.34
Science (Gc)	.60	.35	.06	.00	**.41**	**.17**	-.08	.01	.06	.00	.19	.04	-.06	.00	-.08	.01	.08	.01	**-.30**	**.09**	.68	.32
Reading Vocabulary (Grw/Gc)	.70	.49	**.32**	**.10**	**.36**	**.13**	-.03	.00	-.07	.00	-.01	.00	.09	.01	-.05	.00	.14	.02	.16	.03	.78	.22
Pair Cancellation (Gs)	.43	.18	-.20	.04	.07	.00	**.68**	**.46**	-.03	.00	.01	.00	.07	.01	-.01	.00	.02	.00	-.25	.06	.75	.25
Letter-Pattern Matching (Gs)	.49	.24	-.02	.00	-.07	.00	**.60**	**.36**	-.06	.00	.03	.00	.07	.00	.10	.01	.06	.00	.01	.00	.63	.37
Number-Pattern Matching (PerSpd)	.50	.25	.18	.03	-.15	.02	**.54**	**.29**	-.09	.01	.03	.00	.01	.00	.14	.02	.16	.03	-.10	.01	.67	.33
Word Reading Fluency (Grw/Gs)	.59	.34	.13	.02	.02	.00	**.50**	**.25**	-.02	.00	-.04	.00	-.07	.01	-.05	.00	.19	.04	.17	.03	.69	.31
Math Fact Fluency (Gq/Gs)	.63	.39	.10	.01	.02	.00	**.42**	**.17**	.03	.00	.14	.02	-.14	.02	-.01	.00	-.12	.02	.09	.01	.64	.36
Sentence Reading Fluency (Grw/Gs)	.67	.44	.25	.06	.03	.00	**.40**	**.16**	.02	.00	-.04	.00	-.08	.01	.09	.01	-.01	.00	.22	.05	.73	.27
Rapid Picture Naming (Gs/Glr)	.42	.18	-.05	.00	.14	.02	.29	.08	.17	.03	-.13	.02	-.07	.01	.21	.05	.21	.04	-.15	.02	.44	.56
Nonword Repetition (Ga)	.50	.25	.07	.00	-.05	.00	-.07	.00	**.44**	**.20**	-.08	.01	.03	.00	.16	.02	-.12	.01	.06	.00	.51	.49
Sentence Repetition (Gwm)	.56	.32	.07	.01	.11	.01	-.04	.00	**.44**	**.20**	-.10	.01	-.11	.01	.02	.00	-.03	.00	-.03	.00	.56	.44
Verbal Attention (Gwm)	.61	.38	.06	.00	-.05	.00	-.06	.00	**.44**	**.19**	.08	.01	-.09	.01	-.07	.01	.08	.01	-.03	.00	.60	.40
Memory for Words (Aud Mem)	.51	.26	-.06	.00	-.05	.00	-.09	.01	**.34**	**.12**	.03	.00	.21	.04	-.01	.00	.27	.07	.05	.00	.51	.49
Object-Number Sequencing (Gwm)	.57	.33	-.22	.05	-.01	.00	.16	.03	**.33**	**.11**	.13	.02	.03	.00	.11	.01	.14	.02	-.01	.00	.56	.44

Understanding Directions (Gwm)	.57	.32		.04	.00	.06	.00	-.01	.00	**.30**	**.09**	.12	.01	-.07	.01	.24	.06	-.12	.01	-.10	.01	.52	.48
Number Series (Gf)	.67	.45		.31	.10	-.07	.01	.00	.00	-.01	.00	**.45**	**.20**	-.07	.00	-.11	.01	-.06	.00	-.18	.03	.80	.20
Applied Problems (Gq)	.70	.48		.07	.00	.20	.04	.05	.00	-.07	.00	**.42**	**.17**	-.02	.00	.05	.00	-.12	.01	.03	.00	.73	.27
Calculation (Gq/Gs)	.67	.45		.19	.04	.02	.00	.16	.02	-.08	.01	**.40**	**.16**	-.06	.00	-.07	.01	-.08	.01	-.06	.00	.70	.30
Analysis-Synthesis (Gf)	.50	.25		-.10	.01	.06	.00	.03	.00	-.07	.00	**.39**	**.15**	.19	.04	.17	.03	.12	.01	-.04	.00	.50	.50
Number Matrices (Gf)	.61	.37		.00	.00	.06	.00	.04	.00	.07	.00	**.36**	**.13**	.03	.00	-.22	.05	.06	.00	-.05	.00	.56	.44
Concept Formation (Gf)	.54	.29		-.05	.00	.03	.00	-.04	.00	.07	.00	**.33**	**.11**	.13	.02	.18	.03	.00	.00	.05	.00	.46	.54
Story Recall (Glr)	.46	.21		.08	.01	.12	.01	-.05	.00	.06	.00	**.20**	**.04**	-.02	.00	.29	.08	.06	.00	-.16	.03	.39	.61
Numbers Reversed (Gwm)	.54	.29		-.04	.00	.01	.00	.10	.01	.15	.02	.18	.03	.07	.00	-.03	.00	.01	.00	.09	.01	.37	.63
Sound Blending (Ga)	.35	.12		-.04	.00	.11	.01	-.02	.00	-.07	.01	-.01	.00	**.62**	**.38**	.07	.00	-.01	.00	.13	.02	.54	.46
Segmentation (Ga)	.43	.18		.15	.02	-.08	.01	-.03	.00	-.02	.00	.04	.00	**.59**	**.34**	.07	.00	.11	.01	-.14	.02	.59	.41
Phonological Processing (Ga)	.62	.39		.11	.01	.04	.00	.05	.00	.07	.01	-.01	.00	**.43**	**.18**	-.19	.04	**.31**	**.10**	-.02	.00	.73	.27
Spelling of Sounds (Ga/Grw)	.60	.36		.26	.07	-.09	.01	.07	.00	.08	.01	.05	.00	**.39**	**.15**	-.16	.02	-.20	.04	.01	.00	.66	.34
Visual-Auditory Learning (Glr)	.38	.14		-.01	.00	-.03	.00	-.02	.00	-.03	.00	.16	.02	**.35**	**.13**	.28	.08	-.01	.00	.15	.02	.39	.61
Picture Recognition (Gv)	.32	.10		.08	.01	.01	.00	.11	.01	.06	.00	-.05	.00	.06	.00	**.66**	**.44**	.03	.00	-.04	.00	.57	.43
Visualization (Gv)	.47	.22		-.02	.00	.01	.00	.01	.00	.05	.00	.21	.05	.22	.05	**.35**	**.12**	-.16	.03	.10	.01	.48	.52
Retrieval Fluency (Glr/Gs)	.47	.22		.02	.00	.18	.03	.19	.03	.01	.00	-.02	.00	.05	.00	.02	.00	**.53**	**.28**	-.13	.02	.58	.42
Common Variance (%)		51.8			8.5		8.2		7.0		3.7		4.4		5.4		4.5		3.0		3.4	63.0	37.0
Total Variance (%)		32.6			5.4		5.2		4.4		2.3		2.7		3.4		2.9		1.9		2.1		

Note. *g* = general intelligence factor S^2 = variance explained, h^2 = communality, u^2 = uniqueness, Loadings ≥.30 are ***bolded*** (Carroll, 1993, p. 108; Child, 2006). Note that alignment of subtests with respective CHC stratum I or II factors posited in the WJ-IV Technical Manual is indicted following each subtest name.

Table 5

WJ IV Sources of Variance According to a Schmid-Leiman Orthogonalization (9 Factor) Ages 14 to 19

	Second-Order Factor		First-Order Factors																			
Subtest	*g*	S^2	F1	S^2	F2	S^2	F3	S^2	F4	S^2	F5	S^2	F6	S^2	F7	S^2	F8	S^2	F9	S^2	h^2	u^2
General Information (Gc)	.62	.38	**.58**	**.33**	.04	.00	-.11	.01	-.05	.00	.08	.01	-.11	.01	.11	.01	-.15	.02	-.09	.01	.79	.21
Picture Vocabulary (Gc)	.66	.43	**.55**	**.30**	-.04	.00	.03	.00	-.02	.00	.00	.00	-.07	.01	.08	.01	.14	.02	.08	.01	.78	.22
Social Studies (Gc)	.69	.47	**.47**	**.22**	-.02	.00	.00	.00	-.05	.00	-.05	.00	.19	.03	-.04	.00	.13	.02	-.04	.00	.75	.25
Humanities (Gc)	.67	.45	**.45**	**.20**	-.05	.00	-.09	.01	.06	.00	.05	.00	.07	.00	-.05	.00	.03	.00	-.05	.00	.68	.32
Oral Vocabulary (Gc)	.74	.55	**.44**	**.19**	.00	.00	.04	.00	.00	.00	.06	.00	.04	.00	.02	.00	.01	.00	-.01	.00	.75	.25
Oral Comprehension (Gc)	.65	.42	**.44**	**.19**	-.10	.01	.17	.03	.04	.00	-.05	.00	-.05	.00	.17	.03	.19	.04	-.06	.00	.72	.28
Reading Vocabulary (Grw/Gc)	.75	.57	**.38**	**.14**	.01	.00	.23	.05	-.04	.00	.02	.00	.02	.00	-.03	.00	-.02	.00	.08	.01	.77	.23
Science (Gc)	.68	.46	**.34**	**.11**	-.14	.02	.10	.01	.03	.00	-.06	.00	.26	.07	-.03	.00	.14	.02	.01	.00	.70	.30
Word Reading Fluency (Grw/Gs)	.54	.29	.05	.00	**.65**	**.42**	.01	.00	-.05	.00	-.07	.01	-.03	.00	-.12	.01	.23	.05	.13	.02	.80	.20
Number-Pattern Matching (PerSpd)	.51	.26	-.09	.01	**.60**	**.36**	.15	.02	-.03	.00	-.08	.01	.04	.00	.14	.02	.10	.01	**-.31**	**.10**	.78	.22
Letter-Patten Matching (Gs)	.52	.27	-.09	.01	**.59**	**.34**	-.02	.00	.00	.00	.10	.01	-.03	.00	.14	.02	.13	.02	-.09	.01	.68	.32
Pair Cancellation (Gs)	.48	.23	.02	.00	**.55**	**.30**	-.12	.01	-.05	.00	.13	.02	.03	.00	-.11	.01	.27	.07	-.21	.04	.69	.31
Sentence Reading Fluency (Grw/Gs)	.65	.43	.06	.00	**.50**	**.25**	.16	.02	-.01	.00	-.04	.00	-.06	.00	.05	.00	.11	.01	.20	.04	.77	.23
Math Fact Fluency (Gq/Gs)	.59	.35	.00	.00	**.45**	**.20**	.01	.00	.01	.00	-.12	.02	.21	.04	-.01	.00	-.03	.00	.06	.00	.61	.39
Sentence Writing Fluency (Grw/Gs)	.61	.37	-.09	.01	**.43**	**.19**	.21	.04	.04	.00	-.05	.00	.04	.00	.00	.00	.00	.00	.10	.01	.62	.38
Writing Samples (Grw)	.57	.32	-.03	.00	.03	.00	**.53**	**.28**	-.09	.01	.03	.00	.09	.01	.27	.07	-.02	.00	-.06	.00	.70	.30
Word Attack (Grw/Glr)	.64	.41	.00	.00	-.09	.01	**.50**	**.25**	.09	.01	.13	.02	-.03	.00	-.01	.00	.08	.01	.04	.00	.70	.30
Letter-Word Identification (Grw)	.71	.51	.16	.02	.09	.01	**.50**	**.25**	-.03	.00	-.01	.00	-.04	.00	-.02	.00	-.02	.00	.00	.00	.79	.21
Passage Comprehension (Grw/Glr)	.72	.52	.17	.03	.05	.00	**.43**	**.18**	-.08	.01	.09	.01	.02	.00	.13	.02	-.01	.00	.05	.00	.77	.23
Reading Recall (Grw/Glr)	.48	.23	-.12	.01	.01	.00	**.43**	**.18**	-.04	.00	-.06	.00	.21	.04	.15	.02	.06	.00	.47	.22	.72	.28
Spelling (Grw)	.75	.56	.14	.02	.16	.02	.26	.07	.12	.02	-.04	.00	.00	.00	-.07	.00	-.13	.02	-.03	.00	.71	.29
Oral Reading (Grw)	.65	.43	.14	.02	.12	.01	.24	.06	.04	.00	.16	.02	-.11	.01	-.10	.01	**-.33**	**.11**	.12	.01	.68	.32
Sound Awareness (Grw/Ga)	.63	.40	-.02	.00	-.01	.00	.23	.05	.11	.01	.23	.05	.05	.00	.02	.00	.03	.00	.12	.01	.53	.47
Verbal Attention (Gwm)	.63	.39	.01	.00	.00	.00	.00	.00	**.44**	**.20**	-.12	.01	.07	.00	-.02	.00	-.03	.00	-.15	.02	.63	.37
Nonword Repetition (Ga)	.50	.25	-.06	.00	-.09	.01	.05	.00	**.43**	**.18**	.09	.01	-.11	.01	.11	.01	-.01	.00	.06	.00	.49	.51
Sentence Repetition (Gwm)	.58	.33	.09	.01	-.06	.00	.09	.01	**.40**	**.16**	-.11	.01	-.07	.01	.01	.00	.19	.03	.14	.02	.58	.42
Memory for Words (Aud Mem)	.54	.29	-.01	.00	-.01	.00	-.07	.01	**.39**	**.15**	.11	.01	-.05	.00	.10	.01	.08	.01	-.10	.01	.49	.51
Object-Number Sequencing (Gwm)	.61	.37	.01	.00	.19	.04	-.21	.04	**.31**	**.09**	.05	.00	.10	.01	.15	.02	.12	.01	-.02	.00	.60	.40
Understanding Directions (Gwm)	.56	.31	-.05	.00	-.04	.00	.09	.01	.25	.06	-.01	.00	.15	.02	.17	.03	.18	.03	.23	.05	.52	.48
Numbers Reversed (Gwm)	.60	.36	.02	.00	.11	.01	-.02	.00	.19	.04	.11	.01	.12	.01	.03	.00	-.11	.01	-.13	.02	.47	.53

Editing (Grw)	.76	.57	.17	.03	.09	.01	.19	.04	.18	.03	-.12	.02	.10	.01	-.13	.02	-.18	.03	-.10	.01	.76	.24
Sound Blending (Ga)	.51	.26	.08	.01	-.04	.00	.00	.00	.03	.00	**.51**	**.26**	-.04	.00	-.05	.00	-.06	.00	-.06	.00	.54	.46
Segmentation (Ga)	.53	.28	-.05	.00	-.07	.01	.24	.06	.00	.00	**.49**	**.24**	-.01	.00	.08	.01	.04	.00	-.16	.02	.61	.39
Visual-Auditory Learning (Glr)	.41	.17	.05	.00	-.01	.00	-.01	.00	-.07	.01	**.45**	**.20**	.01	.00	.17	.03	.04	.00	.20	.04	.45	.55
Spelling of Sounds (Ga/Grw)	.66	.44	-.12	.01	.05	.00	.29	.08	.05	.00	**.39**	**.15**	.08	.01	-.19	.04	-.06	.00	.03	.00	.74	.26
Phonological Processing (Ga)	.69	.47	.10	.01	.05	.00	.10	.01	.08	.01	**.30**	**.09**	.06	.00	-.24	.06	.19	.04	-.02	.00	.69	.31
Visualization (Gv)	.53	.28	.01	.00	-.01	.00	.00	.00	.06	.00	.26	.07	.13	.02	.29	.09	-.16	.02	.10	.01	.49	.51
Number Series (Gf)	.67	.45	-.08	.01	-.02	.00	.25	.06	-.04	.00	-.06	.00	**.60**	**.36**	-.09	.01	-.06	.00	.15	.02	.92	.08
Calculation (Gq/Gs)	.72	.51	.04	.00	.16	.03	.10	.01	-.07	.01	.00	.00	**.47**	**.22**	-.07	.01	-.14	.02	.04	.00	.80	.20
Number Matrices (Gf)	.64	.41	.08	.01	.02	.00	-.06	.00	.06	.00	.05	.00	**.45**	**.20**	-.24	.06	.00	.00	.08	.01	.69	.31
Applied Problems (Gq)	.75	.56	.20	.04	.07	.00	.00	.00	-.05	.00	.06	.00	**.39**	**.15**	-.01	.00	-.14	.02	.07	.00	.78	.22
Concept Formation (Gf)	.56	.32	.01	.00	-.02	.00	-.03	.00	-.02	.00	.29	.08	**.31**	**.09**	.07	.00	.14	.02	**.37**	**.14**	.66	.34
Analysis-Synthesis (Gf)	.52	.27	.06	.00	.05	.00	-.11	.01	-.01	.00	.18	.03	**.30**	**.09**	.22	.05	.00	.00	-.04	.00	.46	.54
Picture Recognition (Gv)	.26	.07	.04	.00	.05	.00	.12	.01	.06	.00	.05	.00	-.18	.03	**.69**	**.47**	.20	.04	.06	.00	.64	.36
Story Recall (Glr)	.50	.25	.12	.01	-.08	.01	.05	.00	.10	.01	-.05	.00	.18	.03	**.45**	**.20**	-.07	.01	.02	.00	.52	.48
Rapid Picture Naming (Gs/Glr)	.37	.13	.05	.00	.27	.07	.00	.00	.09	.01	.01	.00	-.12	.01	.15	.02	**.55**	**.31**	.10	.01	.57	.43
Retrieval Fluency (Glr/Gs)	.49	.24	.17	.03	.25	.06	-.05	.00	.03	.00	.01	.00	.02	.00	.07	.00	**.41**	**.17**	-.04	.00	.51	.49
Common Variance (%)		55.6		6.5		7.8		6.1		3.4		4.5		5.0		4.4		3.9		2.9	66.1	33.9
Total Variance (%)		36.8		4.3		5.1		4.0		2.2		3.0		3.3		2.9		2.6		1.9		

Note. *g* = general intelligence factor S^2 = variance explained, h^2 = communality, u^2 = uniqueness, Loadings ≥.30 are ***bolded*** (Carroll, 1993, p. 108; Child, 2006). Note that alignment of subtests with respective CHC stratum I or II factors posited in the WJ-IV Technical Manual is indicted following each subtest name.

Table 6: Summary of Age 9 to 13 Nine Factor Schmid-Leiman Analysis Subtest Loadings

F1=Grw Note: With subtests that have two CHC abilities listed in the WJ IV Technical Manual (i.e., Grw/Gs) the SL results from this study suggest cross loading in many (but not all) cases.	All Grw subtests listed in Technical Manual **Plus** Number Series (Gf)(.31 on Grw; .45 on Gf/Gq)	**Cross Loadings** Oral Reading (Grw)(.35 on Grw; .49 on F9) Sent Writ Fluen (Grw/Gs)(.32 on Grw; .32 on Gs) Reading Vocabulary (Grw/Gc)(.36 with Gc; .32 with Grw) Word Reading Fluency (Grw/Gs)(.25 with Grw) (.50 with Gs) Sound Awarenss (Grw/Ga)(.29 with Ga; .25 w Grw; .29 with Gv) Sentence Reading Fluency (.25 with Grw) (.40 with Gs) Spelling of Sounds (Ga/Grw)(.26 with Grw; .39 with Ga) Number Series (Gf)(.31 on Grw; .45 on Gf/Gq)
F2=Gc	All Gc subtests plus Reading Vocabulary (Grw/Gc) (.32 on Grw; .36 on Gc)	Gen Infor (Gc, .32 on F9) Reading Vocabulary (grw/Gc)(.36 with Gc; .32 with Grw)
F3=Gs	Gs subtests **plus** Sent Writ Fluen (Grw/Gs)(.32 on Grw; .32 on Gs) Word Reading Fluency (Grw/Gs)(.25 with Grw) (.50 with Gs) Sentence Reading Fluency (.25 with Grw) (.40 with Gs) Math Fact Fluency (Gq/Gs)(.42 on Gs; No salient/alignment with Gq) Rapid Picture Naming (Gs/Glr)(.29 on Gs; .21 on F8)	Sentence Writing Fluency (Grw/Gs) (.30 with Grw; .32 with Gs) Word Reading Fluency (Grw/Gs)(.25 with Grw) (.50 with Gs) Sentence Reading Fluency (.25 with Grw) (.40 with Gs)
F4=Gwm	All Gwm subtests **except** Numbers Reverse (Gwm)(.15 with Gwm; No salient/alignment on any factor) **Plus** Nonword Repetition (Ga)(.44 on Gwm; No salient/alignment with Ga)	
F5=Gf/Gq Combined Factor	All Gf/Gq subtests **except** Math Fact Fluency (Gq/Gs)(.42 on Gs; No salient/alignment with Gq)	
F6=Ga	All Ga subtest **except** Nonword Repetition (Ga)(.44 with Gwm; No alignment/salient with Ga) **Plus** Vis Auditory Learning (Glr) (.35 with Ga; .28 with Gv) Sound Awareness (Grw/Ga)(.25 with Grw; .29 with Ga)	Sound Awareness (Grw/Ga)(.25 with Grw; .29 with Ga) Phon Process (Ga)(.43 on Ga; .31 on F9)
F7=Gv	All Gv Subtests (two of them)	Vis Auditory Learning (Glr) (.35 with Ga; .28 with Gv) Sound Awarenss (Grw/Ga)(.29 with Ga; .25 w Grw; .29 with Gv
F8=?	Retrieval Fluency (Glr/Gs)(.53) Phon Process (Ga)(.43 on Ga; .31 on F9)	
F9=?	Oral Read (Grw); Gen Info (Gc) Story Recall (Glr)(.20 on Gf/Gq; .29 on F9)	

Subtests with neither alignment nor salient loading on a factor: Story Recall; Numbers Reversed

Table 7: Summary of Age 14 to 19 Nine Factor Schmid-Leiman Analysis Subtest Loadings

F1=Gc Note: With subtests that have two CHC abilities listed in the WJ IV Technical Manual (i.e., Grw/Gs) the SL results from this study suggest cross loading in many (but not all) cases.	All Gc subtests plus Read Vocabulary (Grw/Gc, .38)	
F2=Gs	All Gs subtest **plus** Math Fact Fluency (Gq/Gs)(.45) Word Read Fluency (Grw/Gs, .65) Sentence Read Fluency (Grw/Gs, .50) Sentence Writing Fluency (Grw/Gs, .43)	
F3=Grw	All Grw subtest **except** Editing (.19),	Cross loading on Gs: Word Reading Fluency (Grw/Gs, .65) Sentence Reading Fluency (Grw/Gs, .50) Sentence Writing Fluency (Grw/Gs, .43)
F4=Gwm	All Gwm subtests except Numbers Reversed (.19) **Plus** Nonword Repetition (Ga)(.43 on Gwm)	
F5=Ga	All Ga subtests except Nonword Repetition plus Visual Auditory Learning (Glr)(.45)	
F6-Gf/Gq Combined Factor	All Gf/Gq subtests Except Math Fact Fluency (Gq/Gs)(.45 with Gs)	Concept Formation (.37 with F9) Math Fact Fluency (Gq/Gs)(.45 with Gs)
F7=Gv	Pic Recog (Gv, .69), Story Recall (Glr, .45) and Visualization (Gv, .29)	
F8= Second Gs???	Rapid Pic Naming (Gs/Glr, .55) Retrieval Fluency (Glr/Gs, .41)	
F9=???	Reading Recall (Grw/Glr, .47) Concept Formation (Gf, .37)	

Subtests with neither alignment nor salient loading on a factor: Numbers Reversed

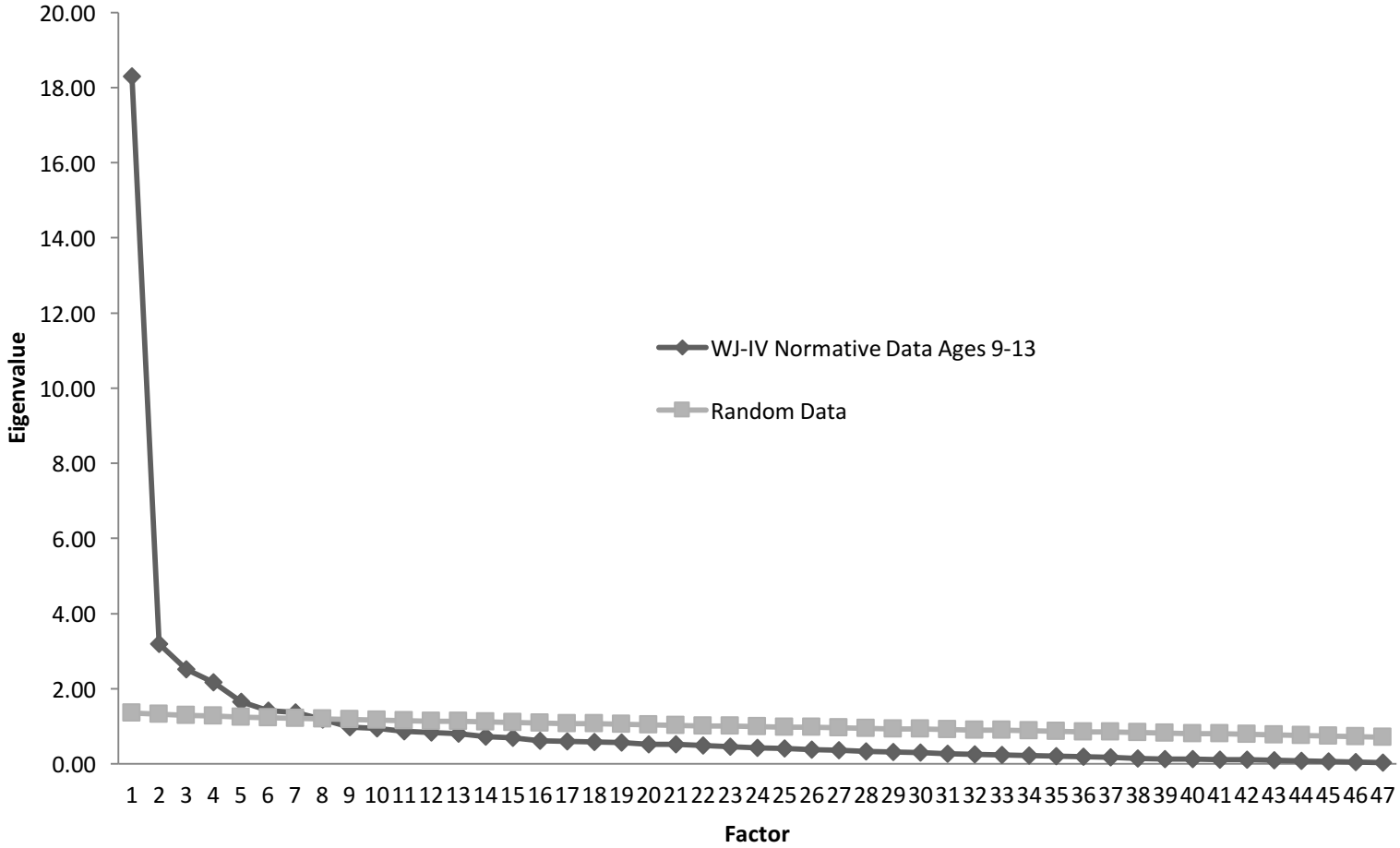

Figure 1. Scree plot of parallel analysis for WJ-IV subtests (ages 9-13).

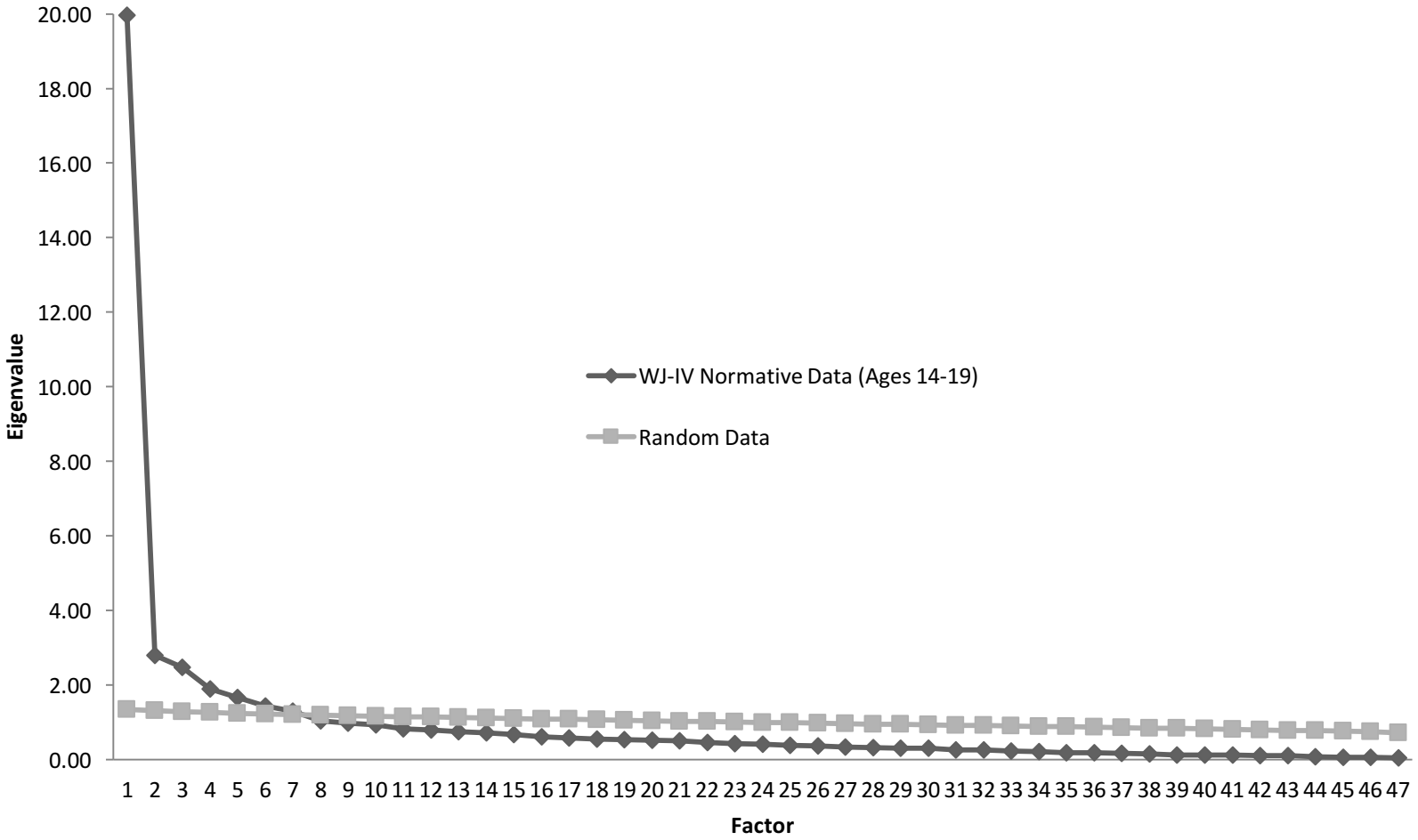

Figure 2. Scree plot of parallel analysis for WJ-IV subtests (ages 14-19).