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Investigating the Structure of the WJ-III Cognitive at School Age

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During its development, the Woodcock-Johnson, Third Edition Cognitive (WJ-III Cognitive; McGrew & Woodcock, 2001) was never subjected to structural analysis using exploratory and higher order factor analyses. Instead, confirmatory factor analyses were conducted on separate sets of WJ-III correlation matrices, yielding a seven-factor model across all age ranges. To see whether the structure holds for the WJ-III Cognitive, currently recognized best practice exploratory factor analysis (EFA) procedures were applied to two school-aged correlation matrices (ages 9–13; 14–19) from the normative sample. Using EFA and higher order factor analysis, four factors emerged at age 9 to 13 and three factors emerged at age 14 to 19. The results of this analysis indicated a robust manifestation of general intelligence (g) that exceeded the variance attributed to the lower order factors. An additional analysis was conducted that disregarded factor extraction rules and forced the seven-factor fit. The resulting solution was only partially aligned (i.e., Gc, Ga, and Gsm) with the theoretical structure posited in the WJ-III Technical Manual. Surprisingly, this study represents the first time to my knowledge that the WJ-III Cognitive has been subjected to EFA analyses given the instrument's significant use by practitioners and that it has served as the initial evidentiary base for Cattell-Horn-Carroll theory.

Keywords: exploratory factor analysis, higher order factor analysis, Cattell-Horn-Carroll theory, Schmid-Leiman orthogonalization, general intelligence

When determining the structure of the Woodcock-Johnson, Third Edition Cognitive (WJ-III Cognitive), the test authors choose to rely exclusively on confirmatory factor analysis (CFA). Sole reliance upon CFA for elucidating internal structure may be inappropriate (Canivez & Watkins, 2010; Dombrowski, Watkins, & Brogan, 2009; Gorsuch, 1983, 1988; Thompson, 2004) and could suggest that our understanding of the WJ-III Cognitive is incomplete. This is not a sole criticism of the WJ-III Cognitive. Several recently developed intelligence tests opted to report only results from CFA (e.g., Elliot, 2007; Roid, 2003; Wechsler, 2008) and have been subsequently criticized for having an unclear factor structure (Canivez, 2008; DiStefano & Dombrowski, 2006). In his seminal text on factor analysis, Gorsuch (1983) indicated that both exploratory (EFA) and confirmatory factor analytic techniques are important to the understanding of the internal structure of a test. The factor analytic research base supports this position and recognizes the complementary relationship between EFA and CFA, but recommends that EFA precede CFA when evaluating a new test or theory (Frazier & Youngstrom, 2007; Gorsuch, 1983; Thompson, 2004). Gorsuch (1983) noted that confidence in a derived structure may be engendered when the results from EFA and CFA converge.

Even in instruments that report EFA procedures, these procedures have sometimes been criticized as incomplete and even inappropriate (e.g., Dombrowski, Brogan, & Watkins, 2009). There are numerous EFA procedures, but specific ones are recommended for the exploration of internal structure in tests of cognitive ability because factors tend to be highly correlated and hierarchical in nature (Carroll, 1993; Gorsuch, 1983; Guttman, 1954; Horn, 1965; Schmid & Leiman, 1957; Velicer, 1976; Velicer, Eaton, & Fava, 2000). The first of these recommended techniques includes the use of principal axis factoring (PAF) with an oblique rotation. In

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developing his *Three Stratum Theory*, Carroll (1993) used a type of oblique rotation called promax. This is only a first step and should be followed by a higher order factor analysis. The Schmid & Leiman (1957) procedure is recommended and widely used procedure because it helps to uncover simple structure by partialing out the influence of higher order factors (Carretta & Ree, 2001; Carroll, 1993, 1995, 2003; Gustafsson & Snow, 1997). Schmid and Leiman (1957) also indicated that this process "preserves the desired characteristics of the oblique solution" and "discloses the hierarchical structure of the variables" (p. 53). Carroll (1995) emphasized that orthogonal factors are appropriate only when produced in the context of a Schmid–Leiman solution: "I insist, however, that the orthogonal factors should be those produced by the Schmid-Leiman (1957) orthogonalization procedure" (Carroll, 1995, p. 437).

Residualizing the variance ascribed to higher order factors affords the clinician an opportunity to understand how reliable test variance is apportioned to higher and lower order dimensions (i.e., g and Cattell-Horn-Carroll [CHC] factors). Although recommended by the psychometric community when attempting to understand internal structure in tests of cognitive ability (e.g., Carroll, 1993, 1995, 1997, 2003; Gorsuch, 1983; McClain, 1996; Ree, Carretta, & Green, 2003; Thompson, 2004), higher order factor analysis is not included in the Technical Manuals of almost all intelligences tests. This omission is not necessarily something that should be summarily dismissed as an esoteric musing of an academic out-of-touch with the school/clinical psychology community; rather, this has implications for how an IQ test should be interpreted. If the factor structure derived by both EFA and CFA converge, then clinicians and researchers can be confident in interpreting the instrument the way in which the test manual suggests. If the instrument is found to have a different factor structure than what is posited in the test manual, then one should exercise caution, if not avoid, interpreting the way in which the test manual suggests. For instance, subsequent independent EFA research on the Stanford-Binet, Fifth Edition, suggested that the instrument is a strong measure of psychometric g (i.e., Full Scale IQ) but recommended against interpretation much beyond this level (see Canivez, 2008; DiStefano & Dombrowski, 2006).

With the WJ-III Cognitive, the omission of EFA analyses, particularly those recommended by John Carroll, is surprising. When developing his *Three Stratum Theory of Cognitive Abilities*, which to date remains a psychometric nonpareil, Carroll (1993) leaned exclusively upon exploratory and higher order factor analysis through the use of the Schmid-Leiman (1957) procedure. Subsequently, Carroll's theory was highly influential in the development of the WJ-III as well as CHC theory. The omission of EFA on tests of cognitive ability, particularly the WJ-III, is inexplicable (e.g., Canivez, 2008; Carroll, 1995; DiStefano & Dombrowski, 2006; Dombrowski et al., 2009; Fabrigar, Wegener, MacCallum, & Strahan, 1999; Frazier & Youngstrom, 2007; Nelson, Canivez, Lindstrom & Hatt, 2007; Thompson & Daniel, 1996; Watkins, 2006).

Because the WJ-III Cognitive has never been subjected to exploratory factor analysis, both within its Technical Manual and in the outside literature, this study seeks to fill this critical empirical gap. The purpose of this study is to conduct an exploratory and higher order factor analysis of the WJ-III Cognitive on two normative sample (e.g., ages 9–13; 14–19) correlation matrices that span the school-aged time period. Because the most psychometrically sound factor extraction decision making rules suggested a solution different from that posited in the Technical Manual, and one that was not readily interpretable beyond g, this study also forced the extraction of seven factors consistent with the CFA model posited in the Technical Manual. The forced seven-factor solution required discarding even the most lenient EFA factor extraction decision rules (e.g., eigenvalue >1). This study represents the first time that the WJ-III cognitive has been subjected to exploratory and higher order factor analysis.

Method

Participants

The WJ-III authors collected and reported information relative to eight age groups: 2 to 3, 4 to 5 years, 6 to 8 years, 9 to 13 years, 14 to 19 years, 20 to 29 years, 30 to 39 years, and 40 years and older. The data for the WJ-III norms were collected from a nationally representative sample of 8,818 participants from age 2 through 90 plus. The WJ-III Technical Manual reports that the normative data were matched to the 2000 U.S. Census for geographic region, community size, gender, race, educational level, and occupation. Detailed demographic characteristics are provided in the WJ-III Technical Manual. For this study, two school-aged (9–13 years and 14–19 years) subtest correlation matrices (20 by 20) were obtained from the Technical Manual. The 9 to 13 age range contained an average of 1,601 participants, while the 14 to 19 age range contained an average of 1,266 participants.

Instrument

The WJ-III Cognitive (Woodcock, McGrew, & Mather, 2001b) contains 20 cognitive tests that are purported to measure g and seven CHC factors. From a theoretical perspective, the authors of the WJ-III reported that they were guided by Carroll's (1993) *Three Stratum Theory of Cognitive Abilities* and the work of Horn and Cattell (1966; Cattell & Horn, 1978), which were then combined into a new theory called Cattell-Horn-Carroll (CHC; McGrew & Woodcock, 2001) theory. The WJ-III Cognitive is hypothesized to measure g and seven CHC factors: visual-spatial thinking (Gv), fluid reasoning (Gf), processing speed (Gs), long-term retrieval (Glr), auditory processing (Ga), short-term memory (STM) (Gsm), and comprehension-knowledge (Gc). The WJ-III also yields a general intellectual ability score reflective of *g*. Within the Technical Manual, the test authors included the 20 subtest correlation matrix across eight different age ranges (2–3 years, 4–5 years, 6–8 years, 9–13 years, 14–19 years, 20–39 years, 40+ years) to show the correlation among cognitive subtests (Woodcock, McGrew, & Mather, 2001a). The Technical Manual presents CFA results, including a path-like analysis of the WJ-III Cognitive subtests with their relationship to g and seven CHC factors. Please see the instrument's respective examiner's manual for a synopsis of subtest demands.

Procedure

The correlation matrices within this study were analyzed using several EFA methodologies. First, the intercorrelation matrices for the two age groups were evaluated by using Bartlett's Test of Sphericity (Bartlett, 1954) and the Kaiser–Meyer–Olkin (KMO; Kaiser, 1974) statistic to ensure that the matrices were suitable for factor analysis. Second, the intercorrelation matrices were subjected to principal axis factoring (Cudeck, 2000; Fabrigar, Wegener, MacCallum, & Strahan, 1999; Tabachnick & Fidell, 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, minimum average partials (MAPs; Velicer, 1976) and parallel analysis (Horn, 1965) were used to determine the number of factors to extract. These procedures were conducted by using O'Connor's (2000) SPSS program. Scree plots (Cattell, 1966) were also inspected as a supplemental means to determine the number of factors to retain for rotation (Thompson, 2004; Velicer, Eaton, & Fava, 2000; Zwick & Velicer, 1986). An additional step was to force the seven-factor solution posited in the Technical Manual. This required disregarding factor extraction decision rules, even the most lenient (e.g., Kaiser Criterion), because several eigenvalues in this solution were well below 1.0. Finally, a higher order factor analysis using the Schmid–Leiman (1957) procedure was applied to the oblique first-order factors to elucidate the structure of the WJ-III using the SPSS program furnished by Wolff and Preising (2005).

Results

Exploratory (First-Order) Analyses

Results from Bartlett's Test of Sphericity (Bartlett, 1950) for both analyses' age ranges indicated that the correlation matrices were not random (9–13 age range, $\chi^2 = 12{,}289.60$, $df = 190$, $p < .0001$; 14–19 age range, $\chi^2 = 11{,}694.57$, $df = 190$, $p < .0001$). For the 9 to 13 and 14 to 19 age ranges, the KMO (Kaiser, 1974) statistic was .888 and .895, respectively, well above the minimum standard 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 appropriate for factor analysis.

Factor Extraction Criteria. Parallel analysis (Horn, 1965) suggested that four factors be retained for the 9 to 13 age range, while three factors were indicated for the 14 to 19 age range. The MAP (Velicer, 1976) criterion recommended retention of two factors for the 9 to 13 age range and one factor for the 14 to 19 age range. A visual scree test indicated evidence for one strong factor with the possibility of two to three additional factors at each age range. We also extracted seven factors in accord with the theoretical structure indicated in the Technical Manual. The extraction of seven factors posited in the Technical Manual came at the expense of even the most lenient factor extraction decision rules. Factors five through seven were essentially trivial factors with nominal root sizes. Psychometrically, the extraction of three and four factors at ages 9 to 13 and 14 to 19, respectively, made most sense, but interpretability and linkage to theory was problematic when attempting to interpret beyond the general factor. Extraction of two factors at ages 9 to 13 was also plausible but offered only a five subtest processing speed (Gs) factor apart from a first factor that represented an agglomeration of the remaining subtests.

Principal Axis Factoring With Promax Rotation. The two school aged correlation matrices were separately subjected to principal axis factoring (PAF) with an oblique (promax) rotation. Tables 1 and 2 present the results of the PAF analyses for the age 9 to 13 and 14 to 19 correlation matrices, respectively, in accord with a seven-factor extraction. Included within both tables are pattern/structure coefficients, eigenvalues for each factor retained, percentage of variance accounted for by each factor, communality coefficients, uniqueness, and the correlation among the extracted factors. In addition, the eigenvalue of the first unretained factor is furnished. The age 9 to 13 and 14 to 19 analyses suggested that the first factor accounted for 31.95% and 36.16% of the variance, respectively. This dwarfed the variance accounted for by the second factor at the 9 to 13 and 14 to 19 age range (9.00% and 8.24%, respectively). Correlations among the extracted factors were as follows: the 9 to 13 age range yielded correlations among the seven factors ranging from .26 to .68 (*Mdn* = .40). Similarly, factor analysis of the 9 to 14 age range yielded correlations among the seven factors ranging from .13 to .74 (*Mdn* = .54). High correlation among factors suggests the possible presence of a higher order factor which needs to be extracted and examined (Gorsuch, 1983; Thompson, 2004).

Higher Order Factor Analysis (Schmid-Leiman Orthogonalization)

Forced Seven-Factor Solution. Results from the Schmid and Leiman (1957) procedure on the seven-factor solution across both age ranges are presented in Tables 3 and 4. Both tables furnish the proportion of variance apportioned to the higher order (g) factor and lower order factors. In the age 9 to 13 Schmid-Leiman (SL) analysis, the higher order factor accounted for 26.08% of the total variance and 52.84% of the common variance. In the age 14 to 19 SL analysis, the higher order factor accounted for 30.7% of the total variance and 56.5% of the common variance. The general factor also accounted for between 7% and 57% (*Mdn* = 28%) of individual subtest variance in the 9 to 13 analysis. The *g* factor accounted for between 9% and 60% (*Mdn* = 32%) of individual subtest variability in the 14 to 19 analysis. For the 9 to 13 analyses, the seven first order factors accounted for a small proportion of the total variance (1.8% to 5.7%) and common variance (3.7% to 11.5). The first and second-order factors combined to measure 49.4% of the variance in the WJ-III Cognitive, reflecting 50.6% unique variance. For the 14 to 19 analyses, the seven, first order factors accounted for 1.6% to 5.8% of the total variance and 2.9% to 10.6% of the common variance. The first and second-order factors of the 14 to 19 analysis combined to measure 54.4% of the variance in the WJ-III, reflecting 45.6% unique variance. The results of both analyses demonstrate a robust manifestation of general intelligence in the WJ-III where the combined influence of general intelligence and uniqueness exceeded the contributions made by the first-order factors.

Higher Order Solution Based on Psychometrically Sound Factor Extraction Rules. Tables 5 and 6 present the results of a higher order factor analysis of the 9 to 13 and 14 to 19 age ranges based upon respective extraction of four and three factors. As noted, the structure at

Table 1
Age 9 to 13 Woodcock-Johnson, Third Edition (WJ-III) Cognitive Principal Axis Factor With Promax Rotation (Forced Seven Factor)

Subtest	Pattern (structure coefficients)								
	I	II	III	IV	V	VI	VII	h^2	u^2
Pair cancellation (Gs)	***.84*** (.76)	.02 (.19)	−.19 (.28)	.09 (.27)	.03 (.35)	−.04 (.14)	−.07 (.14)	.59	.41
Visual matching (Gs)	***.67*** (.77)	−.00 (.27)	.11 (.45)	−.13 (.31)	.13 (.47)	−.01 (.23)	.08 (.38)	.62	.38
Decision speed (Gs)	***.65*** (.71)	−.03 (.22)	.15 (.38)	−.01 (.29)	−.19 (.32)	.09 (.26)	.14 (.49)	.54	.46
Visual auditory delay (Glr)	−.01 (.27)	***.96*** (.95)	.01 (.53)	.01 (.47)	−.03 (.43)	−.03 (.29)	.02 (.25)	.90	.10
Visual auditory (Glr)	.01 (.31)	***.93*** (.96)	.02 (.58)	.00 (.52)	.02 (.51)	.04 (.37)	−.02 (.27)	.93	.07
Spatial relations (Gv)	−.04 (.24)	−.02 (.32)	***.67*** (.59)	.03 (.38)	−.13 (.34)	.04 (.25)	−.00 (.12)	.36	.64
Analysis-synthesis (Gf)	.07 (.35)	−.01 (.39)	***.45*** (.66)	.19 (.55)	.18 (.56)	−.08 (.25)	−.14 (.11)	.49	.51
Concept formation (Gf)	.02 (.38)	.02 (.46)	***.44*** (.72)	.26 (.64)	.20 (.64)	−.08 (.31)	−.08 (.18)	.59	.41
Picture recognition (Gv)	.04 (.21)	.09 (.24)	***.33*** (.32)	−.10 (.19)	−.10 (.19)	.08 (.19)	.09 (.19)	.13	.87
Planning (Gv)	−.06 (.17)	.00 (.22)	***.33*** (.37)	−.09 (.25)	.15 (.32)	.04 (.20)	.03 (.12)	.15	.85
General information (Gc)	.03 (.35)	−.03 (.41)	−.02 (.54)	***.84*** (.84)	−.09 (.57)	.11 (.51)	.05 (.38)	.72	.28
Verbal comprehension (Gc)	−.06 (.34)	.04 (.34)	.04 (.62)	***.84*** (.90)	.02 (.65)	.00 (.48)	.07 (.37)	.82	.18
Memory for words (Gsm)	−.13 (.25)	−.02 (.29)	−.01 (.40)	−.04 (.45)	***.63*** (.62)	.15 (.43)	.09 (.28)	.42	.58
Auditory work memory (Gsm)	.14 (.42)	.00 (.32)	−.17 (.41)	.15 (.52)	***.59*** (.66)	.03 (.36)	−.01 (.30)	.46	.54
Numbers reversed (Gsm)	.01 (.37)	.01 (.33)	.19 (.49)	−.15 (.40)	***.55*** (.61)	.02 (.32)	.06 (.26)	.40	.60
Sound blending (Ga)	.00 (.22)	−.02 (.30)	.08 (.42)	.12 (.48)	.08 (.47)	***.58*** (.67)	−.10 (.23)	.49	.51
Incomplete words (Ga)	−.05 (.18)	.02 (.23)	.00 (.26)	.07 (.35)	.08 (.34)	***.37*** (.48)	.10 (.28)	.25	.75
Auditory attention (Ga)	.23 (.27)	.02 (.16)	−.02 (.22)	−.04 (.21)	.08 (.27)	.27 (.31)	−.10 (.15)	.14	.86
Rapid naming (Gs)	.06 (.40)	.02 (.20)	−.06 (.17)	.02 (.27)	.06 (.28)	.01 (.28)	***.60*** (.65)	.43	.57
Retrieval fluency (Glr)	−.05 (.47)	−.02 (.27)	.05 (.32)	.14 (.42)	.08 (.40)	−.08 (.30)	***.59*** (.67)	.50	.50
Eigenvalue	6.39	1.80	1.26	1.12	0.97	0.93	0.88		
% Variance	31.95%	9.00%	6.28%	5.58%	4.85%	4.65%	4.40%		
Factor 1	1.0								
Factor 2	.30	1.0							
Factor 3	.49	.57	1.0						
Factor 4	.39	.51	.67	1.0					
Factor 5	.51	.49	.68	.71	1.0				
Factor 6	.26	.33	.40	.51	.49	1.0			
Factor 7	.55	.27	.24	.37	.36	.40			

Note. h^2 = communality coefficient; u^2 = uniqueness. Pattern coefficients >.30 are bolded and italicized. The eigenvalue of the eighth, unretained factor was 0.83.

Table 2
Age 14 to 19 Woodcock-Johnson, Third Edition (WJ-III) Cognitive Principal Axis Factor With Promax Rotation (Forced Seven Factor)

Subtest	Pattern (structure coefficients) I	II	III	IV	V	VI	VII	h^2	u^2
Visual auditory delay (Glr)	***.98*** (.96)	.06 (.53)	.01 (.53)	.01 (.36)	−.06 (.57)	−.05 (.32)	−.03 (.15)	.92	.08
Visual auditory (Glr)	***.97*** (.96)	−.03 (.53)	−.01 (.54)	.01 (.40)	−.02 (.60)	.05 (.39)	.04 (.22)	.93	.07
Numbers Reversed (Gsm)	.06 (.45)	***.92*** (.80)	−.18 (.46)	.06 (.46)	.01 (.53)	−.08 (.33)	−.08 (.22)	.66	.34
Auditory work memory (Gsm)	−.08 (.36)	***.69*** (.73)	.13 (.55)	−.03 (.45)	−.03 (.53)	.03 (.41)	.06 (.27)	.54	.46
Memory for words (Gsm)	.02 (.39)	***.65*** (.67)	.06 (.51)	−.07 (.38)	−.08 (.47)	.13 (.44)	.02 (.19)	.47	.53
General information (Gc)	−.03 (.45)	−.06 (.57)	***1.03*** (.90)	.01 (.46)	−.12 (.60)	−.01 (.52)	03 (.19)	.81	.19
Verbal comprehension (Gc)	.06 (.56)	.01 (.65)	***.88*** (.92)	.02 (.50)	.00 (.69)	.00 (.56)	−.04 (.19)	.85	.15
Rapid naming (Gs)	.07 (.27)	−.01 (.37)	−.07 (.32)	***.78*** (.68)	−.11 (.31)	.06 (.31)	−.09 (.28)	.48	.52
Retrieval fluency (Glr)	−.05 (.27)	.00 (.43)	.23 (.46)	***.55*** (.60)	−.02 (.40)	−.01 (.33)	−.08 (.26)	.40	.60
Decision speed (Gs)	−.01 (.24)	−.10 (.35)	−.01 (.32)	***.53*** (.65)	.04 (.40)	.05 (.27)	.26 (.54)	.48	.52
Visual matching (Gs)	−.05 (.28)	.24 (.52)	−.02 (.37)	***.42*** (.69)	.04 (.49)	−.14 (.20)	***.35*** (.64)	.61	.39
Picture recognition (Gv)	.20 (.37)	−.11 (.30)	−.01 (.33)	.23 (.37)	.20 (.39)	.07 (.27)	−.01 (.21)	.21	.79
Spatial relations (Gv)	.01 (.43)	−.01 (.48)	−.02 (.49)	−.00 (.37)	***.71*** (.68)	−.00 (.31)	.−.03 (.28)	.46	.54
Planning (Gv)	−.08 (.22)	−.07 (.26)	−.13 (.27)	−.06 (.19)	***.66*** (.46)	.07 (.20)	−.01 (.19)	.23	.77
Analysis-synthesis (Gf)	.07 (.50)	.15 (.58)	.22 (.61)	.01 (.42)	***.43*** (.68)	−.12 (.32)	−.02 (.27)	.51	.49
Concept formation (Gf)	.10 (.55)	.13 (.62)	.20 (.66)	−.10 (.43)	***.41*** (.73)	.07 (.46)	.08 (.32)	.58	.42
Sound blending (Ga)	.02 (.36)	.22 (.54)	.07 (.53)	−.02 (.40)	−.03 (.45)	***.54*** (.69)	.05 (.18)	.52	.48
Auditory attention (Ga)	.03 (.19)	−.11 (.23)	−.06 (.27)	−.01 (.26)	.04 (.27)	***.52*** (.48)	.20 (.24)	.28	.72
Incomplete words (Ga)	−.08 (.26)	.08 (.42)	.03 (.45)	.20 (.38)	.12 (.38)	***.42*** (.57)	−.21 (.03)	.39	.61
Pair cancellation (Gs)	.01 (.15)	−.04 (.23)	.01 (.18)	−.05 (.39)	−.03 (.32)	.11 (.16)	***.78*** (.75)	.57	.43
Eigenvalue	7.23	1.65	1.25	1.06	1.05	0.92	0.82		
% Variance	36.16%	8.24%	6.24%	5.31%	5.26%	4.59%	4.11%		
Factor 1	1.0								
Factor 2	.55	1.0							
Factor 3	.56	.70	1.0						
Factor 4	.40	.60	.54	1.0					
Factor 5	.63	.72	.74	.57	1.0				
Factor 6	.37	.52	.60	.43	.47	1.0			
Factor 7	.20	.37	.23	.54	.44	.13	1.0		

Note. h^2 = communality coefficient; u^2 = uniqueness. Pattern coefficients >.30 are bolded, italicized. The eigenvalue of the eighth, unretained factor was 0.75.

Table 3
Woodcock-Johnson, Third Edition (WJ-III) Sources of Variance According to a Schmid-Leiman Orthogonalization (Seven 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	h^2	u^2
Pair cancellation (Gs)	.39	16	***.68***	47	.01	00	−.12	01	.05	00	.01	00	−.03	00	−.06	00	.64	.36
Visual matching (Gs)	.51	26	***.54***	29	.00	00	.07	00	−.08	01	.07	00	−.01	00	.07	00	.57	.43
Decision speed (Gs)	.43	19	***.53***	28	−.02	00	.09	01	−.01	00	−.10	01	.07	00	.12	01	.51	.49
Visual auditory delay (Glr)	.56	31	−.01	00	***.76***	58	.01	00	.01	00	−.02	00	−.03	00	.02	00	.90	.10
Visual auditory (Glr)	.62	39	.01	00	***.74***	54	.01	00	.00	00	.01	00	.03	00	−.02	00	.93	.07
Spatial relations (Gv)	.43	19	−.03	00	−.01	00	***.41***	17	.02	00	−.07	00	.03	00	.00	00	.36	.64
Analysis-synthesis (Gf)	.58	34	.06	00	.00	00	*.28*	08	.11	01	.10	01	−.06	00	−.12	01	.46	.54
Concept formation (Gf)	.66	44	.01	00	.02	00	*.27*	07	.15	02	.11	01	−.07	00	−.07	00	.56	.44
Picture recognition (Gv)	.27	07	.03	00	.07	01	*.21*	04	−.06	00	−.05	00	.06	00	.07	01	.13	.87
Planning (Gv)	.32	10	−.05	00	.00	00	*.21*	04	−.05	00	.08	01	.03	00	.03	00	.16	.84
General information (Gc)	.69	47	.03	00	−.02	00	−.01	00	***.49***	24	−.05	00	.09	01	.05	00	.72	.28
Verbal comprehension (Gc)	.75	57	−.05	00	.03	00	.02	00	***.48***	23	.01	00	.01	00	.06	00	.81	.19
Memory for words (Gsm)	.53	28	−.11	01	−.02	00	.00	00	−.03	00	***.34***	11	.12	01	.08	01	.43	.57
Auditory work memory (Gsm)	.58	33	.11	01	.00	00	−.10	01	.09	01	***.32***	10	.02	00	−.01	00	.46	.54
Numbers reversed (Gsm)	.54	29	.01	00	.01	00	.12	01	−.09	01	***.30***	09	.02	00	.05	00	.40	.60
Sound blending (Ga)	.51	26	.00	00	−.02	00	.05	00	.07	00	.04	00	***.47***	22	−.08	01	.49	.51
Incomplete words (Ga)	.37	14	−.04	00	.02	00	.00	00	.04	00	.05	00	***.30***	09	.09	01	.24	.76
Auditory attention (Ga)	.28	08	.18	03	.02	00	−.01	00	−.02	00	.04	00	*.22*	05	−.08	01	.17	.83
Rapid naming (Gs)	.36	13	.05	00	.02	00	−.04	00	.01	00	.03	00	.00	00	***.52***	27	.41	.59
Retrieval fluency (Glr)	.49	24	.04	00	−.01	00	.03	00	.08	01	.04	00	−.06	00	***.51***	26	.52	.48
Common variance (%)	52.84		11.24		11.51		4.66		5.57		3.70		4.16		6.30		49.36	50.64
Total variance (%)	26.08		5.55		5.68		2.30		2.75		1.82		2.05		3.11			

Note. h^2 = communality coefficient; u^2 = uniqueness. Loadings >.20 are *italicized* and are considered to be aligned with their respective first-order factors. Loadings >.30 are ***bolded and italicized*** (Carroll, 1993, p. 108; Child, 2006). Note that alignment of subtests with respective seven broad Cattell-Horn-Carroll (CHC) first-order factors posited in the WJ-III Technical Manual is indicted following each subtest name (Gc, Gs, Ga, Glr, etc).

Table 4
Woodcock-Johnson, Third Edition (WJ-III) Sources of Variance According to a Schmid-Leiman Orthogonalization (Seven 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	h^2	u^2
Visual Auditory Delay (Glr)	.60	36	***.74***	55	.03	00	.00	00	.01	00	−.03	00	−.04	00	−.03	00	.92	.08
Visual Auditory (Glr)	.63	39	***.74***	55	−.02	00	−.00	00	.01	00	−.01	00	.04	00	.03	00	.94	.06
Numbers Reversed (Gsm)	.62	39	.05	00	***.50***	25	−.10	01	.04	00	.00	00	−.06	00	−.07	01	.66	.34
Auditory Work Mem (Gsm)	.62	39	−.06	00	***.38***	14	.07	01	−.02	00	−.02	00	.02	00	.05	00	.54	.46
Memory for Words (Gsm)	.57	32	.02	00	***.36***	13	.03	00	−.05	00	−.04	00	.11	01	.02	00	.47	.53
General Information (Gc)	.71	50	−.03	00	−.03	00	***.57***	33	.00	00	−.05	00	−.01	00	.03	00	.83	.17
Verbal Comprehension (Gc)	.78	60	.04	00	.00	00	***.49***	24	−.02	00	0	00	.00	00	−.04	00	.84	.16
Rapid Naming (Gs)	.43	18	.05	00	−.01	00	−.04	00	***.56***	31	−.05	00	.05	00	−.08	01	.51	.49
Retrieval Fluency (Glr)	.50	25	−.04	00	.00	00	.13	02	***.39***	15	−.01	00	−.01	00	−.07	00	.42	.58
Decision Speed (Gs)	.45	21	−.01	00	−.05	00	−.01	00	***.38***	14	.02	00	.04	00	*.24*	06	.41	.59
Visual Matching (Gs)	.55	30	−.04	00	.13	02	−.01	00	***.30***	09	.02	00	−.11	01	***.32***	10	.52	.48
Picture Recognition (Gv)	.40	16	.15	02	−.06	00	−.01	00	.16	03	.10	01	.06	00	−.01	00	.22	.78
Spatial Relations (Gv)	.59	34	.01	00	−.00	00	−.01	00	−.00	00	***.34***	11	−.00	00	−.03	00	.46	.54
Planning (Gv)	.35	12	−.06	00	−.04	00	−.07	01	−.04	00	***.32***	10	.05	00	−.01	00	.24	.76
Analysis-Synthesis (Gf)	.66	43	.06	00	.08	01	.12	01	.00	00	*.20*	04	−.10	01	−.02	00	.51	.49
Concept Formation (Gf)	.70	50	.08	01	.07	00	.11	01	−.07	00	*.20*	04	.06	00	.07	01	.57	.43
Sound Blending (Ga)	.55	31	.02	00	.12	01	.04	00	−.02	00	−.02	00	***.44***	19	.04	00	.51	.49
Auditory Attention (Ga)	.30	09	.02	00	−.06	00	−.03	00	.00	00	.02	00	***.42***	17	.18	03	.31	.69
Incomplete Words (Ga)	.46	21	−.06	00	.05	00	.16	00	.14	02	.06	00	***.34***	11	−.19	03	.39	.61
Pair Cancellation (Gs)	.31	10	.01	00	−.02	00	.00	00	−.03	00	−.01	00	.08	01	***.71***	51	.61	.39
Common Variance (%)	56.5		10.6		5.3		5.8		6.9		2.9		4.9		7.0		54.4	45.6
Total Variance (%)	30.7		5.8		2.9		3.2		3.8		1.6		2.7		3.8			

Note. h^2 = Communality coefficient. u^2 = Uniqueness. Loadings > .20 are *italicized* and are considered to be aligned with their respective first-order factors. Loadings > .30 are ***bolded, italicized*** (Carroll, 1993, p. 108; Child, 2006). *Note.* that alignment of subtests with respective seven broad Cattell-Horn-Carroll (CHC) first-order factors posited in the WJ-III Technical Manual is indicted following each subtest name (Gc, Gs, Ga, Glr, etc).

Table 5
Woodcock-Johnson, Third Edition (WJ-III) Sources of Variance According To A Schmid-Leiman Orthogonalization (Four Factor) Ages 9 to 13

	Second-order factor		First-order factors									
Subtest	G	Variance	F1	Variance	F2	Variance	F3	Variance	F4	Variance	h^2	u^2
Analysis-synthesis (Gf)	.54	29	***.45***	20	.00	00	.05	00	.01	00	.49	.51
Concept formation (Gf)	.62	39	***.44***	19	.06	00	.03	00	.03	00	.58	.42
Spatial relations (Gv)	.40	16	***.32***	10	−.01	00	.03	00	.05	00	.27	.73
Numbers reversed (Gsm)	.49	24	*.24*	06	.09	01	.13	02	.00	00	.32	.68
Planning (Gv)	.30	09	*.21*	04	.02	00	.02	00	.02	00	.13	.87
Picture recognition (Gv)	.25	06	.10	01	−.01	00	.11	01	.11	01	.10	.90
General information (Gc)	.67	45	.15	02	***.37***	14	−.07	00	−.02	00	.62	.38
Verbal comprehension (Gc)	.73	54	.21	04	***.36***	13	−.11	01	.03	00	.73	.27
Retrieval fluency (Glr)	.47	22	−.12	02	*.28*	08	***.30***	09	.03	00	.40	.60
Rapid naming (Gs)	.35	12	−.24	06	*.27*	07	***.31***	09	.05	00	.35	.65
Sound blending (Ga)	.49	24	.15	02	*.26*	07	−.07	01	−.03	00	.34	.66
Incomplete words (Ga)	.37	14	.01	00	*.26*	07	−.03	00	.01	00	.21	.79
Memory for words (Gsm)	.49	24	.16	03	*.23*	05	−.01	00	−.04	00	.32	.68
Auditory work memory (Gsm)	.53	28	.18	03	*.20*	04	.13	02	−.05	00	.37	.67
Visual matching (Gs)	.45	20	.14	02	−.06	00	***.66***	44	−.01	00	.66	.34
Pair cancellation (Gs)	.35	12	.06	00	−.04	00	***.62***	38	−.02	00	.51	.49
Decision speed (Gs)	.40	16	.04	00	.00	00	***.59***	35	.00	00	.51	.49
Auditory attention (Ga)	.26	07	.08	01	.07	00	.13	02	−.01	00	.10	.90
Visual auditory delay (Glr)	.59	34	.01	00	−.02	00	−.01	00	***.75***	57	.91	.09
Visual auditory (Glr)	.64	41	.06	00	.01	00	−.01	00	***.70***	48	.90	.10
% Common variance	54.2		9.7		7.6		16.3		12.2		44.0	56.0
% Total variance	23.8		4.3		3.3		7.2		5.4			

Note. h^2 = communality coefficient; u^2 = uniqueness. Loadings >.20 are italicized and are considered to be aligned with their respective first-order factors. Loadings >.30 are ***bolded and italicized*** (Carroll, 1993, p. 108; Child, 2006). Note that alignment of subtests with respective seven broad Cattell-Horn-Carroll (CHC) first-order factors posited in the WJ-III Technical Manual is indicted following each subtest name.

Table 6
Woodcock-Johnson, Third Edition (WJ-III) Sources of Variance According to a Schmid-Leiman Orthogonalization (Three Factor) Ages 14 to 19

Subtest	Second-order factor G	First-order factors							h^2	u^2
		Variance	F1	Variance	F2	s	F3	Variance		
Verbal comprehension (Gc)	.82	68	*.24*	06	.04	00	−.11	01	.75	.25
General information (Gc)	.75	56	*.23*	05	−.03	00	−.09	01	.62	.38
Sound blending (Ga)	.59	35	.17	03	−.04	00	.01	00	.38	.62
Auditory work memory (Gsm)	.64	41	.17	03	−.04	00	.08	01	.44	.56
Incomplete words (Ga)	.49	24	.16	03	−.09	01	−.02	00	.28	.72
Memory for words (Gsm)	.60	36	.16	03	.01	00	.01	00	.38	.62
Concept formation (Gf)	.70	49	.15	02	.15	02	.04	00	.54	.46
Analysis-synthesis (Gf)	.64	41	.13	02	.15	02	.04	00	.45	.55
Numbers reversed (Gsm)	.60	36	.12	02	.09	01	.09	01	.39	.61
Spatial relations (Gv)	.54	29	.10	01	.14	02	.08	01	.33	.67
Retrieval fluency (Glr)	.49	24	.09	01	−.05	00	.26	07	.32	.68
Auditory attention (Ga)	.32	10	.07	00	−.03	00	.13	02	.12	.88
Planning (Gv)	.31	10	.06	00	.06	00	.06	00	.11	.89
Visual auditory delay (Glr)	.59	35	−.01	00	***.75***	56	−.05	00	.91	.08
Visual auditory (Glr)	.61	38	−.01	00	***.72***	52	.00	00	.90	.10
Picture recognition (Gv)	.38	14	.03	00	.17	03	.15	02	.19	.81
Visual matching (Gs)	.49	24	.01	00	.00	00	***.61***	37	.60	.40
Decision speed (Gs)	.41	16	.00	00	−.01	00	***.57***	33	.49	.51
Pair cancellation (Gs)	.26	07	−.03	00	.01	00	***.49***	24	.31	.69
Rapid naming (Gs)	.40	16	.03	00	.01	00	***.38***	14	.31	.69
% Common variance	69.0		3.4		13.7		13.9		44.1	55.9
% Total variance	30.0		1.5		6.0		6.1			

Note. h^2 = communality coefficient; u^2 = uniqueness. Loadings >.20 are *italicized* and are considered to be aligned with their respective first-order factors. Loadings >.30 are bolded and italicized (Carroll, 1993, p. 108; Child, 2006). Note that alignment of subtests with respective seven broad Cattell-Horn-Carroll (CHC) first-order factors posited in the WJ-III Technical Manual is indicted following each subtest name.

each age range suggests the prominence of the general factor and generally struggles to find subtest alignment reminiscent of that posited in the Technical Manual. At age 9 to 13, the general factor accounted for 54.2% of the common variance and 23.8% of the total variance, exceeding that accounted for by the lower order factors (7.6% to 16.3% common variance; 3.3% to 7.2% total variance). The first- and second-order factors at age 9 to 13 combine to measure 44.0% of the variance in the WJ-III Cognitive, reflecting 56.0% unique variance. At 14 to 19, the general factor accounted for 69% of the common variance and 30.4% of the total variance, dwarfing that apportioned to lower order factors (3.4% to 13.9% common variance; 1.5% to 6.1% total variance). The first- and second-order factors at age 14 to 19 combine to measure 44.1% of the variance in the WJ-III Cognitive, reflecting 55.9% unique variance. The results of both analyses demonstrate a robust manifestation of general intelligence in the WJ-III where the combined influence of general intelligence and uniqueness exceeded the contributions made by the first-order factors.

Discussion

The WJ-III test authors overlooked EFA analyses and instead relied exclusively upon CFA. This is not a singular criticism of the WJ-III Cognitive. Exclusive reliance on CFA has become a trend in cognitive ability scale development in recent years (e.g., Elliot, 2007a; Roid, 2003; Wechsler, 2008) resulting in criticism of internal structure (Canivez, 2008; DiStefano & Dombrowski, 2006) and concern about confirmation bias (Greenwald, Pratkanis, Leippe, & Baumgardner, 1986). Independent research on the WJ-III has also been based primarily on CFA methodology. This body of research has largely been supportive of the factor structure of the instrument and its relationship with CHC theory (e.g., Floyd, McGrew, Barry, Rafael, & Rogers, 2009; Keith et al., 2010; Keith et al., 2008; Locke, McGrew, & Ford, 2011; Taub et al., 2008; Taub & McGrew, 2004; Vanderwood, McGrew, Flanagan, & Keith, 2002).

Although the WJ-III Cognitive test authors invoked Carroll's theory as a guide to the development of the instrument, they overlooked the EFA procedures (e.g., PAF/promax followed by a Schmid-Leiman Orthogonalization) explicitly recommended by Carroll and other experts in factor analysis (e.g., Carretta & Ree, 2001; Carroll, 1993, 1995, 2003; Gorsuch, 1983; Gustafsson & Snow, 1997; McClain, 1996; Ree, Carretta & Green, 2003; Thompson, 2004). A review of the literature suggests that EFA analyses have never been conducted on the WJ-III cognitive. This lack of independent EFA evaluation of the WJ-III Cognitive is rather surprising given the instrument's wide use by practitioners and considering that it contributed initial, empirical evidence for CHC theory.

In addition, the CFA analyses presented in the Technical Manual appear incomplete. The test authors include only a partial presentation of CFA fit statistics for the various CHC models despite presenting CFA correlation coefficients (p. 199), a path-like analysis without the coefficients (p. 62), and the 42 by 42 correlation matrix for the subtests that contribute to the broad nine factor model. The absence of complete CFA fit statistics and the omission of EFA analyses suggest that our understanding of the structure of the WJ-III Cognitive might be incomplete.

Because of these important evidentiary, theoretical, and psychometric omissions, the two school aged (9 to 13 years; 14 to 19 years) correlation matrices were subjected to EFA and higher order factor analysis. When used in conjunction with CFA analyses presented in the Technical Manual and the extant literature, this study should help to more clearly elucidate the theoretical structure of the WJ-III Cognitive.

Use of EFA factor extraction procedures (e.g., parallel analysis and MAP as supplemented by a visual scree) that are considered to be the most psychometrically robust suggests that the WJ-III Cognitive is a four factor test at ages 9 to 13 and a three factor instrument at ages 14 to 19. However, extracting this number of factors generally renders the instrument less available for interpretation because the subtest alignment lacks full linkage to theory and the structure posited in the WJ-III Technical Manual. At the 9 to 13 age range (Table 5), the subtests that load Gf (Analysis-synthesis and Concept formation) combine with spatial relations (Gv) to form the first factor. The second factor is a two subtest Gc factor, which is consistent with the theoretical alignment in the Technical Manual. The third factor loads all four Gs subtests (Visual Matching, Pair Cancellation, Decision Speed, and Rapid Naming) in addition to Retrieval Fluency (Glr). The fourth factor loads two subtests (Visual Auditory Learning; Visual Auditory Learning Delayed) that are purported to measure Glr. At age 14 to 19 (Table 6), two factors (Gs and Glr) emerged with linkage to the theoretical structure posited in the WJ-III Technical Manual. A final factor locates two Gc subtests (Verbal Comprehension and General Information) but their loadings on this factor are considered nonsalient. Best practice EFA procedures did not locate the Gsm, Gf, Gv, and Ga factors and therefore did not support the seven factor model posited in the Technical Manual. Instead, structural analyses using psychometrically sound EFA procedures suggest that the WJ-III Cognitive is a solid measure of general intelligence. There is also some evidence that the WJ-III Cognitive may provide a measure of Gs and Glr across both age ranges and a measure of Gc at age 9 to 13.

When casting aside factor extraction decision rules and extracting seven factors in accord with the structure posited in the Technical Manual, there were areas of convergence with and divergence from the Technical Manual. As noted in Tables 3 and 4, across both age ranges, the subtests that load Gc (General Information, Verbal Comprehension), Ga (Sound Blending, Incomplete Words, Auditory Attention) and Gsm (Memory for Words, Auditory Working Memory, Numbers Reversed) were aligned with their theoretically consistent CHC factors.

At age 9 to 13, Pair Cancellation (Gs), Visual Matching (Gs) and Decision Speed (Gs) paired with Retrieval Fluency (Glr) to form a second factor reminiscent of Gs. Rapid Naming (Gs) did not load this factor. At age 14 to 19, a slightly different looking Gs factor was present containing Rapid Naming (Gs), Decision Speed (Gs), Visual Matching (Gs), and Retrieval Fluency (Glr). Across both age ranges, a second, two subtest Gs factor was located containing

Pair Cancellation (Gs) and Visual Matching (Gs) at age 14 to 19 and Rapid Naming (Gs) and Retrieval Fluency (Glr) at 9 to 13. At age 14 to 19, Visual Matching cross loaded this factor and the first Gs factor. Across both age ranges, Visual Auditory Learning (Glr) and Visual Auditory Learning—Delayed (Glr) paired together to form a two subtest Glr factor. Retrieval Fluency (Glr) did not load with this factor, but instead paired with selected Gs subtests.

At age 9 to 13, a factor containing Gf and Gv subtests paired together, but contained poor loadings such that only one subtest produced a salient loading (Spatial Relations). At age 14 to 19, a two subtest Gv factor (Spatial Relations and Planning) was located. However, the remaining Gv (Picture Recognition) and Gf subtests (Analysis-Synthesis and Concept Formation) subtests displayed poor loadings with this combined factor. Even when attempting to force the seven factor solution across the 9 to 19 age range by discarding the most lenient factor extraction decision rules, the WJ-III Cognitive structure does not fully hold.

Conclusion and Implications for Practitioners

The results of this study suggest that the structure of the WJ-III Cognitive in school age is hierarchical with the majority of its variance accounted for by the general factor. Across both analyses using psychometrically sound EFA procedures, a Gs and Glr factor emerged. At age 9 to 13, there was also evidence for a Gc factor though there was insufficient evidence for this factor at age 14 to 19.

Bending factor extraction rules and forcing a seven factor solution yielded some areas of convergence with the WJ-III Cognitive structure. The seven factor solution suggests that subtests that measure Gc, Ga and Gsm align with the Technical Manual's theoretically posited structure. There was also some evidence for Gs and Glr factors, but these factors looked different than what is posited in the Technical Manual. The Gf and Gv factors were difficult to identify and interpret because of either poor loadings on theoretically posited factors or loadings on alternate factors.

It is clear that additional exploratory and higher order studies are needed on the WJ-III as well as on existing tests of cognitive ability so that the field may be presented with another vantage from which to view the internal structure of these instruments. This will also help to balance shortcomings of each approach. For instance, the Schmid-Leiman procedure has a proportionality constraint which could overinflate the higher order factor loadings at the expense of the lower order factor loadings (Reise, Moore, & Haviland, 2010). Testing structural invariance via a variety of methods (e.g., maximum likelihood; exploratory bifactor) will better facilitate understanding of internal structure. If the structure derived via multiple approaches converge upon the same solution, then the field may be confident in an instrument's derived factor structure.

The field has moved away from its psychometric roots and cast aside EFA analyses when developing recent versions of IQ scales. Prior cognitive ability instruments used both EFA and CFA (e.g., WJ-R; Stanford-Binet, Fourth Edition (SB-IV)) to elucidate internal structure. This omission could pose a serious problem for at least two reasons. First, research suggests that recent intelligence tests may be over factored (see Frazier & Youngstrom, 2007). Reasons for over factoring have included lenient factor extraction decision-making rules, increasingly complex models of intelligence, and commercial pressure on test publishers for clinically useful assessment instruments with greater perceived, but perhaps illusory, interpretive value. Second, the derived factor structure of an instrument helps determine how it should be interpreted. If a scale's factor structure is investigated using only one modality of factor analysis (i.e., CFA), then a case can be made that we can be less confident in the presented structure. In general, an instrument should be interpreted where there is greatest convergent evidence among the sources of structural validity.

Interpretation much beyond *g* has been discussed as potentially problematic because of concern about the predictive validity of lower order factors (e.g., Glutting, Watkins, Konold, & McDermott, 2006; Kotz, Watkins, & McDermott, 2008; Oh, Glutting, Watkins, Youngstrom, & McDermott, 2004; Parkin & Beaujean, 2012; Watkins, Glutting, & Lei, 2007). This study's results lends support to these criticisms and reaffirms the position against moving much beyond this level of interpretation because of structural validity concerns (Canivez & Watkins, 2010; DiStefano & Dombrowski, 2006; Dombrowski et al., 2009; Nelson & Canivez, 2012; Watkins, 2010).

The caution about moving beyond interpretation of the general factor harkens back several decades to a similar, yet slightly different, argument posed by McDermott, Fantuzzo, and Glutting (1990). These researchers advised psychologists to "just say no to subtest analysis" (p299) and instead interpret at the level of the full scale IQ. Other researchers have subsequently warned against subtest level interpretation for numerous reasons including but not limited to poor reliability of individual subtest scores (see Watkins, Glutting & Youngstrom, 2005, for an insightful overview).

The results of the present study add to the body of structural validity literature which caution against overlooking interpretation of the higher order factor (g) in favor of interpretation of lower order factors (e.g., Canivez & Watkins, 2010; DiStefano & Dombrowski, 2006; Dombrowski et al., 2009; Nelson & Canivez, 2012; Watkins, 2010). The admonition against interpretation of lower order factors should not necessarily be as stark as that posed by McDermott et al. (1990) because the accumulated CFA evidence lends support to interpretation at this level. However, it is concerning that subsequent EFA studies on instruments linked to CHC theory, including this one, have generally failed to produce evidence supportive of interpretation of lower order factors (e.g., Canivez, 2008; DiStefano & Dombrowski, 2006; Dombrowski & Watkins, in press).

The lack of confirmation of CFA results with EFA methods in the current study permits questioning of the structure of the WJ-III Cognitive and its relationship with CHC theory. The practical implications would suggest that the practice of interpretation of lower order factors in the WJ-III Cognitive, other than those for which there is convergent evidence (i.e., Gs, Glr and Gc at 9 to 13), might be ill-advised. This study's results, along with the extant EFA literature, might even permit questioning of the appropriateness of test interpretation approaches such as cross battery assessment (XBA; Flanagan, Ortiz, & Alfonso, 2007) since XBA is predicated upon adequate structural validity of lower order factors.

Consistent with Frazier and Youngstrom (2007), the evidence from this study suggests that the WJ-III Cognitive may be attempting to measure too many factors and appears to be best interpreted as a full scale measure of IQ. There is also evidence for interpretation of some aspect of Gs and Glr across both age ranges and Gc at age 9 to 13. However, the Glr and Gc factors contain only two subtests. Methodologists (e.g., Costello & Osborne, 2005; Fabrigar et al., 1999) generally recommend a minimum of three variables (i.e., subtests) to locate a distinct factor so the evidence for interpretation of the Glr and Gc lower order factors perhaps remains at the edge of psychometric viability.

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