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ARTICLE

The higher order structure of the WISC–IV Italian adaptation using hierarchical exploratory factor analytic procedures

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ABSTRACT

The factor structure of the Wechsler Intelligence Scale for Children–Fourth Edition, Italian adaptation (WISC-IV Itaian; Orsini, Pezzuti, & Picone, 2012; Wechsler, 2012) standardization sample was examined with exploratory factor analytic methods (EFA) not included in the *Technical Manual*. Principal-axis extraction followed by oblique rotation using five-, four-, three-, and two-factor solutions all produced relatively similar results. None of the extraction criteria supported the retention of four factors, as suggested by the WISC–IV Italian *Technical Manual*. However, when the four-factor structure was subjected to second-order factor analysis and transformed with the Schmid and Leiman (1957) orthogonalization procedure, the hierarchical *g* factor accounted for large portions of total and common variance, while the four first-order group factors accounted for small portions of total and common variance, rendering interpretation at the factor index level of questionable value. Clinicians who use the WISC-IV Italian should recognize the strong measurement of general intelligence yielded by the scale and clinical interpretation should avoid the overinterpretation of factor index scores that conflate group factor variance with general intelligence variance.

KEYWORDS
WISC-IV Italian; exploratory factor analysis; factor extraction criteria; Schmid–Leiman higher-order analysis; structural validity

The Wechsler family of intelligence tests are among the most widely used and best-researched scales of psychometric intelligence (Kamphaus, 1993; Sattler, 2008). The Wechsler Intelligence Scales for Children (Wechsler, 2003a, 2003b; 2014a, 2014b) have been found to be the most widely used tests in both school and clinical settings (Alfonso, Oakland, LaRocca, & Spanakos, 2000; Belter & Piotrowski, 2001; Grégoire, 2006; Kaufman & Lichtenberger, 2000; Pfeiffer, Reddy, Kletzel, Schmelzer, & Boyer, 2000; Watkins, Campbell, Nieberding, & Hallmark, 1995; Zhu & Weiss, 2005). Wechsler scales are also the most commonly used intellectual scales in Europe (Evers et al., 2012), with translations and adaptations for the Wechsler Intelligence Scale for Children–Third Edition (WISC-III; cf. Georgas, Van De Vijver, Weiss, & Saklofske (2003), Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV; cf. Grégoire et al., 2008; Wechsler, 2004, 2016a, 2016b), Wechsler Intelligence Scale for Children–Fifth Edition (WISC-V; Wechsler, 2016a, 2016b), Wechsler Preschool and Primary Scale of Intelligence (WPPSI; cf. Liu & Lynn, 2011; Wechsler, 2014c), and the Wechsler Adult Intelligence Scale–Third Edition (WAIS-III; cf. Golay & Lecerf, 2011).

Despite their widespread popularity, Wechsler scales have been criticized for their lack of a strong theoretical foundation (Kush, 1996; Kush, Spring & Barkand, 2012; Macmann & Barnett, 1994). Beginning with the Wechsler Intelligence Scale for Children–Revised (WISC-R; Wechsler, 1974), a disparity emerged between the number of theoretically expected factors and the actual number of factors produced in normative analyses. In many respects, the revisions of the instrument through subtest addition and deletion were more influenced by the structure of the test rather than a well-articulated, theoretical structure of intelligence.

While Wechsler (1939) viewed intelligence as a global capacity, he also believed that his tests, and those of others, could be used as a measure of differentiated ability. This antithetical position has been well articulated by McDermott, Fantuzzo, and Glutting (1990), who described Wechsler's reciprocally exclusive theoretical notions that his tests were measures of global capacity called intelligence *as well as* measures of a wide variety of specific abilities. On the one hand, Wechsler believed that the role of the subtests was not to discover patterns of scatter but instead to assess the global capacity that underlies all subtests (Zachary, 1990); yet simultaneously he argued that an examination of subtest patterns "adds much to an examiner's diagnostic armamentarium" (Wechsler, 1974, p. 7).

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This one–many controversy has continued to the present day despite the fact that Wechsler's original rationale for the selection of subtests was that they were reliable, brief, and easy to administer (Zachary, 1990).

This theoretical incongruence was noted over 50 years ago by Cohen (1952, 1957), who argued that much of the theory put forward in the original Wechsler-Bellevue was not supported by factor analytic results. Beyond the expected verbal and performance factors, Cohen found evidence for an unexpected third factor, Freedom from Distractibility (FD), which sparked excitement among clinicians who hoped for extended utility of the instrument. Originally identified by Cohen (1957) as measuring short-term and auditory memory, and continuing with Kaufman's (1975) factor analysis of the WISC–R standardization sample, the FD factor generated considerable disagreement among psychologists as to what exactly it measured; and most subsequent research has shown that the FD Index was unable to distinguish between learning-disabled and nonhandicapped populations (Barkley, DuPaul, & McMurray, 1990; Gussin & Javorsky, 1995; McDermott et al., 1990; Moura, Simoes, & Pereira, 2014; Thomson, 2003; Watkins, Kush, & Glutting, 1997a, 1997b).

Despite a lack of change in the underlying theory, the Wechsler Intelligence Scale for Children–Third Edition (WISC-III; Wechsler, 1991) added a new subtest in an attempt to strengthen the FD factor; however, the new subtest (Symbol Search) actually caused the FD factor to splinter into two smaller factors, each consisting of two subtests. Subsequent independent analyses found stability of the three-factor model when the new subtest was excluded from the analyses (Reynolds & Ford, 1994); however, factorial instability was widespread, with contradictory evidence in support of either the three- or four-factor solution, depending on the population and factoring technique. In many respects, an unfortunate cycle resulted, with the factor analytic findings of the current test influencing the structure of the next revision of the scale, and only implicit corresponding changes in the underlying theory (e.g., the a-theoretical "discovery" of Working Memory), and many commercially available tests of intelligence are being produced with increased numbers of factors despite their lack of theoretical support, weak factorial invariance, inadequate long-term stability, and miniscule incremental validity (Beaujean & Benson, 2018).

With the creation of the Wechsler Intelligence Scale for Children–Fourth Edition (WISC–IV; Wechsler, 2003a), several new subtests were added (Picture Concepts, Letter-Number Sequencing, Matrix Reasoning, Cancellation, and Word Reasoning), while several others were removed (Picture Arrangement, Object Assembly, and Mazes). The Full Scale IQ was retained as an estimate of general intelligence; however, Verbal and Performance IQs were deleted, with a greater emphasis placed on the interpretation of the four index scores (Verbal Comprehension Index [VCI], Perceptual Reasoning Index [PRI], Working Memory Index [WMI], and Processing Speed Index [PSI]).

The development of the WISC-IV attempted to reflect conceptualizations of intellectual measurement influenced by Carroll, Cattell, and Horn (Carroll, 1993, 2003; Cattell & Horn, 1978; Horn, 1988; Horn & Blankson, 2005; Horn & Cattell, 1966; Schneider & McGrew, 2012). Specifically, the WISC–IV includes subtests that provide estimates of narrow abilities (Carroll's Stratum I), factor indexes that provide estimates of broad abilities (Carroll's Stratum II), and one estimate (i.e., FSIQ) of general intelligence (Carroll's Stratum III) consistent with Wechsler's definition of intelligence (i.e., "global capacity;" Wechsler, 1939b, p. 229) and similar to Carroll's (1993, 2003, 2012) intelligence framework. Further, the basic Wechsler structure was retained for subtests and associations with the VC (G_c), WM ($G_{sm,}$ or minus Arithmetic) and PS (G_s); however, the PR dimension is a combination of two CHC factors with Block Design and Picture Completion thought to measure visual processing (G_v) and Matrix Reasoning and Picture Concepts thought to measure fluid reasoning (G_f). While the WISC-IV retained the four Wechsler factors from the WISC-III, some reported evidence for CHC-based structural models of the WISC-IV (H. Chen, Keith, Chen, & Chang, 2009; Keith, Fine, Taub, Reynolds, & Kranzler, 2006; Weiss, Keith, Zhu, & Chen, 2013), although Canivez and Kush (2013) in critique of Weiss et al. pointed out numerous problems with such CHC conceptualizations.

As theories attempting to characterize the structure of human intelligence have evolved, so too have the factorial models designed to represent them. Typically, models that include a general factor can be described as either bifactor or higher-order representations (Beaujean, 2015) and are distinguished by the manner in which the general factor and other factors in the model are conceptualized. Hierarchical structure studies examine the higher-order relationship of *g* with the first-order factors, with effects of *g* going through first-order factors (*g* fully mediated by first-order factors) with direct effects of first-order factors to the subtests. In this model, the shared variance among measured variables is only used to form the factors and does not contribute to the formation of the general factor. In contrast, bifactor models allow both the general and group factors to have direct paths and influences on the subtests, allowing the effects of *g* on the subtests to be direct rather than indirect. Although often equated in the literature, hierarchical and bifactor models are not equivalent; see Beaujean (2015) for a well-crafted explanation describing the nuances of both models.

As Reise, Widaman, and Pugh (1993) indicated, "no CFA model should be accepted or rejected on statistical grounds alone; theory, judgment, and persuasive argument should play a key role in defending the adequacy of any estimated CFA model" (p. 554). Research examining Wechsler scales has found CFA bifactor models fit data as well as or better than higher-order models, and variance estimates for the general intelligence factor have far exceeded variance estimates of the group factors (Canivez, 2014; Canivez, Watkins, & Dobrowski, 2017; Canivez, Watkins, Good, James, & James, 2017; Gignac, 2005, 2006; Gignac & Watkins, 2013; Golay, Reverte, Rossier, Favez, & Lecerf, 2013; Nelson, Canivez, & Watkins, 2013; Watkins, 2010; Watkins & Beaujean, 2014; Watkins, Canivez, James, Good, & James, 2013). Bifactor models also are more parsimonious conceptual models (Canivez, 2016; Cucina & Byle, 2017; Gignac, 2006, 2008).

In Europe, the WISC–IV revision, for use in the United Kingdom, was published in 2004 (WISC– IV^{UK}; Wechsler, 2004). To date, two studies have examined the factor structure of the WISC–IV^{UK} using CFA methods. Watkins et al. (2013) examined the latent factor structure with a large clinical sample (N = 794) of Irish children who were administered the 10 WISC–IV^{UK} core subtests in clinical assessments of learning difficulties. One through four first-order factor models and both higher-order and bifactor models were tested using confirmatory factor analytic (CFA) methods, and a resulting bifactor model provided the best explanation of WISC–IV^{UK} factor structure. Because only the 10 core subtests were available, it was not possible to examine possible rival CHC-based models. Subsequently, Canivez et al. (2017) completed CFAs with all 15 core *and* supplemental WISC–IV^{UK} subtests with a different sample of referred Irish children (N = 245) to examine both Wechsler- *and* CHC-based structures and determined that bifactor and higher-order representations of Wechsler and CHC structures explained these data equally well. However, in all models the general intelligence factor captured substantially more variance than the four (Wechsler) or five (CHC) group factors.

Results of these WISC–IV^{UK} studies with Irish samples are consistent with results from other WISC–IV studies using EFA or CFA (Bodin, Pardini, Burns, & Stevens, 2009; Canivez, 2014; Nakano & Watkins, 2013; Styck & Watkins, 2016; Watkins, 2006, 2010; Watkins, Wilson, Kotz, Carbone, & Babula, 2006), and with other versions of Wechsler scales and other intelligence tests (Canivez & Watkins, 2010a, 2010b; Canivez, Watkins, & Dombrowski, 2016, 2017; Dombrowski, McGill, & Canivez, 2017; Gignac, 2005, 2006; Golay & Lecerf, 2011; Golay et al., 2013; Lecerf & Canivez, 2017; Lecerf, Rossier, Favez, Reverte, & Coleaux, 2010; McGill & Canivez, 2016; Nelson et al., 2013; Watkins & Beaujean, 2014) in demonstrating that the largest portion of variance is captured by the *g* factor and only relatively small portions of variance were uniquely associated with group factors. Taken together, these findings add to a growing body of evidence that primary interpretation of Wechsler scales (and other intelligence tests) should focus on the FSIQ (an estimate of *g*) because it accounts for the largest portion of common variance.

A Spanish translation of the Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV Spanish; Wechsler, 2005a), developed for Spanish speakers in the United States, was also published, and the first-order factor structure of the WISC–IV Spanish was presented in the *Technical Manual* (Wechsler, 2005b). However, higher-order structure, factor loadings, variance estimates, and model-based reliability estimates were absent. McGill and Canivez (2016) subsequently used higher-order exploratory factor analytic techniques with SL procedure not included in the WISC–IV Spanish *Technical Manual* and found again that the *g* factor accounted for large portions of total and common variance, whereas the four first-order factors accounted for small unique portions of total and common variance. McGill and Canivez (2017) obtained similar results using CFA with the WISC-IV Spanish, where bifactor models were judged best, the *g* factor contained large portions of explained variance, and the four (10 subtest) or five (14 subtest) group factors contained small to trivial portions of explained variance.

In contrast to the four-factor WISC-IV model articulated by the publisher, Flanagan and Kaufman (2004) suggested that the WISC–IV measured six broad abilities, whereas Keith et al. (2006) reported evidence that the WISC-IV measured five broad abilities; and, regarding the French version, Grégoire (2006) also assumed that the WISC-IV measured five broad abilities. Complicating interpretations further, Lecerf et al. (2010) utilized CFA techniques to determine that the French WISC-IV measured six factors: crystallized intelligence (Gc), fluid intelligence (Gf), short-term memory (Gsm), processing speed (Gs), quantitative knowledge (Gq), and visual processing (Gv). In a subsequent analysis using Bayesian structural equation modeling, Golay et al. (2013) found that a direct hierarchical (bifactor) model with five group factors plus a general intelligence factor better represented the structure of the French WISC–IV than did a four-group factor structure; and bifactor models were better than higher-order models by modeling small nonzero subtest cross-loadings.

The Wechsler Intelligence Scale for Children has also been the most widely used intelligence test for children in Italy (Cianci, Orsini, Hulbert, & Pezzuti, 2013). The third edition of the scale was published in 2006 (Orsini & Picone, 2006) and the fourth edition emerged six years later (Orsini, Pezzuti, & Picone, 2012). The theoretical framework of the Italian adaptation mirrored the factor structure reported in the United States edition; however, to date, no independent research exists examining the factor structure of the Wechsler Intelligence Scale for Children–Italian adaptation, based on the standardization sample.

Giofrè and Cornoldi (2015) examined the factor structure of the Italian adaptation of the WISC-IV in samples of children with a clinical diagnosis of specific learning disability (SLD) and those with typical development; they concluded that the four main WISC–IV factor indexes were differently related to intelligence and that not all subtests had the same *g* content in the two groups. Similar findings were subsequently produced, again with the Italian adaptation of the WISC–IV, with a larger sample of students with learning disabilities (Giofrè, Toffalini, Altoè, & Cornoldi, 2017). Additional research with the WISC-IV Italian adaptation demonstrated that, depending on the subtests included, a partial independence exists between global intelligence and working memory—a finding that had been established by others with non-Italian samples (Cornoldi, Orsini, Cianci, Giofrè, & Pezzuti, 2013). Relatedly, issues concerning a floor effect of the WISC-IV Italian was described by Orsini, Pezzutti, and Hulbert (2014), while Poletti (2016) utilized the WISC-IV Italian adaptation (Orsini et al., 2012) to examine the cognitive features of children with specific learning disabilities, concluding that the General Ability Index was the best measure provided by the WISC-IV Italian to identify intellectual functioning. While the Wechsler Intelligence Scale for Children–Fifth Edition (WISC-V; Wechsler, 2014a) recently became available in the United States, the WISC-IV Italian edition is the current version and remains widely used by Italian practitioners. Information regarding the release of the next revision of the WISC-IV Italian is not publicly available.

Following the recommendations of Carroll (1995), the present study used best practices in exploratory factor analytic procedures followed by the Schmid and Leiman (SL; 1957) orthogonalization procedure to better clarify the hierarchical factor structure and allocation of true score variance in the WISC-IV Italian adaptation, as illustrated by Watkins (2006) and Canivez et al. (2016). The Schmid and Leiman (1957) procedure is a commonly used statistical technique to perform this transformation of EFA loadings to apportion subtest variance to the first-order and higher-order dimensions because intelligence test subtests are influenced by both first-order factors *and* the higher-order *g* factor (Carroll, 1993, 2003; Gustafsson & Snow, 1997; Ree, Carretta, & Green, 2003; Thompson, 2004). Additionally, this procedure has been utilized in a great number of previous Wechsler scales studies (Canivez & Watkins, 2010a, 2010b; Canivez et al., 2016; Golay & Lecerf, 2011; Watkins, 2006) and studies of other measures of intelligence (Canivez, 2008, 2011; Canivez, Konold, Collins, & Wilson, 2009; Dombrowski & Watkins, 2013; Dombrowski, Watkins, & Brogan, 2009; Nelson & Canivez, 2012; Nelson, Canivez, Lindstrom, & Hatt, 2007). Specifically, SL transformations re-express factor loadings from higher-order models in a manner that highlights the measured variables and the general factor to aid in factor interpretation (Beaujean, 2015).

Schmid-Leiman transformations in EFA investigations can also guide subsequent confirmatory factor analyses, as CFA "should derive its initial hypotheses with guidance from EFA results, rather than starting from scratch or from a priori hypotheses" (Carroll, 1998, p. 8).

While confirmatory factor analyses that ignore underlying theory and put forward multiple models attempting to maximize model fit have been criticized as "fishing" (e.g., Schreiber, Nora, Stage, Barlow, & King, 2006), EFA techniques are designed to explore the possible underlying factor structure of a set of observed variables without imposing a preconceived structure on the outcome (Child, 2006). As indicated previously, it is not clear that the Wechsler scales are *guided* by any true theory of intelligence, but rather, it appears that with each revision of the instrument the resulting factor structure is attempted to be *explained*, post hoc, with theory. The present exploratory factor analyses are, however, agnostic and are guided by the goals of parsimony, interpretability, and theoretical plausibility; and allow "the data to speak for themselves" (Carroll, 1995, p. 436).

Specific WISC-IV Italian research questions included (a) how many factors should be extracted and retained, (b) what are the subtest relationships with latent factors and is there data to support the publisher's claim of four first-order factors, and (c) when extracting correlated theoretical factors and applying the Schmid and Leiman procedure (Schmid & Leiman, 1957), what proportion of variance is the result of general intelligence as opposed to group ability factors?

Method

Participants

The Italian standardization sample for the WISC-IV Italian adaptation (WISC-IV Italian; Orsini et al., 2012; Wechsler, 2012) consists of 2,200 participants divided into 11 age groups, each of 12 months range, ranging from 6 to 16 years and 11 months old. The sample is representative of the Italian population by parental educational level.

Instrument

The WISC-IV, Italian adaptation (WISC-IV Italian; Orsini et al., 2012) is a general intelligence test that is composed of 15 subtests (*M*s = 10, *SD*s = 3), 10 of which are mandatory and contribute to measurement of four factor-based index scores: Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), and Processing Speed Index (PSI). Each of the four index scores is expressed as a standard score (*M*s = 100, *SD*s = 15). The FSIQ is composed of 10 core subtests (three Verbal Comprehension, three Perceptual Reasoning, two Working Memory, and two Processing Speed).

The manual for the Italian adaptation of the WISC–IV (Orsini et al., 2012) includes the subtest correlation matrix and relationships with Full Scale IQ, the four factor indexes, and two additional indexes (GAI and CPI). In reviewing the WISC-IV Italian test manual, internal consistencies, test–retest stability, interrater agreement, and standard errors of measurement are comparable with those of the English version (Wechsler, 2003a, b).

Procedure and analyses

The intercorrelation matrix of the 15 WISC-IV Italian adaptation subtests for the normative sample of 2,200 children and adolescents (Orsini et al., 2012) was subjected to EFA procedures, specifically principal-axis extraction (Fabrigar, Wegener, MacCallum, & Strahan, 1999), followed by oblique rotation using SPSS 24 for Macintosh OSX. Retained factors were subjected to promax rotation (k = 4; Gorsuch, 1983). Salient factor pattern coefficients were defined as those ≥ .30 (Child, 2006). Additionally, it was specified that each factor should be characterized by two or more salient loadings and no salient cross-loadings (Gorsuch, 1983). As recommended by Gorsuch (1983, 2003), multiple criteria for determining the number of factors to retain were examined and included the scree test (Cattell, 1966), parallel analysis (PA; Horn, 1965), and minimum average partial (MAP; Velicer, 1976). PA was generated using the *Monte Carlo PCA for Parallel Analysis* program (Watkins, 2000) with 100 replications to produce stable eigenvalue estimates. MAP procedures were conducted using O'Connor's (2000) SPSS syntax.

Factor correlations were then subjected to second-order EFA and orthogonalized using the Schmid and Leiman (SL; 1957) procedure as programmed in the *MacOrtho* program (Watkins, 2004). Carroll argued (1993, 2003) that subtest scores on measures of cognitive ability reflect combinations of both first-order *and* second-order factor variance, and as a result, variance from the higher-order factor must be extracted first to residualize the lower-order factors, leaving them orthogonal to the higher-order factor. Omega-hierarchical and omega-hierarchical subscale coefficients (Reise, 2012) were also estimated with the *Omega* program (Watkins, 2013), based on the works of Brunner, Nagy, and Wilhelm (2012), Zinbarg, Revelle, Yovel, and Li (2005), and Zinbarg, Yovel, Revelle, and McDonald (2006). Omega-hierarchical is the model-based reliability estimate for the hierarchical general intelligence factor independent of the variance of group factors, while the omega-hierarchical subscale is the model-based reliability estimate of a group factor with all other group *and* general factors removed (Reise, 2012). At a minimum, omega coefficients should exceed .50; however, .75 is preferred (Reise, 2012; Reise, Bonifay, & Haviland, 2013).

Results

The criteria for determining the number of factors to retain provided incongruent recommendations. Velicer's (1976) MAP procedure identified one factor, the scree test and Horn's (1965) parallel analysis suggested two factors, and the Standard Error of Scree (SE_{Scree}; Zoski & Jurs, 1996) extraction criteria suggested three factors. While the empirical methods indicated that 1 or 2 factors would be sufficient for interpretation, previous research and theory included in the WISC-IV Italian *Technical Manual* suggested that four factors might be needed.

Cattell (1966) recommended that, in making this decision, factor analysts should consider less important the *correct* number of factors but instead emphasize the number of factors that are *worthwhile* to retain. Additionally, it is better to overextract than underextract (Wood, Tataryn, & Gorsuch, 1996) so smaller factors may be assessed. As a result, all plausible solutions were examined.

Exploratory factor analyses

Tables 1–3 present exploratory factor analysis results for five-, four-, three-, and two-factor solutions; all producing somewhat similar results.

Five-factor model

In the five-factor model (Table 1), most subtest *g* loadings were fair (≥ .45) to excellent (≥ .71; Comrey & Lee, 1992), with the exception of Coding, Symbol Search, and Cancellation, which loaded at poor to possibly fair (.27 to .44) levels. Verbal Comprehension and Perceptual Reasoning each consisted of four salient subtest loadings and the alignment of subtests was theoretically consistent and expected. Working Memory, however, consisted of only two salient subtest loadings, Digit Span (Memoria di cifre) and Letter–Number Sequencing (Riordinamento di lettere e numeri). Arithmetic (Ragionamento aritmetico), frequently part of the WM factor, was the sole contributor to the forced extraction of a fifth factor. Given that factors may not be defined by single subtest indicators, the five-factor model was judged inadequate.

Four-factor model

In the four-factor model (Table 2), *g* loadings were again fair (≥ .45) to excellent (≥ .71; Comrey & Lee, 1992), with the exception of Coding, Symbol Search, and Cancellation, which loaded at poor to fair (.28 to .44) levels. Verbal Comprehension and Perceptual Reasoning again consisted of four salient loadings, while Working Memory and Processing Speed each consisted of three subtests, but accounted only for approximately 3% of the total variance each. Each of the subtests produced salient loadings on only one of the group factors illustrating desirable simple structure. The subtests Coding, Symbol Search, and Cancellation comprised a unique fourth factor, but also failed to evidence substantial *g* loadings.

Two- and three-factor models

Within the three-factor model, Working Memory disappeared with its subtests aligning with subtests from

Table 1. Wechsler Intelligence Scale for Children–Fourth Edition, Italian (WISC-IV Italian) exploratory factor analysis: Five oblique factor solution for the total standardization sample (N = 2,200).

	General	F1: Verbal Comprehension		F2: Perceptual Reasoning		F3: Processing Speed		F4: Working Memory		F5: Inadequate		
WISC–IV Italian Subtest	*S*	*P*	*S*	*P*	*S*	*P*	*S*	*P*	*S*	*P*	*S*	h^2
SI	.732	**.658**	.757	.153	.618	.019	.275	.040	.501	−.071	.427	.588
VC	.756	**.863**	.828	−.034	.575	.002	.245	.028	.508	−.051	.449	.687
CO	.628	**.756**	.691	−.073	.463	.051	.238	−.055	.392	.011	.391	.484
IN	.710	**.629**	.733	−.041	.537	−.026	.236	.128	.552	.108	.522	.560
WR	.638	**.591**	.666	.097	.523	−.007	.225	−.075	.408	.093	.437	.453
BD	.546	−.057	.417	**.543**	.604	.149	.389	.010	.399	.056	.387	.388
PC	.597	.256	.559	**.557**	.641	−.045	.222	−.054	.376	−.086	.319	.443
MR	.609	−.050	.485	**.639**	.680	.008	.313	.059	.468	.066	.433	.469
PCn	.586	.132	.516	**.485**	.611	−.043	.235	.089	.449	−.009	.378	.391
DS	.487	.039	.402	.022	.392	−.019	.210	**.494**	.579	.083	.431	.342
LNS	.566	−.003	.454	.054	.469	−.010	.254	**.748**	.730	−.071	.439	.536
AR	.650	.051	.536	.033	.509	−.016	.316	.002	.570	**.804**	.847	.721
CD	.330	−.032	.174	−.113	.245	**.773**	.743	.078	.266	.002	.261	.562
SS	.443	.049	.311	.054	.379	**.557**	.627	.050	.336	.037	.335	.413
CA	.273	.044	.178	.135	.270	**.535**	.530	−.154	.111	−.056	.149	.303
Eigenvalue		5.63		1.56		1.03		0.92		0.68		
% Variance		34.28		6.82		3.48		2.59		1.76		
Factor Correlations		F1: VC		F2: PR		F3: PS		F4: WM		F5		
Verbal Comprehension (VC)		–										
Perceptual Reasoning (PR)		.717		–								
Processing Speed (PS)		.309		.430		–						
Working Memory (WM)		.618		.616		.358		–				
F5		.578		.554		.375		.649		–		

Note. WISC-IV Italian Subtests: SI = Similarities (Somiglianze), VC = Vocabulary (Vocabolario), CO = Comprehension (Comprensione), IN = Information (Informazione), WR = Word Reasoning (Ragionamento con le parole), BD = Block Design (Disegno con i cubi), PC = Picture Completion (Completamento di figure), MR = Matrix Reasoning (Ragionamento con le matrici), PCn = Picture Concepts (Concetti illustrate), DS = Digit Span (Memoria di cifre), LNS = Letter–Number Sequencing (Riordinamento di lettere e numeri), AR = Arithmetic (Ragionamento aritmetico), CD = Coding (Cifrario), SS = Symbol Search (Ricerca di simboli), CA = Cancellation (Cancellazione). S = Structure Coefficient, P = Pattern Coefficient, h^2 = Communality. General structure coefficients are based on the first unrotated factor coefficients (g loadings). Factor pattern and structure coefficients based on principal factors extraction with promax rotation (k = 4). Salient pattern coefficients presented in bold (pattern coefficient ≥ .30).

Table 2. Wechsler Intelligence Scale for Children–Fourth Edition, Italian (WISC-IV Italian) exploratory factor analysis: Four oblique factor solution for the total standardization sample (N = 2,200).

	General	F1: Verbal Comprehension		F2: Perceptual Reasoning		F3: Working Memory		F4: Processing Speed		
WISC-IV Italian Subtest	*S*	*P*	*S*	*P*	*S*	*P*	*S*	*P*	*S*	h^2
Similarities	.734	**.638**	.752	.152	.616	.004	.528	.007	.282	.578
Vocabulary	.758	**.853**	.825	−.023	.577	−.014	.532	−.007	.252	.681
Comprehension	.631	**.768**	.694	−.068	.465	−.065	.421	.054	.245	.488
Information	.713	**.635**	.737	−.052	.537	.225	.599	−.029	.247	.567
Word Reasoning	.639	**.602**	.667	.092	.524	−.002	.456	.000	.234	.449
Block Design	.547	−.057	.418	**.534**	.602	.064	.437	.154	.396	.387
Picture Completion	.599	.250	.557	**.563**	.642	−.122	.388	−.049	.228	.442
Matrix Reasoning	.611	−.054	.486	**.635**	.680	.123	.503	.009	.322	.471
Picture Concepts	.588	.123	.516	**.488**	.612	.087	.466	−.048	.243	.392
Digit Span	.492	−.007	.401	−.004	.389	**.645**	.618	−.048	.217	.384
Letter-Number Sequencing	.555	−.003	.453	.084	.466	**.614**	.653	−.032	.259	.430
Arithmetic	.614	.186	.538	.069	.506	**.431**	.621	.055	.325	.421
Coding	.330	−.039	.177	−.116	.244	.077	.296	**.769**	.738	.555
Symbol Search	.444	.047	.313	.045	.378	.079	.374	**.563**	.631	.417
Cancellation	.275	.046	.179	.136	.270	−.214	.132	**.545**	.531	.307
Eigenvalue		5.63		1.56		0.92				
% Variance		34.09		6.80		3.09		2.46		
Promax-Based Factor Correlations		F1: VC		F2: PR		F3: WM		F4: PS		
F1: Verbal Comprehension (VC)		–								
F2: Perceptual Reasoning (PR)		.718		–						
F3: Working Memory (WM)		.661		.649		–				
F4: Processing Speed (PS)		.323		.439		.416		–		

Note. *S* = Structure Coefficient, *P* = Pattern Coefficient, h^2 = Communality. General structure coefficients are based on the first unrotated factor coefficients (g loadings). Factor pattern coefficients and structure coefficients based on principal factors extraction with promax rotation (k = 4). Salient pattern coefficients presented in bold (pattern coefficient ≥ .30).

Table 3. Wechsler Intelligence Scale for Children–Fourth Edition, Italian (WISC-IV Italian) exploratory factor analysis: Two and three oblique factor solutions for the total standardization sample (N = 2,200).

	Two oblique factors					Three oblique factors			
WISC–IV Italian Subtest	g^1	F1: g	F2: Processing Speed	h^2	g^1	F1:	F2:	F3: Processing Speed	h^2
SI	.736	**.770** (.750)	−.045 (.291)	.565	.737	**.725** (.763)	.044 (.586)	.011 (.326)	.583
VC	.753	**.826** (.776)	−.114 (.246)	.613	.759	**.873** (.815)	−.061 (.568)	−.032 (.288)	.668
CO	.625	**.668** (.641)	−.063 (.228)	.414	.631	**.766** (.682)	−.129 (.452)	.028 (.271)	.472
IN	.714	**.768** (.733)	−.081 (.254)	.542	.711	**.608** (.723)	.195 (.608)	−.071 (.274)	.539
WR	.641	**.683** (.656)	−.060 (.237)	.434	.641	**.662** (.672)	.015 (.502)	−.005 (.270)	.451
BD	.543	**.396** (.513)	.270 (.442)	.322	.542	.138 (.462)	**.319** (.533)	.218 (.437)	.329
PC	.593	**.592** (.598)	.013 (.271)	.357	.591	**.468** (.586)	.145 (.505)	.026 (.289)	.356
MR	.601	**.519** (.587)	.157 (.383)	.365	.602	.193 (.533)	**.412** (.599)	.087 (.376)	.382
PCn	.586	**.564** (.585)	.050 (.296)	.345	.584	**.309** (.549)	**.320** (.553)	.009 (.297)	.349
DS	.479	**.447** (.476)	.066 (.261)	.230	.489	−.046 (.402)	**.654** (.575)	−.088 (.229)	.338
LNS	.543	**.497** (.537)	.092 (.309)	.295	.555	−.031 (.459)	**.701** (.642)	−.069 (.277)	.417
AR	.612	**.550** (.602)	.121 (.360)	.375	.614	.170 (.543)	**.489** (.629)	.027 (.346)	.410
CD	.328	−.087 (.233)	**.735** (.697)	.491	.326	−.125 (.188)	.028 (.307)	**.726** (.390)	.486
SS	.448	.112 (.373)	**.597** (.646)	.427	.446	.021 (.329)	.097 (.412)	**.585** (.643)	.423
CA	.274	−.016 (.208)	**.515** (.508)	.258	.276	.097 (.202)	−.188 (.194)	**.607** (.550)	.317
Eigenvalue		5.63	1.56			5.63	1.56	1.03	
% Variance		33.70	6.53			33.90	6.61	2.94	
Factor correlations		F1	F2			F1	F2	F3	
	F1	–			F1	–			
	F2	.436	–		F2	.739	–		
					F3	.403	.512	–	

Note. WISC-IV Italian Subtests: SI = Similarities (Somiglianze), VC = Vocabulary (Vocabolario), CO = Comprehension (Comprensione), IN = Information (Informazione), WR = Word Reasoning (Ragionamento con le parole), BD = Block Design (Disegno con i cubi), PC = Picture Completion (Completamento di figure), MR = Matrix Reasoning (Ragionamento con le matrici), PCn = Picture Concepts (Concetti illustrate), DS = Digit Span (Memoria di cifre), LNS = Letter-Number Sequencing (Riordinamento di lettere e numeri), AR = Arithmetic (Ragionamento aritmetico), CD = Coding (Cifrario), SS = Symbol Search (Ricerca di simboli), CA = Cancellation (Cancellazione). h^2 = Communality. [1]General structure coefficients based on first unrotated factor coefficients (g loadings). Factor pattern coefficients (structure coefficients) based on principal factors extraction with promax rotation (k = 4). Salient pattern coefficients presented in bold (pattern coefficient ≥ .30).

the Perceptual Reasoning factor. Picture Concepts cross-loaded on two factors, increasing model complexity. The two-factor solution consisted of a very large g factor distinct from the three subtests associated with Processing Speed. No subtest cross-loadings were produced in the two-factor model. Both two- and three-factor models are reflective of factor underextraction (Gorsuch, 1983), as evidenced by the compression of subtests into a small factor space and the distorted fusing of factors.

Hierarchical EFA: SL transformation

On the basis of these first-order EFA results, the four-factor EFA solution appeared to be the most interpretable and was subsequently subjected to second-order EFA,then transformed with the SL orthogonalization procedure. Schmid–Leiman variance partitioning EFA results are presented in Table 4. Following transformation, all subtests aligned with their theoretically proposed factors. The general factor accounted for 31.8% of the total variance and 68.4% of the common variance. The general factor also accounted for between 15% (Cancellation) and 43% (Similarities and Vocabulary) of individual subtest variability.

At the group factor level, VC accounted for an additional 13% to 25% of the variance in the five VC subtests. Additionally, the PR factor accounted for between 6% and 10% of the variance in the four PR subtests, the WM factor contributed 7% to 15% of the variance in its three subtests, and the PS factor provided 13% to 26% of the variance in the three PS subtests. Additionally, the general and first-order group factors accounted for

Table 4. Sources of variance in the Wechsler Intelligence Scale for Children–Fourth Edition, Italian (WISC-IV Italian) for the total standardization sample (N = 2,200) according to a SL orthogonalized higher-order factor model with four first-order factors.

	General		Verbal Comprehension		Perceptual Reasoning		Working Memory		Processing Speed			
WISC–IV Italian Subtest	B	S^2	b	S^2	b	S^2	b	S^2	B	S^2	h^2	u^2
Similarities	.656	.430	**.374**	**.140**	.077	.006	.002	.000	.005	.000	.576	.424
Vocabulary	.655	.429	**.500**	**.250**	−.012	.000	−.008	.000	−.005	.000	.679	.321
Comprehension	.552	.305	**.450**	**.203**	−.035	.001	−.039	.002	.036	.001	.511	.489
Information	.627	.393	**.372**	**.138**	−.026	.001	.136	.018	−.019	.000	.551	.449
Word Reasoning	.565	.319	**.353**	**.125**	.047	.002	−.001	.000	.000	.000	.446	.554
Block Design	.580	.336	−.033	.001	**.272**	**.074**	.039	.002	.102	.010	.423	.577
Picture Completion	.554	.307	.147	.022	**.286**	**.082**	−.074	.005	−.033	.001	.417	.583
Matrix Reasoning	.608	.370	−.032	.001	**.323**	**.104**	.075	.006	.006	.000	.481	.519
Picture Concepts	.553	.306	.072	.005	**.248**	**.062**	.053	.003	−.032	.001	.376	.624
Digit Span	.468	.219	−.004	.000	−.002	.000	**.391**	**.153**	−.032	.001	.373	.627
Letter-Number Sequencing	.534	.285	−.002	.000	.043	.002	**.372**	**.138**	−.021	.000	.426	.574
Arithmetic	.594	.353	.109	.012	.035	.001	**.261**	**.068**	.037	.001	.435	.565
Coding	.505	.255	−.023	.001	−.059	.003	.047	.002	**.510**	**.260**	.521	.479
Symbol Search	.561	.315	.028	.001	.023	.001	.048	.002	**.374**	**.140**	.458	.542
Cancellation	.392	.154	.027	.001	.069	.005	−.130	.017	**.362**	**.131**	.307	.693
Total Variance		.318		.060		.023		.028		.037	.465	.535
Explained Common Variance		.684		.129		.049		.060		.079		
ω_H / ω_{HS}		.813		.266		.143		.195		.286		

Note. b = standardized loading of subtest on factor, S^2 = variance, h^2 = communality, u^2 = uniqueness, ω_H = Omega-Hierarchical (general factor), ω_{HS} = Omega-Hierarchical Subscale (group factors). Bold type indicates coefficients and variance estimates consistent with the theoretically proposed factor. Salient pattern coefficients presented in bold (pattern coefficient ≥ .30)

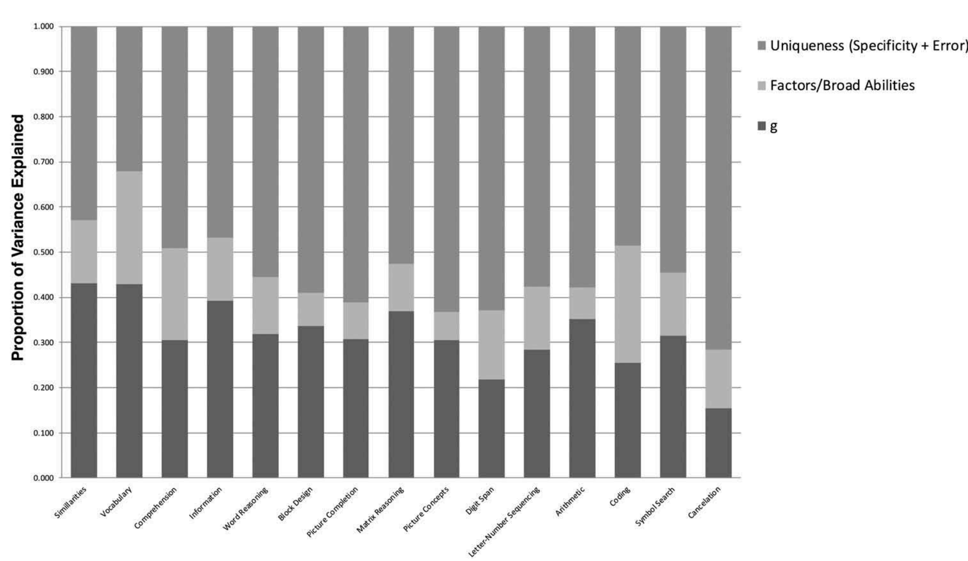

Figure 1. Sources of variance for the 15 WISC-IV Italian Subtests for the total standardization sample (N = 2,200) based on Schmid and Leiman (1957) orthogonalization of higher-order extraction with four first-order factors (verbal comprehension, perceptual reasoning, working memory, processing speed).

46.5% of the total variance, leaving 53.5% unique variance (combination of specific and error variance). Figure 1 illustrates the proportions of subtest variance attributed to the general intelligence dimension and the proportions uniquely attributed to the group factor.

The omega-hierarchical coefficient for general intelligence (.813) was high supporting scale interpretation, but omega-hierarchical subscale coefficients for the four WISC-IV Italian group factors were significantly lower, ranging from .143 (PR) to .286 (PS), and thus, unit-weighted scores based on the subtest indicators within each group factor would contain too little unique true score variance for clinical interpretation (Reise, 2012; Reise et al., 2013).

Discussion

Consistent with an abundance of findings examining the Wechsler scales for both American and international samples, the underlying structure of the WISC–IV Italian is best explained primarily by general intelligence (Bodin et al., 2009; Canivez, 2014; Canivez & Watkins, 2010a, 2010b; Gignac & Watkins, 2013; Nelson et al., 2013; Watkins, 2006, 2010, 2006; Watkins & Beaujean, 2014; Watkins et al., 2013). General cognitive ability accounted for more variance in each of the WISC-IV Italian subtests than any of the proposed first-order group factors (except for Coding). The finding in the current study that the general factor accounted for 68.4% of the common variance in WISC-IV subtests aligns with previous estimates of over 70% in both normative and referred samples (Canivez, 2014; Watkins, 2006).

Current results illustrate that, while the WISC–IV Italian appears to measure four first-order group factors forwarded in the *Technical Manual*, the dominance of the general intelligence factor and poor amounts of unique variance captured by the four group factors argue against clinical interpretations beyond FSIQ as *g* accounts for the vast majority of true score variance and very little unique true score variance is associated with the group factors. This recommendation is consistent with studies in the United States in the general population (Bodin et al., 2009; Canivez, 2014; Styck & Watkins, 2016; Watkins, 2006, 2010; Watkins et al., 2006), and with Native American children (Nakano & Watkins, 2013), as well as in several European WISC versions. Specifically, similar results were found for the WISC-IV^{UK} with Irish students (Canivez et al., 2017; Watkins et al., 2013), and with the WISC-IV Spanish (McGill & Canivez, 2016, 2017).

Examination of model-based reliability of the latent WISC-IV constructs indicated that the broad *g* factor had strong estimates allowing individual interpretation (ω_H = .813). The omega-hierarchical subscale estimates for the four WISC-IV group factors were very low (ω_{HS} = .143 to .286), indicating extremely limited measurment of unique constructs (Brunner et al., 2012; Reise, 2012) and not high enough for individual interpretation. For comparison purposes, standardized path coefficients from the Watkins (2010, 2013) and Canivez (2014) studies were used to calculate omega-hierarchical subscale estimates, and the current results were quite similar. For example, the omega-hierarchical subscale estimates for the four WISC-IV group factors from Watkins (2010) were also low (.112–.388), as were those reported for the four WISC-IV^{UK} group factors (.143–.376) with a large sample of referred Irish children (Watkins et al., 2013). Thus, the dominance of the general factor supports primary interpretation of the FSIQ for the WISC-IV Italian rather than the four factor index scores.

Interestingly, when five factors were extracted, the Arithmetic subtest produced a very high loading on the fifth factor while producing no salient cross-loadings, something similarly found by Lecerf and Canivez (2017). Arithmetic did not load on the Working Memory factor and such factor splitting could be a characteristic of factor overextraction (Gorsuch, 1983). Alternatively, there is some research to suggest that when additional measures are included in the factor analysis of Wechsler scale data, Arithmetic may be associated mostly with math achievement or quantitative reasoning (Phelps, McGrew, Knopik, & Ford, 2005; Watkins & Ravert, 2013). As constructed, however, the WISC-IV Italian appears to reflect four group factors.

It is important to remember that the current study examined the underlying structure of the WISC-IV Italian and not the structure of intelligence per se. Wechsler intelligence tests remain the most widely used and best-researched scales of psychometric intelligence (Kamphaus, 1993; Sattler, 2008) despite the one–many, interpretive dissonance, which can be traced back directly to Wechsler himself. But, as Beaujean and Benson (2018) indicated, cognitive ability tests designed to measure general intelligence will likely have difficulty simultaneously measuring specific cognitive abilities, something directly observed in the present study. Global intelligence remains one of the single best predictors of academic and occupational success (Kaufman, Reynolds, Liu, Kaufman, & McGrew, 2012; Roth et al., 2015) and the general intelligence factor, as a construct, appears invariant and serves as an unbiased predictor across gender, disability, and ethnic groups (Kush & Watkins, 2007; Kush et al., 2001; Nakano & Watkins, 2013; Watkins & Kush, 2002). Despite repeated claims positing the value of clinical interpretations of factor index scores (e.g., Prifitera, Saklofske, & Weiss, 2008; Wechsler, 2003b; Weiss, Saklofske, & Prifitera, 2005; Weiss, Saklofske, Prifitera, & Holdnack, 2006), results of the current study add to a considerable base of evidence that cautions against this practice (Bodin et al., 2009; Canivez, 2014; Canivez & Watkins, 2010a, 2010b; Canivez et al., 2016, 2017; Canivez, Watkins, & McGill, in press; Fennollar-Cortes & Watkins, 2018; Gignac & Watkins, 2013; Lecerf & Canivez, 2017; McGill & Canivez, 2016, 2017; Nelson et al., 2013; Watkins, 2006, 2010; Watkins & Beaujean, 2014; Watkins et al., 2006, 2013). The WISC-IV Italian measures *g* quite well, but unique measurement of group factors is poor. Interpretations beyond Full Scale IQ are a risky proposition that will likely be influenced clinician's illusory correlation and confirmatory bias in decision making.

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