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# Interpretation of KABC-II Scores: An Evaluation of the Incremental Validity of CHC Factor Scores in Predicting Achievement

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Author Note

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## Abstract

This study is an examination of the incremental validity of Cattell-Horn-Carroll (CHC) factor scores from the Kaufman Assessment Battery for Children-Second Edition (KABC-II) for predicting scores on the Kaufman Test of Educational Achievement-Second Edition (KTEA-II). The participants were children and adolescents, ages 7-18, ($N = 2{,}025$) drawn from the KABC-II standardization sample. The sample was nationally stratified and proportional to U.S. census estimates for sex, ethnicity, geographic region, and parent education level. Hierarchical multiple regression analyses were used to assess for factor-level effects after controlling for the variance accounted for by the full scale Fluid-Crystallized Index (FCI) score. The results were interpreted using the $R^2/\Delta R^2$ statistic as effect size indices. Consistent with similar incremental validity studies, the FCI accounted for statistically and clinically significant portions of KTEA-II score variance, with $R^2$ values ranging from .30 to .65. KABC-II CHC factor scores collectively provided statistically significant incremental variance beyond the FCI in all of the regression models, although the effect size estimates were consistently negligible to small (Average $\Delta R^2_{CHC} = .03$). Individually, the KABC-II factor scores accounted for mostly small portions of achievement variance across the prediction models, with none of the individual CHC factors accounting for clinically significant incremental prediction beyond the FCI. Additionally, most of the unique first-order predictive variance was captured by the Crystallized Ability factor alone. The potential clinical and theoretical implications of these results are discussed.

*Keywords:* incremental validity, KABC-II, CHC, test interpretation

# Interpretation of KABC-II Scores: An Evaluation of the Incremental Validity of CHC Factor Scores in Predicting Achievement

The Kaufman Assessment Battery for Children-Second Edition (KABC-II; Kaufman & Kaufman, 2004a) measures the processing and cognitive abilities of children and adolescents between the ages of 3 years and 18 years. According to the test authors, the Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983) underwent a major structural and conceptual revision. Eight subtests were eliminated from the original K-ABC, and 10 measures were created and added to the current battery. Item discrimination and scale ranges were increased, and the KABC-II theoretical foundation was updated from Luria's (1966) sequential-simultaneous processing theory.

The KABC-II utilizes a dual-theoretical foundation: the Cattell-Horn-Carroll (CHC; Schneider & McGrew, 2012) psychometric model of broad and narrow abilities, and Luria's neuropsychological theory of cognitive processing (Luria, 1966). One of the features of the KABC-II is the flexibility that it affords the examiner in determining the theoretical model to administer to the examinee. Although examiners may select either the Luria or CHC interpretive models, several interpretive resources (e.g., Kaufman, Lichtenberger, Fletcher-Janzen, & Kaufman, 2005; Kaufman & Kaufman, 2004b, Singer, Lichtenberger, Kaufman, Kaufman, & Kaufman, 2012) advise users to interpret the KABC-II primarily from the CHC perspective.

The theoretical CHC model of human cognitive abilities is a synthesis of factor analytic research that emphasizes the hierarchical organization of broad and narrow cognitive abilities. The latest iteration of the CHC model was most recently reviewed by Schneider and McGrew (2012). On the KABC-II, the CHC model for school ages (7-18) features 16 subtests (10 core and 6 supplemental), which combine to yield five first-order factor scale scores (Short-Term memory, Long-Term Storage and Retrieval, Visual Processing, Fluid Reasoning, and Crystallized Ability), and a second-order full scale Fluid Crystallized Index (FCI) that is thought to represent psychometric *g*. Each CHC factor scale is composed of two subtest measures, and the FCI is derived from a linear combination of the 10 core subtests that compose the constituent factor scores. Although the KABC-II manual encourages a stepwise progression of interpretation from the FCI to the factor scores, users are encouraged to use the CHC factor scores as the primary point of interpretation for the instrument.

Despite the substantive structural and theoretical revisions to the KABC-II, the test authors relied exclusively upon restricted confirmatory factor analyses (CFA) to examine the structural validity of the instrument. The KABC-II manual describes the proposed alignment of the 10 core subtests by presenting standardized coefficients (Kaufman & Kaufman, 2004b, pp. 106-107) within an indirect hierarchical three-stratum measurement model featuring various combinations of the CHC factors and the second-order *g*-factor. Separate CFA analyses were conducted for age 4, ages 5-6, ages 7-12, and ages 13-18. Although several fit statistics for the proposed CHC model are provided, the authors failed to discuss fit with respect to comparisons with rival measurement models (e.g., bifactor model, correlated factors model). Interestingly, at ages 4-6 a four-factor CHC model, featuring Short-Term Memory, Long-Term Retrieval, Visual Processing, and Crystallized Ability as first-order factors, was supported despite the authors attempts to disentangle Fluid Reasoning from Visual Processing using CFA procedures in an exploratory fashion. For ages 7-18 a five factor CHC measurement model was reported although standardized path coefficients between *g* and Fluid Reasoning ranged from 1.0 and 1.01 in the final models, suggesting isomorphism as *g* and fluid reasoning were indistinguishable. It should be noted that isomorphism between these two latent constructs is also observed in other tests such as the WAIS-IV (Weiss, Keith, Zhu, & Chen, 2013b) and WISC-IV (Weiss, Keith, Zhu, & Chen, 2013c), suggesting that specification of Fluid Reasoning as a factor may produce overfactoring and misguided interpretation in some cognitive measures given the redundancy between Fluid Reasoning and *g*. Interestingly, the aforementioned isomorphism was not observed in a recent structural examination of the French WISC-IV using Bayesian structural equation modeling by Golay and colleagues (2013), suggesting that unitary loadings between *g* and Fluid Reasoning may be an artifact of traditional CFA methods in which non-trivial subtest cross-loadings on first-order factors are fixed to zero.

Subsequent independent CFA analyses (e.g., Bangirana et al., 2009; Morgan, Rothlisberg, McIntosh, & Hunt, 2009; Reynolds, Keith, Flanagan, & Alfonso, 2013; Reynolds, Keith, Fine, Fisher, & Low, 2007) of the KABC-II have tended to support the structure described in the KABC-II manual. In the most substantive of these analyses, Reynolds and colleagues (2007) found that the five-factor CHC measurement model was a better fit to the KABC-II dataset than other rival measurement models, and that the model was invariant across age groups. However, in order to best fit the model, they had to add post-hoc paths (cross-loadings) between several of the subtests and the first-order factors, which almost always results in improved model fit (Canivez & Kush, 2013). Consistent with the results reported the KABC-II manual, the path loading between *g* and the Fluid Reasoning factor in the final model approached unity. Additionally, the study authors utilized a latent variable approach to decomposition subtest variance and found that all of the measures contained non-trivial portions of *g* variance (16%-53%).

Research on the relationships between KABC-II scores and scores on the Woodcock-Johnson III Tests of Achievement (WJ-III ACH; Woodcock, McGrew, & Mather, 2001) and

Wechsler Individual Achievement Test-Second Edition (WIAT-II; Wechsler, 2001) reported in the KABC-II manual (Kaufman & Kaufman, 2004b) showed that the FCI and the CHC factor scores provided moderate to strong prediction of academic achievement. Correlations between the KABC-II Crystallized Ability score and WJ-III ACH cluster scores ranged from .27 to .78. Similar correlation ranges were obtained for the KABC-II Fluid Reasoning score (.22 to .66), Visual Processing score (.10 to .67), Long-Term Storage & Retrieval (.23 to.53), and Short-Term Memory score (.24 to.44). Relationships between the KABC-II FCI composite score and WJ-III ACH cluster scores ranged from .42 to .81. It is worth noting that these cognitive-achievement relationships are consistent with those reported in the technical manuals of other contemporary cognitive measures such as the recently published Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V; Wechsler, 2014).

With respect to the KABC-II, inspection of the zero-order correlation coefficients between the CHC factor scores showed coefficients commensurate with those observed in other intelligence tests (e.g., WISC-V; WJ-IV; McGrew, Laforte, & Schrank, 2014). This suggests that a hierarchical analysis may find that the first-order factors contain relatively large proportions of *g* variance. The absence of apportioned subtest variance to the second-order dimension (*g*) and to the five first-order CHC factors (as insisted by Carroll, 1995) in the KABC-II manual does not allow KABC-II users to judge for themselves whether sufficient variance is captured by the factor scores for interpretation beyond the FCI (Canivez, 2014).

Since their inception, intelligence tests have often been utilized to predict achievement outcomes (Brown, Reynolds, & Whitaker, 1999; Gottfredson & Saklofske, 2009); thus additional consideration of external validity would be beneficial to practitioners who utilize the KABC-II in clinical practice. Specifically, given the fact that many of the subtest measures are estimated to contain large proportions of *g* variance (Reynolds et al., 2007), an examination of the incremental validity of the first-order scores beyond that of the second-order score is vital when cognitive measures are interpreted across multiple levels, as advocated for the KABC-II. Incremental validity is the “extent to which a measure adds to the prediction of a criterion beyond what can be predicted with other data,” (Hunsley, 2003, p. 443). Incremental validity is rooted in the scientific law of parsimony which states “what can be explained by fewer principles is needlessly explained by more” (Jones, 1952, p. 620). When applied to intelligence tests, interpretation of the full scale IQ score is more parsimonious than interpretation at the factor level. Thus, to interpret primarily at the first-order ability level, practitioners should have a compelling reason for doing so. Whereas some researchers have questioned the value of such conservative scientific guidelines (e.g., Hale, Fiorello, Kavanaugh, Holdnack, & Aloe, 2007; Weiss, Keith, Zhu, & Chen, 2013), Meehl (2002) argued that they are essential in research for protecting against the retention of spurious hypotheses.

Simultaneous interpretation of KABC-II scores is potentially confounded by the hierarchical nature of the instrument. Interpreting scores at multiple levels (i.e., full scale, factor scores, and subtest scores) ignores the fact that reliable subtest variance in all cognitive measures is multidimensional. That is, some common variance is apportioned to the general factor, some common variance is allocated to the broad cognitive abilities estimated by the first-order factors, and the remaining reliable variance (referred to as specificity) is unique to the subtest itself. Unfortunately, clinicians do not have a mechanism for disentangling these variances when interpreting measures at the level of the individual thus, interpretive redundancy may occur (Carroll, 1995).

Hierarchical multiple regression analysis is a well-established statistical procedure for assessing incremental validity in the social sciences and has been successfully applied in the technical literature in studies utilizing cognitive assessment data (Canivez, 2013b). In this procedure, the full scale score is entered first into a regression equation followed by the first-order factor scores to predict a criterion achievement variable. This entry technique allows for the predictive effects of the factor scores to be assessed while controlling for the effects of the full scale score and operates conceptually in very much the same way as the Schmid-Leiman procedure (1957) for residualizing variance in exploratory factor analysis.

Incremental validity studies using hierarchical multiple regression analysis have been conducted on various iterations of the Wechsler scales (Canivez, 2013a; Canivez, Watkins, James, James, & Good, 2014; Glutting, Watkins, Konold, & McDermott, 2006), the Cognitive Assessment System (Canivez, 2011), the Differential Ability Scales (Youngstrom, Kogos, & Glutting, 1999), the Reynolds Intellectual Assessment Scales (Nelson & Canivez, 2012), and the Woodcock-Johnson Tests of Cognitive Abilities-Third Edition (WJ-III COG; McGill, 2015; McGill & Busse, 2014). Across these studies, it was consistently demonstrated that the omnibus full scale score on intelligence tests accounted for most of the reliable achievement variance in the regression models and that little additional incremental variance was accounted for by factor scores after controlling for the predictive effects of the general factor. Information as to the incremental validity of the first-order KABC-II CHC scores in predicting achievement outcomes beyond that already accounted for by the FCI are not provided in the KABC-II manual. Additionally, a search of the empirical literature has yielded no related scientific investigations since the publication of the instrument.

## Purpose of Current Study

To address this gap in the literature, the incremental validity of the KABC-II CHC factor scores in accounting for Kaufman Test of Educational Achievement-Second Edition (KTEA-II; Kaufman & Kaufman, 2004c) test scores beyond that already accounted for by the FCI composite was examined. Given the results of previous incremental validity researches, it was anticipated that there would be limited incremental prediction of achievement beyond the FCI. The current study will provide users of the KABC-II with additional information regarding correct interpretation of the measurement instrument.

## Method

### Participants

Participants were children and adolescents ages 7-0 to 18-11 (*N* = 2,025) drawn from the KABC-II/KTEA-II standardization sample. Table 1 presents the relative proportions across demographics for sex, ethnicity, region, parent education level, and exceptionality status for the sample along with comparable 2001 U.S. census estimates. The participants ranged in grade from first grade to grade 12 with a mean age of 11.99 (*SD* = 3.27). The present sample was selected on the basis that it corresponded to the age ranges at which the CHC interpretive model could be fully specified (i.e., Kaufman & Kaufman, 2004b) as well as the fact that it permitted analyses of KABC-II cognitive-achievement relationships across a clinically relevant age span (e.g., primary and secondary school age).

### Measurement Instruments

**Kaufman Assessment Battery for Children-Second Edition.** The KABC-II is a multidimensional test of cognitive abilities for ages 3 to 18 years. The measure is comprised of 16 subtests, 11 of which contribute to the measurement of five CHC-based factor scores:

Crystallized Ability (Gc), Fluid Reasoning (Gf), Visual Processing (Gv), Long-Term Storage and Retrieval (Glr), and Short-Term memory (Gsm). The core subtests are linearly combined to form the full scale FCI composite. All factor and composite variables on the KABC-II are expressed as standard scores with a mean of 100 and a standard deviation of 15. The total norming sample (*N* = 3,025) is nationally representative based upon 2001 U.S. census estimates. Extensive normative and psychometric data can be found in the KABC-II manual (Kaufman & Kaufman, 2004b). Mean internal consistency estimates for the included ages in this study ranged from .88 to .93 for the factor scores. The mean internal consistency estimate for the FCI was .97. Validity evidence is provided in several forms in the KABC-II manual and independent reviews are available (e.g., Bain & Gray, 2008; Thorndike, 2005).

**Kaufman Test of Educational Achievement-Second Edition.** The KTEA-II is a comprehensive academic assessment battery designed to measure four academic domains: Reading, Mathematics, Written Language, and Oral Language. The KTEA-II is comprised of 14 subtests that combine to yield 4 domain composites and a total achievement composite score. All scores are expressed as standard scores with a mean of 100 and a standard deviation of 15. Mean internal consistency estimates for the included ages in this study ranged from .90 to .97 for the subtest and composite scores that were assessed. Additional technical information for the KTEA-II can be found in the KTEA-II manual (Kaufman & Kaufman, 2004d).

## Procedure

According to the KABC-II manual, all normative participants in the KABC-II dataset were administered measures from the KABC-II and the KTEA-II by trained examiners under the direct supervision of a standardization project member. Additionally, each examinee was given the measurement instruments in counterbalanced order.

## Data Analyses

Hierarchical multiple regression analyses were conducted to assess the proportions of KTEA-II score variance accounted for by the observed KABC-II FCI and CHC factor scores. The FCI score was entered into the first block, and the CHC factor scores were entered jointly into the second block of the SPSS version 21 linear regression analysis. CHC factor effects also were individually assessed by entering each factor score alone into the second block of the regression equation. KTEA-II analyses included the Reading Composite, Reading Comprehension, Math Composite, Math Concepts and Applications, Math Calculation, Written Language Composite, Written Expression, Oral Language Composite, and Comprehensive Achievement Composite scores as criterion variables. The change in the KTEA-II achievement variance predicted by the CHC factor scores in the second block of the regression model provided an estimate of the incremental prediction beyond the FCI in the first block of the model. According to Pedhazur (1997), these variance partitioning procedures are appropriate given the predictive nature of the current study.

The results were interpreted using the resulting $R^2$ statistic as an effect size. Guidelines for interpreting $R^2$ as an effect size are found in Cohen (1988); they are “small,” .01; “medium,” .09; and “large,” .25. The critical coefficient in hierarchical multiple regression analysis is the incremental squared multiple correlation coefficient ($\Delta R^2$). The $\Delta R^2$ represents the amount of variance that is explained by an independent variable (IV) after controlling for the effects of IVs previously entered in the regression equation. At present there are no conventional guidelines for interpreting the $\Delta R^2$ coefficient, thus Cohen’s interpretive framework for $R^2$ was applied.

Due to the fact that the KABC-II utilizes different subtest combinations to form the Visual Processing factor across the 7 to 18 age span (see Figure 1), separate analyses were conducted for ages 7 through 12 and 13 through 18 to account for these effects.

## Results

The means, standard deviations, skewness, and kurtosis statistics for all of the study variables are listed in Table 2. The mean (99.60 to 100.19) and standard deviation ranges (14.08 to 15.14) for the cognitive and achievement variables generally reflect values that would be expected for normally distributed standard score variables. Skewness values provided evidence of normally distributed symmetry for all the variables, ranging from -0.06 to 0.09. Additionally, inspection of the residual plots of the data indicated that the regression models utilized in this study met the assumptions for homoscedasticity of the residuals. Zero-order correlations between the KABC-II independent variables across both age ranges are reported in Table 3. Correlations between the FCI and first-order factor scores ranged from .64 to .82 at ages 7-12 and .68 to.81 at ages 13-18, indicating significant overlap between cognitive measures across the age span.

### Ages 7 to 12 (*n* = 1,142)

Table 4 presents the results from hierarchical multiple regression analyses for the KTEA-II scores for participants aged 7 to 12 years. In order to account for potential inflationary effects resulting from multiple statistical comparisons, the Type I error rate was estimated using the guidelines in Cohen, Cohen, West, and Aiken (2003). It was determined that the investigation-wise error rate, with α set at .05, was in the vicinity of .18. To control for the increase in Type I error, the statistical significance of $R^2/\Delta R^2$ was evaluated after adjusting the critical α level using the Bonferroni correction for multiple comparisons (Mundform, Perett, Schaffer, Piconne, & Rooseboom, 2006). The FCI accounted for statistically significant (investigation-wise, $p < .008$)

portions of each of the KTEA-II achievement scores. Across the 9 regression models utilized to predict Reading, Reading Comprehension, Math, Math Concepts and Applications, Math Calculation, Written Language, Written Expression, Oral Language, and Comprehensive Achievement skills on the KTEA-II, the FCI accounted for 30% (Math Calculation) to 62% (Comprehensive Achievement; *Mdn* = 49%) of the criterion variable variance. The $R^2$ values that corresponded to those variance increments all indicate large effects using Cohen's interpretive guidelines.

CHC factor scores entered jointly into the second block of the regression equations accounted for 1% (Math Composite, Math Calculation, and Written Expression) to 6% (Oral Language Composite; *Mdn* = 2%) of the incremental variance. The $\Delta R^2$ values that corresponded to those variance increments were indicative of small effects. The incremental variance coefficients attributed to individual KABC-II CHC factor scores ranged from 0% to 5%, with only the Crystallized Ability factor in the Oral Language Composite model ($\Delta R^2{}_{Gc} = .05$) accounting for more than 3% of achievement variance. Although tests of significance indicated that the CHC factors on the KABC-II contributed statistically significant portions of incremental achievement variance beyond the effects of the FCI, effect size estimates were consistently small across all of the prediction models for the 7 to 12 age group. A post hoc power analysis revealed that for each of the IV blocks, $R^2/\Delta R^2$ effect sizes of less than .02 could be reliably detected with $\alpha$ set at .008, with power at .90 or greater in all of the regression models.

### Ages 13 to 18 (*n* = 883)

Table 5 presents the results from hierarchical multiple regression analyses for the KTEA-II scores for participants aged 13 to 18 years. The FCI accounted for statistically significant (investigation-wise, $p < .008$) portions of each of the KTEA-II achievement scores. Across the 9 regression models utilized to predict Reading, Reading Comprehension, Math, Math Concepts and Applications, Math Calculation, Written Language, Written Expression, Oral Language, and Comprehensive Achievement skills on the KTEA-II, the FCI accounted for 42% (Written Expression) to 65% (Comprehensive Achievement; *Mdn* = 47%) of the criterion variable variance. The $R^2$ values that corresponded to those variance increments all indicate large effects.

CHC factor scores entered jointly into the second block of the regression equations accounted for 1% (Math Composite and Math Calculation) to 8% (Oral Language Composite; *Mdn* = 4%) of the incremental variance. The $\Delta R^2$ values that corresponded to those variance increments were indicative of small effects. The incremental variance coefficients attributed to individual KABC-II CHC factor scores ranged from 0% to 7%, with only the Crystallized Ability factor in the Oral Language Composite model ($\Delta R^2{}_{Gc}$ = .07) accounting for more than a negligible proportion of achievement variance. Although tests of significance indicated that the CHC factors on the KABC-II contributed statistically significant portions of incremental achievement variance beyond the effects of the FCI, effect size estimates were consistently small across all of the prediction models for the 13 to 18 age group. A post hoc power analysis revealed that $R^2/\Delta R^2$ effect sizes of less than .02 could be reliably detected with $\alpha$ set at .008, with power at .78 for the joint blocks and .94 for the individual predictor blocks.

## Discussion

The present study assessed the incremental validity of KABC-II CHC factor scores in predicting achievement beyond that provided by the FCI. Hierarchical multiple regression analyses were used to assess the extent to which KABC-II factor scores provided meaningful improvements in prediction of KTEA-II scores beyond that already accounted for by the FCI composite. Across both age samples, the FCI accounted for statistically significant proportions of achievement in all of the regression models, with clinically significant effect size estimates. This finding is consistent with previous incremental validity researches of other intelligence test measures and samples (e.g., Canivez, 2013a; Glutting et al., 2006; McGill & Busse, 2014), as well as Thorndike's (1986) observation that the vast majority of predictable variance in criterion variables (e.g., achievement measures) is accounted for by the full scale score from a cognitive test battery.

Statistically significant improvements in prediction of KTEA-II scores were provided by the combination of KABC-II CHC factor scores for all of the KTEA-II achievement variables that were assessed. However, corresponding effect size estimates were consistently small ($\Delta R^2 \leq .08$). It is worth noting that in several of the of the KTEA-II regression models (e.g., Reading Composite, Reading Comprehension, and Oral Language Composite) for the adolescent (ages 13 to 18) sample, the incremental predictive effects of the CHC factors entered jointly approached the medium effect size threshold. Though inspection of the coefficients associated with the individual factors indicated that, in isolation, none of the KABC-II CHC factors provided for meaningful incremental predictive effects, and that most of the additional predictive variance was subsumed by the Crystallized Ability factor alone. Although direct comparisons of KABC-II factor score incremental validity in predicting KTEA-II outcomes are not possible as there appear to be no published studies of the incremental validity of the KABC-II measurement instrument in the empirical literature, these results, with respect to the additional variance accounted for by the KABC-II Crystallized Ability factor, are consistent with similar research conducted on other intelligence tests that are modeled according to CHC theory (e.g., McGill & Busse, 2014).

When considering why the CHC factors generally failed to account for meaningful achievement variance beyond the FCI, it is important to remember that all factor-level scores on intelligence tests are comprised of various mixtures of common, unique, and error variances. In a previous examination of the structural validity of the KABC-II, Reynolds et al. (2007), found that all of the KABC-II subtest measures contained non-trivial portions of common variance associated with the second-order dimension (*g*). The results from the present study suggest that when that *g* variance is accounted for in in the first-order CHC factors there is little reliable unique variance left that is useful for predicting norm-referenced achievement on the KTEA-II. The current findings are especially relevant for practitioners who utilize the KABC-II to assess individuals suspected of having a learning disability (LD). Emerging models of LD identification see Flanagan & Alfonso, 2011) encourage practitioners to evaluate relationships between an individual's profile of cognitive strengths and weaknesses and their relationship to achievement indicators. Whereas it may be possible for practitioners to account for general factor effects when interpreting primarily at the first-order ability level, contemporary LD identification models have yet to provide a mechanism for doing so.

Consistent with previous incremental validity researches using cognitive measures, multicollinearity between the FCI and the first-order factor scores was observed across all of the multiple regression analyses in the current study. Multicollinearity refers to a potential threat to validity in multiple regression research that is introduced when a prediction model utilizes independent variables (IVs) that are significantly correlated (Pedhazur, 1997). According to Canivez (2013a), this redundancy is precisely the problem that practitioners must confront when simultaneously interpreting full scale and factor-level scores on intelligence tests such as the KABC-II. , Additionally, it should be noted that multicollinearity is not a threat to validity in predictive studies that are limited to interpreting the $R^2$ statistic (Cohen et al., 2003), nor does it invalidate the use of hierarchical multiple regression analysis to detect improvements in $R^2$ such as those provided by the CHC factor scores beyond the FCI composite (Schneider, 2008). As previously discussed, all of the CHC-clusters on the KABC-II contain common variance associated with the FCI. Unfortunately, practitioners do not have the ability to disaggregate variance when interpreting individual score profiles at the observed level (Schenider, 2013). As a result, practitioners who interpret CHC factor scores on the KABC-II, without accounting for the effects of the FCI risk overestimating the predictive effects of various CHC-related abilities (Glutting, et al., 2006).

Due to the hierarchical structure of the KABC-II measurement instrument, the importance of order of entry when utilizing hierarchical multiple regression analysis to assess the incremental effects of IVs must also be considered. Hale, Fiorello, Kavanaugh, Holdnak, and Aloe (2007) demonstrated that by entering the first-order factor scores from a previous iteration of the Wechsler Intelligence Scale prior to entering the full scale score, the predictive effects of the full scale score were diminished to the point of being inconsequential. As a result, Hale and colleagues argued that order of entry arbitrarily determines whether scores such as the FCI mean everything or nothing due to the long established fact that variables entered into a regression equation capture greater criterion variance than variables entered later (Cohen et al., 2003). However, order of entry is not an arbitrary process and must be determined *a priori* according to expected theoretical relationships between variables (Pedhazur, 1997). The proposed indirect hierarchical structural model for the KABC-II support entering the FCI prior to the first-order factors due to the fact that the factor scores are subordinate to the FCI. Reverse entry conflicts with existing intelligence theory and violates the scientific law of parsimony (Canivez, 2013b; Schneider, 2008).

As previously noted, due to the predictive nature of the study, hierarchical multiple regression analysis was used to examine the incremental predictive effects of observed-level variables on the KABC-II. According to Pedhazur (1997), predictive studies are concerned primarily with determining the most optimal variables or set of variables for predicting an external criterion with a specific sample, whereas in explanatory investigations the goal of the research is to shed light on a relationship with results that will generalize to the population. Whereas this necessarily limits the generalizability of the findings, it is worth noting that the present study utilized the same variables and reference sample upon which users of the KABC-II base their interpretive judgments in clinical practice. Nevertheless, alternative analysis (e.g., Beaujean, Parkin, & Parker, 2014) using structural equation modeling (SEM) would be beneficial for examining explanatory relationships between latent KABC-II dimensions and KTEA-II (or its current iteration) dimensional variance.

While some may interpret the results of this study as indicating that the FCI is the only score worth interpreting on the KABC-II for the purposes of predicting achievement via the CHC interpretive model, this viewpoint may be too one-sided. While an accumulation of scientific evidence (e.g., Canivez, 2013b; Gottfredson, 2002; Schmidt & Hunter, 2004) clearly suggests that second-order full scale cognitive ability scores (e.g., the FCI) are the most parsimonious and reliable point of clinical interpretation if the primary purpose of an evaluation is to predict a broad range of important life outcomes, additional consideration of broad first-order abilities may be of interest to practitioners when diagnosing specific neurocognitive disorders such as specific learning disability (Decker, Hale, & Flanagan, 2013; Keith, 1994).

Despite this implication, users should bear in mind additional psychometric issues that have been raised regarding the diagnostic utility (Watkins, 2000) and long-term stability of such part scores (e.g., Canivez & Watkins, 2001; Watkins & Glutting, 2000) when engaging in diagnostic decision-making. Across multiple cognitive measures it was found that participant part scores fluctuated significantly across various test-retest interval periods diminishing the legitimacy of analyses of score patterns and profiles for individual decision making. In contrast, the stability of the full scale composite IQ score was found to be adequate. Moreover, a recent examination of the WISC-IV (McDermott, Watkins, & Rhoad, 2014) found that assessor bias accounted for non-trivial portions of part score variance across a sample of 2,783 children evaluated for special education eligibility suggesting that clinical inferences from such measures are vitiated by elements of score variation that have nothing to do with actual differences among those latent dimensions. Accordingly, clinicians are encouraged to interpret KABC-II part scores (e.g., CHC factors) with caution until additional evidence is provided to document their technical and/or clinical efficacy.

In sum, the current results suggest users of the KABC-II must be mindful of the influence of the general ability dimension regardless of the level of interpretation (Kranzler & Floyd, 2013; Weiss et al., 2013a), and that additional interpretation of part scores beyond the FCI composite may result in misguided interpretation of the measurement instrument (e.g., Watkins, 2009).

## Limitations

This study is not without limitations that should be considered when interpreting the results. The most important limitation of the present study is the use of an archived standardization sample. Although the sample was relatively large and nationally representative, additional research is needed to determine if these results generalize to specific clinical populations (e.g., individuals suspected of having a learning disability). Research conducted on referred samples (e.g., Nelson & Canivez, 2011; Nelson, Canivez, & Watkins, 2013) suggest that the incremental contribution of first-order factor scores may be higher in specific contexts. The information obtained from such studies is critical for establishing evidence-based standards for clinical interpretation of cognitive measures such as the KABC-II.

Additionally, although improvements in prediction at the first-order level as well as diminished effects associated with the second-order dimension were observed in the older subgroup, the changes were relatively trivial, which is consistent with previous differentiation research that has taken into account the effects of the general factor (e.g., Gignac, 2014; Tucker-Drob, 2009). As was previously discussed, most of the improvements in first-order prediction in the adolescent subgroup were accounted for by the Crystallized Ability factor, which is consistent with the investment theory proposed by Cattell (1987). Cattell argued that cognitive resources are invested selectively in the environment, resulting in the development of specific broad abilities over others. Nevertheless this finding should be interpreted cautiously given the limitations of the methods employed in the present study as well as the potential confound of construct overlap between the predictor and the criterion measure (cf., Kaufman, Reynolds, Liu, Kaufman, & McGrew, 2012). Additional research examining the potential moderating effects of age-differentiation on the predictive validity of cognitive abilities would benefit users who utilize cognitive measures to assess examinees across the age span.

Finally, although adequate power to estimate small to moderate effects was obtained in the current study, the power analysis results from the adolescent (ages 13 to 18) subgroup indicate that the joint entry of multiple IVs in the second block of the HMR regression equations resulted in diminished power, even in the presence of a relatively large sample size. This finding must be considered when conducting similar research with samples smaller than those used in the current study, as is common when conducting incremental validity research with referred or clinical samples. To this author’s knowledge this is the first incremental validity study to report separate power analysis for the joint entry procedure as well as the examination of the effects of individual first-order cognitive predictors.

## Conclusion

The results of this study do not support the recommendation in the KABC-II manual (Kaufman & Kaufman, 2004b), or other interpretive resources (e.g., Kaufman et al., 2005; Singer et al., 2012) that the CHC factor scores should be the primary point of interpretation with this instrument. In contrast, the results indicate that the FCI should be given the greatest interpretive weight when using the CHC interpretive model because it accounted for the largest amount of variance across achievement indicators on the KTEA-II. The FCI consistently accounted for greater portions of achievement variance than that accounted for by the CHC factor scores. Therefore, users who forego interpreting the FCI in favor of the factor scores may risk over-interpretation of the measurement instrument. Additional research is needed to determine whether or not these results generalize to the alternative Lurian interpretive model. Such information is vital to assist in guiding empirically supported interpretation of data obtained by users of this measurement instrument.

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Table 1

*Demographic Information for the KABC-II Standardization Sample Administered the KTEA-II Ages 7-18 (N = 2,025)*

| Variable | *n* | Percent of Sample | Percent of U.S. Population[a] |
|---|---|---|---|
| Sex | | | |
| Female | 1,019 | 50.3 | 50.9 |
| Male | 1,006 | 49.7 | 49.1 |
| Ethnic Group | | | |
| White | 1,257 | 63.0 | 61.7 |
| Hispanic | 352 | 17.4 | 18.7 |
| African American | 286 | 14.1 | 15.3 |
| Other | 112 | 5.5 | 5.1 |
| Census Region | | | |
| South | 695 | 34.3 | 35.3 |
| North Central | 526 | 26.0 | 26.9 |
| West | 527 | 26.0 | 23.8 |
| Northeast | 277 | 13.7 | 19.2 |
| Mother's Education | | | |
| 11th Grade or Less | 301 | 14.9 | 14.3 |
| High School Graduate | 657 | 32.4 | 31.9 |
| 1-3 Years College | 603 | 29.8 | 30.3 |
| 4 Year Degree or Higher | 464 | 22.9 | 23.6 |
| Exceptionality Status | | | |
| Diagnosed or Classified | 429 | 21.2 | 22.4 |
| No Status | 1,596 | 78.8 | 77.6 |

*Note*. Demographic labels correspond to those reported in the KABC-II technical manual (Kaufman & Kaufman, 2004).
[a] 2001 *Current Population Survey* values.

Table 2

*Univariate Descriptive Statistics for KABC-II/KTEA-II Cognitive-Achievement Variables*

| Variables | *N* | *M* | *SD* | Skewness | Kurtosis |
|---|---|---|---|---|---|
| FCI | 2520 | 99.99 | 14.93 | 0.01 | 0.07 |
| Crystallized Ability | 2520 | 99.95 | 14.90 | 0.00 | 0.10 |
| Fluid Reasoning | 2028 | 100.07 | 14.97 | 0.02 | -0.01 |
| Visual Processing | 2520 | 100.06 | 14.97 | 0.00 | 0.03 |
| Long-Term Storage & Retrieval | 2520 | 100.06 | 15.04 | 0.02 | 0.00 |
| Short-Term Memory | 2520 | 100.13 | 15.00 | -0.02 | -0.07 |
| Reading Composite | 2147 | 99.60 | 15.03 | 0.03 | -0.08 |
| Reading Comprehension | 2147 | 99.75 | 14.75 | -0.03 | 0.37 |
| Mathematics Composite | 2328 | 99.95 | 14.72 | 0.01 | -0.05 |
| Math Concepts & Applications | 2520 | 99.84 | 14.86 | 0.09 | 0.18 |
| Math Calculation | 2328 | 100.02 | 14.08 | -0.04 | 0.28 |
| Written Language Composite | 2145 | 99.90 | 14.95 | 0.01 | -0.03 |
| Written Expression | 2520 | 99.69 | 15.14 | -0.06 | 0.07 |
| Oral Language Composite | 2520 | 100.19 | 14.84 | 0.02 | -0.02 |
| Comprehensive Achievement | 2145 | 99.86 | 15.00 | 0.01 | -0.08 |

*Note*. FCI = Fluid-Crystallized Index. Obtained values rounded to the nearest hundredth.

Table 3

*Zero-Order Correlation Coefficients between Independent Variables on the KABC-II*

| | Ages 7-12 | | | | | |
|---|---|---|---|---|---|---|
| Variable | FCI | Gc | Gf | Gv | Gsm | Glr |
| FCI | - | | | | | |
| Crystallized Ability (Gc) | .82 | - | | | | |
| Fluid Reasoning (Gf) | .80 | .61 | - | | | |
| Visual Processing (Gv) | .74 | .49 | .53 | - | | |
| Short-Term Memory (Gsm) | .64 | .41 | .38 | .35 | - | |
| Long-Term Storage & Retrieval (Glr) | .74 | .51 | .48 | .42 | .32 | - |

| | Ages 13-18 | | | | | |
|---|---|---|---|---|---|---|
| Variable | FCI | Gc | Gf | Gv | Gsm | Glr |
| FCI | - | | | | | |
| Crystallized Ability (Gc) | .81 | - | | | | |
| Fluid Reasoning (Gf) | .80 | .60 | - | | | |
| Visual Processing (Gv) | .73 | .45 | .54 | - | | |
| Short-Term Memory (Gsm) | .68 | .45 | .38 | .39 | - | |
| Long-Term Storage & Retrieval (Glr) | .75 | .55 | .50 | .43 | .39 | - |

*Note*. Values rounded to nearest hundredth. All coefficients were statistically significant ($p < .01$, two-tailed). FCI = Fluid Crystallized Index.

Table 4

*Incremental Contribution of Observed Kaufman Assessment Battery for Children-Second Edition CHC Factor Scores in Predicting Kaufman Test of Educational Achievement-Second Edition Scores beyond the FCI for Ages 7-12 (n = 1,142).*

| | Reading Composite | | | Reading Comprehension | | | Math Composite | | |
|---|---|---|---|---|---|---|---|---|---|
| Predictor | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] |
| FCI | .53* | - | 53% | .50* | - | 50% | .49* | - | 49% |
| CHC Factor Scores (*df* = 5)[a] | .56 | .03* | 3% | .53 | .03* | 3% | .50 | .01* | 1% |
| Crystallized Ability | .55 | .02* | 2% | .52 | .02* | 2% | .49 | .01* | 1% |
| Fluid Reasoning | .53 | .00 | 0% | .50 | .00 | 0% | .49 | .00 | 0% |
| Visual Processing | .54 | .01* | 1% | .51 | .01* | 1% | .49 | .00 | 0% |
| Long-Term Storage & Retrieval | .53 | .00 | 0% | .50 | .00 | 0% | .49 | .01* | 1% |
| Short-Term Memory | .53 | .00 | 0% | .50 | .00 | 0% | .49 | .00 | 0% |

| | Math Concepts & Applications | | | Math Calculation | | | Written Language Composite | | |
|---|---|---|---|---|---|---|---|---|---|
| | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] |
| FCI | .52* | - | 52% | .30* | - | 30% | .42* | - | 42% |
| CHC Factor Scores (*df* = 5)[a] | .55 | .03* | 3% | .31 | .01* | 1% | .44 | .02* | 2% |
| Crystallized Ability | .53 | .01* | 1% | .30 | .00 | 0% | .42 | .00 | 0% |
| Fluid Reasoning | .52 | .00 | 0% | .30 | .00* | 0% | .42 | .00 | 0% |
| Visual Processing | .52 | .00 | 0% | .30 | .00 | 0% | .43 | .01* | 1% |
| Long-Term Storage & Retrieval | .53 | .01* | 1% | .30 | .00 | 0% | .43 | .00* | 0% |
| Short-Term Memory | .52 | .00 | 0% | .30 | .00 | 0% | .42 | .00 | 0% |

| | Written Expression | | | Oral Language Composite | | | Comprehensive Achievement | | |
|---|---|---|---|---|---|---|---|---|---|
| | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] |
| FCI | .36* | - | 36% | .44* | - | 44% | .62* | - | 62% |
| CHC Cluster Scores (*df* = 5)[a] | .37 | .01* | 1% | .49 | .06* | 6% | .64 | .02* | 2% |
| Crystallized Ability | .37 | .00 | 0% | .48 | .05* | 5% | .64 | .02* | 2% |
| Fluid Reasoning | .36 | .00 | 0% | .44 | .01* | 1% | .62 | .00 | 0% |
| Visual Processing | .37 | .01* | 1% | .44 | .01* | 1% | .63 | .00* | 0% |
| Long-Term Storage & Retrieval | .37 | .00 | 0% | .44 | .00 | 0% | .62 | .00 | 0% |
| Short-Term Memory | .36 | .00 | 0% | .44 | .00 | 0% | .62 | .00 | 0% |

*Note*. FCI = Fluid-Crystallized Index score. CHC = Cattell-Horn-Carroll factor scores. All coefficients rounded to nearest hundredth, may not equate due to rounding.

[a] Degrees of freedom reflects controlling for the effects of the FCI.
[b] Represents proportion of variance accounted for by variables at their entry point into regression equation. $R^2/\Delta R^2$ values multiplied by 100.
*Investigation-wise, $p < .008$.

Table 5

*Incremental Contribution of Observed Kaufman Assessment Battery for Children-Second Edition CHC Factor Scores in Predicting Kaufman Test of Educational Achievement-Second Edition Scores beyond the FCI for Ages 13-18 (n = 883).*

| | Reading Composite | | | Reading Comprehension | | | Math Composite | | |
|---|---|---|---|---|---|---|---|---|---|
| Predictor | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] |
| FCI | .57* | - | 57% | .47* | - | 47% | .53* | - | 53% |
| CHC Factor Scores (*df* = 5)[a] | .63 | .07* | 7% | .53 | .07* | 7% | .54 | .01* | 1% |
| Crystallized Ability | .63 | .06* | 6% | .53 | .06* | 6% | .53 | .01* | 1% |
| Fluid Reasoning | .57 | .00 | 0% | .47 | .00 | 0% | .53 | .00 | 0% |
| Visual Processing | .59 | .02* | 2% | .48 | .01* | 1% | .53 | .00 | 0% |
| Long-Term Storage & Retrieval | .57 | .00 | 0% | .47 | .00 | 0% | .53 | .00 | 0% |
| Short-Term Memory | .57 | .00 | 0% | .47 | .00 | 0% | .53 | .01* | 1% |

| | Math Concepts & Applications | | | Math Calculation | | | Written Language Composite | | |
|---|---|---|---|---|---|---|---|---|---|
| | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] |
| FCI | .52* | - | 52% | .43* | - | 43% | .44* | - | 44% |
| CHC Factor Scores (*df* = 5)[a] | .53 | .02* | 2% | .44 | .01* | 1% | .49 | .04* | 4% |
| Crystallized Ability | .52 | .01* | 1% | .43 | .00 | 0% | .47 | .03* | 3% |
| Fluid Reasoning | .52 | .00 | 0% | .43 | .00 | 0% | .44 | .00 | 0% |
| Visual Processing | .52 | .00 | 0% | .43 | .00 | 0% | .46 | .02* | 2% |
| Long-Term Storage & Retrieval | .52 | .00 | 0% | .43 | .00 | 0% | .45 | .00 | 0% |
| Short-Term Memory | .52 | .01* | 1% | .43 | .00 | 0% | .45 | .00 | 0% |

| | Written Expression | | | Oral Language Composite | | | Comprehensive Achievement | | |
|---|---|---|---|---|---|---|---|---|---|
| | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] | $R^2$ | $\Delta R^2$ | Increment (%)[b] |
| FCI | .42* | - | 42% | .47* | - | 47% | .65* | - | 65% |
| CHC Cluster Scores (*df* = 5)[a] | .46 | .04* | 4% | .55 | .08* | 8% | .70 | .04* | 4% |
| Crystallized Ability | .44 | .02* | 2% | .54 | .07* | 7% | .70 | .04* | 4% |
| Fluid Reasoning | .43 | .00 | 0% | .47 | .00 | 0% | .65 | .00 | 0% |
| Visual Processing | .44 | .01* | 1% | .49 | .02* | 2% | .66 | .01* | 1% |
| Long-Term Storage & Retrieval | .42 | .00 | 0% | .48 | .00 | 0% | .65 | .00 | 0% |
| Short-Term Memory | .43 | .00 | 0% | .47 | .00 | 0% | .66 | .00 | 0% |

*Note*. FCI = Fluid-Crystallized Index score. CHC = Cattell-Horn-Carroll factor scores. All coefficients rounded to nearest hundredth, may not equate due to rounding.

[a] Degrees of freedom reflects controlling for the effects of the FCI.
[b] Represents proportion of variance accounted for by variables at their entry point into regression equation. $R^2/\Delta R^2$ values multiplied by 100.
*Investigation-wise, $p < .008$.

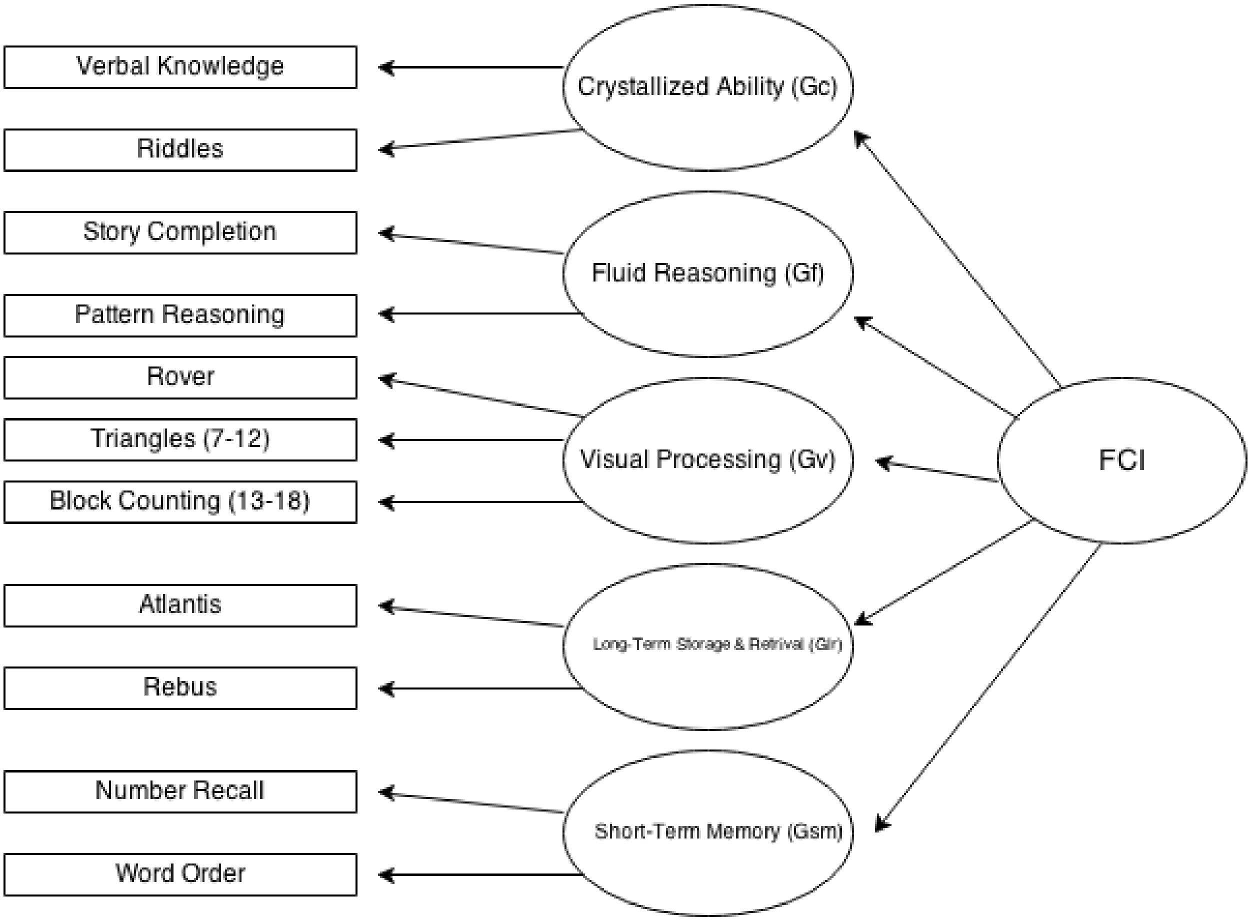

*Figure 1*. Indirect hierarchical Cattell-Horn-Carroll (CHC) interpretive model for the KABC-II. Adapted from the KABC-II Technical Manual (Kaufman & Kaufman, 2004b)