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Exploratory Higher Order Analysis of the Luria Interpretive Model on the Kaufman Assessment Battery for Children-Second Edition (KABC-II) School-Age Battery

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Abstract

Higher order factor structure of the Luria interpretive scheme on the Kaufman Assessment Battery for Children-Second Edition (KABC-II; Kaufman & Kaufman, 2004a) for the 7–12 and 13–18 age groups in the KABC-II normative sample (*N* = 2,025) is reported. Using exploratory factor analysis, multiple factor extraction criteria, and hierarchical exploratory factor analysis (Schmid & Leiman, 1957) not included in the *KABC-II Manual* (Kaufman & Kaufman, 2004b), two-, three-, and four-factor extractions were analyzed to assess the hierarchical factor structure by sequentially partitioning variance appropriately to higher order and lower order dimensions as recommended by Carroll (1993; 1995). No evidence for a four-factor solution was found. Results showed the largest portions of total and common variance were accounted for by the second-order general factor and that interpretation should focus primarily, if not exclusively, at that level of measurement.

Keywords: KABC-II, Exploratory factor analysis, Intelligence, Schmid-Leiman procedure

Exploratory Higher Order Analysis of the Luria Interpretive Model on the Kaufman Assessment Battery for Children-Second Edition (KABC-II) School-Age Battery

Slightly over two decades after the publication of its predecessor, the Kaufman Assessment Battery for Children-Second Edition (KABC-II; Kaufman & Kaufman, 2004a) was published and provided an update to one of the first theory-based, empirically grounded norm-referenced measures of cognitive assessment (Keith, 1985). The KABC-II 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 is grounded in a dual theoretical foundation featuring elements of Luria's neuropsychological model (1973) as well as the Cattell-Horn-Carroll (CHC) theory of cognitive abilities (Schneider & McGrew, 2012). One of the features of the KABC-II is the flexibility that it affords the examiner in determining the appropriate interpretive scheme to apply to the subtests that are administered to the examinee. Examiners may select either the Luria or CHC interpretive schemes, though they must decide which model to use prior to testing. The interpretive models differ both in terms of factor structure (e.g., four factors versus five) as well as in content specifically as it relates to the inclusion of measures of acquired knowledge. The Luria model emphasizes the role of cognitive processing, while de-emphasizing acquired knowledge (i.e., omitting measures of Crystallized Ability from the CHC model).

Although the Manual (Kaufman & Kaufman, 2004b) advises users to interpret the KABC-II primarily from the CHC perspective, the Luria model is preferred in a variety of situations, including but not limited to, examining individuals from culturally and linguistically diverse backgrounds, assessing individuals known or suspected of having autism spectrum disorder, and examining individuals with hearing or language deficits (Kaufman, Lichtenberger, Fletcher-Janzen, & Kaufman, 2005). Not surprisingly, in a recent survey of 323 school psychologists, Sotelo-Dynega and Dixon (2014) found that the KABC-II was the preferred cognitive test battery of 20.4% of the practitioners surveyed when examining individuals from culturally and linguistically diverse backgrounds, making it the most popular measurement instrument for use in such circumstances. Due to the versatility of the measurement instrument, it has been utilized in a variety of clinical disciplines including but not limited to school psychology, clinical psychology, and pediatric neuropsychology (Gallagher & Sullivan, 2011).

Whereas a wealth of psychometric information is provided in the Manual (Kaufman & Kaufman, 2004b) for the CHC model, equivalent information for the Luria model is absent. This is unfortunate as subsequent independent validity studies (e.g., Bangirana et al., 2009; Kaufman et al., 2012; Morgan, Rothlisberg, McIntosh, & Hunt, 2009; Reynolds, Keith, Flanagan, & Alfonso, 2013; Reynolds, Keith, Fine, Fisher, & Low, 2007) of the KABC-II have been limited to examining the fidelity of the CHC model. For example, Reynolds and colleagues (2007) found that a five factor CHC model was a better fit to the KABC-II dataset than rival measurement models, and that the model was invariant across age groups. However these results, no matter how persuasive, cannot be taken as *de facto* evidence for the validity of the Luria model because the CHC and Luria measurement models are not structurally equivalent (Cattell, 1978). Thus, until additional empirical evidence is provided, it cannot be assumed that the same constructs are measured in the Luria model (Nelson, Canivez, & Watkins, 2013).

Although the four first-order Luria factor scores are consistent with respect to content as their counterparts in the CHC interpretive model, relationships between these latent dimensions and the resulting full scale composite (MPI) are presently unknown. Interestingly, no discussion or attempt to examine convergent validity with variables from the Cognitive Assessment System (CAS; Naglieri & Das, 1997) was made in the Manual which is noteworthy given that the CAS (recently revised as the CAS2) is the only individually administer measure of cognitive ability that purports to measure similar Luria constructs.

Despite the substantive structural and theoretical revisions to the KABC-II, the test authors relied exclusively upon restricted confirmatory factor analysis (CFA) to examine the structural validity of the instrument. Again, these analyses were limited to examining the tenability of the CHC model. It is also worth noting that all subsequent construct validity studies of the KABC-II have relied exclusively on CFA methodologies. However, overreliance on CFA procedures for examining the internal structure of intelligence tests can result in the retention of poorly defined factors and has been criticized within the technical literature (Canivez, 2013; Canivez & Watkins, 2010; Frazier & Youngstrom, 2007; Thompson, 2004). Methodologists have consistently recommended that exploratory factor analytic (EFA) procedures be used to compliment CFA procedures especially when evaluating a new test or theory (Gorsuch, 1983; Haig, 2005; Gerbing & Hamilton, 1996; Mulaik, 1987; Schmitt, 2011). Without the presentation of EFA procedures with the KABC-II norming sample data, clinicians are not able to consider the convergence or divergence of CFA and EFA results for the measurement instrument.

The absence of traditional exploratory procedures (e.g., EFA) was justified by the test authors on the basis that these techniques have “a difficult time differentiating between highly correlated abilities” (p. 103). Ironically, EFA procedures have been recommended specifically (Carretta & Ree, 2001; Carroll, 1995; Thompson, 2004) for exploring tests in which factors reflect the hierarchical and highly correlated nature of the cognitive variables measured by the KABC-II. Because lower order factors are abstractions of measured variables, interpreting a higher order factor on the basis of the relationships between these variables can be misleading because performance on any cognitive subtest reflects both a mixture of general and first-order factors (Watkins & Beaujean, 2014). As a result, Carroll (1995) insisted that it is necessary to decompose variance into components that can be sourced more appropriately to higher and lower order dimensions. To accomplish this task, he recommended second-order factor analysis of first-order factor correlations followed by a Schmid-Leiman transformation (Schmid & Leiman, 1957). When applied to factor analytic solutions, the Schmid-Leiman procedure allows for the calculation of first-order subtest loadings that are independent of the influence a higher order general factor (Wolff & Preising, 2005). According to Carroll (1995):

> I argue, as many have done, that from the standpoint of analysis and ready interpretation, results should be shown on the basis of orthogonal factors, rather than oblique, correlated factors. I insist, however, that the orthogonal factors should be those produced by the Schmid-Leiman (1957) orthogonalization procedure, and thus include second-stratum and possibly third-stratum factors (p. 437).

Also missing from the KABC-II Technical Manual were proportions of variance accounted for by the higher order factor (MPI) and the four first-order Luria factors, higher order subtest loadings, and subtest specificity estimates. At present, clinicians do not have the information necessary for determining the relative importance of the KABC-II factor and subtest scores relative to the full scale MPI score which can result in over-interpretation of lower order factors at the expense of the higher order factor (Carretta & Ree, 2001). If the Luria factor or subtest scores fail to capture meaningful portions of true score variance they will likely be of limited clinical utility.

To date, the KABC-II Luria model has not been examined using higher order variance partitioning procedures such as these. The absence of EFA analyses in the manual as well as any direct examination of the Luria factor structure suggests that our understanding of the KABC-II test battery is presently incomplete. Given that the Manual (Kaufman & Kaufman, 2004b) as well as other interpretive resources and book chapters (e.g., Kaufman, Lichtenberger, Fletcher-Janzen, Kaufman, 2005; Singer et al., 2012) encourage users to primarily interpret at the first-order factor level, additional information regarding the integrity and potential clinical utility of these factors is needed in order to evaluate these claims.

Purpose and Goals of the Present Study

Given the structural differences between the KABC-II interpretive models and the popularity of the alternative Luria model amongst practitioners (e.g., Sotelo-Dynega & Dixon, 2014), there is a critical need to provide practitioners with information regarding the psychometric validity of the Luria model with potential applications for applied practice (Gallagher & Sullivan, 2011). Accordingly, the purpose of the present study is to (a) examine the tenability of the proposed four-factor alternative Luria measurement model; and (b) examine the proportions of KABC-II subtest variance attributed to the higher order general dimension (MPI) and to the first-order Luria dimensions using the hierarchical exploratory factor analytic techniques described by Carroll (1993; 1995). Similar procedures have been utilized successfully to examine the structural integrity of many contemporary cognitive measures (e.g., Canivez, 2008; 2011; Canivez & Watkins, 2010; Dombrowski & Watkins, 2013; Dombrowski, Watkins, & Brogan, 2009; Nelson, Canivez, Lindstrom, & Hatt, 2007; Watkins, 2006).

The use of these procedures has consistently found that most of the reliable score variance at the first-order factor level is common variance attributable to the higher order general factor, with relatively small portions of reliable variance attributable to the associated first-order dimensions. It is believed that results from the current study will provide practitioners and researchers with important information regarding the correct interpretation of the KABC-II measurement instrument within clinical practice and will provide much needed information regarding the integrity of the proposed alternative Luria interpretive model.

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. Demographic characteristics are provided in detail in the KABC-II Manual (Kaufman & Kaufman, 2004b). The standardization sample was obtained using stratified proportional sampling across demographic variables of age, sex, race/ethnicity, parent educational level, and geographic region. Examination of the tables in the provided in the Manual revealed a close correspondence to the 2001 U. S. census estimates across the stratification variables. The present sample was selected on the basis that it corresponded to the age ranges at which the Luria interpretive model could be fully specified as well as the fact that it permitted analyses of relationships between cognitive variables across a clinically relevant age span (e.g., primary and secondary school age).

Measurement Instrument

The KABC-II is a multidimensional test of cognitive abilities for ages 3 to 18 years. The measure is comprised of 16 subtests, eight of which contribute to the measurement of four Luria-based factor scores in the school-age battery: Sequential Processing, Simultaneous Processing, Planning, and Learning. The core subtests are linearly combined to form the full scale MPI composite. It should be noted that from ages 3-6, the KABC-II utilizes different subtest measures and not all latent dimensions of the school-age Luria models are replicated.

The Luria measurement model for the KABC-II for ages 7-18 is outlined graphically in Figure 1. 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 MPI was .95. Validity evidence is provided in several forms in the KABC-II manual and independent reviews are available (e.g., Bain & Gray, 2008; Braden & Ouzts, 2005).

Procedure

KABC-II subtest correlation matrices utilized for the present analyses for the two school-age groups (ages 7-12 and 13-18) were obtained from the norming sample data and were exact reproductions of the matrices provided in Tables 8.12 and 8.13 of the Manual (Kaufman & Kaufman, 2004b). The KABC-II norming samples (ages 7-12 and 13-18) were used in separate EFAs due to different subtest compositions of the eight core subtests in the Luria model.

Data Analysis

Principal axis EFA (Fabrigar & Wegner, 2012; Fabrigar, Wegener, MacCallum, & Strahan, 1999) was used to analyze the reliable common variance from each of the two KABC-II norming sample correlation matrices representing the eight core subtests that combine to form the Luria interpretive model using SPSS version 21 for Windows. As recommended by Gorsuch (1983), multiple criteria for determining the number of factors to retain were examined. These procedures included the visual scree test (Cattell, 1966), Horn's parallel analysis (HPA; Horn, 1965), and minimum average partials (MAP; Velicer, 1976). While the scree test was used to visually determine the optimum number of factors to retain it is a subjective methodology. As recommended by Frazier and Youngstrom (2007), HPA and MAP were also included as they potentially protect against the threat of overfactoring in EFA. HPA indicated factors were meaningful when eigenvalues from the KABC-II norming sample data were larger than eigenvalues produced by random data simulations specified to contain the same number of participants and factors (Lautenschlager, 1989) produced from the norming data. Random data for HPA analyses was generated using the Monte Carlo PCA for Parallel Analysis program (Watkins, 2000) with 100 replications to produce stable estimates. MAP procedures were conducted using O'Connor's (2000) SPSS syntax program.

For higher order exploratory analyses, the current study limited iterations in first-order principle axis factor extraction to two in estimating final communality estimates. According to Gorsuch (2003), limiting iterations to two provides an optimal balance between sampling and measurement error in estimating communality. Each correlation matrix for the two KABC-II norming subsamples was subjected to a first-run EFA (principal axis extraction), followed by a promax (oblique) rotations ($k = 4$; Gorsuch, 2003). The resulting first-order factors were orthogonalized in a second-run by removing variance associated with the higher order general factor via the Schmid and Leiman (1957) procedure using the SPSS program by Wolff and Preising (2005). According to Schmid and Leiman (1957), this transforms "an oblique solution containing a hierarchy of higher order factors into an orthogonal solution which not only preserves the desired interpretation characteristics of the oblique solution, but also discloses the hierarchical structuring of the variables" (p. 53). As per Child (2006), salient factor loading coefficients were defined as those ≥ .30.

Results

Factor-Extraction Criteria

Parallel analysis (Horn, 1965) suggested that two factors be retained for the 7 to 12 age range and one factor for the 13 to 18 age range. The MAP (Velicer, 1976) criterion recommended retention of one factor for both age ranges. A visual scree test indicated evidence for one strong general factor with the possibility of two to three additional first-order factors. Given that it is better to over factor than under factor (Wood, Tataryn, & Gorsuch, 1996), we extracted two and three factors for both age groups. We also extracted four factors in accord with the theoretical structure delineated in the Manual (Kaufman & Kaufman, 2004b) in order to provide relevant results for clinicians who utilize the KABC-II in practice.

KABC-II Luria Model Core Subtests (ages 7-12)

The skewness and kurtosis statistics for all eight core subtests reflect values associated with normally distributed variables (Ferguson & Cox, 1993). EFA results produced a Kaiser-Meyer-Olkin Measure of Sampling Adequacy coefficient of .82 and Bartlett's Test of Sphericity $\chi^2 = 2{,}289.69$, $p < .001$. Communality estimates ranged from .33 (Rover) to .54 (Rebus). Based on these obtained values, it was determined that EFA procedures were appropriate (Tabachnick & Fiddell, 2007).

Two-Factor Higher order Solution. Results for the two-factor solution for the 7 to 12 age group of the KABC-II normative sample are presented in Table 1. The correlation between Factor 1 and Factor 2 from the promax rotation (k = 4) was .78 suggesting the presence of a higher order dimension. The second-order (general) factor accounted for 24.4% of the total variance and 60.2% of the common variance. The general factor also accounted for between 18% and 33% of individual subtest variability. At the first-order level, Factor I (Sequential Processing) accounted for an additional 5% of the total variance and 12.5% of the common variance whereas Factor II (combination of Planning, Learning, and Simultaneous Processing measures) accounted for an additional 11.1% of the total variance and 27.3% of the common variance. No cross-loadings were observed although the specification of a two-factor solution resulted in a complexly determined first-order factor (Factor 2) that challenges theoretical interpretation. The first- and second-order factors combined to measure 40.5% of the variance in KABC-II scores resulting in 59.5% unique variance (combination of specific and error variance). Subtest specificity (reliable variance unique to the individual measures) ranged from .32 to .54.

Three-Factor Higher order Solution. Results for the three-factor solution for the 7 to 12 age group are presented in Table 2. Correlations between the first-order factors ranged from .49 to .72 based on the promax rotation (k = 4), and indicated the presence of a higher order dimension. The second-order general factor accounted for 27.8% of the total variance and 65.7% of the common variance. The general factor also accounted for 17% to 44% of the individual subtest variability. At the first-order level, Factor 1 (Sequential Processing) accounted for an additional 7.4% of the total variance and 17.4% of the common variance, Factor 2 (Planning and

Simultaneous Processing) accounted for an additional 2.4% of the total variance and 5.8% of the common variance, and Factor 3 (Learning) accounted for an additional 4.7% of the total variance and 11% of the common variance. The first and second-order factors combined to measure 42.2% of the variance in KABC-II Luria scores resulting in 57.8% unique variance (combination of specific and error variance). Subtest specificity (reliable variance unique to the individual measures) ranged from .32 to .57.

Four-Factor Higher order Solution. Results for the four-factor solution for the 7 to 12 age group are presented in Table 3. Correlations between the first-order factors ranged from .36 to .53 based on the promax rotation ($k = 4$), and indicated the presence of a higher order dimension. The second-order *g* factor accounted for 26.7% of the total variance and 60.3% of the common variance. The general factor also accounted for 12% to 44% of the individual subtest variability. At the first-order level, Factor 1 (Sequential Processing) accounted for an additional 2.4% of the total variance and 5.5% of the common variance, Factor 2 (Planning) accounted for an additional 0.5% of the total variance and 1.1% of the common variance, Factor 3 (Learning) accounted for an additional 4% of the total variance and 9.1% of the common variance, and Factor 4 (Simultaneous Processing) accounted an additional 10.7% of the total variance and 24% of the common variance. KABC-II subtests were generally associated with the theoretically consistent Luria factors however, cross-loading was observed in that the Story Completion and Pattern Reasoning subtests had greater proportions of variance apportioned to the Simultaneous factor than to the Planning factor. The first and second-order factors combined to measure 44.3% of the variance in KABC-II Luria scores resulting in 55.7% unique variance (combination of specific and error variance). Subtest specificity (reliable variance unique to the individual measures) ranged from .33 to .48.

KABC-II Luria Model Core Subtests (ages 13-18)

The skewness and kurtosis statistics for all eight core subtests reflect values associated with normally distributed variables (Ferguson & Cox, 1993). EFA results produced a Kaiser-Meyer-Olkin Measure of Sampling Adequacy coefficient of .83 and Bartlett's Test of Sphericity $\chi^2 = 1{,}992.35$, $p < .001$. Communality estimates ranged from .38 (Story Completion) to .63 (Rebus). Based on these obtained values, it was determined that EFA procedures were appropriate (Tabachnick & Fiddell, 2007).

Two-Factor Higher order Solution. Results for the two-factor solution for the 13 to 18 age group of the KABC-II normative sample are presented in Table 4. The correlation between Factor 1 and Factor 2 from the promax rotation ($k = 4$) was .62 suggesting the presence of a higher order dimension. The second-order (general) factor accounted for 27% of the total variance and 63.3% of the common variance. The general factor also accounted for between 19% and 39% of individual subtest variability. At the first-order level, Factor I (Sequential Processing) accounted for an additional 4.9% of the total variance and 11.5% of the common variance whereas Factor II (combination of Planning, Learning, and Simultaneous Processing measures) accounted for an additional 10.8% of the total variance and 25.3% of the common variance. No cross-loadings were observed although Atlantis failed to load saliently on any individual factors. As with the 7 to 12 age group, specification of a two-factor solution resulted in a complexly determined first-order factor (Factor 2). The first- and second-order factors combined to measure 42.7% of the variance in KABC-II scores resulting in 57.3% unique variance (combination of specific and error variance). Subtest specificity (reliable variance unique to the individual measures) ranged from .29 to .47.

Three-Factor Higher order Solution. Results for the three-factor solution for the 13 to 18 age group are presented in Table 5. Correlations between the first-order factors ranged from .54 to .73 based on the promax rotation ($k = 4$), and indicated the presence of a higher order dimension. The second-order general factor accounted for 31.7% of the total variance and 68% of the common variance. The general factor also accounted for 19% to 47% of the individual subtest variability. At the first-order level, Factor 1 (Sequential Processing) accounted for an additional 7% of the total variance and 15% of the common variance, Factor 2 (Planning and Simultaneous Processing) accounted for an additional 4.1% of the total variance and 8.7% of the common variance, and Factor 3 (Learning) accounted for an additional 4.7% of the total variance and 11% of the common variance. The first and second-order factors combined to measure 46.7% of the variance in KABC-II Luria scores resulting in 53.3% unique variance (combination of specific and error variance). Subtest specificity (reliable variance unique to the individual measures) ranged from .29 to .46.

Four-Factor Higher order Solution. Results for the four-factor solution for the 13 to 18 age group are presented in Table 6. Correlations between the first-order factors ranged from .34 to .70 based on the promax rotation ($k = 4$), and indicated the presence of a higher order dimension. The second-order general factor accounted for 32% of the total variance and 67.5% of the common variance. The general factor also accounted for 17% to 51% of the individual subtest variability. At the first-order level, Factor 1 (Sequential Processing) accounted for an additional 7.5% of the total variance and 15.8% of the common variance, Factor 2 (Planning) accounted for an additional 1.1% of the total variance and 2.4% of the common variance, Factor 3 (Learning) accounted for an additional 3% of the total variance and 6.3% of the common variance, and Factor 4 (Simultaneous Processing) accounted an additional 3.8% of the total variance and 8.1% of the common variance. KABC-II subtests were generally associated with the theoretically consistent Luria factors however, cross-loading was observed in that the Pattern Reasoning subtest had greater proportions of variance apportioned to the Simultaneous factor than to the Planning factor. The first and second-order factors combined to measure 47.4% of the variance in KABC-II Luria scores resulting in 52.6% unique variance (combination of specific and error variance). Subtest specificity (reliable variance unique to the individual measures) ranged from .29 to .46.

Discussion

Given the absence of validity information in the KABC-II Technical Manual (Kaufman & Kaufman, 2004b) and in the available empirical literature for the alternative Luria interpretive model, additional information is needed to support use of these interpretive procedures in applied practice (Wasserman & Bracken, 2013). We are unaware of any EFA analyses that have been conducted on the KABC-II battery of tests. In almost a decade since its publication, this lack of independent evaluation is inexplicable give the ambitious claim by the test publisher that the measurement instrument can be interpreted from multiple, and in many respects, divergent interpretive frameworks (Flanagan, Alfonso, Ortiz, & Dynda, 2013). According to established psychometric standards (e.g., American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 2014), interpretive frameworks for measurement instruments must be empirically derived from psychometric examination of the psychological phenomena thought to best explain individual differences on those measures. In contrast to the claims made in the KABC-II Technical Manual, KABC-II measures do not mysteriously morph from CHC constructs to Luria dimensions simply because the examiner commits to one interpretive scheme over another (Braden & Ouzts, 2005;

Greenwald, Pratkanis, Leippe, & Baumgardner, 1986), nor does the omission of measures of Crystallized Ability suddenly convert the Fluid Reasoning composite into a Planning measure. Accordingly, the purpose of the present study was to examine the structural validity of the Luria interpretive model for the KABC-II across the school-age battery using higher order exploratory procedures. We believe that the results from these analyses will better inform interpretive practice with the KABC-II, especially for practitioners who elect to interpret the measurement instrument from the alternative Luria perspective.

EFA results using multiple factor extraction criteria suggested the extraction of only two to three factors for both age groups using the eight subtest Luria model configuration. These results did not comport with the four-factor measurement model suggested in the Manual. Despite these results, we force extracted four factors in order to better comport with publisher theory. The extraction of four factors resulted in highly correlated first-order dimensions, suggesting the presence of second-order general factor. Gignac (2007) has encouraged researchers to always perform orthogonalization procedures when examining higher order model solutions. Thus, in order to better understand the underlying structure of the Luria interpretive model, we utilized prescribed procedures (e.g., Carroll, 1993; 1995; Schmid-Leiman, 1957) in order to correctly apportion subtest variance appropriately to higher order and lower order dimensions.

The application of the Schmid and Leiman (1957) transformation to the KABC-II school-age norming sample demonstrated that variance for each of the core subtests that comprise the Luria interpretive model can be decomposed into multiple components. The most important of these components was a higher order latent dimension akin to *g*. General cognitive ability accounted for more variance in each of the Luria subtests than any of the proposed first-order factors. As an example, whereas *g* accounted for 36% and 46% of the reliable variance in the subtests comprising the Sequential Processing factor at ages 7-12, approximately 10% of the variance in these measures was attributable to Sequential Processing. As would be expected given the omission of measures of acquired knowledge in the Luria model, the manifestation of the general factor was somewhat weaker than has been observed in previous studies utilizing similar procedures to examine the higher order properties of other related measurement instruments (e.g., Canivez, 2008; Watkins, 2006). However, the combination of *g* and uniqueness overshadowed the contributions made by the four first-order Luria factors (see Tables 3 and 6). Nevertheless, meaningful common variance were accounted for by Simultaneous Processing (24%) at ages 7-12 as well as the Sequential Processing at ages 13-18 (15.8%), suggesting the Luria model may provide users with useful information as it relates to individual performance beyond *g* in certain circumstances.

Although KABC-II subtest loadings were generally consistent with their theoretically assigned factors, the four-factor model appears to be overfactored. No salient subtest loadings (e.g., ≥ .30; Child, 2006; Gorsuch, 1983) were evident for the Planning factor (Fluid Reasoning) at both age levels and only the Story Completion measure met suggested criteria for interpreting a measure as being "aligned" with a factor (e.g., coefficient ≥ .20; Carroll, 1993). These results suggest that Planning is not a viable latent dimension on the KABC-II as a common factor cannot be produced from a singlet loading in EFA (Nunnally & Bernstein, 1994; Preacher & MacCallum, 2003). Overextraction further resulted in theoretically inconsistent migration of the Planning measures to the Simultaneous Processing factor at ages 7-12. In consideration of these findings, it is worth noting that in similar factor analytic investigations (e.g., Dombrowski, Watkins, & Brogan, 2009; Nelson, Canivez, Lindstrom, & Hatt, 2007) where extraction tests were not supportive of the publisher specified measurement model, forcing of those models did not produce theoretically inconsistent factor loadings, which makes the present results even more puzzling.

Additional examinations of more empirically supported two- and three-factor solutions provided a clearer picture of the latent dimensions that may underlie the Luria interpretive scheme. While the more parsimonious two-factor measurement model produced viable common factors (e.g., salient loadings on each factor by multiple indicators) across both age groups, one of the these dimensions was complexly determined, combining measures from multiple Luria domains, thus confounding its interpretation. Furthermore, the Atlantis subtest cross-loaded on both first-order dimensions and failed to load saliently on any individual factors at ages 13-18 (see Table 4). In contrast, the three-factor solution provided the most consistent evidence for the viability of the Sequential Processing and Learning factors as salient subtest loadings on both measures was observed across both age levels. Although the remaining Luria subtests aligned to produce what may be interpreted as a more general “Visual Processing” factor, the residual loadings on this factor were noticeably weak as none of the subtests loaded saliently at ages 7-12, and only one salient loading (Block Counting) was observed at ages 13-18. Additionally, the general factor consistently accounted for the largest portions of total and common variance in both the two- and three-factor solutions.

Without a question, the KABC-II appears to have a complex first-order factor structure that does not satisfy simple structure with subtests having variance apportioned to more than one first-order factor. Additional research using more robust latent variable procedures in which these complex relationships can be modeled more effectively in various two- and three-factor solutions such as exploratory CFA (Asparouhov & Muthen, 2009) and Bayesian structural equation modeling (Golay et al., 2013) would greatly benefit users of the KABC-II. Although examination of a four-factor model is certainly possible via CFA, the relatively weak EFA subtest loadings for the Planning factor across the school-age span in the present study suggest that it is most likely a spurious latent dimension (Preacher & MacCallum, 2003). The current results are a first step in the process of better understanding the underlying structure of the proposed measurement model.

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 such as those referred for specific learning disability evaluations and other related neurological impairments. Given the neuropsychological foci of the Luria model, it would seem that this particular approach would be more beneficial to clinicians who evaluate individuals suspected of having more focal cortical injuries. Though as previously noted, the test authors curiously encourage use of the Luria model with examinee's who present with more generalized cultural and linguistic diverse backgrounds. As noted by Gallagher and Sullivan (2011), although several case studies have been published within the peer reviewed literature (e.g., Cohen, Park, Kim & Pallai, 2010; Donders, Mullarky, & Allchin, 2009), additional evidence supporting the use of the KABC-II in pediatric neuropsychology is needed.

Additionally, the results from the current study suggest that reliability estimates (i.e., coefficient alpha) provided in the KABC-II Manual (Kaufman & Kaufman, 2004b) may overestimate the reliability of the specified first-order Luria composite scores. Although coefficient alpha is commonly utilized in psychometrics to estimate reliability of cognitive measures such as those provided on the KABC-II, Chen et al. (2012) noted that “for multidimensional constructs, the alpha coefficient is complexly determined, and McDonald’s omega-hierarchical (ω_h; 1999) provides a better estimate for the composite score and should be used” (p. 228). The value of the omega coefficient is that it allows for the reliabilities of higher order and lower order variance within a composite to be partitioned and estimated separately. Thus providing practitioners with a more accurate model based reliability estimate that aligns with how these measures are interpreted in clinical practice (i.e., attributing the majority of individual performance to a particular first-order dimension). Unfortunately, the aforementioned cross-loading and theoretically inconsistent subtest migrations in the KABC-II data present a methodological confound as a well-fitting completely orthogonal bifactor model is a prerequisite for the calculation of omega coefficients (Reise, Moore, & Haviland, 2010).

Finally, research on the incremental validity of the KABC-II Luria scores would also likely aid users in diagnostic decision making given the hierarchical structure of the measurement instrument (Hunsley, 2003). Construct validity studies alone are not sufficient for determining the relative importance of higher order factors with respect to lower order factors. Recently, McGill (2015) examined the incremental validity of the KABC-II CHC interpretive model and found that the first-order factor scores accounted for mostly negligible to small amounts of achievement variance (1% to 7%) after the effects of the FCI were controlled. Though, as previously discussed, these results do not generalize to the Luria interpretive model.

Implications for Practice

Overall our results diverge from the four-factor model posited in the KABC-II Technical Manual and therefore suggest caution in moving to interpretation of first-order factors until additional research has been conducted. As a consequence, it is recommended that users of the KABC-II, who utilize the Luria interpretive model in practice, focus most of their interpretive weight on the MPI composite score. We would also like to stress that the effects of the higher order general dimension (MPI) on the KABC-II are not obviated by simply omitting the MPI score from clinical interpretation. The present study illustrates well the apportioned variance of subtests to each of the test levels. Our results suggest that all of the Luria subtest measures contain non-trivial variance attributable to the higher order MPI dimension. Thus, clinicians who wish to interpret beyond the MPI must account for its effects at every level of the KABC-II or risk overinterpetation of the measurement instrument (Glutting, Watkins, Konold, & McDermott, 2006). Unfortunately, examiners do not have the ability to disentangle higher order and lower order effects at the level of the individual (Schneider, 2013). Whereas, the KABC-II manual encourages users to interpret predominately at the factor or first-order level, we encourage practitioners to do so cautiously, if at all, until additional empirical evidence is provided in support of such recommendations.

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Table 1

Sources of Variance in the Kaufman Assessment Battery for Children-Second Edition Two-Factor Luria Interpretive Model for Ages 7-12 (n = 1,142) According to an Orthogonalized (Schmid & Leiman, 1957) Higher order Factor Model

	General		F1: SQ		F2: P/L/SM			
Subtest	*b*	Var	*b*	Var	*b*	Var	*h²*	*u²*
Number Recall	.514	.264	**.450**	.203	-.025	.000	.467	.533
Word Order	.573	.328	**.443**	.196	.031	.001	.526	.474
Story Completion	.457	.209	.018	.000	**.359**	.129	.338	.662
Pattern Reasoning	.553	.306	.052	.003	**.404**	.163	.472	.528
Atlantis	.419	.176	-.031	.000	**.377**	.142	.318	.682
Rebus	.499	.249	-.043	.000	**.455**	.207	.456	.544
Rover	.429	.184	.039	.002	**.315**	.099	.285	.715
Triangles	.487	.237	.022	.000	**.380**	.144	.382	.618
% Total Variance	24.4		5.0		11.1		40.5	59.5
%Common Variance	60.2		12.5		27.3		100.0	

Note. L = Learning, P = Planning, SM = Simultaneous, SQ = Sequential, *b* = standardized loading of subtest on factor, Var = variance (b^2) explained in the subtest, h^2 = communality, u^2 = uniqueness. Salient loading coefficients are presented in bold (coefficient ≥ .30).

Table 2

Sources of Variance in the Kaufman Assessment Battery for Children-Second Edition Three-Factor Luria Interpretive Model for Ages 7-12 (n = 1,142) According to an Orthogonalized (Schmid & Leiman, 1957) Higher order Factor Model

	General		F1: SQ		F2: P/SM		F3: L			
Subtest	*b*	Var	*b*	Var	*b*	Var	*b*	Var	h^2	u^2
Number Recall	.415	.172	**.544**	.296	-.004	.000	-.017	.000	.468	.532
Word Order	.487	.237	**.540**	.292	.009	.000	.018	.000	.529	.471
Story Completion	.554	.307	.005	.000	.182	.033	.068	.005	.345	.655
Pattern Reasoning	.664	.441	.033	.001	***.231***	.053	.036	.001	.497	.503
Atlantis	.496	.246	.008	.000	-.014	.000	**.431**	.186	.432	.568
Rebus	.416	.173	-.012	.000	-.036	.000	**.424**	.180	.353	.647
Rover	.517	.267	.019	.000	.190	.036	.011	.000	.304	.696
Triangles	.614	.377	-.025	.000	***.267***	.071	-.043	.000	.448	.552
% Total Variance		27.8		7.4		2.4		4.7	42.2	57.8
%Common Variance		65.7		17.4		5.8		11.0	100.0	

Note. L = Learning, P = Planning, SM = Simultaneous, SQ = Sequential, *b* = standardized loading of subtest on factor, Var = variance (b^2) explained in the subtest, h^2 = communality, u^2 = uniqueness. Salient loading coefficients are presented in bold (coefficient ≥ .30). Per Carroll (1993), aligned loading coefficients are presented in bold italics (coefficient ≥ .20).

Table 3

Sources of Variance in the Kaufman Assessment Battery for Children-Second Edition Four-Factor Luria Interpretive Model for Ages 7-12 (n = 1,142) According to an Orthogonalized (Schmid & Leiman, 1957) Higher order Factor Model

	General		F1: SQ		F2: P		F3: L		F4: SM			
Subtest	*b*	Var	*b*	Var	*b*	Var	*b*	Var	*b*	Var	h^2	u^2
Number Recall	.602	.362	**.314**	.099	-.002	.000	-.016	.000	-.009	.000	.461	.539
Word Order	.663	.440	**.310**	.096	.000	.000	.017	.000	.017	.000	.536	.464
Story Completion	.445	.198	.002	.000	**.177**	.031	.035	.001	***.319***	.102	.332	.668
Pattern Reasoning	.500	.250	.019	.000	**.087**	.008	.024	.001	***.459***	.211	.469	.531
Atlantis	.530	.281	.004	.000	-.012	.000	**.404**	.163	-.027	.000	.444	.556
Rebus	.591	.349	-.007	.000	.018	.000	**.394**	.155	.068	.005	.510	.490
Rover	.339	.115	.012	.000	-.014	.000	.038	.001	**.456**	.208	.324	.663
Triangles	.377	.142	-.014	.000	.003	.000	-.032	.000	**.572**	.327	.470	.530
% Total Variance	26.7		2.4		0.5		4.0		10.7		44.3	55.7
%Common Variance	60.3		5.5		1.1		9.1		24.0		100.0	

Note. L = Learning, P = Planning, SM = Simultaneous, SQ = Sequential, *b* = standardized loading of subtest on factor, Var = variance (b^2) explained in the subtest, h^2 = communality, u^2 = uniqueness. Bold denotes theoretically consistent first-order factor loadings. Bold italics denote salient cross-loading on theoretically inconsistent first-order factor.

Table 4

Sources of Variance in the Kaufman Assessment Battery for Children-Second Edition Two-Factor Luria Interpretive Model for Ages 13-18 (n = 883) According to an Orthogonalized (Schmid & Leiman, 1957) Higher order Factor Model

	General		F1: SQ		F2: P/L/SM			
Subtest	*b*	Var	*b*	Var	*b*	Var	h^2	u^2
Number Recall	.530	.281	**.450**	.203	-.037	.000	.483	.517
Word Order	.622	.387	**.429**	.184	.055	.003	.574	.426
Story Completion	.446	.199	-.047	.000	**.394**	.155	.354	.646
Pattern Reasoning	.575	.331	.033	.001	**.415**	.172	.504	.496
Atlantis	.434	.188	.060	.004	.278	.077	.269	.731
Rebus	.578	.334	-.010	.000	**.461**	.213	.547	.453
Rover	.461	.213	.017	.000	**.342**	.117	.330	.670
Block Counting	.480	.230	.018	.000	**.356**	.127	.357	.643
% Total Variance	27.0		4.9		10.8		42.7	57.3
%Common Variance	63.3		11.5		25.3		100.0	

Note. L = Learning, P = Planning, SM = Simultaneous, SQ = Sequential , *b* = standardized loading of subtest on factor, Var = variance (b^2) explained in the subtest, h^2 = communality, u^2 = uniqueness. Bold denotes theoretically consistent first-order factor loadings. Salient loading coefficients are presented in bold (coefficient ≥ .30).

Table 5

Sources of Variance in the Kaufman Assessment Battery for Children-Second Edition Three-Factor Luria Interpretive Model for Ages 13-18 (n = 883) According to an Orthogonalized (Schmid & Leiman, 1957) Higher order Factor Model

	General		F1: SQ		F2: P/SM		F3: L			
Subtest	*b*	Var	*b*	Var	*b*	Var	*b*	Var	h^2	u^2
Number Recall	.438	.192	**.540**	.292	-.013	.000	-.003	.000	.484	.516
Word Order	.553	.306	**.514**	.264	.031	.001	.032	.001	.572	.428
Story Completion	.537	.288	-.057	.000	***.218***	.048	.112	.013	.348	.652
Pattern Reasoning	.658	.433	.039	.002	***.290***	.084	.041	.001	.520	.480
Atlantis	.497	.247	.054	.003	-.055	.000	**.389**	.151	.401	.599
Rebus	.689	.475	-.034	.000	.090	.008	**.378**	.143	.626	.374
Rover	.533	.284	.020	.000	***.274***	.075	-.014	.000	.360	.640
Block Counting	.560	.314	.019	.000	**.331**	.110	-.071	.000	.424	.576
% Total Variance	31.7		7.0		4.1		4.7		46.7	53.3
%Common Variance	68.0		15.0		8.7		11.0		100.0	

Note. L = Learning, P = Planning, SM = Simultaneous, SQ = Sequential, *b* = standardized loading of subtest on factor, Var = variance (b^2) explained in the subtest, h^2 = communality, u^2 = uniqueness. Salient loading coefficients are presented in bold (coefficient ≥ .30). Per Carroll (1993), aligned loading coefficients are presented in bold italics (coefficient ≥ .20).

Table 6

Sources of Variance in the Kaufman Assessment Battery for Children-Second Edition Four-Factor Luria Interpretive Model for Ages 13-18 (n = 883) According to an Orthogonalized (Schmid & Leiman, 1957) Higher order Factor Model

	General		F1: SQ		F2: P		F3: L		F4: SM			
Subtest	*b*	Var	*b*	Var	*b*	Var	*b*	Var	*b*	Var	h^2	u^2
Number Recall	.415	.172	**.571**	.326	.031	.001	-.021	.000	-.029	.000	.500	.500
Word Order	.536	.287	**.516**	.266	-.048	.000	.040	.002	.047	.002	.557	.443
Story Completion	.542	.294	-.014	.000	**.237**	.056	.045	.002	.149	.022	.374	.626
Pattern Reasoning	.655	.429	.064	.004	**.170**	.029	.007	.000	.247	.061	.523	.477
Atlantis	.523	.274	.039	.002	-.028	.000	**.354**	.125	-.043	.000	.400	.600
Rebus	.716	.513	-.038	.000	.066	.004	**.328**	.108	.079	.006	.631	.369
Rover	.534	.285	-.022	.000	-.070	.000	.032	.001	**.316**	.100	.387	.613
Block Counting	.554	.307	.002	.000	.025	.001	-.045	.000	**.340**	.116	.423	.577
% Total Variance		32.0		7.5		1.1		3.0		3.8	47.4	52.6
%Common Variance		67.5		15.8		2.4		6.3		8.1	100.0	

Note. L = Learning, P = Planning, SM = Simultaneous, SQ = Sequential, *b* = standardized loading of subtest on factor, Var = variance (b^2) explained in the subtest, h^2 = communality, u^2 = uniqueness. Bold denotes theoretically consistent first-order factor loadings.

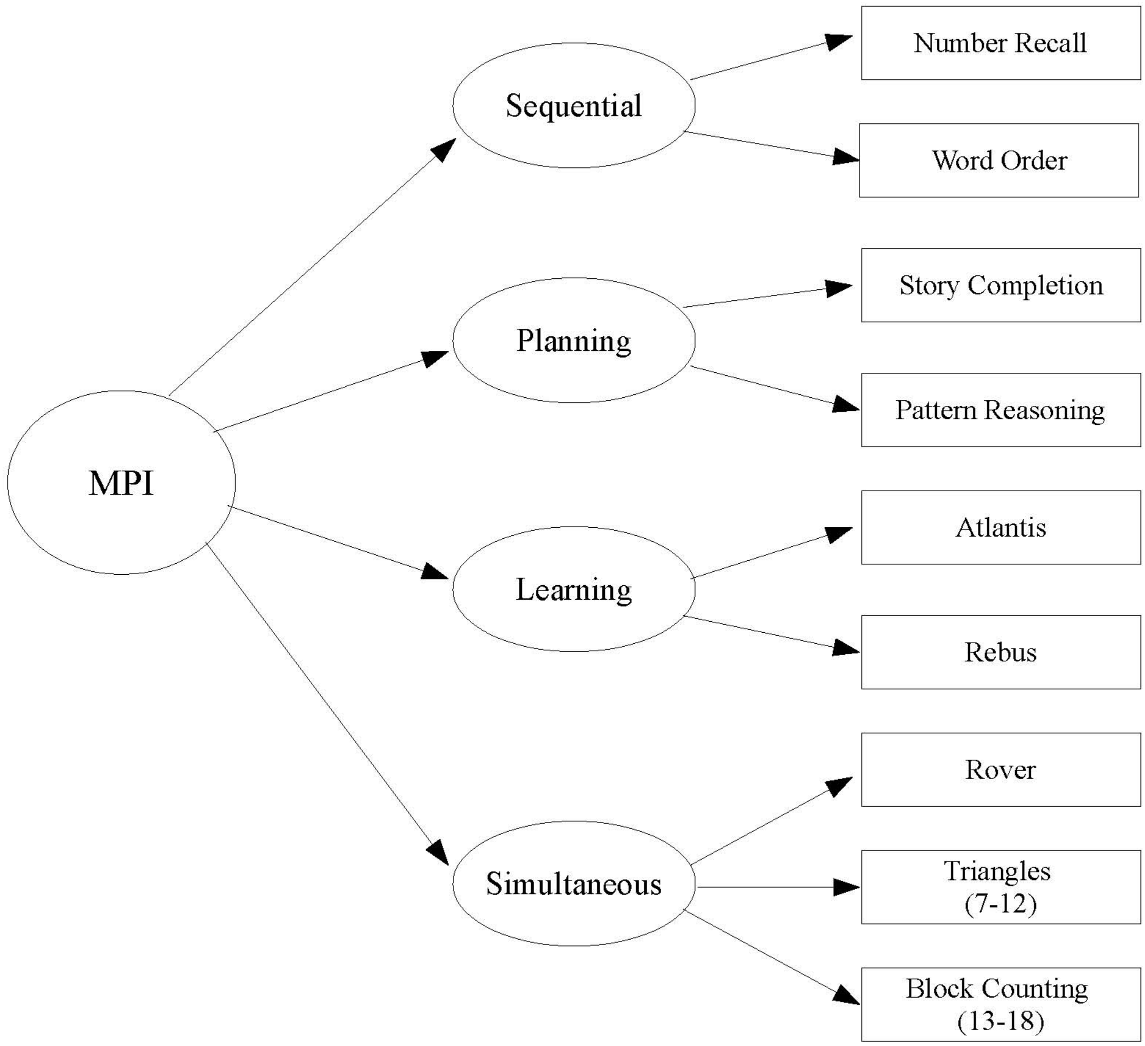

Figure 1. Indirect hierarchical Luria measurement model for the KABC-II. MPI = Mental Processing Index. Whereas the Simultaneous factor includes Rover from ages 7-18, Triangles is included in the composition of the factor score from ages 7-12 and is replaced by Block Counting at ages 13-18. Adapted from (Kaufman & Kaufman, 2004b) with permission.