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Structural Extension of the Cattell-Horn-Carroll Cross-Battery Approach to Include Measures of Visual-Motor Integration

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ACCEPTANCE

This dissertation, STRUCTURAL EXTENSION OF THE CATTELL-HORN-CARROLL CROSS-BATTERY APPROACH TO INCLUDE MEASURES OF VISUAL-MOTOR INTEGRATION, by JANELL HARGROVE BROOKS, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Doctor of Philosophy in the College of Education, Georgia State University.

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ABSTRACT

STRUCTURAL EXTENSION OF THE CATTELL-HORN-CARROLL CROSS-BATTERY APPROACH TO INCLUDE MEASURES OF VISUAL-MOTOR INTEGRATION

by

Janell Hargrove Brooks

In spite of the long-standing tradition of including measures of visual-motor integration in psychological evaluations, visual-motor abilities have not been included in the Cattell-Horn-Carroll (CHC) theory of cognitive abilities or its complementary cross-battery approach to assessment. The purpose of this research was to identify the shared constructs of a popular test of visual-motor integration and a test of intellectual functioning, and to investigate how a test of visual-motor integration would be classified within the CHC model. A large normative sample of 3,015 participants that ranged in age from 5 to 97 years completed the *Bender Visual-Motor Gestalt Test, Second Edition* (Bender-Gestalt II; Brannigan & Decker, 2003) and the *Stanford-Binet Intelligence Scale, Fifth Edition* (SB5; Roid, 2003). Correlational analyses indicated positive moderate correlations across all age ranges between the Bender-Gestalt II Copy measure and the SB5 Nonverbal Visual-Spatial Processing subscale and between the Bender-Gestalt II Recall measure and the SB5 Nonverbal Visual-Spatial Processing and Nonverbal Working Memory subscales. Exploratory factor analyses revealed a three-factor model for four age groupings and four-factor model for one age grouping, suggesting factors which represent crystallized ability, fluid reasoning, and visual-motor ability. The results

of this study suggest that the Bender-Gestalt II measures abilities that are not included in the SB5. Therefore, the Bender-Gestalt II would complement an intelligence test such as the SB5 in order to form a CHC Visual Processing (*Gv*) broad ability factor. These findings also address the need for further research to validate the constructs measured by newer versions of widely-used tests of cognitive ability.

STRUCTURAL EXTENSION OF THE CATTELL-HORN-CARROLL CROSS-BATTERY APPROACH TO INCLUDE MEASURES OF VISUAL-MOTOR INTEGRATION

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ABBREVIATIONS

CHC	Cattell-Horn-Carroll
g	General Intelligence
Ga	Auditory Processing
Gc	Crystallized Intelligence
Gf	Fluid Reasoning
Glr	Long-term Retrieval
Gp	Psychomotor Ability
Gq	Quantitative Knowledge
Grw	Reading and Writing
Gs	Processing Speed
Gsm	Short-term Memory
Gt	Decision/Reaction Time or Speed
Gv	Visual Processing
IQ	Intelligence Quotient
SB5	Stanford-Binet Intelligence Scale, Fifth Edition
VMI	Beery-Buktenica Developmental Test of Visual-Motor Integration
XBA	Cross-Battery Assessment

CHAPTER ONE

ASSSESSMENT OF VISUAL-MOTOR SKILLS WITHIN THE CHC-CROSS BATTERY APPROACH

Introduction

The assessment of visual-motor ability has been a long-standing tradition in the psychological measurement of cognitive and adaptive skills in both children and adults. Instruments for assessing visual-motor impairments such as the *Bender Visual-Motor Gestalt Test* (Bender, 1938) and the *Developmental Test of Visual-Motor Integration* (VMI; Beery, 1967) are among the oldest and most popular assessment devices. Traditionally, these instruments have been administered as a special purpose test to accompany more comprehensive intelligence tests. However, there is little to no current research regarding the usefulness of newer tests of visual-motor ability within contemporary models of intelligence or cognitive assessment. A likely reason for this may be that the role of visual-motor functioning is not well-understood because of the varied uses of older tests of visual-motor integration and criticism of their psychometric properties (e.g., Salvia & Ysseldyke, 2001).

The Cattell-Horn-Carroll (CHC) theory of human cognitive abilities (McGrew, 1997) is currently the most accepted model of human intelligence. CHC theory addresses a wide variety of cognitive constructs including verbal/language skills, reasoning abilities, memory and learning, auditory and visual perception, and specific academic abilities such as reading, mathematics, and writing. Similarly, the CHC-based

Cross-Battery Assessment (XBA) approach systematically integrates data across cognitive and achievement batteries in order to assess the total range of abilities specified by CHC theory. Presently, the CHC taxonomy does not include human sensory abilities (e.g., tactile, kinesthetic, olfactory) and other important cognitive constructs such as general knowledge (e.g., one's domain-specific knowledge), mental speed, and psychomotor ability. Therefore, the CHC model may represent an incomplete, yet growing collection of cognitive constructs. Hence, researchers interested in CHC theory may ask, "How should new constructs be added to the CHC model?" Additionally, practitioners interested in XBA may ask, "What instruments could be used to measure these new constructs?"

While visual-motor tests have practical utility, it is unclear how these tests fit into a model of intelligence such as the CHC framework. More specifically, what CHC abilities are being measured by tests of visual-motor integration? Furthermore, how would these tests fit into the XBA approach? This paper will answer these questions by reviewing CHC theory, its application to modern-day assessment, and the inclusion of visual-motor ability within the CHC-XBA model. The first purpose of this paper is to examine the historical and current uses of CHC theory in intelligence test batteries, including the CHC-driven cross-battery approach to assessment. The second purpose of this paper is to investigate CHC structural extension research which has called for re-evaluation of current CHC broad abilities and the inclusion of new broad abilities. For example, the narrow abilities subsumed under the existing broad domain of Visual Processing are in need of further investigation. Additionally, the broad domain of Psychomotor Ability requires serious consideration for inclusion in the CHC taxonomy.

Thus, this paper will summarize the internal and external structural research on visual processing and psychomotor abilities.

The third objective of this paper is to add to the structural extension research by suggesting the addition of visual-motor integration to the CHC framework. Although assessment of visual-motor abilities has been a tradition in the educational, psychological, and neuropsychological assessment of children and adults, it has been neglected by the CHC and cross-battery literature. Therefore, this paper will review the role of visual-motor processing as a human cognitive ability, the assessment of visual-motor abilities, and role of tests of visual-motor integration within the CHC model and the cross-battery approach to assessment. Potential reasons for the exclusion of visual-motor tests from cross-battery assessment will be explored, as well as a rationale for their inclusion in cross-battery assessment. Finally, suggestions for further research and practice will be offered.

Review

Contemporary Assessment of Intelligence

While significant progress has been made in understanding human cognitive abilities over the past century, the measurement of these abilities has faced many challenges. The assessment of cognitive abilities has been accused of failing to measure a wide variety of abilities that are important for estimating human intelligence (Horn & Blankson, 2005). Additionally, intelligence testing has been plagued by a disconnect between intelligence theory, test development, and test interpretation (Ittenbach, Esters, & Wainer, 1997; Kamphaus, Winsor, Rowe, & Kim, 2005). Older intelligence tests have also been criticized for their ability to predict performance in specific academic domains

(McDermott, Fantuzzo, & Glutting, 1990). Specifically, McGrew, Flanagan, Keith, and Vanderwood (1997) state:

> Most of the anti-specific ability research in school psychology has been conducted with measures that are based on an outdated conceptualization of intelligence…and have used research methods that have placed primary emphasis on *prediction* with little attention to *explanation* and *theoretical understanding* of the relations between general and specific cognitive abilities and school achievement (p.191).

Kamphaus et al. (2005) describe four waves in the history of intelligence test interpretation. The first wave of interpretation of intelligence tests centered on the classifying individuals into groups according to their overall general ability score, or intelligence quotient (IQ). Test interpretation during the second wave focused on interpretation of an individual's subtest score profiles. This clinical profile analysis would shift the focus of interpretation from differences *between* individuals to differences *within* individuals in order to identify a pattern of intra-individual strengths and weaknesses. The third wave sought to remedy the methodological problems of the second wave by using factor analysis to create a psychometrically-based profile. Thus, test interpretation concentrated on factor scores rather than subtest scores. However, research during the third wave generated concern about external and internal validity and a "lack of theoretical clarity" (Kamphaus, et al., 2005, p. 31).

Presently, intelligence test interpretation is within its fourth wave. This wave is characterized by the development of tests that are based on empirically supported theories. Whereas, prior to the 1990's, test interpretation was often made according to the clinician's professional subjectivity, the contemporary interpretation process is guided by theory, the integration of multiple sources of information, and hypothesis-testing (Kamphaus, 2001; Kamphaus et al., 2005). Additionally, current tests have stronger validity evidence for the measurement of a particular construct or a set of constructs of cognitive ability. More importantly, this fourth wave has emphasized the need to comprehensively assess multiple abilities for more accurate and meaningful interpretation.

One of the products of this fourth wave was the inception and application of the CHC theory of human cognitive abilities. CHC theory is considered to be the most well-validated, comprehensive models of cognitive functioning (McGrew, Flanagan, Keith, & Vanderwood, 1997; Evans, Floyd, McGrew, & Leforgee, 2002). It has been designed as a framework for understanding various aspects of cognitive abilities and as a bridge between theory and intelligence test development and interpretation.

Cattell-Horn-Carroll Theory

CHC theory is a hierarchical framework of cognitive abilities based on a century-long collection of factor analytic-based research. It reflects the merger of Raymond B. Cattell and John Horn's extended *Gf*-*Gc* theory (Horn, 1991; Horn & Noll, 1997) and John B. Carroll's three-stratum model of cognitive abilities (Carroll, 1993, 1997).

Briefly, hierarchical models of intelligence were originally based on Spearman's *g*/*s*-factor theory (1904, 1927) which posits *g* as an overall representation of general intelligence and *s* as underlying specific factors. Subsequent hierarchical models, such as one theorized by Thurstone (1931, 1938), led to the identification of seven to nine primary mental abilities that were independent of the higher-order *g*. Furthermore, Cattell (1941, 1957) redefined Spearman's theory by proposing two types of intelligence, Fluid Intelligence (*Gf*) and Crystallized Intelligence (*Gc*), which led to the development of the Cattell-Horn *Gf*-*Gc* theory of cognitive abilities (Horn & Cattell, 1966). After additional research on the Cattell-Horn theory, Horn (1991) revised the model by eliminating the *g* factor and identifying of nine to ten broad *Gf-Gc* abilities: Fluid Intelligence (*Gf*), Crystallized Intelligence (*Gc*), Short-term Acquisition and Retrieval (*Gsm*), Visual Intelligence (*Gv*), Auditory Intelligence (*Ga*), Long-term Storage Intelligence (*Glr*), Cognitive Processing Speed (*Gs*), Correct Decision Speed (CDS), and Quantitative Knowledge (*Gq*). During his research, another factor was added to this model that would recognize reading and writing abilities (*Grw*) (Horn, 1988; McGrew, Werder, & Woodcock, 1991; Woodcock, 1994). Various narrow abilities (e.g., general sequential reasoning, mathematic knowledge, language development, memory span, visualization, phonetic coding, associative memory, perceptual speed, simple reaction time) were subsumed under these ten broad abilities.

In 1993, Carroll published a book, *Human Cognitive Abilities: A Survey of Factor-Analytic Studies*, in which he proposed a three-tier model of cognitive abilities based on his re-analysis of over 460 different data sets of previous factor-analytic research (Carroll, 1993; McGrew, 1997). Carroll identified the *g* factor as being the broadest level, or Stratum III. Next, he presented Stratum II as being comprised of eight broad abilities, some of which were similar to the abilities posited by Horn and Cattell. Carroll’s broad abilities included: Fluid Intelligence (*Gf*), Crystallized Intelligence (*Gc*), Short-term Acquisition and Retrieval (*Gsm*), General Memory and Learning (*Gy*), Broad Visual Perception (*Gv*), Broad Auditory Perception (*Ga*), Broad Retrieval Ability (*Glr*), Broad Cognitive Speediness (*Gs*), and Reaction Time/Decision Speed (*Gt*). Stratum I included 69 narrow abilities which were subsumed under each respective Stratum II factors.

When comparing the Carroll and Cattell-Horn models, similarities include the presence of fluid and crystallized abilities; short-term and long-term storage and retrieval; auditory and visual processes; processing speed; and decision or reaction time. Conversely, the most obvious difference was the inclusion of *g* in Carroll's model, whereas the Cattell-Horn model deemphasized the importance of *g* in understanding cognitive abilities (see Horn & Masunaga, 2000). Other differences were primarily in terms of the broad and narrow abilities such as (a) Carroll's placement of reading and writing abilities under *Gc* as opposed to a separate broad ability for Cattell-Horn; (b) Carroll's placement of quantitative abilities under *Gf* as opposed to a separate broad ability for Cattell-Horn; and (c) Carroll's placement of phonological awareness under *Gc* as opposed to Cattell-Horn including it under *Ga* (McGrew, 1997).

The CHC model was introduced by Kevin McGrew (1997) as an integration of Cattell-Horn and Carroll's theories called the *Synthesized Cattell-Horn and Carroll Gf-Gc Model.* According to McGrew (2005), while Horn and Carroll informally agreed to the name *CHC theory* as an umbrella term, the first formal published definition of CHC theory was presented in the *Woodcock-Johnson Psycho-Educational Battery-Third Edition Technical Manual* (Woodcock, McGrew, & Mather 2001). McGrew retained Carroll's three-strata structure with *g* at Stratum III, 10 broad cognitive abilities at Stratum II, and approximately 70 narrow abilities at Stratum I. The broad abilities and their contemporary definitions are listed in Table 1.

Table 1

CHC Broad Ability/Stratum II Definitions

Broad Ability (Abbreviation)	Definition
Fluid Intelligence (*Gf*)	Ability to reason, form concepts, and problem solve using novel information and/or procedures
Crystallized Intelligence (*Gc*)	Breadth and depth of general knowledge and knowledge of a culture including verbal communication and reasoning with previously learned procedures
Short-term Memory (*Gsm*)	Ability to hold information temporarily in immediate awareness and then use it within a few seconds
Long-term Storage & Retrieval (*Glr*)	Ability to store information and retrieve it later through association
Auditory Processing (*Ga*)	Ability to analyze and synthesize auditory information
Visual Processing (*Gv*)	Ability to analyze and synthesize visual information
Processing Speed (*Gs*)	Ability to perform quickly automatic cognitive tasks, particularly when under pressure to maintain focused concentration
Decision/Reaction Time or Speed (*Gt*)	Quickness in providing correct answers to a variety of moderately difficult problems in comprehension, reasoning, and problem solving
Reading and Writing (*Grw*)	Acquired store of knowledge that includes basic reading, reading fluency, and writing skills required for reading comprehension and written expression
Quantitative Knowledge (*Gq*)	Ability to comprehend quantitative concepts and relationships and to manipulate numerical symbols

Note: From McGrew & Flanagan, 1998; Flanagan et al., 2000; Flanagan & Ortiz, 2001; and Flanagan et al. (2007).

One of strengths of the CHC model is that it provides a framework of "common theoretical nomenclature by which to identify and understand the ability constructs measured by major intelligence batteries" (Phelps, McGrew, Knopik, & Ford, 2005, p. 67). Flanagan, Ortiz, and Alfonso (2007) likened CHC to the creation of nosologies such as the *Diagnostic and Statistical Manual of Mental Disorders*, whereby professionals are able to use consistent terminology in defining and interpreting constructs. Furthermore, the terminology used in CHC is empirically grounded.

Another important aspect of CHC theory is its focus on the cognitive influence on achievement tasks. McGrew noted, "the distinction between intelligence and achievement is largely an artificial dichotomy used in educational settings." (McGrew, 1997, p. 170). Therefore, interpretation of achievement tests requires the same consideration of the cognitive processes involved in completing tasks that one would give when interpreting tasks on traditional intelligence tests. For example, Flanagan, Ortiz, Alfonso, and Mascolo (2006) reviewed at least two decades of research on the relationships between CHC broad and narrow abilities/processes and achievement in the areas of reading, math, and writing. Seven broad abilities were reported: *Gf*, *Gc*, *Gsm*, *Gv*, *Ga*, *Glr*, and *Gs*. All seven areas were found to have significant relations with reading achievement. Every domain except *Gv* was found to have significant relations with writing achievement, while only *Gf*, *Gc*, *Gsm*, *Gv*, and *Gs* were related to math achievement.

Much of the research on the relationship between cognitive abilities and achievement has centered on using *g* to predict achievement (Taub, Floyd, Keith, & McGrew, 2008; Glutting, Watkins, Konold, & McDermott, 2006). However, recent studies have discovered evidence in support of broad and narrow abilities as stronger predictors of achievement than *g*. Specifically, Floyd, Keith, Taub, & McGrew (2007) compared three structural equation models (*g*; *g* and broad abilities; *g*, broad abilities, and narrow abilities) as predictors of reading decoding skills. A model of *g* alone produced large direct effects on reading; however, when *g* was included with a model of broad abilities and a model of broad and narrow abilities, *g* only had indirect effects. The broad abilities of *Ga*, *Gsm*, *Glr*, *Gc*, and *Gs* demonstrated significant effects for reading decoding. Furthermore, the effects of four of the five broad abilities were mediated by narrow abilities (e.g., phonetic decoding, memory span, associate memory, general information, listening ability). Similar studies have yielded comparable results showing the indirect effects of *g* and direct effects of broad and narrow abilities for reading fluency and reading comprehension (Benson, 2008), math (Taub, Floyd, Keith, & McGrew, 2008), and writing (Floyd, McGrew, & Evans, 2008). Overall, these studies conclude that school psychologists should examine these specific cognitive and academic skills beyond just the assessment of general intelligence and achievement constructs. Furthermore, these relationships provide evidence as to the importance of using contemporary tests of intelligence and achievement as part of a comprehensive evaluation for children suspected of having learning disabilities.

Gf-Gc and CHC Coverage in Intelligence Tests

As McGrew worked toward the development of the CHC model, he found that no intelligence test batteries measured the full spectrum of broad and narrow abilities purported by CHC theory. In an effort to classify intelligence tests according to their breadth of coverage of *Gf-Gc* broad and narrow abilities, he examined joint confirmatory factor analytic studies published by Flanagan and McGrew (1998), McGhee (1993), and Woodcock (1990). These studies investigated one or more of the major intelligence test batteries that were prominent during the 1980's and 1990's: the *Differential Ability Scales* (DAS; Elliott, 1990), the *Kaufman Assessment Battery for Children* (K-ABC; Kaufman & Kaufman, 1983), the *Kaufman Adolescent and Adult Intelligence Test* (KAIT; Kaufman & Kaufman, 1993), the *Stanford-Binet Intelligence Scale: Fourth*

Edition (SB-IV; Thorndike, Hagen, & Sattler, 1986), the *Wechsler Preschool and Primary Intelligence Scale-Revised* (WPPSI-R; Wechsler, 1989), the *Wechsler Intelligence Scale for Children-Third Edition* (WISC-III; Wechsler, 1991), the *Wechsler Adult Intelligence Scale-Revised* (WAIS-R; Wechsler, 1981), and the *Woodcock-Johnson Psycho-Educational Battery-Revised* (WJ-R; Woodcock & Johnson, 1989). McGrew's (1997) results indicated that the WJ-R battery provided the broadest coverage of *Gf-Gc* abilities, only lacking adequate representation for *Gt*. The DAS offered the next best coverage of broad and narrow abilities, measuring eight of the ten broad abilities. However, it did not adequately address *Ga* and *Gt*. Each of the remaining tests (K-ABC, KAIT, Wechsler scales, SB-IV) was similar in that they measured narrow abilities under *Gc*, *Gsm*, and *Gv*. These batteries differed in regard to the distribution of the other broad and narrow abilities. For instance, the KAIT, as with the WJ-R, measured aspects of *Glr*. Notably, none of the tests, except for the WJ-R, offered adequate measurement of *Ga*. McGrew concluded that the WJ-R, DAS, and KAIT offered the most unique contributions to psychoeducational assessments given their measurement of broad and narrow abilities that were not included on traditional intelligence tests such as the Wechsler scales and the SB-IV. Thereby, practitioners should consider "cutting" across batteries in order to gain the most comprehensive measurement of Stratum I and II cognitive abilities.

CHC and new intelligence tests. As noted earlier, the *Woodcock-Johnson Psycho-Educational Battery-Third Edition* (WJ III; Woodcock, McGrew, & Mather 2001) was the first major intelligence test to use the terminology of CHC as its theoretical foundation. Since 2000, most major intelligence test battery has purportedly been based on CHC theory: the WJ III, the *Stanford-Binet Intelligence Scale: Fifth Edition*; (SB5; Roid, 2003), the *Kaufman Assessment Battery for Children-Second Edition* (KABC-II; Kaufman & Kaufman, 2004a), and the *Differential Ability Scales: Second Edition* (DAS-II; Elliott, 2007). While the authors of the newly revised Wechsler scales (Wechsler, 1997, 2002, 2003) did not explicitly state that they used CHC theory, *Gf-Gc* and CHC were used as guides in development of these tests (Flanagan, Ortiz, & Alonso, 2007). Each of these new intelligence batteries offers greater coverage of broad and narrow abilities than their predecessors. However, as with the previous edition, the WJ III continues to lead the way in terms of representation of nine of the ten broad cognitive abilities. The DAS-II places second again with strong representation of five broad abilities and two narrow ability subtests that insufficiently measure *Ga* and *Gs* (Phonological Awareness and Speed of Information Processing, respectively). The remaining tests measure four to five broad abilities. In light of the continued underrepresentation of broad cognitive processes, as well as inadequate representation of specific processes critical to the prediction of academic achievement, Flanagan and colleagues (2007) emphasize the need for cross-battery assessment.

Cross-battery assessment. Cross-battery assessment was developed as a parallel process to the inception of CHC theory. The idea of using a “battery-free” approach to gain comprehensive coverage of *Gf-Gc* broad and narrow abilities was proposed by Richard Woodcock’s (1990) joint confirmatory factor analytic studies of major intelligence batteries (McGrew, 2005). Woodcock mapped individual tests from each battery onto the *Gf-Gc* taxonomy and demonstrated how each individual test battery adequately or poorly represented *Gf-Gc* domains. He concluded that cross-battery methods should be employed to fill in voids in underrepresented broad abilities. Furthermore, XBA was seen as a method to evaluate cross-battery equivalence of scores from different batteries (Daniel, 1997). More importantly, “practitioners were given permission and a rationale to ‘think outside their test kits’ in order to conduct more valid assessments” (McGrew, 2005, p. 146). The cross-battery approach was later expanded by McGrew, Flanagan, and colleagues (e.g., McGrew, 1993; McGrew & Flanagan, 1995, 1996; Flanagan & McGrew, 1997; Flanagan & Ortiz, 2001). Most recently, Flanagan and colleagues (Flanagan, Ortiz, & Alfonso, 2007) updated the XBA matrices to include more recent editions of traditional intelligence tests (e.g., WJ III, SB5, KABC-II, DAS-II, Wechsler scales), newer intelligence tests (e.g., RIAS, UNIT), neuropsychological and supplemental processing instruments (e.g., NEPSY, CTOPP, CMS, WRAML-2), and popular broad and specific academic achievement tests (e.g., WJ III Achievement, WIAT-II, KTEA-II, GORT-4, TOWL-3, OWLS, KeyMath-R/NU)[1].

The cross-battery approach is built upon three pillars. The first pillar of XBA is its foundation in CHC theory. The second pillar is the classification of cognitive and achievement tests according to broad (Stratum II) CHC abilities, with a particular focus on avoiding *construct-irrelevant variance* (Messick, 1995). Construct-irrelevant variance refers to how an assessment is so broad that it contains “excess reliable variance

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[1] Reynolds Intelligence Assessment Scales (RIAS; Reynolds & Kamphaus, 2003); Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1999); NEPSY (Korkman, Kirk, & Kemp, 1998); Comprehensive Test of Phonological Awareness (CTOPP; Wagner, Torgesen, & Rashotte, 1999); Children's Memory Scale (CMS; Cohen; 1997); Wide-Range Assessment of Memory and Learning, Second Edition (WRAML-2; Sheslow & Adams, 2006); Woodcock-Johnson Tests of Achievement, Third Edition (WJ III; Woodcock, McGrew, & Mather, 2000); Wechsler Individual Achievement Test, Second Edition (WIAT-II; Wechsler, 2001); Kaufman Test of Educational Achievement, Second Edition (KTEA-II; Kaufman & Kaufman, 2004b); Gray Oral Reading Test, Fourth Edition (GORT-4; Wiederholt & Bryant, 2001); Test of Written Language, Third Edition (TOWL-3; Hammill & Larson, 1996); Oral and Written Language Scales (OWLS; Carrow-Woolfolk, 1995); KeyMath-Revised, Normative Update (KeyMath-R/NU; Walker & Arnault, 1991).

associated with other distinct contrasts…that affects responses in a manner irrelevant to the interpreted constructs" (Messick, 1995, p. 742; cited in Flanagan et al., 2007). In essence, this means that tests or subtests that are thought to be factorially complex, which can complicate interpretation, are not included in XBA. Hence, there is concern that a CHC broad ability cluster may contain subtests that are not pure measures of the underlying construct. For example, at the composite/factor level, the WAIS-III Verbal IQ is considered to be factorially complex. While the construct intended to be measured was *Gc*, it actually contains measures of *Gc* (Information, Similarities, Vocabulary, and Comprehension), *Gq* (Arithmetic), and *Gsm* (Digit Span) (Flanagan et al., 2007). Such problems may also extend to the subtest level. Woodcock (1990) noted that Verbal Analogies tests, such as part of the SB5 and the WJ III Cog, have significant factor loadings on both *Gc* and *Gf*.

The third pillar of XBA involves classifying cognitive and achievement tests in regards to their content, format, and task demand according to narrow (Stratum I) CHC abilities. Different from the second pillar, the focus of the third pillar is on addressing c*onstruct underrepresentation* (Messick, 1995). Construct underrepresentation refers to an assessment that is "too narrow and fails to include important dimensions or facets of a construct" (p. 742, cited in Flanagan et al., 2007). Thus, in XBA, each broad construct is represented by two or more qualitatively different narrow abilities or processes that are subsumed under their respective construct. For example, the *Gsm* factor on the KABC-II is underrepresented because its two subtests (Number Recall and Word Order) are primarily measures of Memory Span. In contrast, the *Gsm* factor on the WJ III Cog is adequately represented because it contains two subtests measuring qualitatively different narrow abilities: Numbers Reversed as a measure of Working Memory and Memory for Words as measure of Memory Span.

Flanagan and colleagues (2007) describe the strengths of XBA as being similar to those previously noted for CHC theory: (a) its foundation is empirically-supported and well-validated; and (b) its use of standard nomenclature facilitates communication among professionals and prevent misinterpretation of constructs. Additionally, XBA is appropriate for assessing individuals who are suspected of having specific learning disabilities because it (a) presents clear relationships between cognitive abilities/processes and academic outcomes; (b) provides a theoretical understanding of the psychological processes underlying learning disabilities; (c) uses empirical research to describe patterns of test performance; and (d) is based on rigorous measurement of constructs. Another strength of XBA is its usefulness in assessing individuals who are culturally and linguistically diverse. XBA provides a systematic means of evaluating the cultural and linguistic factors that may affect test performance. Finally, XBA is flexible enough to allow the practitioner to select a comprehensive constellation of test batteries that will appropriately address the referral concerns of the individual examinee.

The cross-battery approach is not without its criticisms. Watkins, Youngstrom, and Glutting (2002) noted eight general areas of concern regarding XBA: (a) comparability of scores from different tests, (b) order effects, (c) sampling issues, (d) procedures employed to categorize subtests, (e) ipsative interpretation, (f) external validity, (g) efficiency and economy, and (h) vulnerability to misuse. Specifically, Watkins and colleagues criticized XBA saying that its “lack” of an internal norm group could lead to low generalizability of findings and poor correlation of performance on tests that purportedly measured the same construct. Flanagan, Ortiz, and colleagues disputed this claim by emphasizing that the test batteries used in XBA are all normed on nationally-representative samples of the United States population (Ortiz & Flanagan, 2002a; Flanagan et al., 2007). Furthermore, examiners are advised to choose test batteries that are normed within a few years of each other. This in itself minimizes the differences in scores that may be reflective of the “Flynn effect” (Flynn, 1984).

Other criticisms raised by Watkins et al. are that XBA is more complicated than traditional methods of assessment and interpretation, is time-consuming, and violates standardization by changing the order of subtest administration. These issues were also addressed by Flanagan and colleagues who cited the complexities involved in any interpretative process, the increased efficiency of XBA as a result of new automated computer software, and the lack of explicit instructions from test publishers regarding specific subtest sequencing (see Ortiz & Flanagan, 2002b & 2002c for a more detailed rebuttal).

In summary, CHC theory and the cross-battery approach to assessment are based on the sound psychometric theory that was historically missing from tests of intellectual and cognitive functioning. The theory is so well-validated that new intelligence test batteries have been developed on the foundation of CHC and its immediate predecessor, *Gf-Gc* theory. In spite of the increased coverage of broad and narrow ability constructs, no single intelligence test battery has yet to address all ten broad (Stratum II) cognitive abilities. Moreover, there is also concern about construct-relevant representation and the inclusion of multiple, qualitatively different narrow (Stratum I) abilities when constructing CHC clusters. Proponents of CHC theory and cross-battery assessment recommended supplementing primary intelligence test batteries with special purpose tests to ensure comprehensive coverage of broad and narrow abilities.

CHC Structural Extension Research

McGrew and Evans (2004) and Flanagan and colleagues (2007) describe the CHC taxonomy as being dynamic in that the structural research has led to the strengthening of current broad and narrow abilities and the proposal of new broad domains. Both small and large scale studies have been important in providing empirical support for the CHC constructs (e.g., Bickley, Keith, & Wolfe, 1995; McGrew & Woodcock, 2001; Taub & McGrew, 2004; Naglieri & Das, 1997; Flanagan & McGrew, 1998; Phelps et al., 2005). Following Stankov's (2000) suggestion for structural extension of the *Gf-Gc* framework, McGrew and Evans (2004) reviewed factor-analytic research from 1993 to 2003. They classified studies as "either *internal* (e.g., elaboration on the nature of well-established broad CHC factors) or *external* (e.g., research that suggests new broad ability domains or domains that have only been partially investigated)" (p. 13). In regard to internal structural extensions, most of the research on CHC factors has primarily addressed the broad abilities of *Gc*, *Gv*, *Ga*, *Gsm*, and *Gs*. Within each of these domains, more research is needed on specific narrow abilities (e.g., Imagery under *Gv*; Working Memory under *Gsm*). External model extension research has focused on broad abilities such as General Knowledge (*Gkn*), the speed factors (Cognitive Processing Speed – *Gs*; Decision/Reaction Time or Speed – *Gt*; Psychomotor Speed – *Gps*), Psychomotor Abilities (*Gp*), Olfactory Abilities (*Go*), Tactile Abilities (*Gh*), and Kinesthetic Abilities (*Gk*). Of particular interest for this paper is the structural research on visual processing (*Gv*) and psychomotor abilities (*Gp*).

Visual processing. Within the CHC model, the broad/Stratum II *Gv* factor is defined as “the ability to generate, perceive, analyze, synthesize, store, retrieve, manipulate, transform, and think with visual patterns and stimuli” (Lohman, 1994, in Flanagan et al., 2007). *Gv* includes the following narrow/Stratum I abilities: Spatial Relations, Visualization, Visual Memory, Closure Speed, Flexibility of Closure, Spatial Scanning, Serial Perceptual Integration, Length Estimation, Perceptual Illusions, Perceptual Alterations, and Imagery. These skills have been associated with higher-level math and science achievement and related occupations, as well as more skilled-labor technical and industrial occupations (McGrew & Evans, 2004; Lohman, 1996; Shea, Lubinski, & Benbow, 2001).

McGrew and Evan’s (2004) structural extension research on *Gv* describes visual-spatial abilities as falling within a second class status in terms of human intelligence. According to these researchers, this may result from inconsistencies in *Gv*’s ability to predict success in school; a domination over the predictive power of *Gv* when other CHC factors (e.g., *Gc, Gf*) are included in prediction studies; a bias toward verbal measures as criterion variables in prediction studies; and poorly developed measures of visual-spatial functioning. While *Gv* has been included in studies investigating its role in information processing (e.g., Lohman, 1996), McGrew and Evans noted that only a few recent studies have examined *Gv*’s structural characteristics (e.g., Juhel, 1991; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001; Burton & Fogarty, 2003). For example, Julel (1991) confirmed the existence of narrow *Gv* abilities such as Visualization, Spatial Relations, and Visual Memory. Furthermore, *Gv* tasks were reported as varying according to their cognitive complexity, with visualization abilities requiring the most complex cognitive processing and visual memory requiring the least complex processing. It was further suggested that the more complex abilities may be partially dependent on or supported by visual memory. Similarly, Miyake et al. (2001) determined that visualization and spatial relations factors may differ due to the degree of executive involvement, as measured by the visuo-spatial sketchpad of working memory (see Baddeley, 1992).

Psychomotor abilities. According to McGrew and Evans (2004), psychomotor abilities (*Gp*) are “the ability to perform body movements (movement of fingers, hands, legs, etc.) with precision, coordination, or strength” (p. 11). It includes narrow/Stratum I abilities such as Static Strength, Multi-limb Coordination, Finger Dexterity, Manual Dexterity, Control Precision, Aiming, and Gross Body Equilibrium. McGrew and Evans indicate that psychomotor abilities are often considered in the same context as speeded factors referred to as Psychomotor Speed (*Gps*). Carroll (1993) noted that psychomotor ability is distinctive from general cognitive ability. However, neither Carroll nor McGrew and Evans provide adequate explanations as to how isolated psychomotor abilities fit within the CHC model.

Research validating the construct of psychomotor abilities has not come out of educational or cognitive psychology per se, but from military psychology. Researchers such as Thomas Caretta and Malcolm Ree have provided evidence for the existence of a general psychomotor factor (Carretta & Ree, 1997; Ree & Carretta, 1994) in their investigations of personnel selection and training procedures for Air Force pilots. These authors examined the factor structure of a set of cognitive tests and 17 computer-based psychomotor tests designed to measure skills such as control precision, finger dexterity, manual dexterity, multi-limb coordination, rate control, kinesthetic memory, simple reaction time, and tracking (Carretta & Ree, 1997). Results from a confirmatory factor analysis revealed the presence of higher-order factors representing *g* and psychomotor/technical knowledge. The authors noted that the psychomotor/technical knowledge factor was akin to Vernon's (1969) practical factor (k:m) which is also referred to as " 'practical,' 'spatial-mechanical,' and 'spatial-perceptual-motor' " (Carretta & Ree, 1997, p. 13). Seven lower-order psychomotor factors were found: kinesthetic memory, leg reaction, pursuit tracking, complex coordination, rate control, arm/hand movement, and hand dexterity.

Overall, more research is needed to understand the internal structure of visual processing abilities. Furthermore, there is a clear paucity of CHC external research on psychomotor abilities. While both visual processing and psychomotor abilities may relate to higher-order math and science skills and occupational functioning rather than the basic academic functioning which schools may be concerned with, the role of these abilities has important functional utility (e.g., perceptual awareness, fine and gross motor development, hand eye-coordination, handwriting).

Just as *Gv* and *Gp* need more attention within the CHC literature, the role of visual-motor processing as a CHC ability has not been addressed. Visual-motor processing is the integration of visual-perceptual and fine or gross motor abilities. It is often seen as being most important during early school-age years, particularly in terms of academic readiness (Aylward, 1994). Furthermore, Sangkavi and Kelkar (2005) note that about 90% of children with learning disabilities have visual-motor deficits. In regard to assessment of cognitive abilities, tasks measuring visual-motor skills have traditionally been a part of intelligence test batteries or have been used by psychologists as a separate special purpose test to accompany their intelligence tests. The next section reviews the role of visual-motor processing in child development and instruments designed to measure these abilities.

Visual-Motor Processing

Visual-motor processing refers to the ability of eyes and hands to work together to perform smooth and efficient tasks such as construction, drawing, and handwriting (Sanghavi & Kelkar, 2005). Visual-motor ability is distinct from the autonomous systems of visual perception and motor coordination, but clearly may be affected by one or both of these systems. Other terms used to describe visual-motor processing include visually guided motor behavior, perceptual-motor skills, visual-motor association, and visual-motor integration. For the purposes of this paper, the terms "visual-motor skills" and "visual-motor integration" will be used. Furthermore, visual-motor functioning will be defined in terms of the use of fine motor skills, as opposed to gross motor skills.

The importance of visual-perceptual and visual-motor processing can be traced back to 1925, when Dr. Samuel Orton theorized a link between reading disorders and visual processing (Adams and Sheslow, 1995). Orton partly attributed letter reversals and word orientation confusions to deficits in visual processing (Orton, 1925). By the 1960s, his theory had gained popularity and came to be seen as the primary cause of learning disabilities (Kephart, 1960; Frostig, 1968). Moreover, there was an emphasis on creating instruments to assess these visual processing deficits and to develop remediation programs based on training visual-motor skills for children with reading disabilities.

Perspectives of visual-motor development. The role of visual-motor processing within an information processing framework has been just as important as other cognitive abilities (Adams and Sheslow, 1995). For example, Sattler (2001) noted that the assessment of fine and gross motor abilities and visual-motor integration is important for “determining the intactness of the child’s sensory and motor modalities and in developing remediation programs” (p. 322). Since visual-motor tests often involve copying various geometric designs, Sattler further described the processes involved in copying designs:

> Copying designs requires fine motor development, perceptual discrimination ability, the ability to integrate perceptual and motor processes, and the ability to shift attention between the original design and the design being drawn. Inadequate visual-motor performance may result from misperception (receptive difficulties), difficulties in execution (expressive difficulties), or integrative or central processing difficulties (problems with memory storage or retrieval). (pp. 322-323)

Similarly, Adams and Sheslow (1995) described the processes involved in copying words and designs as follows:

> …first the child must look and perceive what is on the page, performing a spatial analysis. Once this analysis is completed, the child must then organize his/her motor system to execute successive coordinated movements with the appropriate fingers and thumb of his dominant hand. Continuously, the child must check whether the production being created is similar to the original spatial analysis and make necessary adjustments as the motor activity proceeds, integrating the visual with fine motor aspects. (p.3)

From a neurocognitive perspective, individuals with visual-motor weaknesses may have difficulty with (a) perception of visual information, including problems with visual acuity, visual discrimination, form constancy, or position in space; (b) motor skills, such as problems with planning motor movement, muscular weakness, or fine motor dexterity; or (c) integrating visual-cognitive and motor abilities. For example, a child may have well-developed visual perception and motor coordination skills, but cannot integrate the two. Physiologically, Beery and Beery (2004) note that visual-motor integration appears to be mediated by parts of the brain other than those for general intelligence or visual perception.

From a developmental perspective, visual-motor functioning is seen as a maturational process based on sensory reception, reception, and motor action (Ghassemzadeh, 1988; Bolen, 2003). Koppitz (1963) suggested that the visual-motor development reached maturation by age 11. However, more recent research suggests that it is not complete until at least late adolescence (Lacks, 1999; Bolen 2003). Most recently, Brannigan and Decker (2003b) reported that visual-motor development increases sharply at younger ages, levels off around the ages of 16 to 49, and then declines at about age 50.

Research from Vereekan (1961; in Berry & Beery, 2004) seems to indicate that visual-motor development also follows a human ontogenetic trajectory. Following Jean Piaget’s theory of spatial perception and reproduction, Vereeken proposed that the earliest stage, the *topological* level, occurs during the first five years of life. During this stage, the following spatial attributes are grasped and reproduced: neighborhood and separation, flatness or pointedness, continuity or discontinuity, containment or enclosure of one object by another. The second level, the *Euclidean* level, is achieved between 5 and 10 years of age. Euclidean spatial dimensions are characterized by direction, rectilinear and curvilinear lines, lengths, and distances. Finally, children proceed to the *Projective* level towards the end of the Euclidean phase. At this point, objects are seen in relation to other objects or from other points of view.

Functional and academic correlates. Weaknesses in visual-motor abilities may cause functional impairment or academic problems for children. Deficits may affect children's adaptive skills, such as their ability to feed themselves, button clothing, tie shoelaces, manipulate toys, use tools, build block structures, and cut with scissors.

Academic adaptation and school adjustment have also been linked to weaknesses in visual-motor abilities (Bart, Hajami, & Bar-Haim, 2007; Carlton & Winsler, 1999; Kurdek & Sinclair, 2000). Bart and colleagues' (2007) review of the research on the relationship between motor abilities and school adjustment particularly noted that much of a kindergartener's day is devoted to fine motor activities (e.g., writing, coloring, and cutting) which require intact visual-motor integration (McHale & Cermak, 1992). Results from Bart et al.'s own study found a positive correlation between visual-motor integration in kindergarten and scholastic adaptation in first grade. Furthermore, poor visual-motor integration and other tested motor functions in kindergarten were associated with a significantly higher incidence of teacher-reported disruptive behavior in the first grade.

Delays in visual-motor development also have implications for academic-related weaknesses in writing, handwriting, and reading. For example, children may have difficulty writing within the lines or margins of a piece of paper, writing neatly and quickly, copying from the board or books, drawing maps and charts, or aligning numbers in math problems. Difficulties in handwriting are particularly noted to be related to visual-motor deficiencies, especially when manuscript writing or copying or transposing from text to cursive (Sanghavi & Kelkar, 2005). Strong correlations between visual-motor integration and writing legibility have also been reported (Maeland, 1992; Weil & Admundson, 1994; Tseng & Murray, 1994). Recently, Volman, van Schendel, and Jongmans (2006) found visual-motor integration to be a significant predictor of poor quality of handwriting in children with handwriting problems. It is important to note that while research has found visual-motor integration to be influential in the primary stages of learning letter formation for young children, the relationship between visual-motor integration and handwriting performance for older children is inconclusive (Goyen & Duff, 2005).

In regard to reading, Mati-Zissi and Zafiropoulou (2003) found significant positive correlations between kindergarteners' drawing abilities and their pre-reading skills and future reading accuracy. It was particularly noted that a subgroup of children with reading disabilities showed drawing errors that were attributed to problems in visuospatial encoding, planning, and short-term memory. The researchers also suggested that evaluation of preschoolers'drawing skills could aid in the detection of reading decoding accuracy in third grade.

Spatial organization of written work was also found to be problematic for children with visual-motor deficiencies (Barnhardt, Borsting, Deland, Pham, & Vu, 2005). When groups of children with and without visual-motor integration problems were given math computation problems to copy and solve and passages to copy, the low visual-motor integration group evidenced significant errors with the alignment of numbers, organization of math problems, and spacing errors of letters and words.

Visual-motor training. Given the difficulties that children may have in the areas of adaptive and academic functioning, intervention for visual-motor deficiencies appears to be warranted. As noted earlier, Orton and other early researchers in perceptual-motor and visual-motor development believed that visual-motor skills should be directly taught for the remediation or prevention of reading difficulties. Special education classes often devoted much instruction to teaching students how to trace and copy with the hopes that their visual-motor skills would become stronger and transfer to academic and other tasks

(Adams & Sheslow, 1995; Beery & Beery, 2004a). However, research did not support this connection because of the limited transfer of broad-based visual-perceptual training to reading processes (Hammill, Goodman, & Wiederholt, 1974).

Although the link between visual-motor training and reading remediation was not proven, it is important to note that visual-motor skill is a learned process that itself can be remediated through instruction. Oftentimes, remediation is required, not necessarily because of academic difficulties, but because the deficits cause functional impairment for the individual. This is particularly true for young children's adaptive skills such as tracing, copying, and handwriting. Subsequently, training programs and curricula are available for teaching these skills (e.g., *The Beery VMI Developmental Teaching Activities*, Beery & Beery, 2004b). According to Beery & Beery (2004a), perceptual-motor and visual-motor learning programs are often based on Piagetian theory of sensory-motor development. Piaget noted that young children tend to learn through physical movement via motor systems. Activities like tracing and copying letters are fundamental means for teaching children to perceive letter forms (Beery & Beery, 2004a).

Visual-motor deficits in children are often remediated through school-based occupational therapy. In spite of the proven improvement in visual-motor abilities for early school-age children (e.g., Dankert, Davis, & Gavin, 2003), children with mild impairments are often not seen by school-based occupational therapists because of economic and organizational constraints (Ratzon, Efraim, & Bart, 2007). Thus, there is a need for evidence-based, short-term interventions for visual-motor impairments. Results from the implementation of a short-term graphomotor intervention program revealed significant improvement in the quality of writing for first-grade children (Ratzon, Efraim, & Bart, 2007). The intervention involved fine-motor activities such as threading beads and inserting pegs, as well as paper-pencil activities such as guided drawing, coloring, and tracing. Given the marked improvement in the visual-motor abilities of the treatment group over those of the control group, the researchers concurred with other researchers' (e.g., Case-Smith, Heaphy, Marr, Galvin, Koch, Good-Ellis, et al., 1998) findings that structured occupational therapy intervention helps close, if not surpass, the developmental gap for children with disabilities.

Assessment of visual-motor integration. While tests of visual-motor functioning may have different formats, the most common format employed has been a *copying* task in which the examinee is shown a figure and asked to draw it (Martin, 2006). The earliest and probably most popular instrument was the *Bender Visual-Motor Gestalt Test* (Bender, 1938). The Bender-Gestalt assessed visual-motor skills in children and adults by having them copy nine geometric designs. In an effort to create a more developmentally oriented visual-motor test for children, Beery developed the *Developmental Test of Visual-Motor Integration* (VMI; Beery, 1967). The VMI was the first visual-motor test to arrange the designs to be copied in a developmental sequence (e.g., younger children first imitated designs and then were presented with designs that became increasingly complicated). Since then, several tests have been published that include stand alone measures of visual-motor integration (e.g., *Bender Visual-Motor Gestalt Test, Second Edition,* Brannigan & Decker, 2003a; *The Beery-Buktenica Developmental Test of Visual-Motor Integration, Fifth Edition,* Beery & Beery, 2004a; *Full Range Test of Visual-Motor Integration,* Hammill, Pearson, Voress, & Reynolds, 2006; *Test of Visual-*

Perceptual Skills-Third Edition, Martin, 2006; *Wide Range Assessment of Visual-Motor Abilities*, Adams & Sheslow, 1995). The Bender-Gestalt II evidences significant enhancement over the original Bender-Gestalt by its expanded age range, its large nationally representative standardization sample, the inclusion of a memory (recall) procedure and supplemental motor and perceptual screeners, and a qualitative Global Scoring System. The fifth edition of the Beery VMI does not depart much from its immediate predecessor. However, Beery and Beery (2004) indicate that this newest edition extended its standardized norms downward to include two-year old children and has a stronger focus on early childhood development and intervention. The Beery VMI also continues to include separate tests to measure motor coordination and visual perception.

Several comprehensive batteries of intelligence or cognitive ability have also included individual subtests measuring visual-motor integration (e.g., SB:IV, DAS, DAS-II, NEPSY, NEPSY-II). For example, the first and second editions of the DAS (Elliott, 1990, 2007) include a subtest named Copying in which the examinee is required to draw copied designs starting with simple straight lines and progressing to more complex geometric figures. Flanagan and her colleagues (2001, 2007), as well as Elliott describe this subtest as being a broad ability/Stratum II measure of *Gv* and a narrow ability/Stratum I measure of Visualization. McGrew & Flanagan (1998) also indicate that Copying may be a narrow ability measure of Finger Dexterity which is subsumed under the broad ability of *Gp*. Another DAS and DAS-II subtest included in the XBA matrix is Recall of Designs. For this subtest, the examinee is exposed to a geometric design for five seconds and asked to draw the design immediately from memory. This subtest purportedly measures (a) the ability to encode and retain visual-spatial information; (b) the level of motor skill proficiency required to reproduce the design; (c) short-term visual recall; (d) perception of spatial orientation; and (e) drawing skills (Elliott, 1990, 2007).

In summarizing the literature on visual-motor processing, the development of visual-motor skills has important implications for children's adaptive skills and academic readiness. The importance of assessing visual-motor functioning can be dated back to the 1920's. However, the utility of testing in this area has been questioned because of the poor normative sampling, low reliability, and poor validity of older tests of visual-motor integration (Salvia & Ysseldyke, 2001). The development of newer versions of widely used tests such as the Beery VMI and the Bender-Gestalt II has remedied these psychometric problems with their nationally-representative normative samples, higher reliability coefficients, and stronger evidence of predictive and construct validity. Therefore, it is important for school psychologists to understand where newer measures of visual-motor ability fit within contemporary cognitive assessment.

Discussion

The purpose of this literature review was to assist psychologists in understanding the importance of including widely-used measures of visual-motor integration within the CHC-cross battery approach to assessment. Currently, research regarding the utility of the visual-motor skills within XBA is not available. More specifically, Flanagan and colleagues (2001, 2007) do not include popular tests of visual-motor integration, such as the Beery VMI or the Bender-Gestalt II, as part of their XBA matrices. Therefore, this researcher poses the following questions: (a) What CHC abilities are being measured by these tests? (b) How would these tests fit into the XBA approach?

The previous review of the cognitive processing and task demands of tests of visual-motor processing appears to indicate that these tests seem to be CHC Stratum II measures of *Gv* and *Gp* and possible Stratum I measures of Visualization, Spatial Relations, Finger Dexterity, Manual Dexterity, and Control Precision. Additionally, copying tasks require visuospatial encoding, estimation, and orientation. Korkman, Kirk, and Kemp (2007) also indicate that other components of these tasks involve visual working memory and central executive processing skills, such as planning and execution. Consequently, have visual-motor skills not been addressed because of concern that they are measuring two or more different broad abilities, mainly *Gv* and *Gp*? If so, then there could be concern that visual-motor tasks contain construct-irrelevant variance, a violation of the second pillar of XBA.

Flanagan and colleagues (2007) do seem to find utility in assessing visual-motor skills in that they included specific visual-motor subtests from more comprehensive intelligence test batteries in their XBA matrix. Both editions of the DAS (Elliott, 1990, 2007) include Copying and Recall of Designs subtests as *Gv* measures of Visualization and Visual Memory, respectively. If Flanagan et al. find certain individual subtests of visual-motor skills to be important, this researcher questions the exclusion of the most widely used tests of visual-motor processing: the Beery VMI and the Bender-Gestalt II Copy and Recall subtests.

Psychometrically, the DAS-II subtests do not appear to differ from the Berry VMI or the Bender-Gestalt II. Specifically, DAS-II Copying has a strong positive correlation with the DAS-II Spatial cluster (the equivalent of *Gv*) (*r* = .87) and the General Conceptual Ability (GCA; the composite IQ score) (*r* = .68) (Elliott, 2007). The DAS-II Recall of Designs subtest is positively correlated with the Spatial cluster (*r* = .88) and the GCA (*r* = .74). Results from confirmatory factor analysis indicated that Copying and Recall of Designs had high factor loadings on the Spatial cluster, .69 and .71, respectively. In comparison, the Bender-Gestalt II was co-normed with the CHC-based Stanford-Binet: Fifth Edition. The Copy measure had strong positive correlations with the SB5 Nonverbal IQ (*r* = .54) and the SB5 Full Scale IQ (*r* = .54) (Brannigan & Decker, 2003b). The Bender-Gestalt II Recall subtest was moderately correlated with the Nonverbal IQ (*r* = .48) and the Full Scale IQ (*r* = .48). Correlations between the Bender-Gestalt II subtests and the SB5's *Gv* factor, Visual-Spatial Processing, have not been reported. Furthermore, factor-analytic data between the Bender-Gestalt II and the SB5 are unavailable. However, an exploratory factor analysis of the Bender-Gestalt II and the WISC-III resulted in high loadings for both the Copy and Recall subtests on a factor representing perceptual organizational tasks and a high loading for the Recall subtest on a short-term memory factor (Decker, Allen, & Choca, 2006). Thus, it was concluded that the Bender-Gestalt II may be considered a pure indicator of visuospatial processes. The Beery VMI manual does not provide up to date psychometric properties for its fifth edition, nor was this author able to find any published validity studies for this edition.

Given the limited to lack of validity research on the Bender-Gestalt II and the Beery VMI, it is plausible that Flanagan and colleagues did not have enough empirical evidence to include these instruments in the cross-battery matrices. Empirical validation of test instruments and the abilities they purport to measure is critical to the CHC framework. Without such evidence, it would be contradictory to include unsubstantiated tests in the CHC-XBA framework. Subsequently, construct validity research is certainly needed to clarify the constructs of the improved editions of the Bender-Gestalt II and the Beery VMI.

In spite of the poor availability of psychometric data of these instruments, the inclusion of visual-motor processing is still important to cross-battery assessment. While visual-motor tests may contain construct-irrelevant variance, instruments such as the Bender-Gestalt II and the Beery VMI may satisfy the requirements of construct representation, the third pillar of XBA. For example, the DAS-II Copying and Recall of Designs subtests are each qualitatively different from the second subtest (e.g., Pattern Construction) with which they are joined to form the *Gv* factor. Since Pattern Construction (a measure of Spatial Relations) and Copying or Recall of Designs are measuring different narrow abilities, then XBA indicates there is adequate representation to form a *Gv* broad ability. This same grouping of tests can also apply to matching a Bender-Gestalt II subtest or the VMI to a test that measures a different *Gv* narrow ability. For instance, Decker et al. (2006) found that the Bender-Gestalt II Copy and Recall subtests each loaded onto the same factor containing the WISC-III Block Design subtest (a measure of Visualization and Spatial Relations). Therefore, one of the Bender-Gestalt II subtests could be paired with a test like Wechsler scales' Block Design or DAS-II Pattern Construction to adequately represent the *Gv* broad domain.

Relevance of the Research

Tests of visual-motor integration have traditionally been used as separate processing instruments to supplement IQ tests. However, researchers and practitioners may ask, “Are tests of visual-motor integration still relevant to everyday psychoeducational test batteries?” This researcher contends that the assessment of visual-motor abilities is useful for several reasons. First, the continued use of visual-motor tests still contributes to the comprehensive assessment of an individual’s abilities. The purpose of XBA is to ensure that a broad spectrum of abilities are assessed, thus we get useful information regarding both visual processing and psychomotor abilities.

Second, tests of visual-motor ability are also used as a screener for potential problems that may require more in-depth assessment. Both the Bender-Gestalt II and the Beery VMI include supplemental measures of visual perception and fine motor development that can direct the practitioner toward further assessment of an underlying visual-perceptual or motor deficiency. Therefore, this aids in differential diagnosis of a disorder or dysfunction.

Measurement of visual-motor functioning also provides information about more subtle deficits that are sequelae of various disabilities. This is especially true for disabilities where vision or motor impairment is less evident, yet daily functioning is impacted by weaknesses in visual-motor ability. For example, one would expect to find visual-motor deficiencies in individuals with visual system impairments, cerebral palsy, muscular dystrophy, or intellectual disabilities. However, dysfunction in visual-motor skills are sequelae of medical and neurological conditions such as low birth weight (Gabbard, Goncalves, & Santos, 2001; Hack, Taylor, Klein, Eiben, Schatschneider, & Mercuri-Minich, 1994), sickle cell disease (Kral, Brown, Connelly, Curé, et al., 2006), intracranial hemorrhage secondary to hemophilia (Bladen, Khair, Liesner, & Main, 2009), prelingual deafness (Horn, Fagan, Dillon, & Miyamoto, 2007), benign childhood occipital seizures (Germanó, Gagliano, Magazú, Sferro, Calarese, Mannarino, & Calamoneri, 2005), and Developmental Coordination Disorder (Bonifacci, 2004). Notably, oftentimes with these conditions, visual-motor dysfunction occurs in spite of intact intellectual functioning (e.g., Grunua, Whitfield, & Davis, 2002; Bonifacci, 2004; Germanó et al., 2005). Moreover, Beery & Beery (2004a) note that the Beery VMI tends to be more sensitive than global measures of intelligence for detecting neuropsychological problems in children.

Visual-motor abilities are much more than the ability to copy from paper to paper and paper to board. These skills are also correlated with school adjustment, school readiness, and social-emotional functioning (Bart, Hajami, & Bar-Haim, 2007; Carlton & Winsler, 1999; Kurdek & Sinclair, 2000; McHale & Cermak, 1992). Visual-motor tests are particularly useful in screening for developmental delays since instruments like the Bender-Gestalt II and the Beery VMI assess skills along a developmental continuum.

Finally, assessment of visual-motor functioning is relevant for identifying the appropriate interventions for children who perform poorly on tests of visual-motor ability. In addition to remediating targeted weaknesses, intervention may supply a child with compensatory strategies when visual-motor dysfunctions cannot be resolved.

Conclusions

In conclusion, future research should continue to explore internal and external extensions of CHC broad and narrow abilities. Specifically, there is a need for clarification of these abilities in order to guide practitioners toward a better understanding of children’s abilities and disabilities and to direct them toward appropriate interventions. As recommended by McGrew and Carroll, more construct validity research using exploratory and confirmatory factor analysis is needed. Carroll (1993) particularly advocated for the use of exploratory factor analytic methodologies. In regard to classification of visual-motor abilities within the CHC framework, research on visual-motor skills should control for intelligence in light of McGrew and Evan's (2004) findings that the effects of *Gv* are often dwarfed by *g* or other broad abilities.

In terms of practice, school psychologists should expand their arsenal of test instruments to ensure more comprehensive assessment of children's cognitive skills. It is important to note that cross-battery assessment is only one model of comprehensive assessment and its use needs further investigation by practitioners, as well as researchers. Part of this comprehensive assessment should continue to include an assessment of visual-motor integration. Since much of our knowledge is based on older and poorly normed visual-motor tests, both researchers and practitioners need to investigate what the newly revised tests tell us beyond global measures of intellectual ability. Additionally, given that contemporary intelligence tests are based on CHC theory, it would be useful to understand how newer tests of visual-motor ability complement them.

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CHAPTER TWO

STRUCTURAL EXTENSION OF THE CATTELL-HORN-CARROLL CROSS-BATTERY APPROACH TO INCLUDE MEASURES OF VISUAL-MOTOR INTEGRATION

Introduction

The assessment of underlying cognitive abilities related to academic achievement has been an area of debate within the fields of school psychology, neuropsychology, cognitive psychology, and special education. This debate has been notably evident as the definition of specific learning disabilities has been operationalized and re-operationalized through federal laws such as the Individuals with Disabilities Education Improvement Act (IDEA) of 2004. However, understanding how students process, store, retrieve, and analyze information extends beyond just the ability to classify students as having a specific learning disability. The assessment of cognitive abilities has implications for understanding how all students learn whether they have neurodevelopmental disorders (e.g., autistic spectrum disorders, Attention Deficit Hyperactivity Disorder), sensory impairments, genetic disorders (e.g., Down Syndrome, Fragile X), mental retardation, traumatic brain injuries, perinatal-related conditions (e.g., cerebral palsy, low birth weight), or medical conditions caused by environmental agents (e.g., lead poisoning). Not only is cognitive assessment important for identifying disabilities, it must also address the abilities of students who are culturally and linguistically diverse, as well as those students who are considered to be intellectually gifted. Therefore, measurement of cognitive functioning must be grounded in theory, sufficiently comprehensive to assess multiple abilities, and linked to instructional interventions.

The Cattell-Horn-Carroll (CHC) theory of human intelligence and the cross-battery assessment approach (XBA) are based on the sound psychometric theory that was historically missing from tests of intellectual and cognitive functioning. The theory is so well-validated that new intelligence test batteries have been developed on the foundation of CHC and its immediate predecessor, *Gf-Gc* theory. In spite of the increased coverage of broad and narrow ability constructs, no single test battery has yet to address all ten broad (Stratum II) cognitive abilities. Moreover, there is also concern about construct-relevant representation and the inclusion of multiple, qualitatively different narrow (Stratum I) abilities when constructing CHC clusters. Therefore, exploration of the constructs of new CHC-based intelligence tests and co-normed specific processing batteries will provide insight for the construction and interpretation of CHC broad abilities.

Structural extension research of CHC abilities (McGrew & Evans, 2004) indicates that more research is needed on existing broad and narrow abilities (internal extension), as well as the discovery of new broad abilities (external extension). One widely assessed area of cognitive processing in need of further CHC investigation is visual-motor processing. Visual-motor processing refers to the ability of eyes and hands to work together to perform smooth and efficient tasks such as construction, drawing, and handwriting (Sanghavi & Kelkar, 2005). Visual-motor skills are correlated with school adjustment, school readiness, and social-emotional functioning (Bart, Hajami, & Bar-

Haim, 2007; Carlton & Winsler, 1999; Kurdek & Sinclair, 2000; McHale & Cermak, 1992). Furthermore, evaluation of visual-motor functioning is significant for the detection of developmental delays, learning disabilities, or impairments in an individual's visual or motor systems.

The assessment of visual-motor processing is an important part of the comprehensive evaluation of children's abilities. Traditionally, psychologists have administered measures of visual-motor processing as a special purpose test to accompany their intelligence tests. While tests of visual-motor skills appear to measure broad/Stratum II abilities of Visual Processing (*Gv*) and Psychomotor Abilities (*Gp*), research specifically addressing visual-motor ability is missing from the CHC and cross-battery literature. Within the cross-battery classification of tests, Flanagan and Ortiz (2001) and Flanagan, Ortiz, and Alfonso (2007) include a few subtests from various comprehensive batteries of cognitive functioning (e.g., first and second editions of the *Differential Ability Scales*; Elliott, 1990, 2007). However, it is unclear why the most widely-used tests of visual-motor integration (e.g., *Bender Visual-Motor Gestalt Test, Second Edition*, Brannigan & Decker, 2003a; *The Beery-Buktenica Developmental Test of Visual-Motor Integration, Fifth Edition*, Beery & Beery, 2004; *Wide Range Assessment of Visual-Motor Abilities*, Adams & Sheslow, 1995) were not included in the XBA matrices.

The following section will review the oldest of measure of visual-motor ability, the *Bender Visual-Motor Gestalt Test* (Bender, 1938) and its revision, the Bender-Gestalt II. Through understanding the historical importance of the Bender-Gestalt and the significant improvements made to the latest version, researchers and practitioners will have a better understanding of where comprehensive tests of visual-motor ability fit within the cross-battery model of assessment.

The Bender-Gestalt Tests

The *Bender Visual-Motor Gestalt Test* (Bender, 1938) is one of the most used and well-researched tests of visual-motor integration functioning (Piotrowski, 1995; Brannigan & Decker, 2003a). Originally developed in 1938 from Lauretta Bender's research on the perceptual principles of Gestalt psychology, the Bender-Gestalt measured perceptual motor skills, neurological maturation, and organic psychopathology in children and adults. Bender operated under the notion that "the visual gestalt function is a fundamental function associated with language ability and closely associated with various functions of intelligence such as visual perception, manual motor ability, memory, temporal, and spatial concepts and organization" (Bender, 1938, p.112). Bender developed the Bender-Gestalt from adaptations of Max Wertheimer's (1923) nine gestalt figures. She observed the copied designs of children from 3 to 11 years of age to determine the developmental progression of visual-motor integration skills. Based on these observations, she developed a scoring system in which she evaluated the overall quality of each design on a scale ranging from 1 to 5 on one design and 1 to 7 on the other eight designs. Bender reportedly advocated for global scoring systems as opposed to error-based systems because the latter system seemed to oversimplify the processes measured (Brannigan & Decker, 2006).

The development of the Bender-Gestalt initiated several models for its clinical use. As previously indicated, Bender used the test as (a) a measure of developmental maturation of skills and (b) a measure of psychopathology. Similarly, Hutt (1945, 1969, 1977, 1985) found the Bender-Gestalt to be a good measure of psychopathology, thus developing two psychodynamic projective personality instruments: the Adience-Abience Scale and the Psychopathology Scale. Having been influenced by Hutt’s work, Pascal and Suttell (1951) developed a quantitative scoring system that would differentiate normal individuals from psychiatric patients. Other models, such as those by Canter (1963, 1966), Hutt and Briskin (1960), and Lacks (1984, 1999) also used the Bender-Gestalt in order to detect neurological impairment and to differentiate psychiatric patients with and without organic brain dysfunction.

Although these interpretative models addressed the use of the Bender-Gestalt as a measure of psychopathology, the Bender-Gestalt’s use as a developmental test of visual-motor integration seemed to be ignored. This use was revived with Koppitz’s (1963, 1975) creation of the Developmental Bender Scoring System. Koppitz’s scoring system was based on a normative group of children aged 5 to 11 years and revolved around 30 discrete errors made when copying designs (e.g. distortion, rotation, perseveration, and integration). While Koppitz included emotional indicators in her revision, the Developmental Scoring System was unique in that it demonstrated the utility of the Bender-Gestalt’s use in psychoeducational assessments. Subsequently, deHirsch, Janksy, and Langford (1966), with Bender’s assistance, modified the Bender-Gestalt test by creating a simplified scoring system and used it as a part of a comprehensive battery that was to predict reading skills in children. A more recent model has been developed by Brannigan and Brunner (1989, 1996, 2002): the Qualitative Scoring System for the Modified Version of the Bender-Gestalt Test. Given the normative data, reliability, and validity of the Qualitative Scoring System, Brannigan and Decker (2003b) concluded that this scoring system was more effective in predicting school achievement than Koppitz's Developmental Scoring System.

In spite of the Bender-Gestalt's utility in clinical and research settings, the instrument was subject to unfavorable critiques. For example, in a comprehensive review of studies between 1966 and 1975, Buckley (1978) indicated, as a result of the statistical inadequacies and poor norms for the Bender-Gestalt, there was no conclusive evidence that the could be used to predict school achievement, neurological impairment, or emotional problems. Dana, Field, and Bolton (1983) were critical of (1) the variations in designs between different revisions, (2) a lack of a single standardized administration procedure, (3) varying administration formats (e.g., copying designs, recall, elaboration, multiple-choice), (4) inconsistent application of the Bender's purported construct(s) (e.g., psychopathology, school achievement, neurological impairment), and (5) the marked variability between the scoring systems. Hence, these inconsistencies may lead to questioning the reliability and validity of the Bender. Salvia and Ysseldyke (2001) also questioned the usefulness of the Bender for these same reasons, as well as because of its lack of normative information.

Development of the Bender-Gestalt II. The *Bender Visual-Motor Gestalt Test, Second Edition* (Bender-Gestalt II; Brannigan & Decker, 2003a) represents marked improvement over the original Bender. This new version measures visual-motor integration skills in children and adults from 4 to 85+ years of age. It also provides an assessment of memory for children and adults from 5 to 85+ years of age. Moreover, the Bender-Gestalt II retained its usefulness for clinical, educational, and neuropsychological assessment.

Whereas the original Bender and its various adaptations and scoring systems were criticized for a lack of normative information, the Bender-Gestalt II has a normative sample of 4,000 individuals representative of the 2000 U.S. census. In addition to the traditional Copy procedure, the Bender-Gestalt II includes a norm-based Recall procedure to assess the individual's memory for the designs. Lacks (1999) criticized the original Bender-Gestalt Recall procedure for its ambiguous scoring criteria and lack of normative data. However, this new revision and normative standardization have remedied such concerns. Supplemental motor and perception tests are included to parcel out whether performance is affected by problems with motor skills, visual perceptual skills, or integrative skills. Finally, the Bender-Gestalt II employs a Global Scoring System to assess the overall quality of reproduction of the designs.

Factor analytic studies of the Bender-Gestalt II. As previously noted, empirical validation of the constructs measured by tests is a vital part of contemporary test interpretation. Validity studies reported in the Bender-Gestalt II *Examiner's Manual* (Brannigan & Decker, 2003b) showed significant correlations for the Copy procedure with other measures of visual-motor integration (e.g., the *Beery-Buktenica Developmental Test of Visual-Motor Integration, Fourth Edition, Revised*; Berry VMI; Beery, 1997) and measurement systems (e.g., Developmental Scoring System; Koppitz 1963, 1975). The Bender-Gestalt II *Examiner's Manual* suggested that the lower correlations of the Recall procedure indicate evidence for the presence of a similar, yet distinct ability from visual-motor ability. A correlational study of the Bender-Gestalt II and the *Stanford-Binet Intelligence Scale: Fifth Edition* (SB5; Roid, 2003a) indicated moderate correlations between the SB5 IQ scores and the Bender-Gestalt II Copy and Recall scores.

Construct validity, as reported in the Bender-Gestalt II *Examiner's Manual*, suggested that the Bender-Gestalt II measures a single underlying construct across all age groups. An independent construct validity study examined the relationship between the Bender-Gestalt II and the *Wechsler Intelligence Scale for Children-Third Edition* (WISC-III; Wechsler, 1991). Using exploratory factor analysis, Decker, Allen, and Choca (2006) found evidence for a four-factor model, with both the Bender-Gestalt II Copy and Recall scores having high loadings on a factor representing WISC-III perceptual organizational tasks, particularly those tasks with a visual-motor component. The Recall procedure, along with the WISC-III Digit Span subtest, had high loadings on a fourth factor, thus creating a short-term memory factor. Decker and colleagues (2006) concluded that the Bender-Gestalt II may be considered a pure indicator of visuospatial processes and can be used with other cognitive test batteries as an initial measure of basic visuospatial functions or as a follow-up measure when deficits are found on more complex visuospatial tasks.

While Decker and colleagues provide evidence that the Bender-Gestalt II Copy procedure may represent a Stratum I/narrow ability measure of visuospatial skills, information regarding the utility of the Bender-Gestalt II within the cross-battery approach is currently not available. Given the exclusion of both editions of the Bender-Gestalt from the XBA matrices, one might question the relevance of tests of visual-motor integration to contemporary psychoeducational assessment. More specifically, does the

Bender-Gestalt II tell us anything more than what a new CHC-based intelligence test would tell us?

When constructs are under-represented by one intelligence test, cross-battery researchers advise practitioners to supplement the test with another test that is normed within a few years of each other. They also note that using co-normed tests wards off the criticism of poor correlations between tests. Therefore, what would the administration of the Bender-Gestalt II with its co-normed SB5 tell practitioners about an individual's cognitive abilities, particularly in the area of visual processing?

Stanford-Binet: Fifth Edition

After almost 100 years since its inception, the *Stanford-Binet Intelligence Scale* continues to be one of the most extensively used measures of intellectual functioning. First published in 1916 as an American revision of the *Binet-Simon Intelligence Scale* (Binet & Simon, 1905), the Stanford-Binet scales have undergone many revisions in an attempt to keep up with or improve upon psychometric theory. The Stanford-Binet: Fifth Edition includes several improvements from its previous versions, including an expanded normative age range (2 to 85+ years of age), enhanced floors and ceiling, standard and scaled scores that can be easily compared to other tests, the use of item response theory, and a foundation based on CHC theory. Table 2 summarizes the SB5 subtests and their respective task demands (e.g., input, processing, output).

Results from confirmatory factor analytic studies reported in the SB5 *Technical Manual* (Roid, 2003b) suggested the presence of five factors, each with a correspondence to CHC theory: Fluid Reasoning (*Gf*), Knowledge (*Gc*), Quantitative Reasoning (*Gq*), Visual-Spatial Processing (*Gv*), and Working Memory (*Gsm*). The SB5 yields both

Table 2

SB5 Subtest Task Analysis

Subscale	Subtest	Stimuli	Processes/abilities required	Response
NV Fluid Reasoning	Object Series/Matrices	Visual	Sequencing, inductive reasoning	Nonverbal/Motor
V Fluid Reasoning	Early Reasoning	Visual	Classification of objects	Verbal/Motor
	Verbal Absurdities	Verbal/Visual	Deductive & inductive reasoning	Verbal
	Verbal Analogies	Verbal	Reasoning, problem-solving	Verbal
NV Knowledge	Procedural Knowledge	Verbal/Visual	Knowledge of human actions	Nonverbal/Motor
	Picture Absurdities	Visual	Common knowledge, drawing inferences, attention to detail	Verbal/Motor
V Knowledge	Vocabulary	Verbal	Vocabulary development, verbal expression	Verbal
NV Quantitative Reasoning	Quantitative Reasoning	Verbal/Visual	Mathematical reasoning	Nonverbal/Motor
V Quantitative Reasoning	Quantitative Reasoning	Verbal/Visual	Mathematical reasoning, knowledge	Verbal
NV Visual-Spatial Processing	Form Board	Visual	Spatial orientation	Nonverbal/Motor
	Form Patterns	Visual	Spatial orientation, planning, problem-solving	Nonverbal/Motor
V Visual-Spatial Processing	Position and Direction	Verbal/Visual	Listening ability, expressive language, visualization	Verbal/Motor
NV Working Memory	Delayed Response	Visual	Short-term memory	Nonverbal/Motor
	Block Span	Visual	Short-term memory, working memory	Nonverbal/Motor
V Working Memory	Memory for Sentences	Verbal	Short-term memory	Verbal
	Last Word	Verbal	Short-term memory, working memory	Verbal

Note. NV = Nonverbal. V = Verbal.

Verbal and Nonverbal indexes which each include all the aforementioned factors. However, subsequent research on the factor structure of the SB5 has questioned the number of factors yielded by the test developers (Dombrowski, DiStefano, & Noonan, 2004; DiStefano & Dombrowski, 2006; Canivez, 2008). More specifically, exploratory and confirmatory factor analyses have only found evidence for one global factor (*g*) as opposed to the five-factor model reported by the test authors. Regarding the SB5's fit into the cross-battery approach, Alfonso, Flanagan, and Radwan (2005) indicated that only four broad abilities were adequately represented: *Gf*, *Gc*, *Gv*, and *Gsm*. The Quantitative Reasoning factor was considered to be a narrow ability that contributes to *Gf*, which is consistent with CHC theory classifications. Flanagan et al. (2007) also summarized broad and narrow ability classifications for the SB5 subtests according to the factor analytic procedures reported in the *Technical Manual* (Roid, 2003b). Additionally, they presented secondary classifications obtained via author (e.g., Flanagan and colleagues) consensus that were over and above the primary classifications reported in the test's manual. Table 3 provides a summary of the SB5 CHC classifications made by Roid, as well as Flanagan and her colleagues.

When reviewing the SB5 factor structure in terms of the second pillar of XBA (*construct-relevant variance*), Flanagan and colleagues' consensus appears to indicate that 8 of the 10 subscales may be mixed, rather than pure, measures of CHC abilities. For instance, the Nonverbal Knowledge subscale appears to be measure of both crystallized intelligence and fluid intelligence. Therefore, the examiner could question whether poor performance on this subscale resulted from the examinee's limited fund of general information, poor listening skills, or difficulties with sequential reasoning. This pattern of

Table 3

CHC Broad and Narrow Ability Classifications of the SB5

Subscale	Primary classification	Secondary classification
NV Fluid Reasoning	*Gf*-General sequential reasoning; Induction	*Gv* (narrow ability not reported)
NV Knowledge	*Gc*-General information; Listening ability	*Gf*-General sequential reasoning
NV Quantitative Reasoning	*Gf*-General sequential reasoning	*Gq*-Mathematical knowledge
NV Visual-Spatial Processing	*Gv*-Spatial relations; Closure speed	(No secondary reported)
NV Working Memory	*Gsm*-Memory span; Working memory	*Gv*-Visual memory
V Fluid Reasoning	*Gf*-General sequential reasoning; Induction	*Gc*-Oral production & fluency
V Knowledge	*Gc*-Lexical knowledge	(No secondary reported)
V Quantitative Reasoning	*Gf*-General sequential reasoning	*Gq*-Mathematical achievement
V Visual-Spatial Processing	*Gv*-Visualization	*Gc*-Lexical knowledge; General information
V Working Memory	*Gsm*-Memory span; Working memory	*Gc*-Language development

Note. NV = Nonverbal. V = Verbal. *Gf* = Fluid intelligence. *Gc* = Crystallized intelligence. *Gv* = Visual processing. *Gsm* = Short-term memory. *Gq* = Quantitative reasoning.

classification is consistent with the findings of DiStefano and Dombrowski (2006) and Canivez (2008) where there was evidence of subtest migration and loadings across factors.

While evidence of construct validity for the second pillar may be problematic, content validity for the third pillar (*construct representation*) appears to be adequate for the four CHC broad abilities. For example, *Gf* is measured by two qualitatively different subscales: Nonverbal Fluid Reasoning and Verbal Quantitative Reasoning. *Gc*, *Gv*, and *Gsm* are adequately represented by the respective verbal and nonverbal subscales as reported by SB5 researchers.

Overall, given the questioning of the broad ability/factor structure of the SB5, more research is needed to understand its fit within XBA. There is also a need to uncover how the Bender-Gestalt II can be a part of CHC theory and the cross-battery approach. A correlational study of the Bender-Gestalt II and the SB5, as reported in the Bender-Gestalt II *Examiner's Manual* (Brannigan & Decker, 2003b), indicated moderate correlations between the SB5 IQ scores and the Bender-Gestalt II Copy and Recall scores. However, the manual does not report the correlations between the SB5 factors and the Bender-Gestalt II subtests. Without knowing the relationship between the factors of these tests, it is not clear how the Bender-Gestalt II can be used to supplement the SB5.

Rationale for Current Study

Proponents of the cross-battery approach suggest that practitioners cross batteries to ensure sufficient coverage of broad and specific CHC abilities. Furthermore, Flanagan and McGrew (2001) recommend using supplemental cognitive batteries when broad abilities are underrepresented on one cognitive measure. However, the validity argument of cross-battery methods is threatened by the paucity of CHC-designed exploratory or confirmatory factor analytic studies that focus on both the broad and narrow classifications of cognitive tests (Phelps, McGrew, Knoptik, & Ford, 2005). Therefore, better classification of the abilities measured by widely-used cognitive tests, such as the SB5 and the Bender-Gestalt II, will assist practitioners in merging instruments to provide a more comprehensive assessment of an individual’s cognitive abilities. Thus, the purpose of this study is to identify the underlying constructs shared by the SB5 and the Bender-Gestalt II and to examine their joint factor structure. These research questions will be addressed in the present study:

1. What are the relationships between the Bender-Gestalt II Copy and Recall subtests and the SB5 subscales?
2. What dimensions do the Bender-Gestalt II subtests and SB5 subscales load on?
3. Does the addition of the Bender-Gestalt II extend the factor structure of the SB5 beyond the one-factor model suggested in independent factor analytic studies?

For the first question, the author hypothesizes that the Bender-Gestalt II Copy subtest will have a strong positive correlation with the SB5 Nonverbal Visual-Spatial Processing subscale. It is also hypothesized that the Bender-Gestalt II Recall subtest will have moderate positive correlations with the SB5 Nonverbal Visual-Spatial Processing and Nonverbal Working Memory subscales. Low correlations are expected between the Bender-Gestalt subtests and the SB5 Verbal subscales, such as Fluid Reasoning, Knowledge, and Working Memory.

For the second question, the researcher hypothesizes that the Bender-Gestalt-II Copy subtest and the SB5 Visual-Spatial Processing subscales will load onto the same factor. It is also hypothesized that the Recall subtest will load onto factors containing the SB5 Nonverbal Visual-Spatial Processing and Nonverbal Working Memory subscales. Finally, in regard to the third research question, the author hypothesizes that the addition of the Bender-Gestalt II Copy and Recall subtests to the SB5 factor structure will produce a multi-factor model.

Methods

Participants

The data were collected from participants as part of normative samples of the Bender-Gestalt II and the SB5. Data are available from the Bender-Gestalt II for ages 4 to 85+ years of age and from the SB5 for ages 2 to 85+ years of age. Only participants that were co-normed on all subtests of both instruments were included in the study. For example, normative data for the Recall subtest of the Bender-Gestalt II begins at age 5, whereas data for the Copy subtest begins at age 4. Thus, the total sample available for this study includes 3,600 participants from the ages of 5 to 85+ years of age. Sampling variables for both instruments were based on the 2000 U.S. Census and are included in Table 4.

Table 4

Demographic Variables for the Bender-Gestalt II and the SB5

	Variable	Bender-Gestalt II	Stanford-Binet 5
Sex	Female	51.0	51.6
	Male	49.0	48.4
Race/Ethnicity	White/Anglo American	69.1	69.8
	Black/African American	12.2	12.4
	Hispanic	12.3	11.8
	Asian	3.8	2.9
	Other	2.7	3.2
Education	<12	18.4	18.9
	12	32.7	32.3
	>12	48.9	48.8
Region	Northeast	19.2	18.2
	Midwest	22.6	23.0
	South	35.4	35.2
	West	22.7	23.7

Note: Percentages are reported. <12 = less than high graduation; 12 = high school graduate or equivalency; >12 = completed education levels beyond high school.

In addition to the standardization samples, clinical samples were collected for each instrument. According to the technical manuals for both instruments, the individuals in these special groups were matched with control samples to study the differential effects of group inclusion on test performance. Although the participants from the clinical and special populations were not included in the current study, they are worthy of being noted.

The Bender-Gestalt II *Examiner's Manual* (Brannigan & Decker, 2003b) indicates that the clinical samples were identified through various criteria belonging to each exceptionality (e.g., state education agency or IDEA definitions of a disability, DSM-IV-TR diagnostic criteria). The special populations included individuals with mental retardation, specific learning disabilities, Attention Deficit Hyperactivity Disorder, serious emotional disturbance, autism, Alzheimer's disease, and giftedness. Similar criteria for the selection of participants in the special groups were used by the SB5. More specifically, the SB5 *Technical Manual* (Roid, 2003b) included individuals with documented membership in the categories of mental retardation, giftedness, developmentally delayed, autism, limited English language proficiency, speech/language disorders, learning disabilities, Attention Deficit Hyperactivity Disorder, serious emotional disturbance, and orthopedic or motor impairment.

Instruments

Stanford-Binet Intelligence Scale, Fifth Edition. The normative sample of the SB5 included a nationally representative sample of 4,800 individuals and reflected the demographic characteristics of the 2000 U.S. Census. Twenty-three age groups were defined, with the sample ranging in age from 2 years, 0 months to 89 years, 11 months.

Internal reliability coefficients for the Full Scale IQ ranged from .97 to .98 across the 23 age groupings. Average reliabilities across ages for the Nonverbal IQ and Verbal IQ were .95 and .96, respectively. Additionally, average correlations for the five factor index scores ranged from .90 to .92. Internal consistency for the ten subscales was assessed by using the Spearman-Brown formula for computing split-half reliability. The mean reliability coefficients across the age groupings spanned from .84 to .89.

Test-retest stability coefficients were reported in the SB5 *Technical Manual* according the following age groupings: 2-5, 6-20, 21-59, and 60 and older. The Full Scale IQ coefficients across all age ranges were high, ranging from .93 to .95. Correlations for the Nonverbal IQ were from .89 to .93, and for the Verbal IQ, .92 to .95. The correlations for the Factor Indexes spanned from .79 to .85, with a median of .88. Finally, stability coefficients across the subscales ranged from .66 to.93 (Nonverbal Working Memory for ages 21-59 and Verbal Knowledge for ages 21-59, respectively). Median correlations for each age group were reported as .82 for 2-5, .87 for 6-20, .79 for 21-59, and .86 for 60-plus. Interrater agreement correlations ranged from .74 to .97, with a median of .90.

The *Technical Manual* offers evidence of content, criterion, and construct-related validity for the SB5. Content validity was established through expert review of test items and experts in CHC theory. Strong evidence of criterion validity was reported for the SB5 Full Scale IQ and the *Stanford-Binet Intelligence Scale, Fourth Edition* (SB:IV; Thorndike, Hagen, & Sattler, 1986) Test Composite score (r = .90). Criterion validity was also reported for the SB5 ABIQ and FSIQ, with a correlation of .81 for the 2-5 age group and a correlation of .87 for ages 6 and above. In order to measure construct-related validity, several studies investigated age trends; intercorrelations of IQ, factor, and subscale scores; evidence for general ability (*g* loadings); and confirmatory factor analysis. In regards to the presence of a general ability factor, the mean subtest principal axis loadings across age groups ranged from .66 to .81, while the mean principal component loadings ranged from .70 to .83. Although still considered to be a fair measure of *g* as suggested by Kamphaus (1993), the lowest average principal axis loading was noted for Nonverbal Fluid Reasoning (r = .66). Results of confirmatory factor analyses confirmed the presence of verbal and nonverbal domains and a five-factor model by using split-half subscale scores (total of 20 scores).

Bender Visual-Motor Gestalt Test: Second Edition. The normative sample of the Bender-Gestalt II included a sample of 4,000 individuals and reflected the demographic characteristics of the 2000 U.S. Census. The sample was divided into 21 age groups and ranged in age from 4 years, 0 months to 85 years and older. The Bender-Gestalt II was co-normed with the SB5. Interrater reliabilities for the Copy and Recall phases were .85 and .92, respectively. Internal consistency for the two procedures was assessed by using the Spearman-Brown formula for computing split-half reliability. The overall reliability for the standardization group was .91. Test-retest stability coefficients were divided according to the four age groupings: 4-7, 8-17, 18-49, and 50 and older. Corrected coefficients for the Copy phase ranged from .80 to .88, whereas the range for the Recall phase was from .80 to .86.

Content validity of the Bender-Gestalt items was determined through years on the original Bender and its scoring systems. Criterion validity was established via correlations with the Beery VMI (Copy r = .65; Recall r = .44) and the Koppitz Developmental Bender Scoring System (Copy r = .80; Recall r = .51). Exploratory factor analysis yielded high factor loadings on a single factor. Explained variances ranged from 47.51% to 64.70%, with the highest percentage for the 4 to 7 age group.

Statistical Analyses

A complete data set (e.g., all subtest scores from the Bender-Gestalt II and the SB5) was available for 3,015 participants ranging in age from 5 to 97 years. Data were analyzed by five separate age groupings: 5-7, 8-12, 13-18, 19-50, and 51 and up. These groupings were chosen based on a compromise between age groups reported in the Bender-Gestalt II *Examiner's Manual* (Brannigan & Decker, 2003b) and the SB5 *Technical Manual* (Roid, 2003b). These groupings also represent the developmental progression of visual-motor ability as described by Brannigan and Decker. Specifically, growth curves of the Bender-Gestalt II show that visual-motor development increases sharply at younger ages, levels off around the ages of 16 to 49, and then declines at about age 50.

All statistical analyses were conducted using SPSS 16.0. Correlational analyses between all of the SB5 subscales and Bender-Gestalt II Copy and Recall subtests were conducted for each age grouping. Based on the resulting correlation matrix, an exploratory factor analysis (EFA) of the SB5 and the Bender-Gestalt II was performed. Exploratory factor analysis is often used to generate theories about the variables being tested. More specifically, EFA is advantageous because of its (a) usefulness when there is a weak literature base; (b) ability to determine the number of factors present; (c) ability to determine whether the factors are correlated or uncorrelated; and (d) lenience in that the variables are free to load on all factors (Stevens, 2002). Thus, EFA is appropriate for the current study because previous research has yielded inconsistent results regarding the factor structure of the SB5 and there is a paucity of factor analytic research on the Bender-Gestalt II. Additionally, the Bender-Gestalt II *Examiner's Manual* reports the correlations between the Copy and Recall subtests and the SB5 Full Scale, Nonverbal, and Verbal IQ scores, but not the correlations between the subtests and the CHC factor scores. The use of EFA has also been recommended by CHC theorists and researchers (e.g., Carroll, 1993; McGrew, 1997; Phelps, McGrew, Knoptik, & Ford, 2005; Dombrowski et al., 2004) in order to strengthen models of broad and narrow abilities and to support the models presented in the test batteries' technical manuals.

When conducting an EFA, Fabrigar, Wegener, MacCallum, and Strahan (1999) suggest that the researcher should consider the following methodological issues: (a) decide the variables to be included and the size and nature of the sample; (b) determine if EFA is appropriate for the goals of the project; (c) select a specific procedure to fit the model to the data; (d) decide how many factors should be included in the model; and (e) select a method for rotating the initial factor analytic solution in order to yield a final solution that is readily interpreted.

The factor-extraction procedure used in the present study was the Maximum Likelihood procedure. Maximum Likelihood is suggested by Fabrigar et al. (1999) because it "permits statistical significant testing of factor loadings and correlations among factors" (p. 277). It also produces a chi-square (x^2) statistic as a measure of goodness-of-fit, or the probability that a model correctly represents the data being analyzed. Bartlett's (1950) chi-square statistic tests the hypothesis that the remaining eigenvalues are equal. Factors are entered into the statistical program sequentially until the chi-square test fails to reject the null hypothesis. In other words, a non-significant result is indicative of a good model fit. Use of the chi-square statistic may be disadvantageous because it is easily influenced by large sample sizes. More specifically, for large samples, chi-square statistics will remain significant even if the model is slightly incorrect.

Determination of the number of factors to retain in the current investigation employed the use of multiple criteria, including application of the Kaiser (1960) rule of selecting factors with eigenvalues greater than one; the chi-square statistic; examination of the percentage of variance that each factor subsequently added to the total variance; and expert judgment based on theoretical and content knowledge. When selecting the numbers of factors to include in a model, it is important to find a balance between specifying too few or too many factors. Fabrigar et al. (1999) and Hayton, Allen, and Scarpello (2004) indicated that methodologists have traditionally regarded underfactoring as being more severe than overfactoring. Therefore, researchers are advised to use multiple criteria when deciding on an appropriate number of factors to retain.

Rotation of the original factor matrix is important for the interpretability of factor loadings. Thurstone (1947) suggested guidelines for factor rotation that would produce a “simple structure” in which

> …each factor was defined by a subset of measured variables that had large loadings relative to the other measured variables (i.e., high within-factor variability in loadings) and in which each measured variable loaded highly on only a subtest of common factors (i.e., low factorial complexity in defining variables) (Fabrigar, 1999, p.281).

The two methods for rotating factor solutions are orthogonal and oblique rotations. The orthogonal rotation produces factors that are uncorrelated, whereas factors are permitted to correlate with oblique rotations. Gorsuch (1983) and Fabrigar and colleagues (1999) indicate that oblique rotations are more useful for constructs in psychology because of the tendency for the constructs to be correlated with one another. Although oblique rotations may reflect the best fit to real world scenarios, the disadvantage of oblique rotations is that the results produced are less likely to be replicated by future studies. Gorsuch advises using promax rotation (Hendrickson & White, 1964), a type of oblique rotation. The promax rotation involves altering the orthogonal rotation to get an oblique solution.

For the present study, a promax rotation was performed first in order to obtain a factor correlation matrix. This was followed by conducting a varimax (orthogonal) rotation to compare the results. However, the promax rotation was found to produce the simplest structure and more interpretable factor loadings.

Factor interpretation also requires both statistical criteria and expert judgment. Stevens (2002) suggests limiting factor interpretation to those subtests that have factor loadings of .40 or higher. Thus, subtests which share at least 16% of the variance of a construct would be included as a salient part of that factor. Comrey and Lee (1992) defined factor loadings of .32 to .44 as poor, .45 to .54 as fair, .55 to .62 as good, .63 to .70 as very good, and .71 and greater as excellent.

Results

Research Question One

Correlational analyses were performed in order to examine the relationship between the Bender-Gestalt II Copy and Recall subtests and the SB5 subscales. Means, standard deviations, and Pearson correlations for each age group are summarized in Tables 5 through 9. For all age groups, all correlations between the Bender-Gestalt II and the SB5 subtests were positive and significant at $p < .01$.

Ages 5-7. For the Copy measure, correlations for ages 5-7 ranged from .30 to .43, indicative of moderate correlations between Bender-Gestalt II Copy subtest and the SB5 subscales (see Table 5). The lowest intercorrelations for Bender-Gestalt II Copy were with Verbal Fluid Reasoning (r = .30) and Verbal Knowledge (r = .30), and the highest correlation was with Verbal Quantitative Reasoning (r = .42). The Copy subtest was moderately correlated with Nonverbal Visual-Spatial Processing (r = .37).

Correlations between the Bender-Gestalt II Recall subtest and the SB5 subscales ranged from .23 to .35, suggesting low to moderate intercorrelations. The highest correlation for the Recall measure was with Verbal Quantitative Reasoning (r = .42). Bender-Gestalt II Recall was moderately correlated with Nonverbal Visual-Spatial Processing (r = .33). However, there was a low correlation between Recall and Nonverbal Working Memory (r = .27).

Ages 8-12. For ages 8 through 12, moderate correlations were found between Bender-Gestalt II Copy subtest and the SB5 subscales, ranging from .35 to .45 (see Table 6). The lowest correlations for the Copy measure were with Nonverbal Working Memory (r = .35) and Verbal Working Memory (r = .35). The highest correlation was with Verbal Quantitative Reasoning (r = .45). The Copy subtest was moderately correlated with Nonverbal Visual-Spatial Processing (r = .44).

Correlations between the Bender-Gestalt II Recall subtest and the SB5 subscales ranged from .32 to .40, indicative of moderate correlations. The Recall measure’s highest

Table 5

Bender-Gestalt II and SB5 Means, Standard Deviations, and Pearson Correlations (Ages 5-7)

Subtest	M	SD	1	2	3	4	5	6	7	8	9	10	11
Bender-Gestalt II													
1. Copy	101.22	12.66											
2. Recall	101.24	13.96	.43**										
SB5													
3. NFR	9.90	3.65	.37**	.32**									
4. NKN	10.02	2.15	.31**	.23**	.48**								
5. NQR	10.10	2.14	.34**	.27**	.48**	.50**							
6. NVS	10.12	3.04	.37**	.33**	.48**	.47**	.51**						
7. NWM	10.00	2.82	.38**	.27**	.47**	.41**	.50**	.50**					
8. VFR	10.06	3.13	.30**	.24**	.50**	.53**	.43**	.49**	.48**				
9. VKN	10.07	2.97	.30**	.24**	.46**	.52**	.41**	.42**	.35**	.53**			
10. VQR	10.28	2.50	.42**	.35**	.55**	.48**	.56**	.56**	.49**	.48**	.44**		
11. VVS	10.41	2.56	.31**	.25**	.46**	.54**	.55**	.49**	.45**	.53**	.55**	.53**	
12. VWM	10.16	3.12	.31**	.27**	.46**	.50**	.49**	.46**	.44**	.44**	.46**	.50**	.53**

Note. NFR = Nonverbal Fluid Reasoning, NKN = Nonverbal Knowledge, NQR = Nonverbal Quantitative Reasoning, NVS = Nonverbal Visual-Spatial Processing, NWM = Nonverbal Working Memory, VFR = Verbal Fluid Reasoning, VKN = Verbal Knowledge, VQR = Verbal Quantitative Reasoning, VVS = Verbal Visual-Spatial Processing, VWM = Verbal Working Memory.

N=487. **$p < .01$, two-tailed.

Table 6

Bender-Gestalt II and SB5 Means, Standard Deviations, and Pearson Correlations (Ages 8-12)

Subtest	M	SD	1	2	3	4	5	6	7	8	9	10	11
Bender-Gestalt II													
1. Copy	100.35	13.35											
2. Recall	100.37	14.84	.59**										
SB5													
3. NFR	9.90	3.17	.41**	.33**									
4. NKN	9.96	2.99	.44**	.40**	.51**								
5. NQR	9.90	2.88	.45**	.39**	.59**	.61**							
6. NVS	10.20	2.84	.44**	.38**	.50**	.60**	.56**						
7. NWM	9.55	2.92	.35**	.32**	.44**	.47**	.55**	.51**					
8. VFR	10.02	2.99	.36**	.32**	.52**	.62**	.56**	.54**	.47**				
9. VKN	9.87	2.98	.40**	.37**	.46**	.60**	.53**	.51**	.46**	.61**			
10. VQR	10.01	2.77	.45**	.38**	.49**	.61**	.68**	.58**	.53**	.57**	.55**		
11. VVS	10.23	2.87	.37**	.33**	.52**	.62**	.65**	.58**	.50**	.56**	.59**	.65**	
12. VWM	9.96	2.68	.35**	.36**	.43**	.53**	.53**	.50**	.52**	.57**	.54**	.51**	.56**

Note. NFR = Nonverbal Fluid Reasoning, NKN = Nonverbal Knowledge, NQR = Nonverbal Quantitative Reasoning, NVS = Nonverbal Visual-Spatial Processing, NWM = Nonverbal Working Memory, VFR = Verbal Fluid Reasoning, VKN = Verbal Knowledge, VQR = Verbal Quantitative Reasoning, VVS = Verbal Visual-Spatial Processing, VWM = Verbal Working Memory.

N=905. ***p* < .01, two-tailed.

correlation was with Nonverbal Knowledge (*r* = .40). Bender-Gestalt II Recall was moderately correlated with Nonverbal Visual-Spatial Processing (*r* = .38) and Nonverbal Working Memory (*r* = .32).

Ages 13-18. Table 7 shows the Bender-Gestalt II subtest and SB5 subscale intercorrelations for ages 13 to 18. For the Copy measure, moderate correlations ranged from .35 (Nonverbal Fluid Reasoning) to .48 (Verbal Quantitative Reasoning). The Bender-Gestalt II Copy subtest was moderately correlated with Nonverbal Visual-Spatial Processing (*r* = .46).

Correlations between the Bender-Gestalt II Recall subtest and the SB5 subscales ranged from .37 to .50, suggesting moderate correlations. The highest correlation for the Recall measure was with Verbal Quantitative Reasoning (*r* = .50). Bender-Gestalt II Recall was moderately correlated with Nonverbal Visual-Spatial Processing (*r* = .44) and Nonverbal Working Memory (*r* = .47).

Ages 19-50. For ages 19 through 50, moderate correlations were found between Bender-Gestalt II Copy subtest and the SB5 subscales, ranging from .39 to .51 (see Table 8). The lowest correlation with the Copy measure was Verbal Knowledge (*r* = .39), while the highest correlation was with Nonverbal Quantitative Reasoning (*r* = .51). The Copy subtest was moderately correlated with Nonverbal Visual-Spatial Processing (*r* = .40).

Correlations between the Bender-Gestalt II Recall subtest and the SB5 subscales ranged from .38 to .53, indicative of moderate to strong correlations. The Recall measure shared strong correlations with both Verbal and Nonverbal Quantitative Reasoning (*r* = .53 for both intercorrelations). Bender-Gestalt II Recall was moderately correlated with Nonverbal Visual-Spatial Processing (*r* = .38) and Nonverbal Working Memory (*r* = .40).

Table 7

Bender-Gestalt II and SB5 Means, Standard Deviations, and Pearson Correlations (Ages 13-18)

Subtest	M	SD	1	2	3	4	5	6	7	8	9	10	11
Bender-Gestalt II													
1. Copy	100.36	15.26											
2. Recall	100.60	15.14	.65**										
SB5													
3. NFR	9.98	2.94	.35**	.37**									
4. NKN	10.05	3.05	.46**	.47**	.49**								
5. NQR	9.99	3.38	.47**	.48**	.58**	.67**							
6. NVS	10.15	3.10	.46**	.44**	.44**	.57**	.58**						
7. NWM	10.01	3.63	.41**	.47**	.47**	.53**	.61**	.49**					
8. VFR	9.98	3.01	.40**	.45**	.48**	.63**	.60**	.53**	.53**				
9. VKN	9.61	2.67	.41**	.40**	.49**	.61**	.58**	.49**	.48**	.62**			
10. VQR	10.15	3.28	.48**	.50**	.55**	.67**	.74**	.62**	.64**	.67**	.61**		
11. VVS	10.01	3.27	.47**	.49**	.51**	.69**	.69**	.61**	.61**	.62**	.62**	.72**	
12. VWM	9.85	2.71	.37**	.38**	.46**	.55**	.59**	.46**	.55**	.51**	.52**	.57**	.59**

Note. NFR = Nonverbal Fluid Reasoning, NKN = Nonverbal Knowledge, NQR = Nonverbal Quantitative Reasoning, NVS = Nonverbal Visual-Spatial Processing, NWM = Nonverbal Working Memory, VFR = Verbal Fluid Reasoning, VKN = Verbal Knowledge, VQR = Verbal Quantitative Reasoning, VVS = Verbal Visual-Spatial Processing, VWM = Verbal Working Memory.

N=746. ***p* < .01, two-tailed.

Table 8

Bender-Gestalt II and SB5 Means, Standard Deviations, and Pearson Correlations (Ages 19-50)

Subtest	M	SD	1	2	3	4	5	6	7	8	9	10	11
Bender-Gestalt II													
1. Copy	100.61	15.92											
2. Recall	101.47	14.91	.63**										
SB5													
3. NFR	10.08	2.77	.41**	.41**									
4. NKN	10.32	3.20	.48**	.52**	.58**								
5. NQR	10.45	3.33	.51**	.53**	.62**	.66**							
6. NVS	10.36	3.34	.40**	.38**	.47**	.62**	.58**						
7. NWM	10.50	3.34	.40**	.41**	.50**	.59**	.59**	.61**					
8. VFR	10.38	3.08	.41**	.45**	.52**	.61**	.60**	.51**	.53**				
9. VKN	10.32	3.10	.39**	.41**	.54**	.63**	.59**	.51**	.48**	.63**			
10. VQR	10.41	3.29	.50**	.53**	.60**	.72**	.80**	.65**	.65**	.67**	.65**		
11. VVS	10.37	3.34	.47**	.47**	.60**	.70**	.74**	.61**	.59**	.63**	.62**	.80**	
12. VWM	10.23	3.13	.40**	.42**	.50**	.60**	.62**	.63**	.62**	.58**	.56**	.64**	.62**

Note. NFR = Nonverbal Fluid Reasoning, NKN = Nonverbal Knowledge, NQR = Nonverbal Quantitative Reasoning, NVS = Nonverbal Visual-Spatial Processing, NWM = Nonverbal Working Memory, VFR = Verbal Fluid Reasoning, VKN = Verbal Knowledge, VQR = Verbal Quantitative Reasoning, VVS = Verbal Visual-Spatial Processing, VWM = Verbal Working Memory.

N=374. **p < .01, two-tailed.

Ages 51+. Table 9 shows the Bender-Gestalt II and SB5 subtest intercorrelations for adults aged 51 and higher. For the Copy measure, moderate correlations ranged from .31 (Verbal Working Memory) to .44 (Nonverbal Quantitative Reasoning). The Bender-Gestalt II Copy subtest was moderately correlated with Nonverbal Visual-Spatial Processing (r = .43).

Correlations between the Bender-Gestalt II Recall subtest and the SB5 subscales ranged from .30 to .41, with the highest correlation between the Recall measure and Nonverbal Quantitative Reasoning (r = .41). Moderate correlations were found between Bender-Gestalt II Recall and Nonverbal Visual-Spatial Processing (r = .35) and Nonverbal Working Memory (r = .34).

Research Questions Two and Three

The Maximum Likelihood method of factor extraction and oblique (promax) rotation were utilized to reveal the dimensions on which the Bender-Gestalt II sutests and the SB5 subscales load. Additionally, multiple criteria (e.g., eigenvalue >1, x^2 statistic, interpretation of the last factor, theoretical explanation) were used to determine the number of factors to retain, thus suggesting the simplest structural model for the Bender-Gestalt II and the SB5. Factor loadings of all subtests were calculated separately for each age grouping.

Ages 5 to 7. For children who were 5 to 7 years old, three factors were extracted, accounting for 51% of the variance in test scores. This three-factor model produced eigenvalues of 5.3, .5, and .3. The chi-square goodness-of-fit test was not significant (x^2 = 35.70, df = 33, p = .343), suggesting that the three-factor solution could be the best model for this age group.

Table 9

Bender-Gestalt II and SB5 Means, Standard Deviations, and Pearson Correlations (Ages 51 and up)

Subtest	M	SD	1	2	3	4	5	6	7	8	9	10	11
Bender-Gestalt II													
1. Copy	101.27	14.77											
2. Recall	100.85	15.16	.54**										
SB5													
3. NFR	10.27	2.91	.32**	.31**									
4. NKN	10.50	2.77	.43**	.37**	.48**								
5. NQR	10.38	2.82	.44**	.41**	.58**	.63**							
6. NVS	10.29	2.73	.43**	.35**	.52**	.61**	.56**						
7. NWM	10.44	2.68	.35**	.34**	.56**	.54**	.55**	.60**					
8. VFR	10.38	2.66	.42**	.37**	.49**	.65**	.56**	.57**	.55**				
9. VKN	10.71	2.90	.32**	.30**	.49**	.54**	.45**	.41**	.46**	.54**			
10. VQR	10.39	2.70	.39**	.38**	.50**	.67**	.71**	.61**	.61**	.58**	.48**		
11. VVS	10.30	2.69	.37**	.32**	.54**	.64**	.64**	.61**	.58**	.59**	.47**	.68**	
12. VWM	10.48	2.72	.31**	.30**	.45**	.51**	.48**	.55**	.53**	.50**	.47**	.53**	.49**

Note. NFR = Nonverbal Fluid Reasoning, NKN = Nonverbal Knowledge, NQR = Nonverbal Quantitative Reasoning, NVS = Nonverbal Visual-Spatial Processing, NWM = Nonverbal Working Memory, VFR = Verbal Fluid Reasoning, VKN = Verbal Knowledge, VQR = Verbal Quantitative Reasoning, VVS = Verbal Visual-Spatial Processing, VWM = Verbal Working Memory.

N=503. $^{**}p < .01$, two-tailed.

Factor loadings for the rotated matrix for each subtest are presented in Table 10. The factor intercorrelations were *r* = .78 for Factors 1 and 2, *r* = .65 for Factors 1 and 3, and *r* = .49 for Factors 2 and 3.

Table 10

Rotated Factor Matrix with Bender-Gestalt II and SB5 Subtests by Factor Weight (Ages 5-7)

Subtest	Factor		
	1	2	3
NV Quantitative Reasoning	**.80**	-.01	-.08
NV Working Memory	**.68**	-.05	.06
V Quantitative Reasoning	**.64**	.03	.14
NV Visual-Spatial Processing	**.60**	.05	.12
V Working Memory	**.45**	.28	-.01
V Visual-Spatial Processing	**.44**	**.43**	-.11
NV Fluid Reasoning	**.40**	.23	.15
V Knowledge	-.18	**.89**	.07
V Fluid Reasoning	.25	**.49**	.01
NV Knowledge	.33	**.47**	-.07
Bender-Gestalt Recall	-.03	.00	**.65**
Bender-Gestalt Copy	.08	.01	**.61**

Note. NV = Nonverbal. V = Verbal. Maximum Likelihood solution using promax with Kaiser normalization. Rotation converged in 6 iterations. All loadings >.40 in boldface (Stevens, 2002).

The first and second factors only include loadings from subscales from the SB5. In keeping with Comrey and Lee's (1992) factor loading classifications, Factor 1 consisted of good to excellent loadings (> .55) from the Nonverbal Quantitative Reasoning, Nonverbal Working Memory, Verbal Quantitative Reasoning, and Nonverbal Visual-Spatial Processing subscales. Factor 1 loadings from the Verbal Working Memory, Verbal Visual-Spatial Processing, and Nonverbal Fluid Reasoning subscales were poor to fair (.32 to .54). For Factor 1, the highest subscale loadings appear to indicate that this factor mostly represents a factor for nonverbal/visual tasks.

The second factor consisted of an excellent loading from the Verbal Knowledge subscale and fair loadings from the Verbal Fluid Reasoning and Nonverbal Knowledge subscales. The Verbal Visual-Spatial Processing subscale evidenced cross-loadings on Factors 1 and 2. However, this subtest's loadings on both factors are considered to be poor (≤ .44). Factor 2 appears to reflect verbally-related abilities, particularly a child's language-based general knowledge.

The Bender-Gestalt II Copy and Recall scores were highly loaded on the third factor. This factor can clearly be defined as representing the Bender-Gestalt II, or visual-motor processing.

Ages 8 to 12. Three factors were extracted for the 8 through 12 age grouping, which accounted for 58% of the variance in test scores. Eigenvalues yielded from these three factors were 6.1, .6, and .2. The chi-square goodness-of-fit test was significant ($x^2 = 86.42$, $df = 33$, $p = .000$). However, when analyses were computed until a non-significant result was obtained (e.g., five-factor model), this resulted in over-factoring (e.g., lack of substantial loadings on fourth and fifth factors). Therefore, based on theoretical interpretation of the last factor, three factors were retained.

Factor loadings for the rotated matrix for each subtest are presented in Table 11. The factor intercorrelations were $r = .83$ for Factors 1 and 2, $r = .59$ for Factors 1 and 3, and $r = .62$ for Factors 2 and 3.

The Verbal Knowledge and Verbal Fluid Reasoning subscales yielded excellent loadings on Factor 1. This factor also contained good loadings from the Verbal Working

Table 11

Rotated Factor Matrix with Bender-Gestalt II and SB5 Subtests by Factor Weight (Ages 8-12)

Subtest	Factor		
	1	2	3
V Knowledge	**.80**	-.06	.05
V Fluid Reasoning	**.78**	.05	-.05
V Working Memory	**.59**	.14	.00
NV Knowledge	**.58**	.19	.07
NV Visual-Spatial Processing	.39	.30	.11
NV Quantitative Reasoning	-.04	**.89**	-.01
V Quantitative Reasoning	.20	**.60**	.04
V Visual-Spatial Processing	**.44**	**.47**	-.10
NV Fluid Reasoning	.19	**.45**	.09
NV Working Memory	.26	**.42**	.01
Bender-Gestalt Copy	-.06	.03	**.90**
Bender-Gestalt Recall	.12	-.02	**.62**

Note. NV = Nonverbal. V = Verbal. Maximum likelihood solution using promax with Kaiser normalization. Rotation converged in 5 iterations. All loadings >.40 in boldface (Stevens, 2002).

Memory and Nonverbal Knowledge subscales. Therefore, Factor 1 appears to reflect verbally-mediated tasks, especially those involving verbal stimuli and/or a verbal response.

The Verbal Visual-Spatial Processing subscale cross-loaded on Factors 1 and 2, but only produced poor to fair loadings on each factor. Nevertheless, Factor 2 contained an excellent loading from the Nonverbal Quantitative Reasoning subscale and a good loading from the Verbal Quantitative Reasoning subscale. The Verbal Visual-Spatial Processing and Nonverbal Fluid Reasoning subscales were only considered to have fair loadings on Factor 2. The subtest loadings on Factor 2 seem to represent mathematical reasoning skills, as well as the ability to reason through visual means.

Once again, Factor 3 only included substantial loadings from the Bender-Gestalt II subtests. The Copy subtest had a markedly high loading, while the Recall subtest had a good loading. Factor 3 reflects visual-motor processing skill.

Ages 13 to 18. Similar to the previous age groupings, three factors were extracted for ages 13 to18. These factors accounted for 62% of the variance in test scores with eigenvalues of 3.3, 4.0, and .2. The chi-square goodness-of-fit test was significant (x^2 = 71.75, df = 33, p = .000). However, the three-factor model appeared to be the best fit based on the fact that two of the factors had eigenvalues > 1 and the meaningful interpretation of the third factor. In spite of decreasing x^2 statistics, the fourth and fifth models were less meaningful and their inclusion would have resulted in over-factoring.

Table 12 includes the factor loadings for the rotated matrix for each subtest. The correlation between Factors 1 and 2 was r = .85, between Factors 1 and 3 was r = .60, and between Factors 2 and 3 was r = .55.

No evidence of subtest cross-loadings was found between the three factors. Factor 1 consists of excellent loadings from Nonverbal Working Memory and Nonverbal Quantitative Reasoning, a very good loading from Verbal Quantitative Reasoning, and good loadings from Verbal Visual-Spatial Processing and Verbal Working Memory. Nonverbal Fluid Reasoning yielded a fair loading on this factor, while Nonverbal Visual-Spatial Processing yielded a poor loading. Based on these subscale loadings, Factor 1 appears to reflect tasks that require reasoning (mathematical, sequential, and inductive), memory, and visual-spatial analysis.

Table 12

Rotated Factor Matrix with Bender-Gestalt II and SB5 Subtests by Factor Weight (Ages 13-18)

Subtest	Factor		
	1	2	3
NV Working Memory	**.81**	-.08	.01
NV Quantitative Reasoning	**.80**	.05	.01
V Quantitative Reasoning	**.68**	.21	.00
V Visual-Spatial Processing	**.55**	.31	.01
V Working Memory	**.55**	.17	-.01
NV Fluid Reasoning	**.54**	.13	-.01
NV Visual-Spatial Processing	**.44**	.22	.11
V Knowledge	.01	**.77**	.01
V Fluid Reasoning	.18	**.65**	-.02
NV Knowledge	.34	**.47**	.04
Bender-Gestalt Copy	-.07	.00	**1.04**
Bender-Gestalt Recall	.26	.03	**.49**

Note. NV = Nonverbal. V = Verbal. Maximum likelihood solution using promax with Kaiser normalization. Rotation converged in 4 iterations. All loadings >.40 in boldface (Stevens, 2002).

High loadings on Factor 2 were obtained from Verbal Knowledge and Verbal Fluid Reasoning. Nonverbal Knowledge had a fair loading on this factor. Therefore, the second factor may represent one's general fund of information and verbal reasoning abilities, also known as Crystallized Intelligence. By contrast, Factor 3 represents visual-motor processing abilities, with a substantially high loading from the Bender-Gestalt II Copy subtest. The Recall subtest only yielded a fair loading on the third factor.

Ages 19 to 50. For adults who were 19 to 50 years of age, four factors were extracted, accounting for 67% of the variance in test scores. Eigenvalues yielded from these four factors were 3.5, 4.0, .3, and .2. The chi-square goodness-of-fit test was not significant ($x^2 = 27.04$, $df = 24$, $p = .303$), suggesting that the four-factor solution could be the best model for this age group.

Factor intercorrelations were $r = .83$ for Factors 1 and 2, $r = .77$ for Factors 1 and 3, $r = .55$ for Factors 1 and 4, $r = .81$ for Factors 2 and 3, $r = .62$ for Factors 2 and 4, and $r = .55$ for Factors 3 and 4. Factor loadings for the rotated matrix for each subtest are presented in Table 13.

Table 13

Rotated Factor Matrix with Bender-Gestalt II and SB5 Subtests by Factor Weight (Ages 19-50)

Subtest	Factor			
	1	2	3	4
NV Visual-Spatial Processing	**.78**	.05	-.02	-.03
NV Working Memory	**.75**	.10	-.08	.01
V Working Memory	**.71**	-.05	.15	.01
NV Knowledge	.29	.26	.26	.10
V Quantitative Reasoning	.10	**.80**	.04	.01
NV Quantitative Reasoning	.07	**.78**	-.01	.06
V Visual-Spatial Processing	.10	**.73**	.11	-.05
NV Fluid Reasoning	.08	**.40**	.26	.01
V Knowledge	-.03	.01	**.88**	-.03
V Fluid Reasoning	.14	.16	**.49**	.04
Bender-Gestalt Recall	-.03	-.06	-.01	**1.05**
Bender-Gestalt Copy	.05	.19	.00	**.49**

Note. NV = Nonverbal. V = Verbal. Maximum likelihood solution using promax with Kaiser normalization. Rotation converged in 6 iterations. All loadings >.40 in boldface (Stevens, 2002).

Factor 1 consists of excellent loadings from Nonverbal Verbal Visual-Spatial Processing and both Verbal and Nonverbal Working Memory. This factor may reflect skills requiring visual-spatial awareness and memory. The second factor included excellent subscale loadings from both Verbal and Nonverbal Quantitative Reasoning and Verbal Visual-Spatial Processing. Nonverbal Fluid Reasoning met Steven's (2002) criteria for interpretation, but is still considered as poorly loading onto Factor 2. Nevertheless, Factor 2 likely represents tasks involving reasoning and problem-solving.

Verbal Knowledge yielded an excellent loading on Factor 3. This factor also consisted of a fair loading from the Verbal Fluid Reasoning subscale. Based on the tasks generally presented to this age grouping, this factor represents lexical knowledge and verbal reasoning. Consistent with the other age groupings, Factor 4 reflects visual-motor ability as measured by the Bender-Gestalt II. However, unlike the other age levels, the Recall subtest yielded an exceptionally high loading over the Copy subtest. For this four-factor model, Nonverbal Knowledge had low loadings across three of the four factors; thus, it could not be interpreted on any factor.

Ages 51+. Three factors were extracted for adults aged 51 and higher. These factors accounted for 58% of the variance in test scores with eigenvalues of 6.0, .7, and .3. The chi-square goodness-of-fit test was significant ($x^2 = 98.16$, $df = 33$, $p = .000$). However, this model was retained based on theoretical explanation of the second and third factors.

Table 14 includes the factor loadings for the rotated matrix for each subtest. The correlation between Factors 1 and 2 was $r = .84$, between Factors 1 and 3 was $r = .58$, and between Factors 2 and 3 was $r = .56$.

Verbal Knowledge, Verbal Fluid Reasoning, and Verbal Working Memory produced very good to excellent loadings on the first factor. Factor 1 also included fair to

Table 14

Rotated Factor Matrix with Bender-Gestalt II and SB5 Subtests by Factor Weight (Ages 51 and up)

Subtest	Factor		
	1	2	3
V Knowledge	**.77**	-.11	.00
V Fluid Reasoning	**.69**	.06	.07
V Working Memory	**.63**	.08	-.03
NV Fluid Reasoning	**.56**	.15	-.02
NV Working Memory	**.53**	.25	-.03
NV Knowledge	**.46**	.33	.06
NV Visual-Spatial Processing	**.45**	.28	.08
V Quantitative Reasoning	.01	**.89**	-.04
NV Quantitative Reasoning	.05	**.72**	.09
V Visual-Spatial Processing	.30	**.55**	-.03
Bender-Gestalt Copy	-.03	-.05	**.95**
Bender-Gestalt Recall	.05	.11	**.51**

Note. NV = Nonverbal. V = Verbal. Maximum likelihood solution using promax with Kaiser normalization. Rotation converged in 5 iterations. All loadings >.40 in boldface (Stevens, 2002).

good loadings from the Nonverbal Fluid Reasoning, Nonverbal Working Memory, Nonverbal Knowledge, and Nonverbal Visual-Spatial Processing subscales. This factor may be representative of tasks requiring higher-order skills of reasoning, problem-solving, and working memory, as well as the application of these skills to one's general knowledge base. These abilities occur through both verbal and nonverbal modalities.

The second factor includes excellent loadings from both Verbal and Nonverbal Quantitative Reasoning. The Verbal Visual-Spatial Processing subscale yielded a good loading on Factor 2. This factor likely represents tasks involving mathematical reasoning and the use of visualization in order to solve problems. Finally, Factor 3 includes a high loading from the Bender-Gestalt II Copy subtest and a fair loading from the Recall subtest. This third factor was representative of visual-motor ability.

Discussion

The purpose of this study was to examine the joint factor structure of the Bender-Gestalt II and the Stanford-Binet: Fifth Edition and to understand its fit within CHC-cross battery assessment. The Bender-Gestalt II has been neglected by CHC and cross-battery literature. Furthermore, the factor structure of the SB5 as reported by the test author has been questioned in independent factor analytic studies. Therefore, the current study investigated the latent constructs of two popular instruments in order to guide practitioners in selecting tests that provide a comprehensive assessment of an individual's cognitive abilities. The study also followed methodologists' suggestions for using exploratory factor analytic procedures to clarify the broad and narrow abilities measured by the Bender-Gestalt II and the SB5.

The first research question sought to explore the relationship between the co-normed Bender-Gestalt II subtests and the SB5 subscales beyond what is published in the Bender-Gestalt II's *Examiner's Manual*. The Bender-Gestalt II Copy and Recall subtests were positively correlated with all ten SB5 subscales across all age ranges. Specifically, for every age grouping, the Copy measure was moderately correlated with the SB5 Nonverbal Visual-Spatial Processing subscale. The tasks comprising this subscale are measures of spatial orientation which involve visual input and a motor response, as well as more advanced tasks requiring planning and problem-solving. These processes are similar to those required by the Bender-Gestalt II Copy subtest. This relationship is also consistent with Decker and colleagues' (2006) finding of a moderate correlation between the Copy subtest and WISC-III Block Design (*r* = .40), another measure of visual-spatial ability.

The Quantitative Reasoning subscales were consistently the highest correlated subtest with the Bender-Gestalt II Copy measure, with moderate correlations with the Verbal subscale for ages 5 through 12 and the Nonverbal subscale for ages 13 and greater. This finding seems to confirm research by Flanagan, Ortiz, Alfonso, and Mascolo (2006) who found visual processing abilities (*Gv*) to be related to higher-level math skills (e.g., geometry, calculus). As expected, the lowest correlations with the Bender-Gestalt II Copy subtests were among the Verbal subtests, with the exception of Nonverbal Fluid Reasoning for 13 to 18 year-olds.

Similar to the Copy subtest, the Bender-Gestalt-II Recall subtest was most highly correlated with Verbal Quantitative Reasoning for most age ranges. For the 13 to 18 age grouping, the correlations between the Recall subtest and Verbal Visual-Spatial subscale were at the upper limits of the moderate range. At this level, the Verbal Visual-Spatial Processing subscale consists of tasks requiring visualization abilities, as well as the need to remember orally-presented directions. Thus, these subtests may share similar processing requirements.

Moderate correlations were found between Bender-Gestalt II Recall and the Nonverbal Visual-Spatial Processing and Nonverbal Working Memory subscales. While these correlations were highest for the 13 to 18 age grouping, the correlations tended to be slightly lower than the correlations between the Copy measure and Nonverbal Visual-Spatial Processing and Nonverbal Working Memory. Furthermore, there was a low to moderate correlation between Recall and Nonverbal Working Memory which may indicate that Recall measures a different form of visual memory. For example, the Bender-Gestalt Recall subtest requires a more holistic, or simultaneous, recall of visual information. Conversely, the Nonverbal Working Memory subtest requires sequential recall of visual information.

The purpose of the second research question was to examine the factor loadings of the Bender-Gestalt II subtests and the SB5 subscales. Three factors emerged for all age groups with the exception of the 19-50 age grouping, which produced four factors. Across all the ages, the Bender-Gestalt II Copy and Recall subtests loaded on a factor separate from the SB5 subtests. Thereby, this reflected a factor only measuring visual-motor processing. This was inconsistent with results from the joint factor analysis of the Bender-Gestalt II and the WISC-III (Decker et al., 2006) in which the Copy subtest had high loadings on a perceptual organization factor and the Recall subtest had fair loadings on perceptual organization and short-term memory factors. Nevertheless, the current results are similar to the exploratory factor analysis of the Bender-Gestalt II alone, which determined the Bender-Gestalt II to be a unitary construct (Brannigan & Decker, 2003b).

The remaining factors in the present investigation included SB5 subscale loadings of varying degrees among the different age groups. For the 5 to 7 age group, Factor 1 represented a nonverbal factor while Factor 2 represented a verbal factor. This verbal-nonverbal dichotomy confirms previous findings of the presence of a two-factor, verbal-nonverbal model for children below 11 years of age (DiStefano & Dombrowski, 2006; Canivez, 2008). From the ages of 8 to 50, a second factor emerged reflecting verbal abilities, or Crystallized Intelligence (*Gc*). Subscales loading on this factor generally measured the participants’ general fund of information, listening ability, oral expression, and ability to reason through verbal means.

The third factor obtained did not represent a clear construct across the age groups. It was a mixture of reasoning and problem-solving abilities and memory (memory span and working memory). The four-factor model generated for the 19 to 50 age grouping separated this factor into one containing reasoning abilities and another containing memory and spatial abilities. While these factors were selected because of the moderate subtest loadings, they may be as regarded as too factorially complex to fit into CHC theory. Factors containing fluid reasoning and working memory subtests are more reflective of neuropsychological or information processing theories. More specifically, fluid reasoning and working memory are associated with executive functioning.

Finally, the third research question was answered according to the results from the second question. The addition of the Bender-Gestalt II did produce a multi-factor model with two factors representing abilities from SB5 subscales and the third factor representing visual-motor ability as measured by the Bender-Gestalt II. When a two-factor model was produced during data analysis, the SB5 loaded onto one factor and the Bender-Gestalt II loaded on a separate factor. However, a two-factor model was not the best model fit based on the multiple methods used to determine the number of factors to extract. Therefore, underfactoring with a one- or two-factor model would have ignored minor factors that were theoretically valuable (Zwick & Velicer, 1986).

Conclusions

The results of this study suggest that the Bender-Gestalt II measures abilities that are not included in the SB5. Thus, use of the Bender-Gestalt II as a complement to an intelligence test such as the SB5 continues to be warranted. In regard to the utility of the Bender-Gestalt within cross-battery approach, the Bender-Gestalt II is qualitatively different from the SB5 Visual-Spatial Processing factor; therefore, the Copy or Recall subtest could be used with the Verbal Visual-Spatial subscale or the Nonverbal Visual-Spatial subscale in order to form a Visual Processing (*Gv*) broad ability factor. This combination of tests would satisfy the requirements of the third pillar of cross-battery assessment: adequate construct representation.

This findings also substantiated previous research indicating that the SB5 is factorially complex and does not fit into CHC theory as purported by Roid (2003b). The five-factor structure was not reproduced in the present study, nor was a two-factor verbal-nonverbal model confirmed. Given the method of factor rotation employed during data analysis, cross-loadings of subtests across factors was minimal. However, subtest migration across the verbal and nonverbal domains was evident.

The present study was methodologically different from other studies examining the SB5. For example, DiStefano and Dombrowski (2006) used parallel analysis (Horn, 1965) and the minimum average partial (MAP) criterion (Velicer, 1976) as their factor analytic procedures. These procedures are actually methods that are part of Principal Components Analysis (PCA). PCA procedures are suitable if the goal is to reduce data. However, since the goal of the current investigation was to understand the structure of correlations among the variables and to identify the latent constructs, the use of a common factor model was appropriate for this study. Therefore, it is plausible that PCA and common factor procedures would produce different results. In Canivez's (2008) factor analysis of the SB5, he employed MAP as a preliminary analysis, but followed up with principal axis factoring with an oblique (promax) rotation. However, the results may not be comparable to the current study given the different age groupings used in both studies.

Limitations of the Research

One limitation of the current study is that the analyses performed were restricted by the data available from the Bender-Gestalt II and SB5 standardization samples. Future studies should administer these tests to a different sample of individuals, especially in light of the fact that this is the third independent study of the SB5 using the same standardization sample.

Additionally, different procedures within exploratory research may produce different results. Therefore, replication of the current findings may be limited by the factor extraction method used (e.g., Maximum Likelihood), the factor rotation procedure (e.g. oblique rotation using a promax procedure), and the variety of methods used to determine factor retention. Moreover, the chi-square statistic may have been affected by large sample size for three of the five age groupings.

Implications for Further Research

The current findings address the need for further research which validates the constructs measured by newer versions of widely-used tests of cognitive ability. The present study was the first to investigate the underlying constructs between the newly revised Bender-Gestalt II and a reportedly CHC-based intelligence test. Therefore, further investigation of the Bender-Gestalt II with other CHC-based tests (e.g., *Woodcock-Johnson Psycho-Educational Battery–Third Edition*, Woodcock, McGrew, & Mather 2001; *Kaufman Assessment Battery for Children-Second Edition*, Kaufman & Kaufman, 2004; DAS-II) is needed to confirm the usefulness of the Bender-Gestalt II within the cross-battery approach. While joint factor analytic studies with the Wechsler scales (Wechsler, 1997, 2002, 2003) may not clarify CHC classifications as much as CHC-based tests would possibly do, previous research with the WISC-III has demonstrated that the Bender-Gestalt II does share similar constructs with the Wechsler scales.

Given the exploratory nature of this study, future studies should consider using factor analysis with other extraction and rotation methods. For example, parallel analysis has been recommended as one of the most accurate factor extraction methods (Hayton et al., 2004). Furthermore, confirmatory factor analysis would be appropriate for testing the models yielded by exploratory procedures. Results from the present investigation revealed significant, moderate correlations between the Bender-Gestalt II and the SB5. Therefore, researchers may also wish to conduct regression analyses to create prediction models of SB5 Full Scale or Verbal and Nonverbal scores from the Bender-Gestalt II subtest scores.

Finally, an important implication of the present study relates to the usefulness of the Bender-Gestalt II and the SB5 in identifying visual-motor weaknesses in children and adults. Given the use of the normative sample for this study, further research should analyze data from the clinical samples obtained during the standardization of each instrument. This is particularly important for developing cognitive profiles of individuals with specific impairments or disorders. Research on similar clinical populations should also extend beyond the use of the standardization samples of the Bender-Gestalt II and the SB5.

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