Chapter One

OVERVIEW[1]

The Cross-Battery Assessment approach (hereafter referred to as the XBA approach) was introduced by Flanagan and her colleagues over 15 years ago (Flanagan & McGrew, 1997; Flanagan, McGrew, & Ortiz, 2000; Flanagan & Ortiz, 2001; McGrew & Flanagan, 1998). The XBA approach is based on the Cattell-Horn-Carroll (CHC) theory (and now also integrated with neuropsychological theory). It provides practitioners with the means to make systematic, reliable, and theory-based interpretations of any ability battery and to augment that battery with cognitive, achievement, and neuropsychological subtests from other batteries to gain a more psychometrically defensible and complete understanding of an individual's pattern of strengths and weaknesses (Flanagan, Ortiz, & Alfonso, 2007).

Moving beyond the boundaries of a single cognitive, achievement, or neuropsychological battery by adopting the rigorous theoretical and psychometric XBA principles and procedures represents a significant improvement over single-battery assessment because it allows practitioners to focus on accurate and valid measures of the cognitive constructs and neurodevelopmental functions that are most

DON'T FORGET

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1. This chapter was adapted with permission from Oxford University Press. Flanagan, D. P., Alfonso, V. C., Ortiz, S. O., & Dynda, A. M. (in press). Cognitive assessment: Progress in psychometric theories of the structure of cognitive abilities, cognitive tests, and interpretive approaches to cognitive test performance. In D. Saklofske and V. Schwean (Eds.), *Oxford Handbook of Psychological Assessment of Children and Adolescents*. Copyright 2013. All Rights Reserved.

germane to referral concerns (e.g., Carroll, 1998; Decker, 2008; Kaufman, 2000; Wilson, 1992).

According to Carroll (1997), the CHC taxonomy of human cognitive abilities "appears to prescribe that individuals should be assessed with respect to the *total range* of abilities the theory specifies" (p. 129). However, because Carroll recognized that "any such prescription would of course create enormous problems," he indicated that "[r]esearch is needed to spell out how the assessor can select what abilities need to be tested in particular cases" (p. 129). Flanagan and colleagues' XBA approach clearly spells out how practitioners can conduct assessments that approximate the total range of cognitive and academic abilities and neuropsychological processes more adequately than what is possible with any collection of co-normed tests.

In a review of the XBA approach, Carroll (1998) stated that it "can be used to develop the most appropriate information about an individual in a given testing situation" (p. xi). In Kaufman's (2000) review of XBA, he said that the approach is based on sound assessment principles, adds theory to psychometrics, and improves the quality of the assessment and interpretation of cognitive abilities and processes. More recently, Decker (2008) stated that the XBA approach "may improve school psychology assessment practice and facilitate the integration of neuropsychological methodology in school-based assessments [because it] shift[s] assessment practice from IQ composites to neurodevelopmental functions" (p. 804). Finally, a recent listserv thread of the National Association of School Psychologists focused on the potential weaknesses of the XBA approach. In that thread, Kevin McGrew (2011, March 30) stated, "In the hands of 'intelligent' intelligence examiners the XBA system is safe and sound."

Noteworthy is the fact that assessment professionals "crossed" batteries long before Woodcock (1990) recognized the need and before Flanagan and her colleagues introduced the XBA approach. Neuropsychological assessment has crossed various standardized tests in an attempt to measure a broader range of brain functions than that offered by any single instrument (Hale & Fiorello, 2004; Hale, Wycoff, & Fiorello, 2011; Lezak, 1976, 1995; Lezak, Howieson, & Loring, 2004; see Wilson, 1992, for a review). Nevertheless, several problems with crossing batteries plagued assessment related fields for years. Most of these problems have been circumvented by Flanagan and colleagues' XBA approach (see Table 1.1 for examples). But unlike the XBA approach, other various so-called cross-battery and flexible battery techniques applied within the fields of school psychology and neuropsychology are not grounded in a systematic approach that is theoretically and psychometrically sound. Thus, as Wilson (1992) cogently pointed out, the field of neuropsychological assessment is in need of an approach

Table 1.1. Parallel Needs in Cognitive Assessment–Related Fields Addressed by the XBA Approach

Need Within Assessment-Related Fields	Need Addressed by XBA Approach
School psychology, clinical psychology, and neuropsychology have lagged in the development of conceptual models of the assessment of individuals. There is a need for the development of contemporary models.	The XBA approach provides a contemporary model for measurement and interpretation of cognitive and academic abilities and neuropsychological processes.
Likely there is a need for events external to a field of endeavor to give impetus to new developments and real advances in that field.	Carroll and Horn's *Fluid-Crystallized* theoretical models (and more recently Schneider and McGrew's [2012] CHC model) and research in cognitive psychology and neuropsychology provided the impetus for and continued refinements to the XBA approach and led to the development of better assessment instruments and interpretive procedures.
There is a need to utilize a conceptual framework to direct any approach to assessment. This would aid both in the selection of instruments and methods and in the interpretation of test findings.	The XBA approach is based mainly on CHC theory but also neuropsychological theory. Since the XBA approach links all the major cognitive and achievement batteries as well as selected neuropsychological instruments to CHC theory, in particular, selection of tests and interpretation of test findings are easier.
The conceptual framework or model underlying assessment must incorporate various aspects of neuropsychological and cognitive ability function that can be described in terms of constructs recognized in the neuropsychological and cognitive psychology literature.	The XBA approach incorporates various aspects of neuropsychological and cognitive ability functions that are described in terms of constructs recognized in the literature. In fact, a consistent set of terms and definitions within the CHC literature (e.g., Schneider & McGrew, 2012) and the neuropsychology literature (e.g., Miller, 2013) underlie the XBA approach.
There is a need to adopt a conceptual framework that allows for the measurement of the full range of behavioral functions subserved by the brain. In	XBA assessment allows for the measurement of a wide range of broad and narrow cognitive abilities specified in CHC theory and neuropsychological processes specified

(*continued*)

Table 1.1. (*Continued*)

Need Within Assessment-Related Fields	Need Addressed by XBA Approach
neuropsychological assessment, no inclusive set of measures is standardized on a single normative population.	by neuropsychology theory and research. Although an XBA norm group does not exist, the crossing of batteries and the interpretation of assessment results are based on sound psychometric principles and procedures.
Because there are no truly unidimensional measures in psychological assessment, there is a need to select subtests from standardized instruments that appear to reflect the neurocognitive function of interest. In neuropsychological assessment, the aim therefore is to select those measures that, on the basis of careful task analysis, appear mainly to tap a given construct.	The XBA approach is defined in part by a CHC classification system. Most subtests from the major cognitive and achievement batteries as well as selected neuropsychological instruments were classified empirically as measures of broad and narrow CHC constructs (either via CHC within- or cross-battery factor analysis or expert consensus or both). In addition, the subtests of cognitive and neuropsychological batteries were classified according to several neuropsychological domains (e.g., attention, visual-spatial, auditory-verbal, speed and efficiency, executive). Use of evidence-based classifications allows practitioners to be reasonably confident that a given test taps a given construct.
An eclectic approach is needed in the selection of measures, preferably subtests rather than the omnibus IQs, in order to gain more specificity in the delineation of patterns of function and dysfunction.	The XBA approach ensures that two or more relatively pure, but qualitatively different indicators of each *broad* cognitive ability are represented in a complete assessment. Two or more qualitatively similar indicators are necessary to make inferences about specific or *narrow* CHC abilities. This process is eclectic in its selection of measures.
There is a need to solve potential problems that can arise from crossing normative groups as well as sets of measures that vary in reliability.	In the XBA approach, baseline data in cognitive functioning typically can be achieved across seven to nine CHC broad abilities through the use of only two well-standardized batteries, which minimizes the effects of error due to norming differences. Also, since interpretation of both broad and narrow CHC abilities is made at the cluster (rather than subtest)

Table 1.1. (*Continued*)

Need Within Assessment-Related Fields	Need Addressed by XBA Approach
	level, issues related to low reliability are less problematic in this approach. Finally, because cross-battery composites are generated using median reliabilities and intercorrelations, the data yielded by this approach are psychometrically sound.

Source: Information obtained, in part, from Wilson (1992).

to guide practitioners through the selection of measures that would result in more specific and delineated patterns of function and dysfunction—an approach that provides more clinically useful information than one that is "wedded to the utilization of subscale scores and IQs" (p. 382).

"Indeed, all fields involved in the assessment of cognitive and neuropsychological functioning have some need for an approach that would aid practitioners in their attempt to tap all of the major cognitive areas, with emphasis on those most suspect on the basis of history, observation, [current hypotheses] and on-going test findings" (Wilson, 1992, p. 382; see also Flanagan, Alfonso, Ortiz, & Dynda, in press; Miller, in press). Ever since publication of the first edition of *Essentials of Cross-Battery Assessment* (Flanagan & Ortiz, 2001), the XBA approach has met this need and it now provides practitioners with a framework that is based on more psychometrically and theoretically rigorous procedures than ever before. For those new to the approach, the definition of and rationale for XBA is presented next followed by a description of the XBA method. Figure 1.1 provides an overview of the information presented in this chapter.

DEFINITION

The XBA approach is a method of assessing cognitive and academic abilities and neuropsychological processes that is grounded in CHC theory and research and neuropsychological theory and research (e.g., Miller, 2007, 2010, 2013). It allows practitioners to measure a wider range (or a more in-depth but selective range) of ability and processing constructs than that represented by any given stand-alone assessment battery, in a reliable and valid manner. The XBA

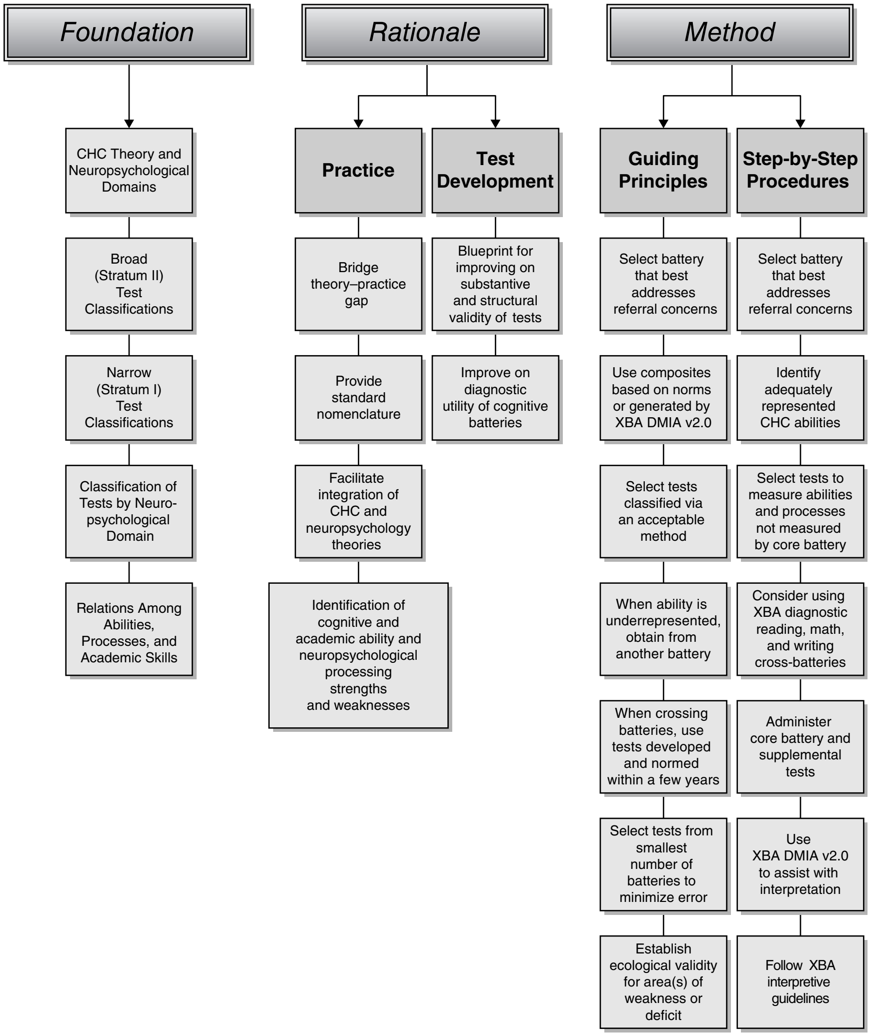

Figure 1.1. Overview of the XBA Approach

Note: CHC = Cattell-Horn-Carroll

XBA DMIA = Cross-Battery Data Management and Interpretive Assistant v2.0. This program automates the XBA approach and is found on the CD accompanying this book.

approach is based on four foundational sources of information that together provide the knowledge base necessary to organize a theory-driven, comprehensive assessment of cognitive, academic, and neuropsychological constructs.

DON'T FORGET

The XBA approach allows practitioners to reliably measure a wider range (or a more in-depth but selective range) of abilities than that represented by any single assessment battery.

FOUNDATION OF THE XBA APPROACH

The foundation of the XBA approach rests, in part, on CHC theory and the broad and narrow CHC ability classifications of all subtests that comprise current cognitive, achievement, and selected neuropsychological batteries (i.e., tests published after 2000). CHC theory is discussed first, followed by a summary of the broad and narrow CHC ability classifications of tests. The fourth foundational source of information underlying the XBA approach—relations among cognitive abilities, neuropsychological processes, and academic skills—is discussed in Chapter 2.

CHC THEORY

Psychometric intelligence theories have converged in recent years on a more complete or expanded multiple intelligences taxonomy, reflecting syntheses of factor analytic research conducted over the past 60 to 70 years. The most recent representation of this taxonomy is the CHC structure of cognitive abilities. CHC theory is an integration of Cattell and Horn's *Gf-Gc* theory and Carroll's three-stratum theory of the structure of cognitive abilities.

Original *Gf-Gc* Theory and the Cattell-Horn Expanded *Gf-Gc* Theory: First Precursors to CHC Theory

The original conceptualization of intelligence developed by Cattell in the early 1940s was a dichotomous view of cognitive ability and was referred to as fluid-crystallized theory or *Gf-Gc* theory. Cattell based his theory on his own factor-analytic work as well as on that of Thurstone, conducted in the 1930s. Cattell believed that fluid intelligence (*Gf*) included inductive and deductive reasoning abilities that were influenced by biological and neurological factors as well as incidental learning through interaction with the environment. He postulated further that crystallized intelligence (*Gc*) consisted primarily of acquired knowledge abilities that reflected, to a large extent, the influences of acculturation (Cattell, 1957, 1971).

In 1965, Cattell's student, John Horn, reanalyzed Cattell's data and expanded the dichotomous *Gf-Gc* model to include four additional abilities, namely visual perception or processing (*Gv*), short-term acquisition and retrieval (SAR; now coded *Gsm*), long-term storage and retrieval (or tertiary storage and retrieval [TSR]; now coded *Glr*), and speed of processing (*Gs*). Later, Horn also added auditory processing ability (*Ga*) to the theoretical model and refined the definitions of *Gv*, *Gs*, and *Glr* (Horn, 1967; Horn & Stankov, 1982). By the early 1990s, Horn had added a factor representing an individual's quickness in reacting (reaction time) and making decisions (decision speed). The decision speed factor was labeled *Gt* (Horn, 1991). Finally, factors for quantitative ability (*Gq*) and broad reading/writing ability (*Grw*) were added to the model, based on the research of Horn (e.g., 1991) and Woodcock (1994), respectively. As a result of the work of Horn and his colleagues, *Gf-Gc* theory expanded to a 10-factor model (see Figure 1.2) that became known as the Cattell-Horn *Gf-Gc* theory, or sometimes as contemporary or *modern* Gf-Gc *theory* (Horn, 1991; Horn & Blankson, 2005; Horn & Noll, 1997).

Carroll's Three-Stratum Theory: Second Precursor to CHC Theory

In his seminal review of the world's literature on cognitive abilities, Carroll (1993) proposed that the structure of cognitive abilities could be understood best via three strata that differ in breadth and generality (see Figure 1.3). The broadest and most general level of ability is represented by stratum III. According to Carroll, stratum III represents a general factor consistent with Spearman's (1927) concept of *g* and subsumes both broad (stratum II) and narrow (stratum I) abilities. The various broad (stratum II) abilities are denoted with an uppercase *G* followed by a lowercase letter or letters, much as they had been written by Cattell and Horn (e.g., *Gf* and *Gc*). The eight broad abilities included in Carroll's theory subsume approximately 70 narrow (stratum I) abilities (Carroll, 1993; see also Carroll, 1997).

Comparison of the Cattell-Horn and Carroll Theories

Figure 1.4 provides a comparison of the Cattell-Horn *Gf-Gc* theory and Carroll's three-stratum theory (with only broad abilities shown). These theories are presented together in order to highlight the most salient similarities and differences between them. It is readily evident that the theories have much in common;

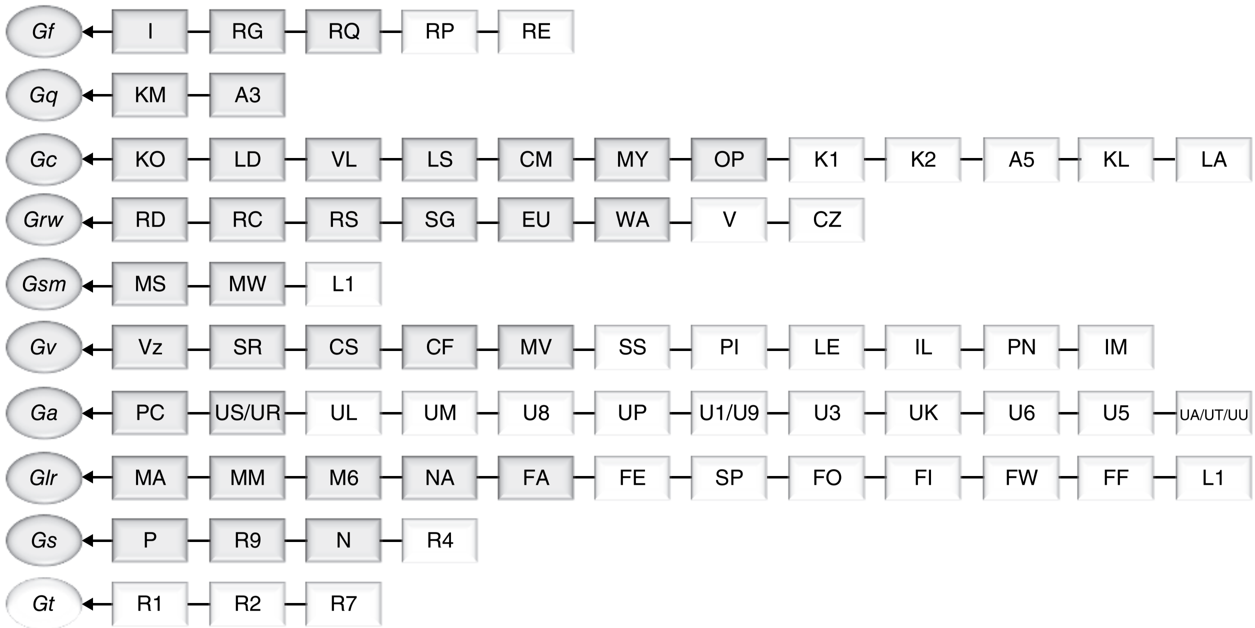

Figure 1.2. Cattell-Horn-Carroll Theory of Cognitive Abilities That Guided Intelligence Test Construction in the First Decade of the New Millennium

Note: This figure is based on information presented in McGrew (1997) and in Flanagan et al. (2000). Ovals represent broad abilities and rectangles represent narrow abilities. Overall *g*, general ability, is omitted from this figure intentionally, due to space limitations. Darker rectangles represent those narrow abilities that are most consistently represented on tests of cognitive and academic abilities. See Rapid Reference 1.1 (on page 17) for the definitions of the broad abilities that correspond to the codes in the ovals in this figure. See Appendix A for the definitions and examples of the narrow abilities that correspond to the codes in the rectangles.

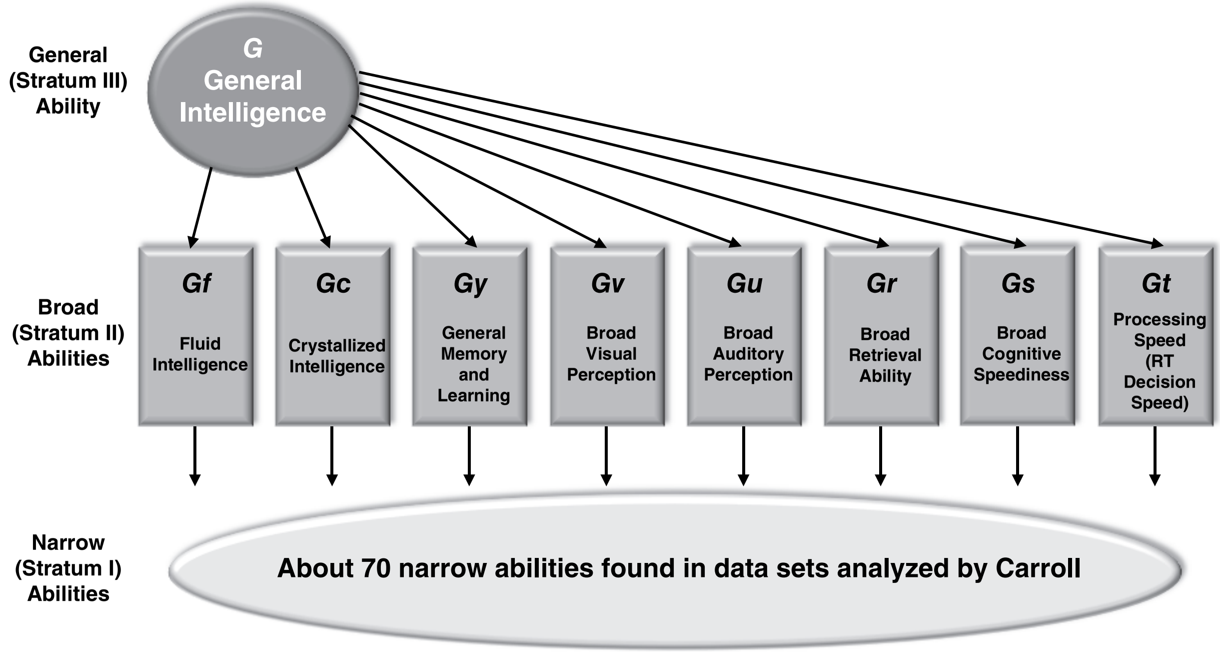

Figure 1.3. Carroll's (1993) Three-Stratum Theory of Cognitive Abilities

Note: Figure adapted with permission from D. P. Flanagan, K. S. McGrew, and S. O. Ortiz. Copyright 2000. *The Wechsler Intelligence Scales and Gf-Gc theory: A contemporary approach to interpretation.*

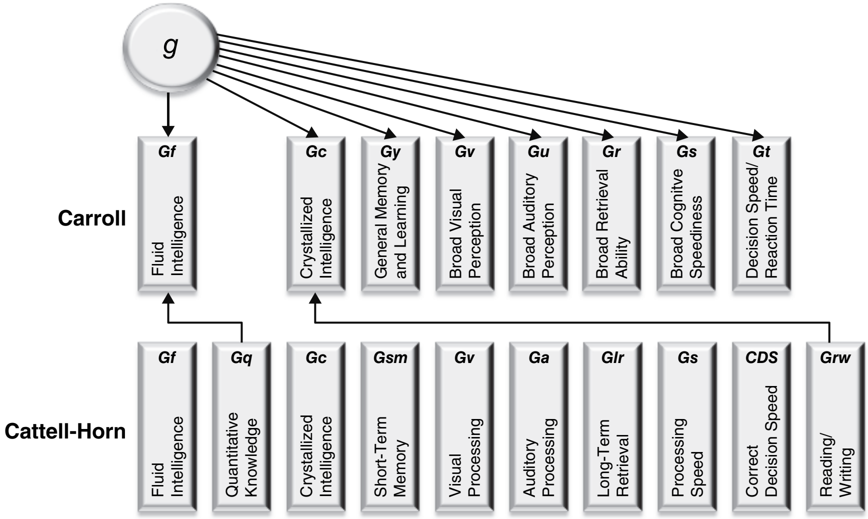

Figure 1.4. A Comparison of Cattell-Horn *Gf-Gc* Theory and Carroll's Three-Stratum Theory

Note: Figure adapted with permission from D. P. Flanagan, K. S. McGrew, and S. O. Ortiz. Copyright 2000. *The Wechsler Intelligence Scales and Gf-Gc theory: A contemporary approach to interpretation.*

each posits multiple broad (stratum II) abilities that, for the most part, have similar or identical names and abbreviations. But at least four major structural differences between the two models deserve mention.

1. Carroll's theory includes a general ability factor (stratum III) whereas the Cattell-Horn theory does not, as Horn and Carroll differed in their beliefs about the existence of this elusive construct (see Schneider & McGrew, 2012, for a more detailed discussion regarding *g* in this context).
2. The Cattell-Horn theory includes quantitative reasoning as a distinct broad ability (i.e., *Gq*) whereas Carroll's theory includes quantitative reasoning as a narrow ability subsumed by *Gf.*
3. The Cattell-Horn theory includes a distinct broad reading and writing (*Grw*) factor. Carroll's theory includes reading and writing as narrow abilities subsumed by *Gc.*
4. Carroll's theory includes short-term memory with other memory abilities, such as associative memory, meaningful memory, and free-recall memory,

under *Gy* whereas the Cattell-Horn theory separates short-term memory (*Gsm*) from associative memory, meaningful memory, and free-recall memory, because the latter abilities are purported to measure long-term retrieval (*Glr* in Figure 1.2). Notwithstanding these differences, Carroll (1993) concluded that the Cattell-Horn *Gf-Gc* theory represented the most comprehensive and reasonable approach to understanding the structure of cognitive abilities at that time.

Decade of CHC Theory (2001–2011)

In the late 1990s, McGrew (1997) attempted to resolve some of the differences between the Cattell-Horn and Carroll models. On the basis of his research, McGrew proposed an "integrated" *Gf-Gc* theory, and he and his colleagues used this model as a framework for interpreting the Wechsler Scales (Flanagan et al., 2000). This integrated theory became known as the CHC theory of cognitive abilities (using the initials of the authors in order of contribution, Cattel, Horn, then Carroll) shortly thereafter (see McGrew, 2005). The Woodcock-Johnson III Normative Update Tests of Cognitive Abilities (WJ III NU COG; Woodcock, McGrew, & Mather, 2001, 2007) was the first cognitive battery to be based on this theory. The components of CHC theory are depicted in Figure 1.2. This figure shows that CHC theory consists of 10 broad cognitive abilities and more than 70 narrow abilities.

The CHC theory presented in Figure 1.2 omits a *g* or general ability factor, primarily because the utility of the theory (as it is employed in assessment-related disciplines) is in clarifying individual cognitive and academic strengths and weaknesses that are understood best through the operationalization of broad (stratum II) and narrow (stratum I) abilities (Flanagan et al., 2007). Others, however, continue to believe that *g* is the most important ability to assess because it predicts the lion's share of the variance in multiple outcomes, both academic and occupational (e.g., Canivez & Watkins, 2010; Glutting, Watkins, & Youngstrom, 2003). Regardless of one's position on the importance of *g* in understanding various outcomes (particularly academic), there is considerable evidence that both broad and narrow CHC cognitive abilities explain a significant portion of variance in specific academic abilities, over and above the variance accounted for by *g* (e.g., Floyd, McGrew, & Evans, 2008; McGrew, Flanagan, Keith, & Vanderwood, 1997; Vanderwood, McGrew, Flanagan, & Keith, 2002). The research on the relationship between cognitive abilities and academic skills (or the fourth foundational source of information underlying XBA) is presented in Chapter 2.

Refinements and Extensions to CHC Theory

Recently, Schneider and McGrew (2012) reviewed CHC-related research and provided a summary of the CHC abilities (broad and narrow) that currently have the most evidence to support them as viable constructs. In their attempt to provide a CHC overarching framework that incorporates the best-supported cognitive abilities, they articulated a 16-factor model containing over 80 narrow abilities (see Figure 1.5). Because of the greater number of abilities represented by CHC theory now, as compared to past CHC models (e.g., Figure 1.2), the broad abilities in Figure 1.5 have been grouped conceptually into six categories to enhance comprehension, in a manner similar to that suggested by Schneider and McGrew (i.e., Reasoning, Acquired Knowledge, Memory and Efficiency, Sensory, Motor, and Speed and Efficiency). Space limitations preclude a discussion of all the ways in which CHC theory has evolved and the reasons why certain refinements and changes have been made (see Schneider & McGrew for a discussion). However, to assist the reader in transitioning from the 10-factor CHC model (Figure 1.2) to the 16-factor CHC model (Figure 1.5), the next brief explanations are offered.

Of the 10 CHC factors depicted in Figure 1.2, all were refined by Schneider and McGrew (2012) except *Gq*. Following is a brief list of the most salient revisions and refinements to CHC theory.

1. With regard to *Gf*, Piagetian Reasoning (RP) and Reasoning Speed (RE) were deemphasized (and, therefore, are not included in Figure 1.5). The primary reason is that there is little evidence that they are distinct factors.
2. Four narrow abilities—Foreign Language Proficiency (KL), Geography Achievement (A5), General Science Information (K1), and Information about Culture (K2)—were moved to a different CHC broad ability, called Domain-Specific Knowledge (*Gkn*; defined below). Also, within the area of *Gc*, Foreign Language Aptitude (LA) was dropped, as it is a combination of abilities designed for the purpose of predicting one's success in learning foreign languages and, as such, is not considered a distinct ability. The final refinement to *Gc* involved dropping the narrow ability of Oral Production and Fluency (OP) because it is difficult to distinguish it from the narrow ability of Communication Ability (CM).
3. In the area of *Grw*, Verbal (Printed) Language Comprehension (V) was dropped because it appears to represent a number of different abilities (e.g., reading decoding, reading comprehension, reading speed) and, therefore, is not a distinct ability. Likewise, Cloze Ability (CZ) was dropped from *Grw* because it is not meaningfully distinct from reading comprehension. Rather, CZ appears to be an alternative method of measuring reading

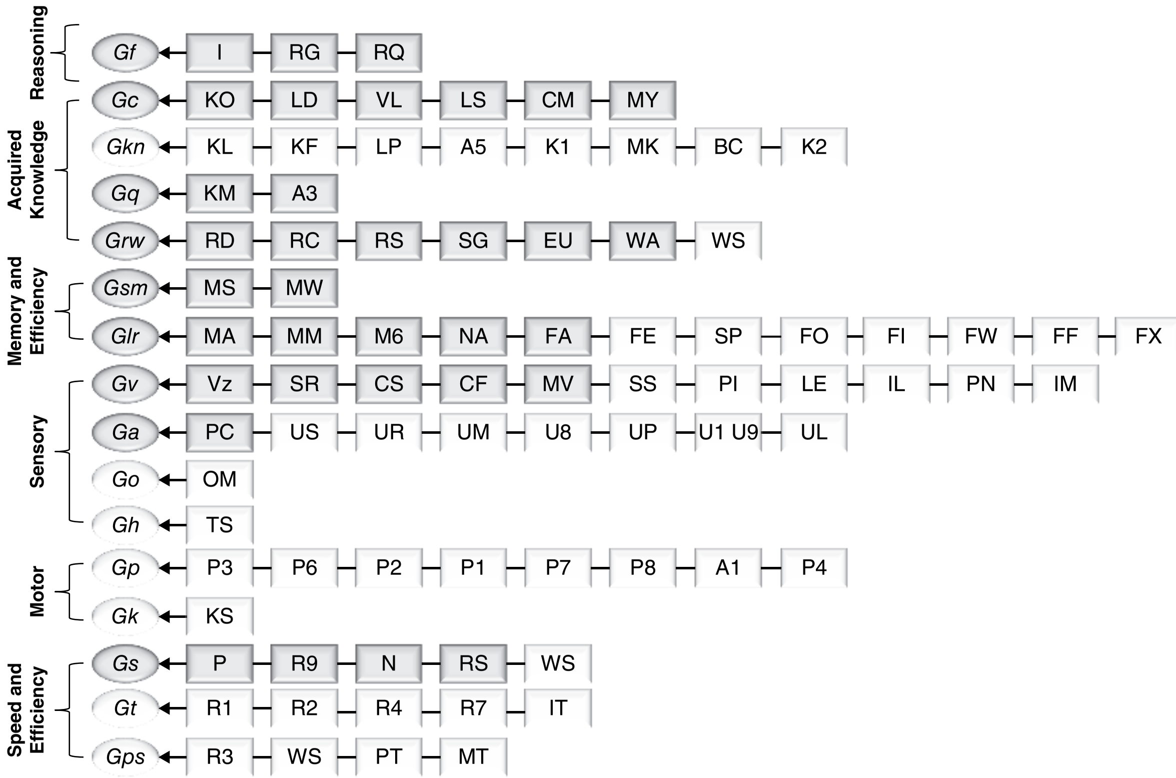

Figure 1.5. Current and Expanded Cattell-Horn-Carroll (CHC) Theory of Cognitive Abilities

Note: This figure is based on information presented in Schneider and McGrew (2012). Ovals represent broad abilities and rectangles represent narrow abilities. Overall *g*, or general ability, is omitted from this figure intentionally due to space limitations. Darker rectangles represent those narrow abilities that are most consistently represented on tests of cognitive and academic abilities. Conceptual groupings of abilities were suggested by Schneider and McGrew. See Rapid Reference 1.1 for definitions of broad abilities and Appendix A for definitions of narrow abilities.

comprehension. As such, current reading comprehension tests that use the cloze format as well as those formally classified as CZ (e.g., WJ III NU ACH Passage Comprehension) are classified as Reading Comprehension (RC) here. The final refinement to *Grw* involved adding the narrow ability of Writing Speed (WS), as this ability appears to cut across more than one broad ability (see Schneider & McGrew, 2012).

4. Several refinements were made to the broad memory abilities of *Glr* and *Gsm.* Learning Abilities (L1) was dropped from *Glr* and *Gsm.* It appears that Carroll conceived of L1 as a superordinate category consisting of different kinds of long-term learning abilities. Schneider and McGrew (2012) referred to this category (i.e., L1) as "*Glr*-Learning Efficiency," which includes the narrow abilities of Free Recall Memory (M6), Associative Memory (MA), and Meaningful Memory (MM). The remaining *Glr* narrow abilities are referred to as "Retrieval Fluency" abilities (see Figure 1.5). In the area of *Gsm*, the name of the Working Memory (MW) narrow ability was changed to *Working Memory Capacity* (also MW), as Schneider and McGrew believed the latter term is more descriptive of the types of tasks that are used most frequently to measure MW (e.g., Wechsler Letter-Number Sequencing).
5. In the area of *Gv*, one change was made: the narrow ability name Spatial Relations (SR) was changed to *Speeded Rotation* (also SR) to more accurately describe this ability. Speeded Rotation is the "ability to solve problems quickly using mental rotation of simple images" (Schneider & McGrew, 2012, p. 129). This ability is similar to visualization because it involves rotating mental images, but it is distinct because it has more to do with the *speed* at which mental rotation tasks can be completed (Lohman, 1996; Schneider & McGrew, 2012). Also, Speeded Rotation tasks typically involve fairly simple images. It is likely that the majority of tests that were classified as Spatial Relations in the past should have been classified as measures of *Vz* (Visualization) *only* (rather than SR, Vz). All tests that were classified as SR (Spatial Relations) were reevaluated according to their task demands and, when appropriate, were reclassified as Vz in this edition. No tests were reclassified as SR (Speeded Rotation).
6. In the area of *Ga*, Temporal Tracking (UK) tasks are thought to measure Attentional Control within working memory. As such, UK was dropped as a narrow ability comprising *Ga.* In addition, six *Ga* narrow abilities—General Sound Discrimination (U3), Sound-Intensity/Duration Discrimination (U6), Sound-Frequency Discrimination (U5), and Hearing and Speech Threshold (UA, UT, UU)—were considered to represent sensory acuity

factors, which fall outside the scope of CHC theory and, therefore, were dropped (Schneider & McGrew, 2012).

7. In the area of *Gs*, Reading Speed (RS) and Writing Speed (WS) were added. Although tasks that measure these abilities clearly fall under the broad ability of *Grw*, they demand quick, accurate performance and are, therefore, also measures of *Gs*. The narrow *Gs* ability of Semantic Processing Speed (R4) was moved to *Gt*. Tests previously classified as R4 were reclassified as Perceptual Speed (P; a narrow *Gs* ability) in this edition. Also, the narrow ability of Inspection Time (IT) was added to the broad ability of *Gt* (see Schneider & McGrew, 2012, for details).

In addition to the within-factor refinements and changes just mentioned, the CHC model has been expanded to include six additional broad abilities: General (Domain-Specific) Knowledge (*Gkn*), Olfactory Abilities (*Go*), Tactile Abilities (*Gh*), Psychomotor Abilities (*Gp*), Kinesthetic Abilities (*Gk*), and Psychomotor Speed (*Gps*) (McGrew, 2005; Schneider & McGrew, 2012). Noteworthy is the fact that the major intelligence tests do not measure most (or any) of these additional factors directly, likely because these abilities (with the possible exception of *Gkn*) do not contribute much to the prediction of achievement, which is a major purpose of intelligence and cognitive ability tests. However, some of these factors are typically assessed by neuropsychological instruments because these tests are intended, in part, to understand the sensory and motor manifestations of typical and atypical fine- and gross-motor development, traumatic brain injury, and other neurologically based disorders. For example, several tests of the Dean-Woodcock Neuropsychological Battery (Dean & Woodcock, 2003) appear to measure *Gh* (e.g., Tactile Examination: Finger Identification; Tactile Examination: Object Identification; Tactile Examination: Palm Writing; Tactile Identification: Simultaneous Localization) (Flanagan et al., 2010; see Appendix G for the neuropsychological domain classifications of several ability tests included in this

CAUTION

The major intelligence batteries do not directly measure the recently added factors, however, these abilities (with the possible exception of *Gkn*) do not contribute much to the prediction of academic achievement.

DON'T FORGET

The CHC model has been expanded to include six additional broad abilities: General (Domain-Specific) Knowledge (*Gkn*), Olfactory Abilities (*Go*), Tactile Abilities (*Gh*), Psychomotor Abilities (*Gp*), Kinesthetic Abilities (*Gk*), and Psychomotor Speed (*Gps*).

Rapid Reference 1.1

Definitions of 16 Broad CHC Abilities

Broad Ability	**Definition**
Fluid Reasoning (*Gf*)	The deliberate but flexible control of attention to solve novel, on-the-spot problems that cannot be performed by relying exclusively on previously learned habits, schemas, and scripts
Crystallized Intelligence (*Gc*)	The depth and breadth and of knowledge and skills that are valued by one's culture
Quantitative Knowledge (*Gq*)	The depth and breadth of knowledge related to mathematics
Visual Processing (*Gv*)	The ability to make use of simulated mental imagery (often in conjunction with currently perceived images) to solve problems
Auditory Processing (*Ga*)	The ability to detect and process meaningful nonverbal information in sound
Short-Term Memory (*Gsm*)	The ability to encode, maintain, and manipulate information in one's immediate awareness
Long-Term Storage and Retrieval (*Glr*)	The ability to store, consolidate, and retrieve information over periods of time measured in minutes, hours, days, and years
Processing Speed (*Gs*)	The ability to perform simple, repetitive cognitive tasks quickly and fluently
Reaction and Decision Speed (*Gt*)	The speed of making very simple decisions or judgments when items are presented one at a time
Reading and Writing (*Grw*)	The depth and breadth of knowledge and skills related to written language
Psychomotor Speed (*Gps*)	The speed and fluidity with which physical body movements can be made
Domain-Specific Knowledge (*Gkn*)	The depth, breadth, and mastery of specialized knowledge (knowledge not all members of society are expected to have)
Olfactory Abilities (*Go*)	The ability to detect and process meaningful information in odors
Tactile Abilities (*Gh*)	The abilities to detect and process meaningful information in haptic (touch) sensations
Kinesthetic Abilities (*Gk*)	The abilities to detect and process meaningful information in proprioceptive sensations
Psychomotor Abilities (*Gp*)	The abilities to perform physical body motor movements (e.g., movement of fingers, hands, legs) with precision, coordination, or strength

Note: CHC broad ability definitions are from Schneider and McGrew (2012).

book). Also noteworthy is the fact that there are no commonly used comprehensive intelligence or neuropsychological batteries that measure *Go*, *Gt*, or *Gps*. Rapid Reference 1.1 includes definitions of all CHC broad abilities included in Figure 1.5; Appendix A includes definitions of and task examples for all CHC narrow abilities included in Figure 1.5.

In sum, despite the number of refinements, changes, and extensions that have been made to CHC theory recently, approximately 9 broad cognitive abilities and 35–40 narrow abilities are measured consistently by popular cognitive, achievement, and neuropsychological tests. These commonly measured abilities are shaded gray in Figures 1.2 and 1.5. All tests in this edition of *Essentials of Cross-Battery Assessment* were classified according to the latest iteration of CHC theory (Figure 1.5). The purpose of classifying tests according to the broad and narrow CHC abilities they measure is discussed next.

DON'T FORGET

Approximately 9 broad cognitive abilities and 35–40 narrow abilities are measured consistently by popular cognitive, achievement, and neuropsychological tests.

CHC Broad (Stratum II) Classifications of Cognitive, Academic, and Neuropsychological Ability Tests

Based on the results of a series of cross-battery confirmatory factor analysis studies of the major intelligence batteries (see Keith & Reynolds, 2010, 2012; Reynolds, Keith, Flanagan, & Alfonso, 2012) and task analyses performed by a variety of cognitive test experts, Flanagan and colleagues classified all the subtests of the major cognitive and achievement batteries as well as select neuropsychological batteries according to the particular CHC broad abilities they measured (e.g., Flanagan et al., 2010; Flanagan, Ortiz, Alfonso, & Mascolo, 2002, 2006; Flanagan et al., 2007; McGrew, 1997; McGrew & Flanagan, 1998; Reynolds et al., 2012). To date, more than 100 batteries and nearly 800 subtests have been classified according to the CHC broad and narrow abilities they are believed to measure, based in part on the results of these studies and analyses. The CHC classifications of cognitive, achievement, and neuropsychological batteries assist practitioners in identifying measures that assess the various broad and narrow abilities represented in CHC theory.

Classification of tests at the broad ability level is necessary to improve on the validity of cognitive assessment and interpretation. Specifically, broad ability classifications ensure that the CHC constructs that underlie assessments are clean or pure and minimally affected by *construct-irrelevant variance* (Messick, 1989, 1995). In other words, knowing what tests measure what abilities enables clinicians to organize tests into *construct-relevant* clusters—clusters that contain only measures that are *relevant to* the construct or ability of interest (McGrew & Flanagan, 1998).

To clarify, *construct-irrelevant variance* is present when an "assessment is too broad, containing excess reliable variance associated with other distinct constructs . . . that affects responses in a manner irrelevant to the interpreted constructs" (Messick, 1995, p. 742). For example, the Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV; Wechsler, 2003) Perceptual Reasoning Index (PRI) has construct-irrelevant variance because, in addition to its two indicators of *Gf* (i.e., Picture Concepts, Matrix Reasoning), it has one indicator of *Gv* (i.e., Block Design). Therefore, the PRI is a mixed measure of two, relatively distinct, broad CHC abilities (*Gf* and *Gv*); it contains reliable variance (associated with *Gv*) that is irrelevant to the interpreted construct of *Gf*. Through CHC-driven confirmatory factor analysis (CFA), Keith, Fine, Taub, Reynolds, and Kranzler (2006) showed that a five-factor model that included *Gf* and *Gv* (not PRI) fit the WISC-IV standardization data very well. As a result of their analysis, Flanagan and Kaufman (2004, 2009) provided *Gf* and *Gv* composites for the WISC-IV and she and her colleagues use them in the XBA approach because they contain primarily construct relevant variance. The ongoing cross-battery CFAs conducted by Keith and colleagues will continue to lead to improvements in how cognitive subtests are classified, in general, and organized within the context of XBA, in particular (e.g., Reynolds et al., 2012).

CAUTION

Construct-irrelevant variance is present when a composite assesses two or more distinct constructs (i.e., the Perceptual Reasoning Index on the WISC-IV measures both *Gf*, via Picture Concepts and Matrix Reasoning, and *Gv*, via Block Design). Construct-irrelevant variance can occur at the subtest and composite levels, leading to psychologically ambiguous scores that confound interpretation.

Construct-irrelevant variance can also operate at the subtest (as opposed to composite) level. For example, a Verbal Analogies test (e.g., Sun is to *day* as moon is to ______.) measures both *Gc* and *Gf*. That is, in theory-driven factor-analytic studies, Verbal Analogies tests have significant loadings on both the *Gc* and *Gf* factors (e.g., Woodcock, 1990). Therefore, these tests are considered factorially complex—a condition that complicates interpretation (e.g., Is poor performance due to low vocabulary knowledge [*Gc*] or to poor reasoning ability [Gf], or both?).

According to Guilford (1954), "Any test that measures more than one common factor to a substantial degree [e.g., Verbal Analogies] yields scores that are psychologically ambiguous and very difficult to interpret." (p. 356; cited in Briggs & Cheek, 1986). Therefore, cross-battery assessments typically are designed using only empirically strong or moderate (but not factorially complex or mixed) measures of CHC abilities (Flanagan et al., 2007; McGrew & Flanagan, 1998).

CHC Narrow (Stratum I) Classifications of Cognitive, Academic, and Neuropsychological Ability Tests

Narrow ability classifications were originally reported in McGrew (1997), then reported in McGrew and Flanagan (1998) and Flanagan et al. (2000) following minor modifications. Flanagan and her colleagues continued to gather content validity data on cognitive ability tests and expanded their analyses to include tests of academic achievement (Flanagan et al., 2002, 2006) and more recently tests of neuropsychological processes (e.g., Flanagan, Alfonso, Mascolo, & Hale, 2011; Flanagan et al., 2010). For this edition of the book, the three authors and one of their colleagues, Dr. Agnieszka M. Dynda, classified hundreds of subtests according to the broad and narrow CHC abilities they measured. Inter-rater reliability estimates were calculated and disagreements were reviewed by all four raters, and inconsistencies ultimately resolved. The classification process along with results of inter-rater reliability analyses are provided in Appendix L.

Classifications of cognitive ability tests according to content, format, and task demand at the narrow (stratum I) ability level were also necessary to improve further on the validity of cognitive assessment and interpretation (see Messick, 1989). Specifically, these narrow ability classifications were conducted to ensure that the CHC constructs that underlie assessments are well represented (McGrew & Flanagan, 1998). According to Messick (1995), construct underrepresentation is present when an "assessment is too narrow and fails to include important dimensions or facets of the construct" (p. 742).

> **CAUTION**
>
> Construct underrepresentation occurs when too few features (i.e., narrow abilities) are evaluated in the measurement of a construct (i.e., a broad ability) or when a composite includes two or more measures of the same narrow ability.

Interpreting the WJ III NU COG (Woodcock et al., 2001, 2007) Concept Formation (CF) test as a measure of Fluid Reasoning (i.e., the broad *Gf* ability) is an example of construct underrepresentation. This is because CF measures one narrow aspect of *Gf* (viz., Inductive

Reasoning). At least one other *Gf* measure (i.e., subtest) that is qualitatively different from Inductive Reasoning is necessary to include in an assessment to ensure adequate representation of the *Gf* construct (e.g., a measure of General Sequential [Deductive] Reasoning). Two or more qualitatively different indicators (i.e., measures of two or more narrow abilities subsumed by the broad ability) are needed for adequate construct representation (see Comrey, 1988; Keith & Reynolds, 2012; McGrew & Flanagan, 1998; Messick, 1989, 1995). The aggregate of CF (a measure of Inductive Reasoning at the narrow ability level) and the WJ III NU COG Analysis-Synthesis test (a measure of General Sequential [Deductive] Reasoning at the narrow ability level), for example, would provide an adequate estimate of the broad *Gf* ability because these tests are strong measures of *Gf* and represent qualitatively different aspects of this broad ability.

DON'T FORGET

Two or more qualitatively different indicators (i.e., subtests representing different narrow abilities) are needed to represent a construct (i.e., a broad ability) adequately.

The Verbal Comprehension Index (VCI) of the Wechsler Adult Intelligence Scale–Fourth Edition (WAIS-IV; Wechsler, 2008) is an example of good construct representation. This is because the VCI includes Vocabulary and Similarities (measures of mainly Lexical Knowledge [VL]), and Information (a measure of General Information [K0]), which represent qualitatively different aspects of *Gc*.

Most cognitive batteries yield construct-relevant composites, although some of these composites underrepresent the broad ability intended to be measured. This is because construct underrepresentation can also occur when the composite consists of two or more measures of the same narrow (stratum I) ability. For example, the Number Recall and Word Order subtests of the Kaufman Assessment Battery for Children–Second Edition (KABC-II; Kaufman & Kaufman, 2004) were intended to be interpreted as a representation of the broad *Gsm* ability. However, these subtests primarily measure Memory Span, a narrow ability subsumed by *Gsm*. Thus, the *Gsm* Scale of the KABC-II is most appropriately interpreted as Memory Span (a narrow ability) rather than an estimate of the broad ability of Short-Term Memory.

A scale or broad CHC ability cluster will yield more information—and, hence, be a more valid measure of a construct—if it contains more differentiated or qualitatively different tests of the construct (Clarke & Watson, 1995). Cross-battery assessments circumvent the misinterpretations that can result from underrepresented constructs by specifying the use of two or more qualitatively different indicators to represent each broad CHC ability. In order to ensure that qualitatively different aspects of broad abilities are represented in assessment, classification of cognitive and academic ability tests at the narrow (stratum I) ability level was necessary (Flanagan et al., 2007; McGrew & Flanagan, 1998). The subtests of current cognitive, achievement, and neuropsychological batteries as well as numerous special-purpose tests (e.g., memory batteries, language batteries) have been classified at both the broad and narrow ability levels (see Flanagan et al., 2002, 2006, 2007, 2010).

In sum, the classifications of tests at the broad and narrow ability levels of CHC theory guard against two ubiquitous sources of invalidity in assessment: construct-irrelevant variance and construct underrepresentation. Taken together, CHC theory and the CHC classifications of tests that underlie the XBA approach provide the necessary foundation from which to organize assessments that are theoretically driven, psychometrically defensible, relevant to the referral concerns, and supported by current research.

Prior to discussing the applications of the XBA approach, it is important to highlight the various ways in which the approach has evolved. Rapid Reference 1.2 lists the major changes that have taken place in the XBA approach since 2007, when the second edition of *Essentials of Cross-Battery Assessment* was published (Flanagan et al., 2007). These changes are discussed throughout this book and are evident in the software programs on the accompanying CD.

Rapid Reference 1.2

What's New to This Edition?

- Use of expanded CHC theory (e.g., Schneider & McGrew, 2012) and its research base as the foundation for organizing assessments and interpreting ability test performance.
- Inclusion of all current intelligence batteries (i.e., WJ III NU, WPPSI-III, WPPSI-IV, WISC-IV, SB5, KABC-II, DAS-II, and WAIS-IV), major tests of academic achievement (e.g., WJ III NU ACH, KTEA-II, WIAT-III, KeyMath3, WRMT-3), selected neuropsychological instruments (e.g., D-KEFS, NEPSY-II), and numerous special-purpose tests (e.g., speech-language tests, memory tests, phonological processing tests, orthographic processing, and fine motor tests).
- Classification of nearly 800 tests and subtests according to CHC theory only or according to both CHC theory and neuropsychological domains (e.g., sensory-motor, visual-spatial, speed and efficiency, executive).
- Inclusion of inter-rater reliability statistics supporting the CHC theory classifications for the majority of new tests.

- Classification of all achievement, speech/language, phonological, and orthographic processing tests according to the Individuals with Disabilities Education Improvement Act (IDEIA, 2004) area of specific learning disability (e.g., reading decoding tests were classified as tests of Basic Reading Skill; math reasoning tests were classified as tests of Math Problem Solving).
- Inclusion of variation in task task demands and characteristics of cognitive, achievement, and neuropsychological batteries—information important for conducting a demand analysis of test performance
- Calculation of all cross-battery clusters in a psychometrically defensible way using median estimates of subtest reliabilities and intercorrelations.
- Update and summary of current research on the relations among cognitive abilities, neuropsychological processes, and academic skills with greater emphasis on forming narrow CHC ability composites, given their importance in predicting academic performance.
- Extensive revision of the XBA DMIA with significantly increased functionality, easier navigation, interpretive statements, and enhanced graphing capabilities (see Rapid Reference 2.4 in Chapter 2 for details).
- Replacement of the *SLD Assistant v1.0* with the XBA *Pattern of Strengths and Weaknesses Analyzer (XBA PSW-A* v1.0*)* that provides guidance in analysis and evaluation of cognitive and achievement data for individuals suspected of having an SLD (see Appendix H for details).
- Significant revision of the XBA Culture-Language and Interpretive Matrix (XBA C-LIM v2.0), which includes culture-language classifications for selected cognitive batteries, special-purpose tests, and neuropsychological instruments, has automated capability for evaluating individuals based on varying levels of language proficiency and acculturative knowledge, includes experimental, special purpose tabs for evaluating giftedness in English Learners as well as Spanish-language tests (i.e., WISC-IV Spanish, Bateria III).
- Inclusion of a comprehensive approach to identification of specific learning disabilities (SLD) following Flanagan and colleagues' (2002, 2006, 2007, 2011, 2012) operational definition of SLD, currently known as the *Dual Discrepancy/ Consistency (DD/C) Operational Definition of SLD.*
- Inclusion of examples of how the cross-battery approach is used within the context of various state and district criteria for SLD identification (see Appendix J).
- Inclusion of examples of linking findings of cognitive weaknesses or deficits to intervention (including educational strategies, accommodations, compensatory strategies, and curricular modifications).

RATIONALE FOR THE XBA APPROACH

The XBA approach has significant implications for practice, research, and test development. A brief discussion of these implications follows.

Practice (2000–2010)

Initially, the XBA approach provided "a much needed and updated bridge between current intellectual theory and research and practice" (Flanagan & McGrew, 1997, p. 322). The need for the XBA "bridge" was evident following Flanagan and colleagues' review of the results of several cross-battery factor analyses that were conducted prior to 2000 (Flanagan & Ortiz, 2001; Flanagan et al., 2002; McGrew & Flanagan, 1998). In particular, the results demonstrated that none of the intelligence batteries in use at that time contained measures that sufficiently approximated the full range of broad abilities that defined the structure of intelligence specified in contemporary psychometric theory (see Table 1.2). Indeed, the

Table 1.2. Representation of Broad CHC Abilities on Nine Intelligence Batteries Published Prior to 2000

	Gf	*Gc*	*Gv*	*Gsm*	*Glr*	*Ga*	*Gs*
WISC-III	×	✓	✓	o	×	×	✓
WAIS-R	×	✓	✓	o	×	×	o
WPPSI-R	×	✓	✓	o	×	×	o
KAIT	✓	✓	o	×	o	×	×
K-ABC	o	×	✓	o	×	×	×
CAS	×	×	✓	o	×	×	✓
DAS	✓	✓	✓	o	o	×	o
WJ-R	✓	o	✓	o	o	o	o
SB:FE	✓	✓	✓	o	×	×	×

✓- Adequately measured
o - Underrepresented
×- Not measured
Note: WISC-III = *Wechsler Intelligence Scale for Children–Third Edition* (Wechsler, 1991); WAIS-R = *Wechsler Adult Intelligence Scale–Revised* (Wechsler, 1981); WPPSI-R = *Wechsler Preschool and Primary Scale of Intelligence–Revised* (Wechsler, 1989); KAIT = *Kaufman Adolescent and Adult Intelligence Test* (Kaufman & Kaufman, 1993); K-ABC = *Kaufman Assessment Battery for Children* (Kaufman & Kaufman, 1983); CAS = *Cognitive Assessment System* (Naglieri & Das, 1997); DAS = Differential Ability Scales (Elliott, 1990); WJ-R = *Woodcock-Johnson Psycho-Educational Battery–Revised* (Woodcock & Johnson, 1989); SB:FE = *Stanford-Binet Intelligence Scale–Fourth Edition* (Thorndike, Hagen, & Sattler, 1986).

joint factor analyses conducted by Woodcock (1990) suggested that it might be necessary to "cross" batteries to measure a broader range of cognitive abilities than that provided by a single intelligence battery.

As may be seen in Table 1.2, most batteries fell far short of measuring all seven of the broad cognitive abilities listed. Of the major intelligence batteries in use prior to 2000, most failed to measure three or more broad CHC abilities (viz., *Ga*, *Glr*, *Gf*, *Gs*) that were (and are) considered important in understanding and predicting school achievement (Flanagan et al., 2006; McGrew & Wendling, 2010; see Chapter 2, this volume, for a summary). In fact, *Gf*, often considered to be the essence of intelligence, was either not measured or not measured adequately by most of the intelligence batteries included in Table 1.2 (i.e., WISC-III, WAIS-R, WPPSI-R, K-ABC, and CAS) (Alfonso, Flanagan, & Radwan, 2005; Flanagan, Alfonso, Mascolo, et al., 2011).

The finding that the abilities not measured by the intelligence batteries listed in Table 1.2 are important in understanding children's learning difficulties provided much of the impetus for developing the XBA approach (McGrew & Flanagan, 1998) as well as perhaps engendering the current movement away from sole or primary reliance on IQ in evaluating learning disabilities. In effect, the XBA approach was developed to systematically augment the batteries in Table 1.2 with tests from another battery (i.e., replace the X's and O's with ✓'s). As such, XBA guides practitioners in the selection of tests, both core and supplemental, that together provide measurement of abilities that are considered sufficient in both breadth and depth for the purpose of addressing referral concerns, particularly those that pertain to learning difficulties in the classroom.

Another benefit of the XBA approach for practice was that it facilitated communication among professionals. Most scientific disciplines have a standard nomenclature (i.e., a common set of terms and definitions) that facilitates communication and guards against misinterpretation (McGrew & Flanagan, 1998). For example, the standard nomenclature in chemistry is reflected in the Periodic Table; in biology, it is reflected in the classification of animals according to phyla; in psychology and psychiatry, it is reflected in the *Diagnostic and Statistical Manual of Mental Disorders*; and in medicine, it is reflected in the *International Classification of Diseases*. Underlying the XBA approach is a standard nomenclature or Table of Human Cognitive Abilities (McGrew & Flanagan, 1998) that includes classifications of hundreds of tests according to the broad and narrow CHC abilities they measure (see also Alfonso et al., 2005; Flanagan & Ortiz, 2001; Flanagan et al., 2002, 2006, 2007, 2010). The XBA classification system had a positive impact on communication among practitioners, led to improvements in research on the relations between cognitive and academic abilities (Flanagan et al., 2011a; McGrew & Wendling, 2010), and has resulted in improvements in the measurement of cognitive constructs, as may be seen in the design and structure of current cognitive and intelligence batteries.

Finally, the XBA approach offered practitioners a psychometrically defensible means to identify population-relative (or normative) strengths and weaknesses. By focusing interpretation on cognitive ability composites (i.e., via combinations of construct-relevant subtests) that contain either qualitatively different indicators of each CHC broad ability construct (to represent broad ability domains) or qualitatively similar indicators of narrow abilities (to represent narrow or specific ability domains), the identification of normative strengths and weaknesses via XBA is possible. Adhering closely to the guiding principles and steps of the approach (described later) helped to ensure that the strengths and weaknesses identified via XBA were interpreted in a theoretically and psychometrically sound manner. In sum, the XBA approach addressed the long-standing need within the entire field of assessment, from learning disabilities to neuropsychological assessment, for methods that "provide a greater range of information about the ways individuals learn—the ways individuals receive, store, integrate, and express information" (Brackett & McPherson, 1996, p. 80).

TEST DEVELOPMENT

Although there was substantial evidence of at least eight or nine broad cognitive CHC abilities by the late 1980s, the tests of the time did not reflect this diversity in measurement. For example, Table 1.2 shows that the WPPSI-R, K-ABC, KAIT, WAIS-R, and CAS batteries measured only two broad CHC abilities adequately. The WPPSI-R primarily measured *Gv* and *Gc* and, to a lesser extent, *Gsm* and *Gs*. The K-ABC primarily measured *Gv* and, to a lesser extent, *Gsm* and *Gf*, while the KAIT primarily measured *Gf* and *Gc* and, to a lesser extent, *Gv* and *Glr*. The CAS measured *Gs* and *Gv* and, to a lesser extent, *Gsm*. Finally, while later tests, such as the DAS, SB:FE, and WISC-III, did not provide sufficient coverage of abilities to narrow the gap between contemporary theory and practice, their comprehensive measurement of approximately three CHC abilities was nonetheless an improvement over the above-mentioned batteries. Table 1.2 shows that only the WJ-R included measures of all broad cognitive abilities compared to the other batteries available at that time. Nevertheless, most of the broad abilities were not measured adequately by the WJ-R (Alfonso et al., 2005; McGrew & Flanagan, 1998).

In general, Table 1.2 shows that *Gf*, *Gsm*, *Glr*, *Ga*, and *Gs* were not measured well by the majority of intelligence batteries published prior to 2000. Therefore, it was clear that most test authors did not use contemporary psychometric theories of the structure of cognitive abilities to guide the development of their intelligence batteries. As such, a substantial theory–practice gap existed—that is, theories of the structure of cognitive abilities were far in advance of the instruments used to operationalize them. In fact, prior to the mid-1980s, theory seldom played a role in intelligence test development. The numerous X's and O's in Table 1.2 exemplify the theory–practice gap that existed in the field of intellectual assessment at that time (i.e., prior to 2000; Alfonso et al., 2005; Flanagan & McGrew, 1997).

In the past decade, CHC theory has had a significant impact on the revision of old and development of new cognitive batteries. For example, a wider range of broad and narrow abilities is represented on current cognitive and intelligence batteries than that which was represented on previous editions of these tests. Table 1.3 provides several salient examples of the impact that CHC theory and the XBA classifications have had on cognitive test development over the past two

Table 1.3. Impact of CHC Theory and XBA CHC Classifications on Intelligence Test Development

Test (Year of Publication) CHC and XBA Impact	**Revision (Year of Publication)** CHC and XBA Impact
K-ABC (1983) No obvious impact.	**KABC-II (2004)** Provided a second global score that includes fluid and crystallized abilities; included several new subtests measuring reasoning; interpretation of test performance may be based on CHC theory or Luria's theory; provided assessment of five CHC broad abilities.
SB:FE (1986) Used a three-level hierarchical model of the structure of cognitive abilities to guide construction of the test: The top level included general reasoning factor, or *g*; the middle level included three broad factors called crystallized abilities, fluid-analytic abilities, and short-term memory; the third level included more specific factors including verbal reasoning, quantitative reasoning, and abstract/visual reasoning.	**SB5 (2003)** Used CHC theory to guide test development; increased the number of measures of fluid reasoning; included a Working Memory Factor based on research, indicating its importance for academic success.

(*continued*)

Table 1.3. (*Continued*)

WPPSI-R (1989) No obvious impact.	**WPPSI-III (2002)** Incorporated measures of Processing Speed that yielded a Processing Speed Quotient based on recent research indicating the importance of processing speed for early academic success; enhanced the measurement of fluid reasoning by adding the Matrix Reasoning and Picture Concepts subtests.
WJ-R (1989) Used modern *Gf-Gc* theory as the cognitive model for test development; included two measures of each of eight broad abilities.	**WJ III NU (2001, 2007)** Used CHC theory as a blueprint for test development; included two or three qualitatively different narrow abilities for each broad ability; the combined cognitive and achievement batteries of the WJ III NU include nine of the ten broad abilities subsumed in CHC theory at the time of its development.
WISC-III (1991) No obvious impact.	**WISC-IV (2003)** Eliminated Verbal and Performance IQs; replaced the Freedom from Distractibility Index with the Working Memory Index; replaced the Perceptual Organization Index with the Perceptual Reasoning Index; included the measurement of fluid reasoning by adding Matrix Reasoning and Picture Concepts; enhanced measurement of Processing Speed with the Cancellation subtest.
DAS (1990) No obvious impact.	**DAS-II (2007)** Measures seven broad CHC abilities and also includes measures of certain narrow abilities not found on other major cognitive batteries (e.g., M6 or free recall memory).
WAIS-III (1997) No obvious impact.	**WAIS-IV (2008)** Eliminated Verbal and Performance IQs; replaced the Perceptual Organization Index with the Perceptual Reasoning Index; enhanced the measurement of fluid reasoning by adding the Figure Weights and Visual Puzzles subtests; enhanced measurement of Processing Speed with the

Table 1.3. (*Continued*)

	Cancellation subtest; enhanced measurement of memory with the Working Memory Index.
WPPSI-III (2002) Incorporated measures of Processing Speed that yielded a Processing Speed Quotient based on recent research indicating the importance of processing speed for early academic success; enhanced the measurement of fluid reasoning by adding the Matrix Reasoning and Picture Concepts subtests.	**WPPSI-IV (2012)** Eliminated Verbal and Performance IQs; introduced a Visual Spatial Index and a Fluid Reasoning Index; added two measures of visual memory and another measure of processing speed.

Note: This table was adapted with permission from Alfonso et al., 2005. All rights reserved.
Source: Adapted with permission from Guilford (2005). All rights reserved.
K-ABC = *Kaufman Assessment Battery for Children* (Kaufman & Kaufman, 1983); KABC-II = *Kaufman Assessment Battery for Children–Second Edition* (Kaufman and Kaufman, 2004); SB:FE = *Stanford-Binet Intelligence Scale–Fourth Edition* (Thorndike, Hagen, & Sattler, 1986); SB5 = *Stanford-Binet Intelligence Scales–Fifth Edition* (Roid, 2003); WAIS-III = *Wechsler Adult Intelligence Scale–Third Edition* (Wechsler, 1997); WAIS-IV = *Wechsler Adult Intelligence Scale–Fourth Edition* (Wechsler, 2008); WPPSI-R = *Wechsler Preschool and Primary Scale of Intelligence–Revised* (Wechsler, 1989); WPPSI-III = *Wechsler Preschool and Primary Scale of Intelligence–Third Edition* (Wechsler, 2002); WPPSI-IV = *Wechsler Preschool and Primary Scale of Intelligence–Fourth Edition* (Pearson, 2012); WJ-R = *Woodcock-Johnson Psycho-Educational Battery–Revised* (Woodcock & Johnson, 1989); WJ III NU = *Woodcock-Johnson III Normative Update Tests of Cognitive Abilities* (Woodcock, McGrew, & Mather, 2001, 2007); WISC-III = *Wechsler Intelligence Scale for Children–Third Edition* (Wechsler, 1991); WISC-IV = *Wechsler Intelligence Scale for Children–Fourth Edition* (Wechsler, 2003); KAIT = *Kaufman Adolescent and Adult Intelligence Test* (Kaufman & Kaufman, 1993); DAS = *Differential Ability Scales* (Elliott, 1990); DAS-II = *Differential Ability Scales–Second Edition* (Elliott, 2007).

decades. In addition, Table 1.3 lists the major intelligence tests in the order in which they were revised, beginning with those tests with the greatest number of years between revisions (i.e., K-ABC) and ending with newly revised tests (i.e., WPPSI-IV). As is obvious from a review of the table, CHC theory and the CHC XBA classifications have had a significant impact on recent test development (Alfonso et al., 2005).

Of the seven intelligence batteries that were published since 2000, the test authors of four used CHC theory explicitly and XBA classifications as a blueprint

DON'T FORGET

Of the seven intelligence batteries that were published since 2000, the test authors of four (WJ III NU, SB5, KABC-II, DAS-II) explicitly used CHC theory and XBA classifications as a blueprint for test development and the other three (Wechsler Scales) have implicit connections to it.

for test development (i.e., WJ III NU, SB5, KABC-II, and DAS-II). Only the authors of the Wechsler Scales (i.e., WPPSI-IV, WISC-IV, WAIS-IV) did not state outright that CHC theory was used as a guide for revision. Nevertheless, the authors of the Wechsler Scales do acknowledge the research of Cattell, Horn, and Carroll in their most recent manuals (Wechsler, 2003, 2008, 2012), and it seems that CHC theory did play an important role in shaping the final version of each test, whether expressly stated or not. Currently, as Table 1.3 shows, nearly all intelligence batteries that are used with some regularity subscribe either explicitly or implicitly to CHC theory (Alfonso et al., 2005; Flanagan et al., 2007).

Convergence toward the incorporation of CHC theory is also evident in Table 1.4. This table is similar to Table 1.2, except it includes all the major intelligence batteries that were published after 2000, including recent revision of many of the tests from Table 1.2. This table also includes the narrow CHC abilities that are measured by the subtests within each of the batteries. A comparison of Table 1.2 and Table 1.4 shows that many of the gaps in measurement of broad cognitive abilities have been filled. Specifically, the majority of tests published after 2000 now measure four to five broad cognitive abilities adequately (see Table 1.4) as compared to two to three (see Table 1.2). Table 1.4 shows that the WISC-IV, WAIS-IV, KABC-II, and SB5 measure four to five broad CHC abilities. The WISC-IV and WAIS-IV measure *Gf*, *Gc*, *Gv*, *Gsm*, and *Gs* while the KABC-II measures *Gf*, *Gc*, and *Gv* adequately and to a lesser extent *Gsm* and *Glr*. The SB5 measures four CHC broad abilities (i.e., *Gf*, *Gc*, *Gv*, *Gsm*) and the DAS-II measures five (i.e., *Gf*, *Gc*, *Gv*, *Gsm*, and *Glr*) adequately and to a lesser extent *Ga* and *Gs*. Finally, the WJ III NU COG measures seven broad cognitive abilities adequately.

Table 1.4 shows that the WJ III NU and DAS-II include measures of seven broad cognitive abilities. While the WJ III NU measures each of seven broad abilities adequately, the abilities of *Ga* and *Gs* are underrepresented on the DAS-II. A comparison of Tables 1.2 and 1.4 also indicates that two broad abilities not measured by many intelligence batteries prior to 2000 are now measured by the majority of intelligence batteries available today—that is, *Gf* and *Gsm*. These broad abilities may be better represented on revised and new intelligence batteries because of the accumulating research evidence regarding their importance in

Table 1.4. Broad and Narrow CHC Ability Representation on Seven Current Intelligence Batteries

	Gf	*Gc*	*Gv*	*Gsm*	*Glr*	*Ga*	*Gs*
WISC-IV	Matrix Reasoning (I) Picture Concepts (I)	Vocabulary (VL) Information (K0) Similarities (VL, *Gf*:I) Comprehension (K0) Word Reasoning (VL, *Gf*:I)	Block Design (Vz) Picture Completion (CF, *Gc*:K0)	Digit Span (MS, MW) Letter-Number Sequencing (MW) Arithmetic (MW; *Gf*: RQ)	**Not Measured**	**Not Measured**	Symbol Search (P) Coding (R9) Cancellation (P)
WAIS-IV	Matrix Reasoning (I) Figure Weights (RQ)	Vocabulary (VL) Information (K0) Similarities (VL, *Gf*:I) Comprehension (K0)	Block Design (Vz) Picture Completion (CF, *Gc*:K0) Visual Puzzles (Vz)	Digit Span (MS, MW) Letter-Number Sequencing (MW) Arithmetic (MW; *Gf*: RQ)	**Not Measured**	**Not Measured**	Symbol Search (P) Coding (R9) Cancellation (P)
WPPSI-IV	Matrix Reasoning (I)	Picture Concepts (*Gc*: K0, *Gf*:I) Vocabulary (VL) Information (K0) Similarities (VL, *Gf*:I) Comprehension (K0)	Block Design (Vz) Object Assembly (CS) Picture Memory (MV)	**Not Measured**	**Not Measured**	**Not Measured**	Animal Coding (R9) Bug Search (P) Cancellation (P)

(*continued*)

Table 1.4. (*Continued*)

	Gf	*Gc*	*Gv*	*Gsm*	*Glr*	*Ga*	*Gs*
		Receptive Vocabulary (VL) Picture Naming (VL)	Zoo Locations (MV) **Not Measured**				
KABC-II	Pattern Reasoning (I; *Gv*:Vz)[1] Story Completion (RG, *Gc*:K0)[2]	Expressive Vocabulary (VL) Verbal Knowledge (VL, K0) Riddles (VL, *Gf*:RG)	Face Recognition (MV) Triangles (Vz) Gestalt Closure (CS) Rover (SS, *Gf*: RG) Block Counting (Vz) Conceptual Thinking (Vz; *Gf*:I)	Number Recall (MS) Word Order (MS, MW) Hand Movements (MS, *Gv*: MV)	Atlantis (MA) Rebus (MA) Atlantis Delayed (MA) Rebus Delayed (MA)	**Not Measured**	**Not Measured**
WJ III NU	Concept Formation (I) Analysis-Synthesis (RG)	Verbal Comprehension (VL, *Gf*:I) General Information (K0)	Spatial Relations (Vz) Picture Recognition (MV) Planning (SS, *Gf*:RG)	Memory for Words (MS) Numbers Reversed (MW) Auditory Working	Visual-Auditory Learning (MA) Retrieval Fluency (FI)	Sound Blending (PC) Auditory Attention (UR) Incomplete Words (PC)	Visual Matching (P) Decision Speed (P) Pair Cancellation (P)

				Memory (MW)	Visual-Auditory Learning Delayed (MA) Rapid Picture Naming (NA; *Gs*: R9)		
SB5	Nonverbal Fluid Reasoning (I; *Gv*) Verbal Fluid Reasoning (I, RG, *Gc*:CM) Nonverbal Quantitative Reasoning (RQ, *Gq*:A3) Verbal Quantitative Reasoning (RQ, *Gq*:A3)	Nonverbal Knowledge (K0, LS, *Gf*:RG) Verbal Knowledge (VL,K0)	Nonverbal Visual-Spatial Processing (Vz) Verbal Visual-Spatial Processing (Vz, *Gc*:VL, K0)	Nonverbal Working Memory (MS, MW) Verbal Working Memory (MS, MW)	**Not Measured**	**Not Measured**	**Not Measured**
DAS-II	Matrices (I) Picture Similarities (I) Sequential & Quantitative Reasoning (RQ)	Early Number Concepts (VL, *Gq*: A3) Naming Vocabulary (VL)	Pattern Construction (Vz) Recall of Designs (MV)	Recall of Digits-Forward (MS) Recall of Digits-	Rapid Naming (NA; *Gs*: R9)[3] Recall of Objects-	Phonological Processing (PC)	Speed of Information Processing (P)

(continued)

Table 1.4. (*Continued*)

Gf	*Gc*	*Gv*	*Gsm*	*Glr*	*Ga*	*Gs*
	Word Definitions (VL) Verbal Comprehension (LS) Verbal Similarities (VL, *Gf*:I)	Recognition of Pictures (MV) Copying (Vz) Matching Letter-Like Forms (Vz)	Backward (MW) Recall of Sequential Order (MW)	Immediate (M6) Recall of Objects-Delayed (M6)		

Note: CHC classifications are based on the literature and primary sources, such as Carroll (1993); Flanagan and Ortiz (2001), Flanagan, Ortiz, and Alfonso (2007); Flanagan, Ortiz, Alfonso, and Mascolo (2006); Horn (1991); Keith, Fine, Taub, Reynolds, and Kranzler (2006); McGrew (1997); and McGrew and Flanagan (1998).

WISC-IV = *Wechsler Intelligence Scale for Children–Fourth Edition* (Wechsler, 2003); WAIS-IV = *Wechsler Adult Intelligence Scale–Fourth Edition* (Wechsler, 2008); WPPSI-III = *Wechsler Preschool and Primary Scale of Intelligence–Fourth Edition* (Wechsler, 2012); KABC-II = *Kaufman Assessment Battery for Children–Second Edition* (Kaufman & Kaufman, 2004); WJ III NU = *Woodcock-Johnson III Normative Update Tests of Cognitive Abilities* (Woodcock, McGrew, & Mather, 2001, 2007); SB5 = *Stanford-Binet Intelligence Scales–Fifth Edition* (Roid, 2003); DAS-II = *Differential Ability Scales–Second Edition* (Elliot, 2007); WPPSI-IV = Wechsler Preschool and Primary Scale of Intelligence–Fourth Edition (Wechsler, 2012).

Gf = Fluid Reasoning; *Gc* = Crystallized Intelligence; *Gv* = Visual Processing; *Gsm* = Short-Term Memory.

Glr = Long-Term Storage and Retrieval; *Ga* = Auditory Processing; *Gs* = Processing Speed; *Gq* = Quantitative Knowledge; RQ = Quantitative Reasoning; I = Induction; RG = General Sequential Reasoning; VL = Lexical Knowledge; K0 = General (verbal) Knowledge; LS = Listening Ability; MV = Visual Memory; Vz = Visualization; SS = Spatial Scanning; CF = Flexibility of Closure; CS = Closure Speed; MW = Working Memory; MS = Memory Span; MA = Associative Memory; FI = Ideational Fluency; NA = Naming Facility; M6 = Free Recall Memory; PC = Phonetic Coding; UR = Resistance to Auditory Stimulus Distortion; P = Perceptual Speed; R9 = Rate of Test Taking; A3 = Math Achievement.

[1] Pattern Reasoning appears to be a measure of *Gv*:Vz as a primary broad ability and *Gf* as a second broad ability at ages 5 to 6 years.

[2] *Gc*:K0 appears to be the primary ability measured by Story Completion at ages 5 to 6 years. At older ages (i.e., ages 7+), the primary ability measured by Story Completion appears to be *Gf*:RG.

[3] Elliot (2007) places Rapid Naming under the construct *Gs* based on the results of factor analysis. The current authors place this test under the construct *Glr* based on theory and *Gs* as a second broad ability.

overall academic success (see Flanagan et al., 2006, 2011a; McGrew & Wendling, 2010). Finally, Table 1.4 reveals that intelligence batteries continue to fall short in their measurement of three CHC broad abilities: *Glr*, *Ga*, and *Gs*. In addition, current intelligence batteries do not provide adequate measurement of most specific or narrow CHC abilities, many of which are important in predicting academic achievement (Flanagan et al., 2007; McGrew & Wendling; see Chapter 2 for details). Thus, although there is greater coverage of CHC broad abilities now than there was just a few years ago, practitioners interested in measuring the full range of cognitive abilities will likely need to supplement testing in some manner (e.g., use of the XBA approach), since a significant number of narrow abilities remain inadequately measured by current intelligence tests (Alfonso et al., 2005).

GUIDING PRINCIPLES OF THE XBA APPROACH

In order to ensure that XBA procedures are theoretically and psychometrically sound, it is recommended that practitioners adhere to several guiding principles (McGrew & Flanagan, 1998). These principles are listed in Rapid Reference 1.3 and are defined here.

1. *Select a comprehensive ability battery as your core battery in assessment.* It is expected that the battery of choice is one that is deemed most responsive to referral concerns. These batteries may include, but are certainly not limited to, the Wechsler Scales, WJ III NU, SB5, DAS-II, KABC-II, and NEPSY-II. It is important to note that the use of co-normed tests, such as

Rapid Reference 1.3

Seven Guiding Principles of XBA

1. Select battery that best addresses referral concerns.
2. Use composites based on norms when available or alternatively, those generated by the XBA DMIA v2.0 or XBA PSW-A v1.0.
3. Select tests classified through an acceptable method.
4. When a broad ability is underrepresented, obtain it from another battery.
5. When crossing batteries, use tests developed and normed within a few years of each other.
6. Select tests from the smallest number of batteries to minimize error.
7. Establish ecological validity for area(s) of weakness or deficit.

the WJ III NU COG and ACH and the KABC-II and KTEA-II, may allow for the widest coverage of broad and narrow CHC abilities and processes.

2. *Use norm-based clusters/composites from a single battery whenever possible to represent broad CHC abilities.* In other words, best practices involve using actual test battery norms whenever they are available in lieu of various other methods of aggregating or deriving scores (e.g., averaging, use of formulas). In the past, cross-battery assessment involved converting subtest scaled scores from different batteries to a common metric and then averaging them (after determining that there was a nonsignificant difference between the scores) in order to build construct-relevant broad CHC ability clusters. Because the revision of cognitive and intelligence batteries benefited greatly from CHC theory and research, the practice of averaging scores or using formulas to create cross-battery composites is seldom necessary at *the broad ability level.* However, aggregating scores across batteries continues to be necessary at the narrow ability level and when testing hypotheses regarding aberrant performance within broad ability domains. Unlike the arithmetic averaging method advocated for this purpose in the previous editions of this book, current procedures now utilize mathematical formulas based on median estimates of subtest reliabilities and median intercorrelations to create narrow ability composites, thus improving on the psychometric defensibility of XBA. Chapter 3 focuses more specifically on how cross-battery composites are derived and interpreted.
3. *When constructing CHC broad and narrow ability clusters, select tests that have been classified through an empirically acceptable method, such as through CHC theory-driven within- or preferably cross-battery factor analyses or expert consensus content validity studies.* All test classifications included in this book have been classified through these methods. For example, when constructing broad (stratum II) ability composites or clusters, relatively pure CHC indicators should be included (i.e., tests that had either strong or moderate [but not mixed] loadings on their respective factors in theory driven within- or cross-battery factor analyses). Furthermore, to ensure appropriate construct representation when constructing broad (stratum II) ability composites, two or more qualitatively different narrow (stratum I) ability indicators should be included to represent each domain. Without empirical classifications of tests, constructs may not be adequately represented, and therefore, inferences about an individual's broad (stratum II) ability cannot be made. Of course, the more broadly an ability is represented (i.e., through

the derivation of composites based on multiple qualitatively different narrow ability indicators), the more confidence one has in drawing inferences about the broad ability underlying a composite. A minimum of two qualitatively different indicators per CHC broad ability is recommended in the XBA approach for practical reasons (viz., time-efficient assessment). Noteworthy is the fact that most intelligence tests typically include two qualitatively different indicators (subtests) to represent broad abilities, which is why constructing broad ability clusters in the initial design of a battery, as part of the XBA approach, is seldom necessary.

4. *When at least two qualitatively different indicators of a broad ability of interest are not available on the core battery, supplement the core battery with at least two qualitatively different indicators of that broad ability from another battery.* In other words, if an evaluator is interested in measuring Auditory Processing (*Ga*) and the core battery includes only one or no *Ga* subtests, select a *Ga composite* from another battery to supplement the core battery. This procedure avoids the potential problems involved in generating a composite score from two separate batteries and effectively ensures that actual norms are used when interpreting broad ability performance.
5. *When crossing batteries (e.g., augmenting a core battery with relevant CHC composites from another battery) or when constructing CHC broad or narrow ability composites using tests from different batteries, select tests that were developed and normed within a few years of one another to minimize the effect of spurious differences between test scores that may be attributable to the Flynn effect (Kaufman & Weiss, 2010).* The collection of tests included in this book were normed within 10 years of one another.
6. *Select tests from the smallest number of batteries to minimize the effect of spurious differences between test scores that may be attributable to differences in the characteristics of independent norm samples (McGrew, 1994).* In many cases, using select tests from a single battery to augment the constructs measured by any of the major intelligence or cognitive batteries is sufficient to represent approximately seven broad cognitive abilities adequately as well as to allow for at least two or three qualitatively different narrow ability indicators of most broad abilities (Flanagan et al., 2007). However, in order to measure multiple narrow abilities adequately, more than two batteries will be necessary.
7. *Establish ecological validity for any and all test performances that are suggestive of normative weaknesses or deficits.* The finding of a cognitive weakness or deficit is largely meaningless without evidence of how the weakness manifests in activities of daily living, such as academic achievement

(Flanagan, Alfonso, & Mascolo, 2011). The validity of test findings is bolstered when clear connections are made between the cognitive dysfunction (as measured by standardized tests) and the educational impact of that dysfunction (e.g., as observed in classroom performance and as may be gleaned from a student's work samples).

CONCLUSIONS

The XBA approach is a method that allows practitioners to augment or supplement any ability battery to ensure reliable and valid measurement of a wider range of abilities in a manner consistent with contemporary theory and research. The foundational sources of information on which the XBA approach was built (i.e., the classifications of ability batteries according to CHC theory) along with its guiding principles and steps (Chapter 2) provide a way to systematically construct a theoretically driven, comprehensive, and valid assessment of abilities. For example, when the XBA approach is applied to the Wechsler Scales, it is possible to measure important abilities that would otherwise go unassessed (e.g., *Ga*, *Glr*, orthographic processing)—abilities that are important in understanding school learning and a variety of vocational and occupational outcomes (e.g., Flanagan et al., 2006; Flanagan & Kaufman, 2009).

The XBA approach guides and facilitates measurement of the major cognitive areas specified in CHC theory with emphasis on those considered most critical on the basis of history, observation, and available test data. The CHC classifications of a multitude of ability tests bring stronger content and construct validity evidence to the evaluation and interpretation process. As test development continues to evolve and becomes increasingly more sophisticated (psychometrically and theoretically), batteries of the future will undoubtedly possess stronger content and construct validity. (A comparison of Tables 1.2 and 1.4 illustrates this point.) Notwithstanding, it would be unrealistic from an economic and practical standpoint to develop a battery that operationalizes contemporary CHC theory fully because the range of broad and narrow abilities is simply too numerous (Carroll, 1998; Flanagan et al., 2007). Therefore, it is likely that the XBA approach will become increasingly useful as the empirical support for CHC theory mounts (Reynolds et al., 2012).

With a strong research base and a multiplicity of CHC measures available, XBA procedures can aid practitioners in the selective measurement of abilities that are important with regard to the examinee's presenting problem(s). In particular, because the XBA approach was developed following important psychometric and validity principles, practitioners are able to address the "disorder in a basic psychological process" component of learning disability more reliably and validly (see Flanagan, Alfonso, & Mascolo, 2011 and Chapter 4 of this book).

In the past, the lack of theoretical clarity of widely used intelligence tests (e.g., the Wechsler Scales) confounded interpretation and adversely affected the examiner's ability to draw clear and useful conclusions from the data. The XBA approach has changed the direction of ability assessment in several ways. It has aided test authors and publishers in clarifying the theoretical underpinnings of their instruments. It has influenced the interpretation approaches of several commonly used intelligence batteries (e.g., KABC-II, WISC-IV). It has provided a means for understanding the relations between specific cognitive and academic abilities, thereby aiding significantly in the design and interpretation of assessments of individuals suspected of having a learning disability. And it has assisted in narrowing the gap between theory and practice in assessment-related fields. As a result, measurement and interpretation of abilities via the XBA approach is guided more by science than clinical acumen.

TEST YOURSELF

1. The XBA classification system has had a positive impact on communication among practitioners, has improved research on the relationship between cognitive and academic abilities, and has resulted in substantial improvements in the measurement of cognitive constructs, as seen in the design and structure of current cognitive batteries. True or False?

2. Fluid Reasoning (*Gf*), Crystallized Intelligence (*Gc*), and Visual Processing (*Gv*) are examples of:

a. general (stratum III) abilities.
b. broad (stratum II) abilities.
c. narrow (stratum I) abilities.
d. none of the above.

3. Two broad abilities not measured by many intelligence batteries published prior to 2000 that are now measured by the majority of intelligence batteries available today are:

a. *Gc* and *Gv.*
b. *Gf* and *Ga.*
c. *Gf* and *Gsm.*
d. *Gsm* and *Gt.*

4. The three pillars of the XBA approach are CHC theory, CHC broad (stratum II) classifications of ability tests, and:

a. CHC narrow (stratum I) classifications of ability tests.
b. CHC general (stratum III) classifications of ability.
c. a and b.
d. neither a nor b.

5. **All of the following are guiding principles, except:**
   a. use composites based on actual norms when possible.
   b. use subtests and composites from a single battery whenever possible to represent broad CHC abilities.
   c. select tests that have been classified through an acceptable method, such as through CHC theory-driven factor analyses or expert consensus content-validity studies.
   d. create broad ability CHC composites instead of narrow ability CHC composites when possible.
6. **An example of a composite that contains construct-irrelevant variance is the:**
   a. WISC-IV PRI.
   b. WJ III NU COG Comprehension-Knowledge Factor.
   c. DAS-II Verbal Cluster.
   d. KABC-II Simultaneous/*Gv* Scale.
7. **Most composites that are found in today's comprehensive intelligence batteries are relatively pure (i.e., containing only construct-relevant tests) and well-represented (i.e., containing qualitatively different measures of the broad ability underlying the composite). True or False?**
8. **Which of the following is *not* a good descriptor of the XBA approach?**
   a. Time efficient
   b. Theory focused
   c. Test kit focused
   d. Empirically supported
9. **XBAs guard against construct-irrelevant variance by:**
   a. using tests classified into broad and narrow abilities, ensuring practitioners are aware of the constructs they are measuring.
   b. using only tests that are reliable.
   c. using only tests that are valid.
   d. all of the above.
10. **When conducting XBA, it is important to select tests from a limited number of batteries. True or False?**

Answers: 1. True; 2. b; 3. c; 4. a; 5. d; 6. a; 7. True; 8. c; 9. d; 10. True

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