Woodcock Johnson® IV

# Technical Manual

Kevin S. McGrew ◆ Erica M. LaForte ◆ Fredrick A. Schrank

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# About the Authors of the WJ IV

## Fredrick A. Schrank

Fredrick A. (Fred) Schrank guided the development of the Woodcock-Johnson® IV (WJ IV™) as the author team leader. He managed the test development company Measurement Learning Consultants (MLC) and provided stewardship to the Woodcock-Muñoz Foundation.

Dr. Schrank is a licensed psychologist (Washington) and a board certified specialist in school psychology from the American Board of Professional Psychology (ABPP). He worked in the Dodgeville, North Fond du Lac, and De Forest (Wisconsin) school districts before earning a PhD from the University of Wisconsin–Madison. Dr. Schrank then taught at Truman State University (Missouri) and the University of Puget Sound (Washington) prior to a 25-year career devoted almost exclusively to the development and publication of the Woodcock-Johnson family of tests. In service to professional psychology, he has been an oral examiner for the American Board of School Psychology (ABSP) and president of the American Academy of School Psychology (AASP). Fred was instrumental in the development of the organizational and interpretive plan for the WJ IV, including the Woodcock-Johnson online scoring and reporting program.

## Kevin S. McGrew

Kevin S. McGrew is Director of the Institute for Applied Psychometrics (IAP), LLC, a private research and consulting organization he established in 1998. He was an Associate Director of Measurement Learning Consultants and Research Director of the Woodcock-Muñoz Foundation. He also is a Visiting Lecturer in Educational Psychology (School Psychology Program) at the University of Minnesota and Director of Research for Interactive Metronome, a neurotechnology and rehabilitation company. He holds a PhD in Educational Psychology (Special Education) from the University of Minnesota and an MS in School Psychology and a BA in Psychology from Minnesota State University–Moorhead.

Dr. McGrew was a practicing school psychologist for 12 years in Iowa and Minnesota. From 1989 to 2000, he was a Professor in the Department of Applied Psychology at St. Cloud State University, St. Cloud, Minnesota. He has served as a measurement consultant to a number of psychological test publishers, national research studies, and organizations.

He has authored numerous publications and made state, national, and international presentations in his primary areas of research interest in human intelligence, intellectual assessment, human competence, applied psychometrics, and the Cattell-Horn-Carroll (CHC) theory of cognitive abilities. He is an active distributor of theoretical and research information via three professional blogs and The MindHub® web portal.

Dr. McGrew was the primary measurement consultant for the WJ-R and served in the same capacity as coauthor of the *Mini-Battery of Achievement* (MBA), *Sharpe-McNear-McGrew Braille Assessment Inventory* (BAI), WJ III, *Woodcock-Johnson Diagnostic Supplement to the Tests of Cognitive Abilities*, *Batería III Woodcock-Muñoz®* (Batería III), *Woodcock-Johnson III Normative Update* (WJ III NU), *Woodcock-Johnson III*–Australian Adaptation, and WJ IV. He was the psychometric and statistical consultant for the development of the *Children's Psychological Processes Scale*.

## Nancy Mather

Nancy Mather is a Professor at the University of Arizona in the Department of Disability and Psychoeducational Studies. She holds an MA in Behavior Disorders and a PhD from the University of Arizona in Special Education and Learning Disabilities. She completed a postdoctoral fellowship under the mentorship of Dr. Samuel Kirk at the University of Arizona.

Dr. Mather assisted Dr. Richard Woodcock with several aspects of test development for the *Woodcock-Johnson Psycho-Educational Battery–Revised* (WJ-R®), including coauthoring the Examiner's Manuals for the WJ-R Tests of Cognitive Ability and Achievement. She has been a coauthor of both the *Woodcock-Johnson III* (WJ III®) and the WJ IV and has coauthored two books on the interpretation and application of the WJ III—*Essentials of WJ III Tests of Achievement Assessment* and *Woodcock-Johnson III: Reports, Recommendations, and Strategies*.

She has served as a learning disabilities teacher, a diagnostician, a university professor, and an educational consultant. Dr. Mather conducts research in the areas of reading and writing development. She has published numerous articles, conducts workshops on assessment and instruction both nationally and internationally, and has coauthored several books linking assessment and intervention, including *Learning Disabilities and Challenging Behaviors: A Guide to Intervention and Classroom Management*, *Evidence-Based Interventions for Students with Learning and Behavioral Challenges*, *Essentials of Assessment Report Writing*, *Essentials of Evidence-Based Academic Interventions*, *Writing Assessment and Instruction for Students with Learning Disabilities*, and most recently, *Essentials of Dyslexia: Assessment and Intervention*.

## Contributing Author

Erica M. LaForte coauthored the WJ IV Technical Manual with Kevin McGrew and Fredrick Schrank. She is an educational measurement professional with over 15 years of experience in clinical, educational, licensure, and certification test development and publishing. She holds an MA in Research Methodology from Loyola University–Chicago and a PhD in Educational Psychology (with a focus in Measurement, Evaluation, Statistics, and Assessment) from the University of Illinois at Chicago. During the development of the WJ IV, Erica provided the primary leadership in psychometric item analysis, scaling, test equating, and reliability analysis of the tests and clusters. She also assisted the author team in the analysis of the concurrent validity and clinical studies. Prior to her work on the WJ IV, Erica was employed for over 13 years at Riverside, where she held various positions in test development and research.

# Acknowledgments

The *Woodcock-Johnson IV* was developed from the contributions of thousands of individuals, spanning time and distance, each motivated by a desire or a call to make a valuable contribution to the future of contemporary assessment practice. Although it is impossible to acknowledge everyone individually, a few key people have made such significant contributions that even special mention seems inadequate as an expression of their impact.

When author team meetings were scheduled, **Barbara Wendling** was deemed to be so invaluable that she was always invited to participate. Her experience as an educator and diagnostician, her work in educational and test publishing, and the insights she has gleaned from developing and delivering trainings on learning disabilities and assessment over many years are reflected in the examiner's manuals and all of the WJ IV materials.

From the Measurement Learning Consultants project center offices on the beautiful Oregon coast, **Mary Ruef** fostered and supervised a staff of highly qualified employees who prepared standardization materials and scored the test results from the standardization and validity studies. In addition, she helped prepare the final data for analysis, including the preparation of preliminary data reports from which publication items were selected.

Extensive expertise in test publishing dedicated to the Woodcock-Johnson family of tests made **Melanie Bartels Graw** an indispensable asset to the quality of the published materials. Her painstaking attention to detail is evidenced throughout the battery, from the item keys to the user-friendliness of the examiner instructions. She single-handedly managed the monumental coordination effort of submitting and reviewing multiple iterations of all of the tests, test records, response booklets, and manuals to Riverside.

The critical task of converting standardization data to norms was accomplished through the superior craftsmanship of **David Dailey**, who not only trained and managed a staff of norms construction technicians, but also was instrumental in managing all of the nuances of the WJ IV blueprint so that each successive iteration of the battery plan could be reviewed and improved by the authors. A professional statistician, he played a key consulting role for a variety of statistical analyses reported in the *Woodcock-Johnson IV Technical Manual*.

Based on his years of experience creating the software programs for the Woodcock-Johnson family of tests, both in the United States and internationally, **Todd Simmons** expertly programmed the Woodcock-Johnson online scoring and reporting program, offering the perspective of ease-of-use in software design. He was ably assisted in his efforts by **Melanie Pammer Maerz** who assured that the software program worked as intended.

Joining the team in the latter years of the project, **Erica LaForte** brought a wealth of Rasch measurement expertise to the development effort. She completed a number of statistical analyses and helped write the *Woodcock-Johnson IV Technical Manual*. Throughout the half-decade-long developmental effort, the technical quality of the data analyses has been ensured by the contributions of **Dr. Jack McArdle** and **Dr. Mark Davison**.

Under the thoughtful guidance of **Dr. Ana Muñoz-Sandoval**, three Spanish oral language tests were adapted from parallel English oral language tests for use with Spanish-speaking bilingual individuals. **Dr. Lynne Jaffe** and **Dr. Criselda Alvarado** assisted with sections of the examiner's manuals, providing expertise for accommodations for students with specific disabilities, Spanish oral language assessment, and English language learners. **Dr. Kathleen Donalson** provided expertise in item content analysis for several of the reading and spelling tests.

Finally, sincere appreciation is expressed to the more than 8,000 standardization and validity study participants who contributed their time and invaluable test-taking efforts to this project.

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## Chapter 1

# Overview of the WJ IV

The *Woodcock-Johnson® IV* (WJ IV™) (Schrank, McGrew, & Mather, 2014a) consists of three distinct, co-normed batteries: the *Woodcock-Johnson IV Tests of Cognitive Abilities* (WJ IV COG) (Schrank, McGrew, & Mather, 2014b), the *Woodcock-Johnson IV Tests of Achievement* (WJ IV ACH) (Schrank, Mather, & McGrew, 2014a), and the *Woodcock-Johnson IV Tests of Oral Language* (WJ IV OL) (Schrank, Mather, & McGrew, 2014b). Together, these batteries form a comprehensive system for measuring general intellectual ability (*g*), specific cognitive abilities, oral language, and academic achievement across a wide age range. Normative data are based on a large, nationally representative sample of 7,416 individuals ranging in age from 2 to 90+ years.

This chapter provides an outline and discussion of the WJ IV revision goals and design objectives with attention to the WJ IV procedures for comparing test and cluster scores and their relevance to current assessment practices. Succeeding chapters provide information supporting the psychometric characteristics of the WJ IV norm data and the various scores provided.

## WJ IV Revision Goals and Design Objectives

The WJ IV is a theoretical, structural, and interpretive revision of the *Woodcock-Johnson III* (WJ III®) (Woodcock, McGrew, and Mather, 2001) designed to provide measures of general intellectual ability; broad and narrow cognitive abilities as defined by contemporary Cattell-Horn-Carroll (CHC) theory, including oral language, reading, mathematics, writing abilities, and academic domain-specific aptitudes; and academic knowledge. The following WJ IV revision goals and design objectives maintain the traditional Woodcock-Johnson focus on quality while advancing CHC theory from its initial articulation in the *Woodcock-Johnson Psycho-Educational Battery–Revised* (WJ-R®) (Woodcock & Johnson, 1989) and WJ III in ways that provide more administration and interpretive options for meeting contemporary assessment needs.

1. The WJ IV is designed to provide the most contemporary measurement model of an evolving CHC theory of human cognitive abilities:
   a. By creating new tests and interpretive clusters, based on extant research and professional practice needs, to measure the most important cognitive, language, and academic abilities;
   b. By focusing on the ecological and predictive validity of key interpretive clusters in the cognitive, oral language, and achievement batteries by increasing the cognitive complexity of selected tests; and
   c. By offering a new fluid-crystallized (*Gf-Gc*) cognitive composite in the WJ IV COG for comparison to other measures of cognitive processing, linguistic competency, and academic achievement to determine relative strengths and weaknesses across all domains.

2. The WJ IV is organized into three distinct, co-normed batteries that can be used independently or in any combination to provide greater flexibility for professional examiners:
    a. By recognizing the importance of oral language abilities as essential correlates of cognitive and academic functioning and making the WJ IV OL available to examiners who conduct cognitive ability, academic achievement, or language proficiency evaluations;
    b. By including an overall index of oral language ability in Spanish as well as in English and suggesting a practical option for administering the Spanish tests; and
    c. By offering three parallel forms of the WJ IV ACH standard battery to avoid overexposure to items on any given form.
3. The WJ IV provides new and useful options for comparing abilities within and across batteries:
    a. By offering options to explore individual strengths and weaknesses across cognitive, linguistic, and academic abilities;
    b. By organizing each battery for ease of use, leading with a core set of tests in each battery that can be used as a predictor pool for calculations identifying relative strengths and weaknesses among administered tests and clusters; and
    c. By creating new academic domain-specific scholastic aptitude clusters that allow for efficient and valid predictions of achievement.
4. The WJ IV retains the focus on psychometric quality that has been associated with the previous editions of Woodcock-Johnson batteries:
    a. By providing a new, large, and nationally representative norming sample drawn from the U.S. population;
    b. By updating items and simplifying test administration and interpretation procedures;
    c. By augmenting the underlying scaling of speeded tests; and
    d. By utilizing state-of-the-art data collection, test development, and data analytic methods as models to facilitate progress in the field of applied test development.

## Evolution of CHC Theory in the WJ IV

The WJ IV represents the fourth generation of a comprehensive battery of psycho-educational tests that began in 1973 and was first published as the *Woodcock-Johnson Psycho-Educational Battery* (WJ) (Woodcock & Johnson, 1977). Initially, there was no underlying theoretical model that guided development of the tests. The WJ was based on a pragmatic decision-making model (McGrew, 1986, 1994; Woodcock, 1984). Formative research consisted of a number of controlled experiments to measure learning abilities. Test construction followed a scientific-empirical method. The WJ included a heterogeneous mix of tasks designed to fall on a continuum from lower mental processes (simple operations) to higher mental processes (complex operations). Factor and cluster analyses were conducted to help define a small number of broad functions measured by the battery (Woodcock, 1978). The initial analyses can be described as the beginning of Woodcock and coauthors' cross-generational quest for increased understanding of the nature of human cognitive abilities, how these abilities can be operationalized in applied standardized measures, and how these abilities influence learning. Today this quest continues in the form of an evolving base of knowledge known as contemporary CHC theory.

A primary goal for the first revision of the Woodcock-Johnson was articulation of a model of human intelligence that could be used for test development and interpretation. Richard Woodcock attended a 1985 conference hosted by the University of Illinois to honor a noted scholar of intelligence, Lloyd Humphreys. At the conference, John Horn presented a theory of human intelligence that later became widely known as *Gf-Gc* theory (Horn, 1991). Horn's insights into the structure of human intellectual capabilities captured Woodcock's imagination and suggested an interpretive model for the *Woodcock-Johnson Psycho-Educational Battery–Revised* (Woodcock & Johnson, 1989). Following Horn's presentation, Woodcock enlisted the help of Kevin McGrew, and in frequent consultation with John Horn and Jack Carroll, synthesized the extant exploratory and confirmatory factor analyses of the 1977 WJ. These analyses resulted in a blueprint for planning and organizing a revision of the WJ to more closely approximate *Gf-Gc* theory. With the assistance of Nancy Mather and others, new tests were added to the *Woodcock-Johnson Psycho-Educational Battery–Revised*, and the test battery became a prominent model for measuring the broad cognitive and academic abilities articulated by *Gf-Gc* theory (McGrew, 2005). Following publication of the WJ-R, Woodcock's (1990) joint analyses of all major intelligence batteries enhanced the understanding of the WJ-R tests as well as the *Gf-Gc* abilities measured by other intelligence batteries.

Increased specification of the nature and complexity of human cognitive abilities became a revision goal for the *Woodcock-Johnson III* (Woodcock, McGrew, & Mather, 2001). A major influence on this revision was Carroll's (1993) *Human Cognitive Abilities: A Survey of Factor-Analytic Studies*. Often described as three stratum theory (Carroll, 1993, 1998, 2003), Carroll's work is based on factor-analytic evidence from 461 psychometric test data sets that suggested human cognitive abilities could be conceptualized within a three-level hierarchy. Carroll identified approximately 70 specific, or narrow (stratum I), cognitive abilities that were similar to the Well Replicated Common Factor (WERCOF) abilities identified by Horn and his associates (Ekstrom, French, & Harman, 1979; Horn, 1989). In addition, Carroll grouped the narrow abilities into broad categories of cognitive abilities (stratum II) that are similar to the broad *Gf-Gc* factors described by Horn and his associates. Carroll (1993) recognized the similarities when, after a review of historical and contemporary theories, he concluded that the Horn-Cattell *Gf-Gc* model "appears to offer the most well-founded and reasonable approach to an acceptable theory of the structure of cognitive abilities" (p. 62). Subsequently, the synthesis of Cattell-Horn-Carroll research came to be called CHC theory (McGrew, 2005, 2009) and was used as the blueprint to build more breadth into the broad factors of the WJ III. This was accomplished for most factors by creating broad ability cluster scores from two or more tests of qualitatively different narrow, or stratum I, abilities. Carroll also identified a general intellectual ability factor (*g*) at the apex of his three-stratum model. This provided substantive validity for the inclusion of a differentially weighted general intellectual ability (*g*) score in the WJ III.

At the University of Virginia in 1994, John Carroll (1998) offered a self-critique of his three-stratum theory. Among other considerations, he cautioned that the specifications in his theory were based on considerable subjectivity in sorting and classifying factors from independently derived data sets. In addition, he noted that his specification of abilities was based primarily on scores from psychometric tests and that cross-validation of the proposed constructs was needed from other data sets and other forms of scientific research. These two caveats, in particular, became foci for development in the WJ IV. CHC theory has evolved beyond its initial specifications (Schneider & McGrew, 2012) through both simplification and elaboration (see Appendix A). In addition, throughout the development of the WJ IV, other venues of research have been examined to cross-validate, modify, or add clarity to some of the theoretical constructs proposed by Cattell, Horn, Carroll, Woodcock, and their colleagues.

## Revised or New CHC Broad and Narrow Ability Constructs in the WJ IV

The interpretive model for the WJ IV reflects the most contemporary specification of CHC theory at the time of publication. Analysis of the WJ-R, WJ III, and WJ IV norming samples provided three large, multi-ability data sets that were used to either confirm or revise initial construct specifications. Support for changes to the interpretive constructs was gleaned from other sources of neuroscience research. The most significant changes to the WJ IV interpretive model are found in the contemporary constructs of working memory, speed of lexical access, and memory for sound patterns.

### *Short-Term Working Memory (Gwm)*

In the WJ III, the term *short-term memory* (*Gsm*) was used to refer to the ability to apprehend and maintain awareness of elements of information in the immediate situation. The WJ III *Gsm* was derived primarily from the work of Horn (1965, 1988, 1989, 1991) and Horn and Noll (1997), although Carroll's (1993) stratum II factor, General Memory and Learning (2Y), also included auditory memory span (MS) tasks. In addition, a distinction was made in the WJ III between tasks that relied solely on auditory storage and maintenance of information and tasks that required active manipulation of information held in immediate awareness. The latter tasks were defined as measures of working memory (WM).

Within the decade that followed the publication of the WJ III, the term *working memory* became increasingly cited in neuroscience research with operational definitions that either replaced or included the construct of short-term memory. It became clear that the hierarchical placement of working memory under *Gsm* in the CHC taxonomy was outdated and incorrect (Dehn, 2008). In its broadest sense, working memory refers to a dynamic, temporary storage system that allows information—either sensory inputs or prior knowledge—to be held in immediate awareness and manipulated (Goldman-Rakic, 1992; Miller, Galanter, & Pribram, 1960). In contrast, for many contemporary neuroscientists, the term *short-term memory* refers solely to "tasks that involve significant storage but only minimal processing" (Gathercole & Alloway, 2008, p. 21). In professional nomenclature, *working memory* refers to a broader, more complex construct than short-term memory span (MS). *Working memory* suggests an active manipulation of information and can invoke other cognitive functions, including visualization or memory and retrieval processes, to effect goal attainment.

In the WJ IV COG, short-term working memory (*Gwm*) is defined as a broad cognitive ability, consistent with current neuroscience research that posits a dynamic system for both temporary storage and manipulation of information in human cognition. In contrast to the WJ IV narrow Auditory Memory Span (MS) cluster, which consists solely of tasks that measure span of storage in oral language processing using sound-based coding, the WJ IV Short-Term Working Memory (*Gwm*) cluster is composed of tasks that involve both temporary storage *and* active review or manipulation of words and numbers. As a consequence of task complexity, short-term working memory may more frequently invoke visual imagery or semantic representations for successful completion. The WJ IV Short-Term Working Memory (*Gwm*) cluster also may be defined as a measure of *working memory capacity* (WM), a diagnostically important and quantifiable aspect of the more broadly encompassing working memory construct used in contemporary neuroscience. Working memory capacity is an important interpretive construct. Limited working memory capacity can act as a bottleneck for learning and may be related to learning disabilities (Gathercole, 2004; Gathercole, Lamont, & Alloway, 2006). Many children with identified reading, writing, and mathematics disabilities show related impairments in working memory capacity (Bull & Scerif, 2001; de Jong, 1998; Mayringer & Wimmer, 2000; Siegel & Ryan, 1989; Swanson, 1994; Swanson, Ashbaker, & Lee, 1996). Limited working memory capacity may be an identified causal factor in learning disabilities that are not domain-specific. Gathercole and Alloway (2008) stated, "Learning difficulties that extend across both reading and mathematics, or language, therefore appear to be characteristic of children with poor working memory function" (p. 25).

### Speed of Lexical Access (LA)

Although not coded at the time of publication, analysis of the WJ III standardization data suggested a common variance between the speeded serial naming task measured in WJ IV OL Test 4: Rapid Picture Naming and the speeded name-generation facility measured in WJ IV OL Test 8: Retrieval Fluency. This covariance clearly emerged again in the WJ IV norming data and suggested the need to identify the factor in the WJ IV and in contemporary CHC architecture (see Chapter 5).

Task analysis shows that although the two speeded naming tests differ in some methodological ways, the covariance may be explained by a common construct. Rapid Picture Naming is an example of a speeded serial naming task requiring rapid object recognition, similar to tasks described in the literature as rapid automatized naming (RAN) (Kirby, Georgiou, Martinussen, & Parrila, 2010; Norton & Wolf, 2012). Such tasks represent a microcosm of multiple cognitive processes involved in reading that have been strongly linked to reading disabilities (Norton & Wolf, 2012). In Rapid Picture Naming, highly familiar visual object stimuli are presented as a large set (not one by one). Examinees are asked to start at the beginning of the set of pictures and name the objects as quickly as possible. Scores are based on the number of objects named correctly in the allotted 2 minutes. Examinees who quickly and accurately proceed through a greater number of the stimulus pictures obtain better scores than those who progress slowly and consequently provide fewer object names in the allotted time.

Retrieval Fluency is an example of a speeded name-generation task. It differs from Rapid Picture Naming in important ways. There are no pictured objects to name. Rather, the individual is asked to generate and name examples of a semantic category—things to eat or drink and names of people or animals. The task requires activation of a semantic network to retrieve and generate the names (Martin, 1998, 2009). Although Retrieval Fluency is similar to Rapid Picture Naming in that both are speeded naming tests, in Retrieval Fluency the time allotment for each category (1 minute) is sufficient for most individuals to provide as many examples as they can generate. Many individuals exhaust their naming effort before the allotted 1 minute expires. Strategy use, self-monitoring, working memory, and divergent thinking can contribute to network activation and, subsequently, to increases in the number of examples named (Vannorsdall, Maroof, Gordon, & Schretlen, 2012).

Naming facility (NA) is identified as the CHC narrow ability measured by Rapid Picture Naming; ideational fluency (FI) is the narrow ability associated with Retrieval Fluency. The two different speeded naming tasks were tentatively identified as a single naming factor in the WJ III (Woodcock, McGrew, & Mather, 2001). However, a subsequent review of related research suggests that a type of verbal efficiency (Perfetti, 1985) or automaticity for lexical access (LaBerge & Samuels, 1974; Neely, 1977) may be common to both tasks. In the WJ IV and in contemporary CHC theory, this common factor is identified as speed of lexical access (LA). Evidence to support this ability factor in the WJ IV is presented in Chapter 5.

### Memory for Sound Patterns (UM)

Carroll (1993) identified a narrow auditory processing ability that appeared to involve memory as a critical component. Although his data sets were small and composed primarily of tests utilizing patterns of nonspeech sounds, Carroll was intrigued with the possibility of distinguishing an auditory factor analogous to the narrow visual memory (MV) factor. In classic cognitive psychology research, Neisser (1967) postulated the existence of an echoic memory, or sensory register, whose function is retention of auditory information for a brief period of time (3 or 4 seconds). Neisser, who is now considered the father of cognitive psychology, suggested that a language function of echoic memory may be to hold auditory input in suspension until subsequent auditory input is added so that a sequence of sounds can be processed as a unit, such as a whole word. Decades later, a parallel body of research, not previously integrated with CHC theory, posited the existence of a phonological storage ability or short-term memory function for speech sounds (Gathercole & Baddeley, 1989; Gathercole, Willis, Emslie, & Baddeley, 1992, 1994). These and similar studies have suggested a need to expand the CHC operational definition of memory for sound patterns (UM) to include memory for speech sounds and also to support the inclusion of Test 12: Nonword Repetition in the WJ IV COG. (Evidence for the expanded UM definition is presented in Chapter 5.)

## Cognitive Complexity

One interpretive feature that has remained constant throughout all editions of the Woodcock-Johnson is the analysis of test requirements via level of cognitive complexity. By deliberate design, the WJ, WJ-R, and WJ III all included tasks that fall on a continuum from simple cognitive operations to complex cognitive processes. In the WJ IV, a concerted effort was directed to increasing the cognitive complexity requirements for selected tests and clusters to provide greater ecological validity and interpretive relevance of the measures.

Increasing the cognitive complexity of a test is often accomplished by making the test a mixed measure of more than one narrow CHC ability. A second approach is to increase the complexity of information processing demands of the tests *within* a specific narrow CHC domain (Lohman & Lakin, 2011; McGrew, 2012). This second form of cognitive complexity, not to be confused with factorial complexity, places greater demands on cognitive information processing (cognitive load), requires greater allocation of key cognitive resources (working memory or attentional control), and invokes the involvement of more cognitive control or executive functions (Arend et al., 2003; Jensen, 2011; Lohman & Lakin, 2011; Marshalek, Lohman, & Snow; 1983). This second approach to increasing cognitive test complexity was a primary design principle for the WJ IV.

For example, increased cognitive complexity is clearly evidenced in the composition of the WJ IV COG Auditory Processing cluster. A second example, from the WJ IV ACH, illustrates how the introduction of the cognitively complex Test 8: Oral Reading can help examiners measure the construct of reading fluency more broadly and validly. The introduction of cognitive complexity in other new or revised tests is described in Chapter 2.

### *Auditory Processing*

The two tests that compose the WJ IV COG Auditory Processing cluster (Test 5: Phonological Processing and Test 12: Nonword Repetition) are designed to measure cognitively complex, ecologically relevant processes that involve auditory processing abilities. Following the publications of Carroll's (1993) treatise and the WJ III (Woodcock, McGrew, & Mather, 2001, 2007), there has been an explosion of research on auditory abilities (Schneider & McGrew, 2012). A wide-ranging collection of auditory processing (*Ga*) characteristics have been related to disorders of reading, speech, and language. *Ga* abilities are now recognized as playing a pivotal scaffolding role in the development of language and general cognitive abilities (Conway, Pisoni, & Kronenberger, 2009). Two new auditory processing tests were added to the WJ IV to measure some of these important abilities. Each test is based on a combination of narrow abilities that spans one or more other broad abilities. The two new tests are WJ IV COG Test 5: Phonological Processing and WJ IV COG Test 12: Nonword Repetition. The less cognitively complex, but instructionally relevant, phonetic processing tasks are included in the WJ IV OL.

Test 5: Phonological Processing measures three aspects of speech sound processing that lead to the construction of sound-based lexical representations. Also referred to as phonological awareness or phonological sensitivity (Pufpaff, 2009), these types of tasks are closely associated with word learning (de Jong, Seveke, & van Veen, 2000). Phonological processing is considered important when learning to read because phonology is mapped onto orthography when sounding out words (Liberman, Shankweiler, & Liberman, 1989; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993; Wagner, Torgesen, & Rashotte, 1994). Subtest 5A Word Access measures the ability to access an appropriate word contained in the mental lexicon via a phonological cue. The task for the easiest Word Access items requires the examinee to point to a picture that has the same starting sound as a word provided by the examiner. The remaining items provide a word that has a specific phonemic element in a specific location. Subtest 5B Word Fluency measures the extent to which a network of words can be activated via a phonological connection. Subtest 5C Substitution measures a type of phonological sensitivity that allows for oral production of a new word by substituting a sound or part of a word in working memory. In the context of contemporary CHC theory, the overall test score reflects a combination of auditory processing, fluency, and long-term retrieval abilities.

Test 12: Nonword Repetition is a cognitively complex test that measures a combination of auditory processing and short-term working memory abilities sometimes referred to as phonological short-term memory. The task requires temporary storage of phonological segments in immediate awareness, an ability characterized by marked individual differences among people (Gathercole & Baddeley, 1989; Gathercole et al., 1992, 1994). Recent research with nonword repetition tasks has suggested a link between nonword repetition and new word learning (Gathercole, 2006; Michas & Henry, 1994) and that tests of nonword repetition can provide insights into vocabulary development (Edwards, Beckman, & Munson, 2004). Additionally, performance on nonword repetition tasks has been related to reading and language disorders (Archibald & Gathercole, 2006; de Bree, Wijnen, & Gerrits, 2010; Gathercole, 2006).

### *Reading Fluency*

Reading fluency is a multifaceted construct. One design objective of the WJ IV is to offer an improved and ecologically valid methodology for evaluating reading fluency that conforms to contemporary concepts of fluent reading performance.

The objective was spawned by concern over current practices that purport to measure reading fluency with simple word reading rate or automaticity tasks, which are highly influenced by practice effects. Examinees read well-practiced words more rapidly than they read words that are not well practiced (Seidenberg & McClelland, 1989). Although timed readings from word lists are commonly used benchmarks for reading fluency, these word-level speed and accuracy tests are narrow in scope and underrepresent the construct of reading fluency. Appropriate oral expression of connected discourse is now considered a defining component of fluent reading (Kuhn & Stahl, 2003; National Reading Panel, 2000).

Two qualitatively different tests compose the WJ IV ACH Reading Fluency cluster. Test 8: Oral Reading measures fluency of oral expression in connected discourse. Fluent reading requires attention to the grammatical structure of prose. The way to ascertain whether an individual has attained this ability requires listening to him or her read connected discourse orally, noting any errors or omissions, including mispronunciations, word substitutions, hesitations, repetitions, transpositions, and attention to punctuation. Test 9: Sentence Reading Fluency is a timed task that requires an individual to silently read a series of sentences and comprehend meaning by deciding whether each statement is true or false. Fluent readers can silently read sentences quickly and understand what they have read. Together, these two tests provide a broader, more cognitively complex reading fluency cluster intended to reduce the error inherent in making generalizations about the broad construct of fluent reading from a single, narrow aspect of performance, such as automaticity in word recognition.

## Organization Into Three Distinct Batteries

The complete WJ IV is organized into three distinct batteries to facilitate a broad range of tailored and comprehensive assessments by one or more assessment professionals. Depending on the purpose of the assessment, the three batteries may be used alone or in combination with tests and clusters from one or two of the other batteries. The complete system of WJ IV tests and clusters is designed to provide a wide breadth of coverage for individually administered assessment of important abilities in a variety of settings. The wide age range and breadth of coverage allow the tests and clusters to be used for educational, clinical, or research purposes from the preschool to the geriatric level. The procedures used in the development of all of the WJ IV clusters and comparison procedures described in this chapter are presented in subsequent chapters of this manual.

The three WJ IV batteries are described next. Tables 1-1 through 1-3 summarize the tests and cluster configurations for the WJ IV COG, WJ IV OL, and WJ IV ACH batteries.

### WJ IV Tests of Cognitive Abilities

The WJ IV COG includes 18 tests for measuring general intellectual ability, broad and narrow cognitive abilities, academic domain-specific aptitudes, and related aspects of cognitive functioning. Two easel test books house the Standard Battery (Tests 1 through 10) and the Extended Battery (Tests 11 through 18). Table 1-1 provides information about the interpretive organization of the WJ IV COG tests. Some tests measure a single, narrow cognitive ability as articulated by contemporary CHC theory. Other tests are constructed or revised to emphasize cognitive complexity. When tests were selected for inclusion in the battery, consideration was given to psychometric characteristics and to the importance of the ability, or combination of abilities, for learning, intervention, or accommodation.

The tests are ordered to maximize interpretive options with the least amount of testing and to provide a foundation for additional testing on a selective basis. The 10 tests that compose the Standard Battery are intended to represent, for many assessment purposes, a standard cognitive assessment:

- Tests 1 through 3 compose the Brief Intellectual Ability (BIA) score, consisting of one representative test from the comprehension-knowledge (*Gc*), fluid reasoning (*Gf*), and short-term working memory (*Gwm*) factors. This subset of WJ IV cognitive tests has a very strong correlation with general intellectual ability and, unlike the WJ III BIA score, does not include a measure of cognitive processing speed (*Gs*).
- Tests 1 through 7 compose the General Intellectual Ability (GIA) score, consisting of one representative test from the comprehension-knowledge (*Gc*), fluid reasoning (*Gf*), short-term working memory (*Gwm*), processing speed (*Gs*), auditory processing (*Ga*), long-term retrieval (*Glr*), and visual processing (*Gv*) CHC ability domains. Each test selected for inclusion among the first seven tests (a) was a strong indicator of the respective CHC ability domain, (b) had high loadings on the general intelligence (*g*)

factor, (c) was high in cognitive complexity, and (d) was among the strongest predictors of academic achievement in the WJ IV ACH. This set serves as the required pool of tests for evaluation of strengths and weaknesses among tests and clusters that measure other cognitive abilities.

- Tests 1 through 10 include all clusters and functions described above with the addition of the following clusters: Comprehension-Knowledge (*Gc*), Fluid Reasoning (*Gf*), Short-Term Working Memory (*Gwm*), Cognitive Efficiency, and the *Gf-Gc* Composite.

The eight tests included in the Extended Battery enhance the interpretive information available from the standard battery. Any of these tests may be administered selectively and independently or may be used to create a cluster score for the following broad and narrow cognitive abilities: Cognitive Processing Speed (*Gs*), Auditory Processing (*Ga*), Long-Term Retrieval (*Glr*), Visual Processing (*Gv*), Perceptual Speed (P), Quantitative Reasoning (RQ), and Number Facility (N). When combined with tests from the WJ IV OL, the narrow cognitive ability clusters of Vocabulary (LD/VL) and Auditory Memory Span (MS) can be created. Any additional test or cluster that is administered is automatically included in the intra-cognitive variations procedure for evaluation of relative strengths and weaknesses when Tests 1 through 7 have been administered.

***Table 1-1.***
*Selective Testing Table for the WJ IV COG Showing Tests and Interpretive Clusters*

| | | | Cognitive Composites | | | CHC Factors | | | | | | | Narrow Ability and Other Clinical Clusters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | General Intellectual Ability (*GIA*) | Brief Intellectual Ability | *Gf-Gc* Composite | Comprehension-Knowledge (*Gc*) | Fluid Reasoning (*Gf*) | Short-Term Working Memory (*Gwm*) | Cognitive Processing Speed (*Gs*) | Auditory Processing (*Ga*) | Long-Term Retrieval (*Glr*) | Visual Processing (*Gv*) | Quantitative Reasoning (RQ) | Auditory Memory Span (MS) | Number Facility (N) | Perceptual Speed (P) | Vocabulary (VL/LD) | Cognitive Efficiency |
| Standard Battery | COG 1 | Oral Vocabulary | ■ | ■ | ■ | ■ | | | | | | | | | | | ■ | |
| | COG 2 | Number Series | ■ | ■ | ■ | | ■ | | | | | | ■ | | | | | |
| | COG 3 | Verbal Attention | ■ | ■ | | | | ■ | | | | | | | | | | □ |
| | COG 4 | Letter-Pattern Matching | ■ | | | | | | ■ | | | | | | | ■ | | ■ |
| | COG 5 | Phonological Processing | ■ | | | | | | | ■ | | | | | | | | |
| | COG 6 | Story Recall | ■ | | | | | | | | ■ | | | | | | | |
| | COG 7 | Visualization | ■ | | | | | | | | | ■ | | | | | | |
| | COG 8 | General Information | | | ■ | ■ | | | | | | | | | | | | |
| | COG 9 | Concept Formation | | | ■ | | ■ | | | | | | | | | | | |
| | COG 10 | Numbers Reversed | | | | | | ■ | | | | | | | ■ | | | ■ |
| Extended Battery | COG 11 | Number-Pattern Matching | | | | | | | | | | | | | ■ | ■ | | □ |
| | COG 12 | Nonword Repetition | | | | | | | | ■ | | | | | | | | |
| | COG 13 | Visual-Auditory Learning | | | | | | | | | ■ | | | | | | | |
| | COG 14 | Picture Recognition | | | | | | | | | | ■ | | | | | | |
| | COG 15 | Analysis-Synthesis | | | | | □ | | | | | | ■ | | | | | |
| | COG 16 | Object-Number Sequencing | | | | | | □ | | | | | | | | | | |
| | COG 17 | Pair Cancellation | | | | | | | ■ | | | | | | | | | |
| | COG 18 | Memory for Words | | | | | | | | | | | | ■ | | | | |
| Oral Language Battery | OL 1 | Picture Vocabulary | | | | □ | | | | | | | | | | | ■ | |
| | OL 5 | Sentence Repetition | | | | | | | | | | | | ■ | | | | |

■ Tests required to create the cluster listed.
□ Additional tests required to create an extended version of the cluster listed.

## WJ IV Tests of Oral Language

The WJ IV OL battery includes 12 tests for measuring oral language ability and listening comprehension (in English and Spanish), oral expression, and two important cognitive-linguistic abilities: phonetic coding and speed of lexical access. Table 1-2 contains information on the interpretive organization of the WJ IV OL tests. The WJ IV OL tests are contained in a single easel test book for use as a diagnostic supplement in a more comprehensive cognitive or achievement evaluation. The battery also may be used independently of the WJ IV COG or WJ IV ACH, contributing important oral language and language-related information to a diagnostic assessment.

***Table 1-2.***
*Selective Testing Table for the WJ IV OL Showing Tests and Interpretive Clusters*

| | | | Oral Language Clusters | | | | | | | | | OL + COG | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Oral Language | Broad Oral Language | Oral Expression | Listening Comprehension | Phonetic Coding | Speed of Lexical Access | Lenguaje oral | Amplio lenguaje oral | Comprensión auditiva | Vocabulary (VL/LD) | Auditory Memory Span (MS) |
| Oral Language Battery | OL 1 | Picture Vocabulary | ■ | ■ | ■ | | | | | | | ■ | |
| | OL 2 | Oral Comprehension | ■ | ■ | | ■ | | | | | | | |
| | OL 3 | Segmentation | | | | | ■ | | | | | | |
| | OL 4 | Rapid Picture Naming | | | | | | ■ | | | | | |
| | OL 5 | Sentence Repetition | | | ■ | | | | | | | | ■ |
| | OL 6 | Understanding Directions | | ■ | | ■ | | | | | | | |
| | OL 7 | Sound Blending | | | | | ■ | | | | | | |
| | OL 8 | Retrieval Fluency | | | | | | ■ | | | | | |
| | OL 9 | Sound Awareness[1] | | | | | | | | | | | |
| | OL 10 | Vocabulario sobre dibujos | | | | | | | ■ | ■ | | | |
| | OL 11 | Comprensión oral | | | | | | | ■ | ■ | ■ | | |
| | OL 12 | Comprensión de indicaciones | | | | | | | | ■ | ■ | | |
| Cognitive Abilities Battery | COG 1 | Oral Vocabulary | | | | | | | | | | ■ | |
| | COG 18 | Memory for Words | | | | | | | | | | | ■ |

■ Tests required to create the cluster listed.
[1] This is a screening test and does not contribute to a cluster.

The WJ IV OL tests are placed in an order that maximizes interpretive options with the least amount of testing and provides a foundation for evaluation of strengths and weaknesses among areas of oral language and cognitive-linguistic abilities.

- Tests 1 and 2 compose the Oral Language cluster in English.
- Tests 1 through 4 compose a core set of tests that are required for calculation of intra-oral language variations and determination of relative strengths and weaknesses among the English tests and clusters.
- Tests 1 through 8 provide test and cluster scores for Broad Oral Language, Listening Comprehension, Oral Expression, Phonetic Coding, and Speed of Lexical Access.
- Test 9: Sound Awareness is intended for use as a phonological screening measure and is most appropriate for children ages 5 through 7 or for older individuals who have a deficit in speech sound awareness.

As an option for assessment of English-Spanish bilingual individuals, the tests that compose the WJ IV OL Oral Language and Listening Comprehension clusters in English have been adapted for administration in Spanish. The adaptation process produced parallel forms (rather than direct translations) of the tests. Data from a large Spanish calibration sample were used to equate the difficulty of the Spanish items to the scale underlying the WJ IV English tests. As a result of the equating process, examinee performance on the Spanish tests can be directly compared to their performance on the parallel English tests to determine language dominance and relative proficiency in each language.

## WJ IV Tests of Achievement

The WJ IV ACH includes 20 tests for measuring academic achievement in reading, mathematics, written language, science, social studies, and the humanities. Two easel test books house the Standard Battery (Tests 1 through 11) and the Extended Battery (Tests 12 through 20). Table 1-3 provides information on the interpretive organization of the WJ IV ACH tests. The tests are placed in an order to maximize interpretive options with the least amount of testing and provide a foundation for additional selective testing.

***Table 1-3.***
*Selective Testing Table for the WJ IV ACH Showing Tests and Interpretive Clusters*

| | | | Reading | | | | | | Mathematics | | | | Writing | | | | Cross-Domain Clusters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reading | Broad Reading | Basic Reading Skills | Reading Comprehension | Reading Fluency | Reading Rate | Mathematics | Broad Mathematics | Math Calculation Skills | Math Problem Solving | Written Language | Broad Written Language | Basic Writing Skills | Written Expression | Academic Skills | Academic Fluency | Academic Applications | Academic Knowledge | Phoneme-Grapheme Knowledge | Brief (or Broad) Achievement |
| Standard Battery | ACH 1 | Letter-Word Identification | ■ | ■ | ■ | | | | | | | | | | | | ■ | | | | | ■ |
| | ACH 2 | Applied Problems | | | | | | | ■ | ■ | | ■ | | | | | | | ■ | | | ■ |
| | ACH 3 | Spelling | | | | | | | | | | | ■ | ■ | ■ | | ■ | | | | | ■ |
| | ACH 4 | Passage Comprehension | ■ | ■ | | ■ | | | | | | | | | | | | | ■ | | | ● |
| | ACH 5 | Calculation | | | | | | | ■ | ■ | ■ | | | | | | ■ | | | | | ● |
| | ACH 6 | Writing Samples | | | | | | | | | | | ■ | ■ | | ■ | | | ■ | | | ● |
| | ACH 7 | Word Attack | | | ■ | | | | | | | | | | | | | | | | ■ | |
| | ACH 8 | Oral Reading | | | | | ■ | | | | | | | | | | | | | | | |
| | ACH 9 | Sentence Reading Fluency | | ■ | | | ■ | ■ | | | | | | | | | | ■ | | | | ● |
| | ACH 10 | Math Facts Fluency | | | | | | | | ■ | ■ | | | | | | | ■ | | | | ● |
| | ACH 11 | Sentence Writing Fluency | | | | | | | | | | | | ■ | | ■ | | ■ | | | | ● |
| Extended Battery | ACH 12 | Reading Recall | | | | ■ | | | | | | | | | | | | | | | | |
| | ACH 13 | Number Matrices | | | | | | | | | | ■ | | | | | | | | | | |
| | ACH 14 | Editing | | | | | | | | | | | | | ■ | | | | | | | |
| | ACH 15 | Word Reading Fluency | | | | | | ■ | | | | | | | | | | | | | | |
| | ACH 16 | Spelling of Sounds | | | | | | | | | | | | | | | | | | | ■ | |
| | ACH 17 | Reading Vocabulary | | | | □ | | | | | | | | | | | | | | | | |
| | ACH 18 | Science | | | | | | | | | | | | | | | | | | ■ | | |
| | ACH 19 | Social Studies | | | | | | | | | | | | | | | | | | ■ | | |
| | ACH 20 | Humanities | | | | | | | | | | | | | | | | | | ■ | | |

■ Tests required to create the cluster listed.
□ Additional test required to create an extended version of the cluster listed.
● Additional tests required to create the Broad Achievement cluster.

The most widely used achievement tests are contained in the Standard Battery. Because the WJ IV ACH Standard Battery tests are often administered by more than one assessment professional or at more than one time in a year, three parallel forms are available to reduce any potential overexposure to the same test items. The 11 tests that compose the Standard Battery support several standard assessment options:

- Tests 1 through 3 compose the Brief Achievement cluster that consists of the three most widely utilized tests in the WJ IV ACH: Test 1: Letter-Word Identification, Test 2: Applied Problems, and Test 3: Spelling.
- Tests 1 through 6 compose the core set of tests in the WJ IV ACH required to obtain the standard two-test Reading, Mathematics, and Written Language clusters. Tests from this set also create the Academic Skills and Academic Applications clusters. (These clusters are composed of one skill or one application test from the respective achievement domains.) This set serves as the required pool of tests for evaluation of strengths and weaknesses among tests and clusters that measure other areas of reading, writing, and mathematics performance.
- Test 7: Word Attack is included in the Standard Battery to reflect the importance of mapping phonology onto orthography in the development and evaluation of Basic Reading Skills.
- Test 8: Oral Reading was developed to expand the measurement of Reading Fluency to include fluent oral production of connected discourse.
- Test 9: Sentence Reading Fluency, Test 10: Math Facts Fluency, and Test 11: Sentence Writing Fluency add measures of automaticity in reading, mathematics, and written language and compose the Academic Fluency cluster. This allows for an important cross-academic performance comparison among academic skills, fluency, and application constructs. When administered together with Tests 1 through 6, these tests also produce the Broad Reading, Broad Mathematics, and Broad Written Language clusters.

The nine tests that are included in the Extended Battery expand the interpretive information available from the Standard Battery. Any of these tests may be administered selectively and independently or may be used to create cluster scores for Reading Comprehension, Math Problem Solving, Basic Writing Skills, Reading Rate, and Phoneme-Grapheme Knowledge. Any additional reading, mathematics, or writing test or cluster that is administered is automatically included in the intra-achievement variations procedure for evaluation of relative strengths and weaknesses when Tests 1 through 6 have been administered. Tests 18 through 20 are full-length Science, Social Studies, and Humanities tests that compose the Academic Knowledge cluster. In contemporary CHC theory, the Academic Knowledge cluster is considered a measure of comprehension-knowledge (*Gc*) and possibly a mixed measure of domain-specific knowledge (*Gkn*). As implemented in the WJ IV, it can serve as an important diagnostic comparison to measures of reading, mathematics, writing, and some language-related abilities from the WJ IV OL (phonetic coding and speed of lexical access).

## Comparing Abilities Within and Across Batteries

Because the WJ IV COG, WJ IV OL, and WJ IV ACH are co-normed, the three batteries form a comprehensive assessment system for evaluating domain-specific and domain-general academic skills with related cognitive and oral language abilities. Data-based predictions and comparisons can be made among selected cluster scores derived from the batteries. Both within and across batteries, variations among scores and comparisons between scores can be used to determine and describe performance patterns that may be useful for diagnostic decision making and educational planning.

The WJ IV reports two types of *difference score* information—variations and comparisons. Variation scores are descriptive in nature; they describe a person's pattern of strengths and weakness (PSW) and are not intended to evaluate hypotheses about an individual's performance. In contrast, comparison scores are used to test the hypothesis that the examinee's performance is outside the range of predicted scores. As described in Chapter 3, the WJ IV variation and comparison procedures are based on the same general statistical model and norm calculation procedures; the methods differ in the interpretation of the resulting difference scores. The WJ IV variation and comparison procedures are described below.

## Intra-Cognitive Variations

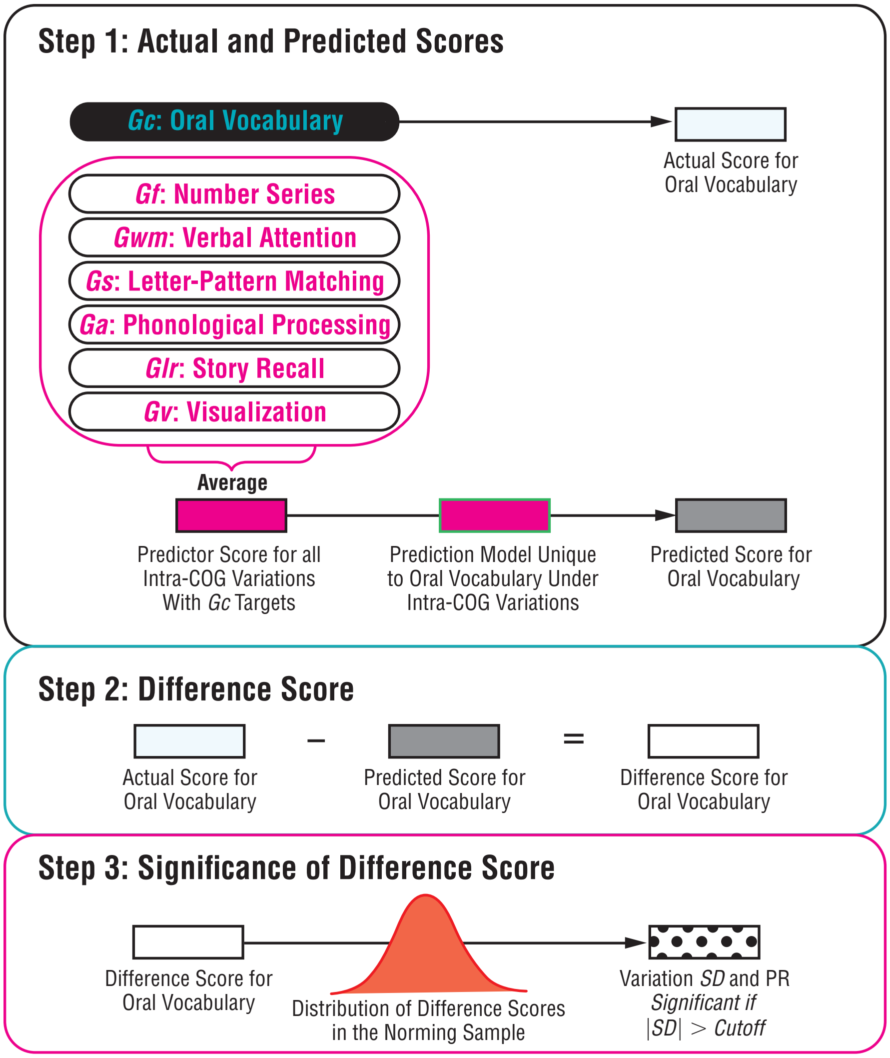
The intra-cognitive variations procedure is the basis for determination of relative strengths and weaknesses among the WJ IV COG tests and clusters. WJ IV COG Tests 1 through 7 compose the required (core) pool of tests for calculation of intra-cognitive variations. Each test represents a marker for one of seven broad CHC factors: comprehension-knowledge (*Gc*), fluid reasoning (*Gf*), short-term working memory (*Gwm*), processing speed (*Gs*), auditory processing (*Ga*), long-term retrieval (*Glr*), and visual processing (*Gv*). Standard scores from all WJ IV COG and selected WJ IV OL tests and clusters are compared to a predictor standard score that is derived from the six core tests, excluding the target test and any tests or clusters measuring the same broad ability as the target test.

Figure 1-1 contains a schematic representation of the calculations used to determine relative strengths and weaknesses using the evaluation of Test 1: Oral Vocabulary as the exemplar target test.[1] In Step 1, the actual and predicted scores for Test 1: Oral Vocabulary are calculated. Using the examinee's age (or grade placement) and the value of the predictor score (i.e., the average of the six non-*Gc* core tests), the predicted score is derived using a model developed from data in the norming sample. This prediction model corrects the predictor score for regression to the mean. In Step 2, the predicted score is subtracted from the actual score to obtain a difference score. When the actual score exceeds the predicted score, this observed difference score is positive. Conversely, when the actual score is less than the predicted score, this observed difference score is negative. In Step 3, the observed difference score is compared to the distribution of difference scores within the norming sample to determine its significance. This comparison is presented in two forms: (a) in the standard deviation of the difference-score metric and (b) as a percentile rank that represents the examinee's relative standing in the distribution of difference scores from the examinee's same age or grade reference group in the norming sample. A relative strength is defined as an actual score that exceeds the predicted score by a certain number of standard deviations of the difference score. A typical cutoff used in practice is 1.50 standard deviations, but examiners may choose other cutoffs for determining significance. Conversely, a relative weakness is defined as an actual score that falls short of the predicted score by a certain number of standard deviations of the difference score.

To evaluate linguistic factors and cognitive functions jointly, WJ IV OL Tests 1 through 8 and derived OL clusters are automatically included in the intra-cognitive variations procedure when administered with the core WJ IV COG tests. Table 1-4 includes a list of the required tests and optional tests and clusters included in the intra-cognitive variations procedure.

[1] See Chapter 3 for additional explanation of the statistical procedures and calculations underlying all WJ IV variation and comparison procedures.

***Figure 1-1.***
*Steps involved in calculating intra-cognitive variations using WJ IV COG Test 1: Oral Vocabulary.*




For example, the predictor standard score for Test 1: Oral Vocabulary is the average of earned standard scores for Tests 2 through 7, and because Test 1 is a primary WJ IV *Gc* marker task, the predictor standard score for each of the additional optional *Gc* tests and clusters is also the average of earned standard scores for Tests 2 through 7. The optional tests and clusters (COG Test 8: General Information, OL Test 1: Picture Vocabulary, OL Test 2: Oral Comprehension, the Comprehension-Knowledge cluster, the Comprehension-Knowledge–Extended cluster, the Vocabulary cluster, and the Oral Language cluster) all have predicted scores based on the same predictor score that is used to generate the predicted Oral Vocabulary standard score. To determine whether any of these tests and clusters is a relative strength or weakness, it would be compared to the average of the scores from COG Tests 2 through 7.

As another example, if the OL Speed of Lexical Access cluster score is available, the predicted Speed of Lexical Access score will be based on the average of the same six COG tests used to predict the Letter-Pattern Matching (*Gs*) test (COG tests 1 through 3 and tests 5 through 7).

**Table 1-4.**
*Intra-Cognitive Variations Procedure: Core Tests and Optional Tests and Clusters*

| Core Tests | Optional Tests and Clusters |
|---|---|
| COG 1: Oral Vocabulary<br>COG 2: Number Series<br>COG 3: Verbal Attention<br>COG 4: Letter-Pattern Matching<br>COG 5: Phonological Processing<br>COG 6: Story Recall<br>COG 7: Visualization | *(Compared as Oral Vocabulary)*<br>COG 8: General Information<br>OL 1: Picture Vocabulary<br>OL 2: Oral Comprehension<br>Comprehension-Knowledge (*Gc*)<br>Comprehension-Knowledge–Extended<br>Vocabulary (VL/LD)<br>Oral Language<br>*(Compared as Number Series)*<br>COG 9: Concept Formation<br>COG 15: Analysis-Synthesis<br>ACH 13: Number Matrices<br>Fluid Reasoning (*Gf*)<br>Fluid Reasoning–Extended<br>Quantitative Reasoning (RQ)<br>*(Compared as Verbal Attention)*<br>COG 10: Numbers Reversed<br>COG 16: Object-Number Sequencing<br>COG 18: Memory for Words<br>OL 5: Sentence Repetition<br>OL 6: Understanding Directions<br>Short-Term Working Memory (*Gwm*)<br>Short-Term Working Memory–Extended<br>Auditory Memory Span (MS)<br>*(Compared as Letter-Pattern Matching)*<br>COG 11: Number-Pattern Matching<br>COG 17: Pair Cancellation<br>OL 4: Rapid Picture Naming<br>OL 8: Retrieval Fluency<br>Cognitive Processing Speed (*Gs*)<br>Perceptual Speed (P)<br>Speed of Lexical Access (LA)<br>*(Compared as Phonological Processing)*<br>COG 12: Nonword Repetition<br>OL 3: Segmentation<br>OL 7: Sound Blending<br>Auditory Processing (*Ga*)<br>Phonetic Coding (PC)<br>*(Compared as Story Recall)*<br>COG 13: Visual-Auditory Learning<br>Long-Term Retrieval (*Glr*)<br>*(Compared as Visualization)*<br>COG 14: Picture Recognition<br>Visual Processing (*Gv*) |

## Intra-Oral Language Variations

The intra-oral language variations procedure is the basis for determination of relative strengths and weaknesses among the WJ IV OL tests and clusters. The procedures for determining and interpreting relative strengths and weaknesses and for determining significance are the same as those used in the intra-cognitive variations procedure example. To evaluate selected cognitive factors jointly with oral language abilities, certain WJ IV COG tests and derived clusters are automatically included in the intra-oral language variations procedure. Table 1-5 includes a list of the required tests and optional tests and clusters included in the intra-oral language variations procedure. As presented in Table 1-5, WJ IV OL Tests 1 through 4 are the required (core) pool of tests for the calculation of intra-oral language variations. Each test represents a marker for a qualitatively different aspect of oral language ability: expressive vocabulary, listening comprehension, phonological sensitivity, and naming automaticity.

***Table 1-5.***
*Intra-Oral Language Variations Procedure: Core Tests and Optional Tests and Clusters*

| Core Tests | Optional Tests and Clusters |
|---|---|
| OL 1: Picture Vocabulary | *(Compared as Picture Vocabulary)* |
| OL 2: Oral Comprehension | OL 5: Sentence Repetition |
| OL 3: Segmentation | COG 1: Oral Vocabulary |
| OL 4: Rapid Picture Naming | Oral Expression |
| | Vocabulary (VL/LD) |
| | *(Compared as Oral Comprehension)* |
| | OL 6: Understanding Directions |
| | Listening Comprehension |
| | *(Compared as Segmentation)* |
| | OL 7: Sound Blending |
| | COG 5: Phonological Processing |
| | COG 12: Nonword Repetition |
| | Phonetic Coding (PC) |
| | Auditory Processing (*Ga*) |
| | *(Compared as Rapid Picture Naming)* |
| | OL 8: Retrieval Fluency |
| | Speed of Lexical Access (LA) |

Tests 1 through 8 from the WJ IV OL, including any derived OL clusters, and selected WJ IV COG tests and resulting clusters are compared to a predictor score that is derived from the other three core tests, excluding the target test, and any tests or clusters measuring the same broad ability. For example, the predictor score for OL Test 1: Picture Vocabulary, as well as all other expressive vocabulary tests and clusters (OL Test 5: Sentence Repetition, COG Test 1: Oral Vocabulary, the Oral Expression cluster, and the Vocabulary cluster), comprises OL Tests 2 through 4. In another example, if OL Tests 1 through 4 are administered along with OL Test 8: Retrieval Fluency, both the Retrieval Fluency test and resulting Speed of Lexical Access cluster variations will have predicted scores based on the same predictor set used to predict the Rapid Picture Naming test—OL Tests 1 through 3.

## Intra-Achievement Variations

The intra-achievement variations procedure is the basis for determination of relative strengths and weaknesses among the WJ IV ACH tests and clusters. The procedures for determining relative strengths and weaknesses and for determining significance are the same as those used in the intra-cognitive and intra-oral language variations procedure examples. Table 1-6 includes a list of the required tests and optional tests and clusters included in the intra-achievement variations procedure.

***Table 1-6.***
*Intra-Achievement Variations Procedure: Core Tests and Optional Tests and Clusters*

| Core Tests | Optional Tests and Clusters |
|---|---|
| ACH 1: Letter-Word Identification | *(Compared as Letter-Word Identification)* |
| ACH 2: Applied Problems | ACH 7: Word Attack |
| ACH 3: Spelling | ACH 8: Oral Reading |
| ACH 4: Passage Comprehension | Basic Reading Skills |
| ACH 5: Calculation | Reading Fluency |
| ACH 6: Writing Samples | *(Compared as Applied Problems)* |
| | ACH 13: Number Matrices |
| | Math Problem Solving |
| | *(Compared as Spelling)* |
| | ACH 14: Editing |
| | ACH 16: Spelling of Sounds |
| | Basic Writing Skills |
| | *(Compared as Passage Comprehension)* |
| | ACH 9: Sentence Reading Fluency |
| | ACH 12: Reading Recall |
| | ACH 15: Word Reading Fluency |
| | ACH 17: Reading Vocabulary |
| | Reading Comprehension |
| | Reading Comprehension–Extended |
| | Reading Rate |
| | *(Compared as Calculation)* |
| | ACH 10: Math Facts Fluency |
| | Math Calculation Skills |
| | *(Compared as Writing Samples)* |
| | ACH 11: Sentence Writing Fluency |
| | Written Expression |

WJ IV ACH Tests 1 through 6 make up the required (core) pool of tests for calculation of intra-achievement variations. Each test represents a marker defined by an achievement skill or an application of a set of related skills to achievement performance: reading decoding, mathematics problem solving, spelling, reading comprehension, math calculation skills, and sentence writing. Each of the Tests 1 through 17 from the WJ IV ACH, including any derived clusters, are compared to a predictor score that is derived from five of the six core tests, excluding the target test, and any tests or clusters measuring a similar academic skill or requiring the application of a similar skill. For example, the predictor score for ACH Test 1: Letter-Word Identification comprises Tests 2 through 6, and because Test 7: Word Attack and Test 8: Oral Reading each require reading decoding, both are compared to the same predictor score as Test 1.

## Academic Skills/Academic Fluency/Academic Applications Variations

When ACH Tests 1 through 6 and Tests 9 through 11 are administered to the same individual, a cross-domain comparison is made to determine if a meaningful pattern exists. In this procedure, the Academic Skills cluster is compared to a predictor score that is derived from the Academic Applications and Academic Fluency clusters, the Academic Applications cluster is compared to a predictor score that is derived from the Academic Skills and Academic Fluency clusters, and the Academic Fluency cluster is compared to a predictor score that is derived from the Academic Skills and Academic Applications clusters. The procedures used for determining and interpreting relative strengths and weaknesses and for determining significance are the same as those used for the intra-cognitive, intra-oral language, and intra-achievement variations.

Some related WJ IV speed or fluency clusters are automatically included in this variation procedure when the appropriate tests also are administered. The WJ IV COG Cognitive Processing Speed (*Gs*), Perceptual Speed (P), and the WJ IV ACH Reading Rate clusters also are compared to the same "other" score as Academic Fluency. Table 1-7 contains a list of required tests and optional clusters that may be included in the academic skills/academic fluency/academic applications variations procedure.

***Table 1-7.***
*Academic Skills/Academic Fluency/Academic Applications Variations Procedure: Required and Optional Clusters and Tests*

| Required Cluster/Test | Optional Cluster/Test |
|---|---|
| Academic Skills | *(Compared as Academic Fluency)* |
| ACH 1: Letter-Word Identification | Cognitive Processing Speed |
| ACH 3: Spelling | COG 4: Letter-Pattern Matching |
| ACH 5: Calculation | COG 17: Pair Cancellation |
| Academic Fluency | Perceptual Speed |
| ACH 9: Sentence Reading Fluency | COG 4: Letter-Pattern Matching |
| ACH 10: Math Facts Fluency | COG 11: Number-Pattern Matching |
| ACH 11: Sentence Writing Fluency | Reading Rate |
| Academic Applications | ACH 9: Sentence Reading Fluency |
| ACH 2: Applied Problems | ACH 15: Word Reading Fluency |
| ACH 4: Passage Comprehension | |
| ACH 6: Writing Samples | |

## Academic Knowledge/Achievement Comparisons

The WJ IV ACH Tests 18 through 20 provide a broad survey of academic knowledge in science, social studies, and the humanities. In contemporary CHC theory, the WJ IV Academic Knowledge cluster is primarily a measure of comprehension-knowledge, or *Gc*, and may provide a mixed measure of domain-specific knowledge abilities (*Gkn*). The WJ IV academic knowledge/achievement comparison procedure allows the Academic Knowledge score to be used as an ability measure to determine if any significant differences exist between the Academic Knowledge cluster score and other key WJ IV ACH cluster scores. In this procedure, standard scores from each of the targeted clusters are compared to a unique predicted standard score that is corrected for regression to the mean. If no significant difference is identified, the relationship between Academic Knowledge and the targeted cluster may be interpreted as consistent. A significant difference is interpreted as a discrepancy between Academic Knowledge and the defined area of achievement. In this procedure, an identified discrepancy may suggest the need for a more comprehensive evaluation that includes an evaluation of cognitive and/or oral language abilities.

When administered, the WJ IV OL Phonetic Coding and Speed of Lexical Access clusters also are included in the comparison. Inclusion of these clusters can provide important information, especially if any identified academic knowledge/achievement discrepancy occurs along with a discrepancy between Academic Knowledge and Phonetic Coding or Speed of Lexical Access. Table 1-8 lists the WJ IV ACH and WJ IV OL clusters that can be compared to the Academic Knowledge cluster. A visual schematic of the conceptual summary of academic knowledge/achievement comparison procedures is presented in Figure 1-2.

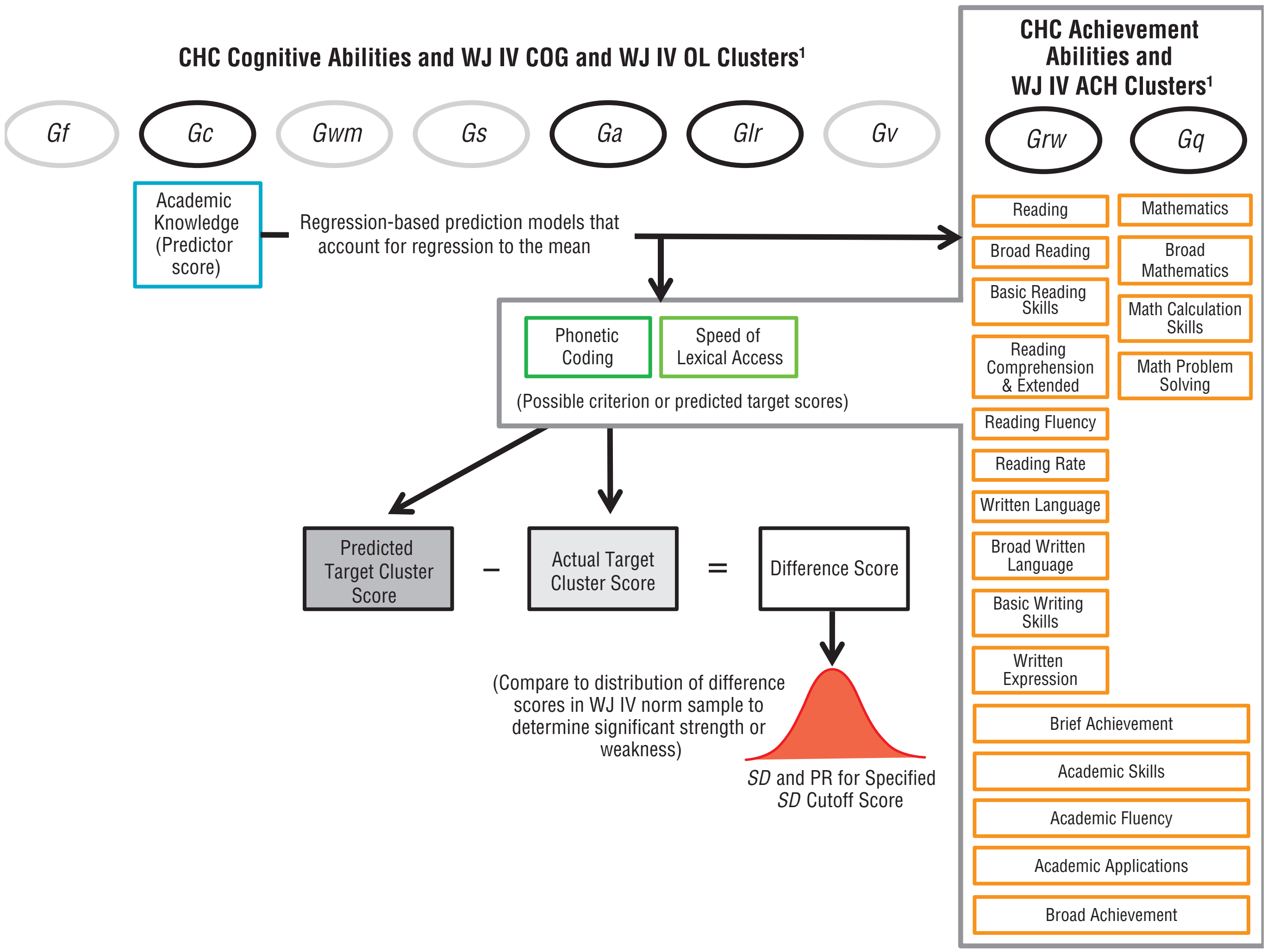
***Table 1-8.***
*Comparison of WJ IV ACH and WJ IV OL Clusters to Academic Knowledge Cluster*

| Predictor Cluster and Component Tests | Criterion Clusters |
|---|---|
| Academic Knowledge | Brief Achievement |
| ACH 18: Science | Broad Achievement |
| ACH 19: Social Studies | |
| ACH 20: Humanities | Reading |
| | Broad Reading |
| | Basic Reading Skills |
| | Reading Comprehension |
| | Reading Comprehension–Extended |
| | Reading Fluency |
| | Reading Rate |
| | |
| | Mathematics |
| | Broad Mathematics |
| | Math Calculation Skills |
| | Math Problem Solving |
| | |
| | Written Language |
| | Broad Written Language |
| | Basic Writing Skills |
| | Written Expression |
| | |
| | Academic Skills |
| | Academic Fluency |
| | Academic Applications |
| | |
| | Phonetic Coding (PC) |
| | Speed of Lexical Access (LA) |

## Oral Language/Achievement Comparisons

A comparison between an individual's oral language ability and his or her levels of academic achievement can have rich interpretive value. For example, teachers often expect a student to perform academically at a level commensurate with his or her observed oral language proficiency. In addition, some learning problems may be related to limited oral language ability. The WJ IV oral language/achievement comparison procedure allows an evaluator to determine if an individual's levels of academic achievement are commensurate with, or discrepant from, his or her oral language ability.

***Figure 1-2.***
*Academic knowledge/ achievement comparison procedure.*




[1] See Table 1-8 for the specific tests and cluster information.

The three-test Broad Oral Language cluster in the WJ IV OL incorporates both receptive and expressive oral language abilities as well as verbal working memory. In the context of contemporary CHC theory, the WJ IV OL Broad Oral Language cluster is primarily a measure of comprehension-knowledge (*Gc*) that also includes an application of working memory capacity (WM). The WJ IV oral language/achievement comparison procedure allows the Broad Oral Language cluster score to be used as an ability measure to determine if any discrepancies exist between the Broad Oral Language cluster and any of the WJ IV ACH reading, mathematics, and written language clusters. In this procedure, standard scores from the targeted achievement clusters are compared to a predicted standard score that is derived from the Broad Oral Language cluster. If no significant difference is identified, the relationship between Broad Oral Language and the targeted achievement cluster may be interpreted as being commensurate, expected, or reasonably consistent. An identified discrepancy may suggest that the individual is not achieving at the level that would be predicted by his or her oral language ability. The individual's academic achievement may be higher or lower than would be predicted based on his or her oral language ability.

An important provision in the WJ IV OL is the Broad Oral Language cluster in Spanish, Amplio lenguaje oral. Amplio lenguaje oral also may be used as an ability measure for comparison to reading, mathematics, and written language measures in English when Spanish is the student's dominant language. This unique comparison is based on well-replicated research that suggests a Spanish-dominant bilingual student should be able to attain levels of oral language proficiency and academic achievement in English that are commensurate with his or her Spanish oral language ability if provided with intensive, interactive English language development instruction that includes appropriate bilingual support and intervention in academic content areas (August & Shanahan, 2006; Genesee, Lindholm-Leary, Saunders, & Christian, 2006; Gersten et al., 2007; Short & Fitzsimmons, 2007).

Table 1-9 contains information on the oral language/achievement comparisons. For English-Spanish bilingual individuals, either the Broad Oral Language or the Amplio lenguaje oral clusters can be used as the predictor score for comparison to measures of academic achievement in English. The Phonetic Coding and Speed of Lexical Access clusters are compared to the English Broad Oral Language cluster only. A visual schematic conceptual summary of oral language/achievement comparison procedures is presented in Figure 1-3.

***Table 1-9.***
*Oral Language/Achievement Comparisons*

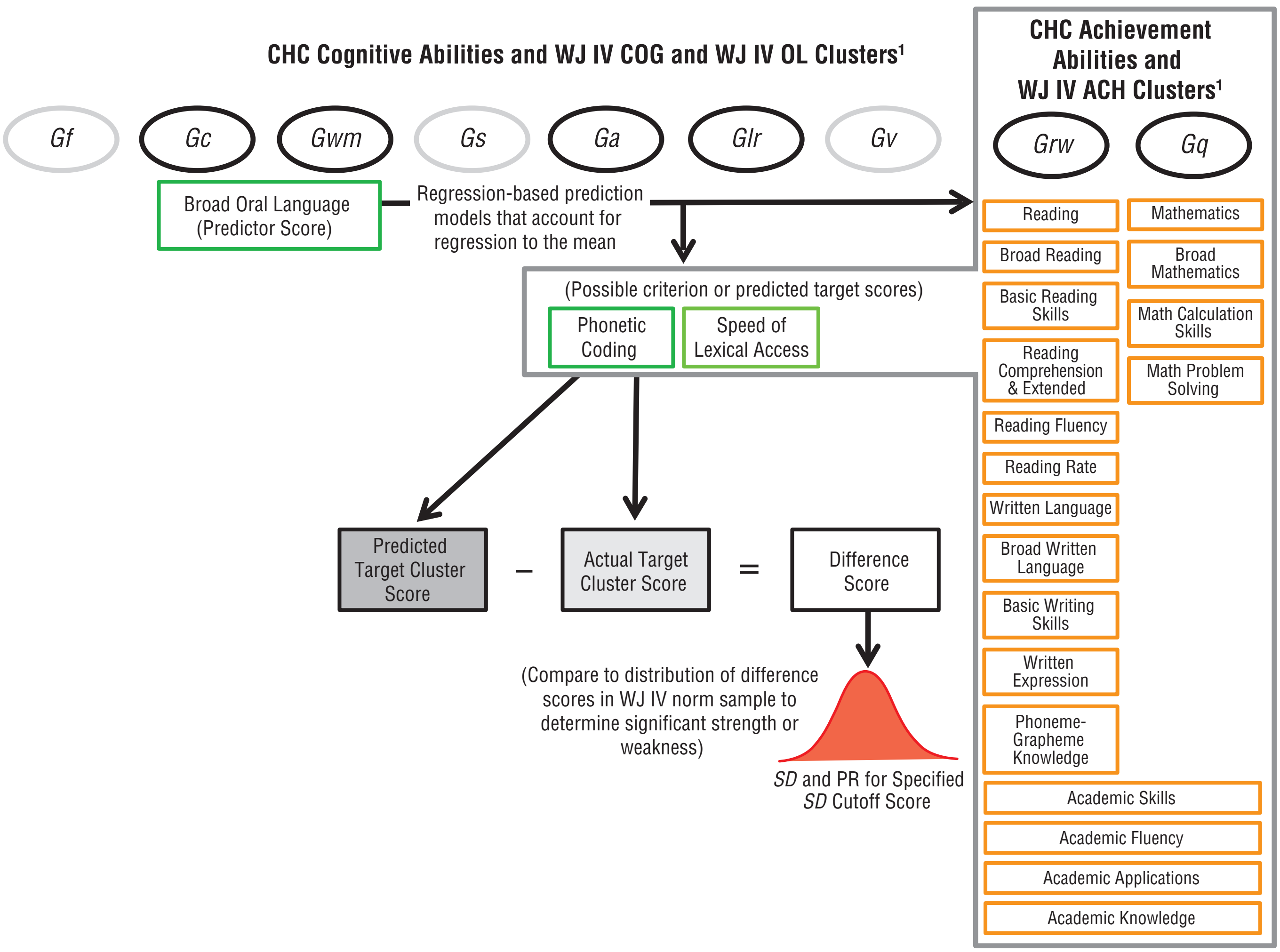
| Predictor Clusters and Component Tests | Criterion Clusters |
|---|---|
| Broad Oral Language | Reading |
| OL 1: Picture Vocabulary | Broad Reading |
| OL 2: Oral Comprehension | Basic Reading Skills |
| OL 6: Understanding Directions | Reading Comprehension |
| | Reading Comprehension–Extended |
| Amplio lenguaje oral | Reading Fluency |
| OL 10: Vocabulario sobre dibujos | Reading Rate |
| OL 11: Comprensión oral | |
| OL 12: Comprensión de indicaciones | Mathematics |
| | Broad Mathematics |
| | Math Calculation Skills |
| | Math Problem Solving |
| | |
| | Written Language |
| | Broad Written Language |
| | Basic Writing Skills |
| | Written Expression |
| | |
| | Academic Skills |
| | Academic Fluency |
| | Academic Applications |
| | Academic Knowledge |
| | Phoneme-Grapheme Knowledge |
| | |
| | Phonetic Coding (PC)* |
| | Speed of Lexical Access (LA)* |

*Compared to Broad Oral Language only

## Scholastic Aptitude/Achievement Comparisons

The WJ IV COG Scholastic Aptitude clusters are content-specific predictor scores developed for comparison to current achievement levels in reading, mathematics, and written language. Each Scholastic Aptitude cluster score is derived from a small set of cognitive tests that is highly related to the area of achievement. Inclusion of these clusters represents a return to a set of comparison procedures included in the WJ and the WJ-R. The purpose of these comparisons is to determine if an individual's present academic performance level in each targeted area is consistent with, or discrepant from, his or her performance on tests of related cognitive abilities. A consistent relationship is interpreted to mean that the individual is performing at a level that would be predicted, based on his or her closely related cognitive abilities. A discrepancy between aptitude and achievement shows that the relationship is unexpected and warrants further consideration to determine the precise nature of the discrepancy. The scholastic aptitude/achievement comparisons are intended to be descriptive and predictive and not causal or diagnostic.

***Figure 1-3.***
*Oral language/achievement comparison procedure.*




[1] See Table 1-9 for the specific tests and cluster information.

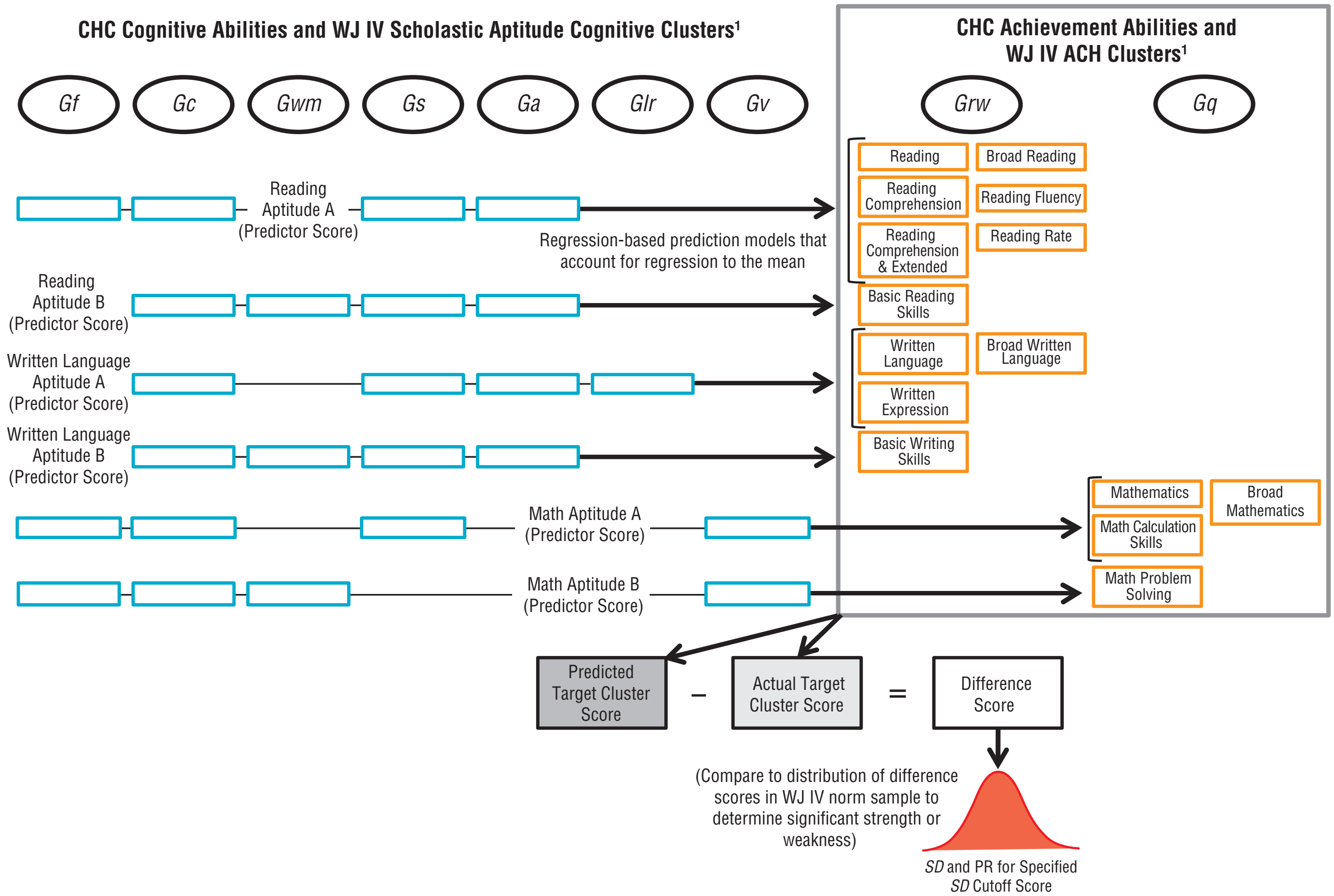
The development of the aptitude clusters was based on a series of stepwise multiple regression analyses completed at targeted age and grade samples across the entire norming sample. Prior to completion of the stepwise regressions in each of the areas, tests that were deemed to be contaminated by highly similar content with the criterion were eliminated from inclusion in the analyses. For example, although the correlation between WJ IV COG Test 2: Number Series and the WJ IV ACH Math Problem Solving cluster is quite high, Number Series was not allowed to be included in the stepwise regression analyses because it shared similar content with the target tasks. For each achievement area, those tests that were most consistently predictive of the criterion measures across all targeted samples were selected for inclusion in the respective aptitude cluster. After the four best tests for each cluster were identified via stepwise regression methods, the final clusters were constructed by the simple averages of the *W* scores from the four tests.

All of the tests included in the Scholastic Aptitude clusters are drawn from the WJ IV COG Standard and Extended Batteries. Table 1-10 shows the Selective Testing Table for the Scholastic Aptitude clusters. This table provides information on the tests that compose the aptitude score for each achievement comparison. The interpretive profile for the Scholastic Aptitude cluster comparisons includes a column for the scholastic aptitude score, a predicted cluster score for the target cluster, and the obtained (actual) cluster score. The predicted cluster score is based on a calculation that accounts for correction for regression to the mean. As with all other WJ IV comparison procedures, information about the magnitude of any differences and base rate information are provided. A visual schematic conceptual summary of the scholastic aptitude/achievement comparison procedure is presented in Figure 1-4.

***Table 1-10.***
*Selective Testing Table for the WJ IV Scholastic Aptitude Clusters*

| | | | Target Tasks for Scholastic Aptitude/Achievement Comparisons | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reading | | | | | | Mathematics | | | | Writing | | | |
| | | | Reading | Broad Reading | Basic Reading Skills | Reading Comprehension | Reading Fluency | Reading Rate | Mathematics | Broad Mathematics | Math Calculation Skills | Math Problem Solving | Written Language | Broad Written Language | Basic Writing Skills | Written Expression |
| Standard Battery | COG 1 | Oral Vocabulary | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | COG 2 | Number Series | | | | | | | ■ | ■ | ■ | | | | | |
| | COG 3 | Verbal Attention | | | ■ | | | | | | | | | | ■ | |
| | COG 4 | Letter-Pattern Matching | | | | | | | | | | | | | | |
| | COG 5 | Phonological Processing | ■ | ■ | ■ | ■ | ■ | ■ | | | | | ■ | ■ | ■ | ■ |
| | COG 6 | Story Recall | | | | | | | | | | | ■ | ■ | | ■ |
| | COG 7 | Visualization | | | | | | | ■ | ■ | ■ | ■ | | | | |
| | COG 8 | General Information | | | | | | | | | | | | | | |
| | COG 9 | Concept Formation | ■ | ■ | | ■ | ■ | ■ | | | | | | | | |
| | COG 10 | Numbers Reversed | | | | | | | | | | ■ | | | | |
| Extended Battery | COG 11 | Number-Pattern Matching | ■ | ■ | ■ | ■ | ■ | ■ | | | | | ■ | ■ | ■ | ■ |
| | COG 12 | Nonword Repetition | | | | | | | | | | | | | | |
| | COG 13 | Visual-Auditory Learning | | | | | | | | | | | | | | |
| | COG 14 | Picture Recognition | | | | | | | | | | | | | | |
| | COG 15 | Analysis-Synthesis | | | | | | | | | | ■ | | | | |
| | COG 16 | Object-Number Sequencing | | | | | | | | | | | | | | |
| | COG 17 | Pair Cancellation | | | | | | | ■ | ■ | ■ | | | | | |
| | COG 18 | Memory for Words | | | | | | | | | | | | | | |

***Figure 1-4.***
*Scholastic aptitude/ achievement comparison procedure.*




1 See Table 1-10 for the specific tests and cluster information.

## General Intellectual Ability/Achievement Comparisons

Comparisons between intellectual ability and achievement scores are often used to determine the presence and severity of ability/achievement discrepancies. Although there are many unresolved issues surrounding the appropriate determination and application of discrepancy information in the field of learning disabilities, an ability/achievement discrepancy may be considered as part of the selection criteria for learning disability (LD) programs. Ability/achievement comparison information may also be useful for describing an individual's pattern of abilities in non-special education classification contexts. The WJ IV includes the most technically sound procedure for determining the presence and severity of ability/achievement discrepancies: actual discrepancy calculations, based on correction for regression to the mean, derived from co-normed ability and achievement measures.

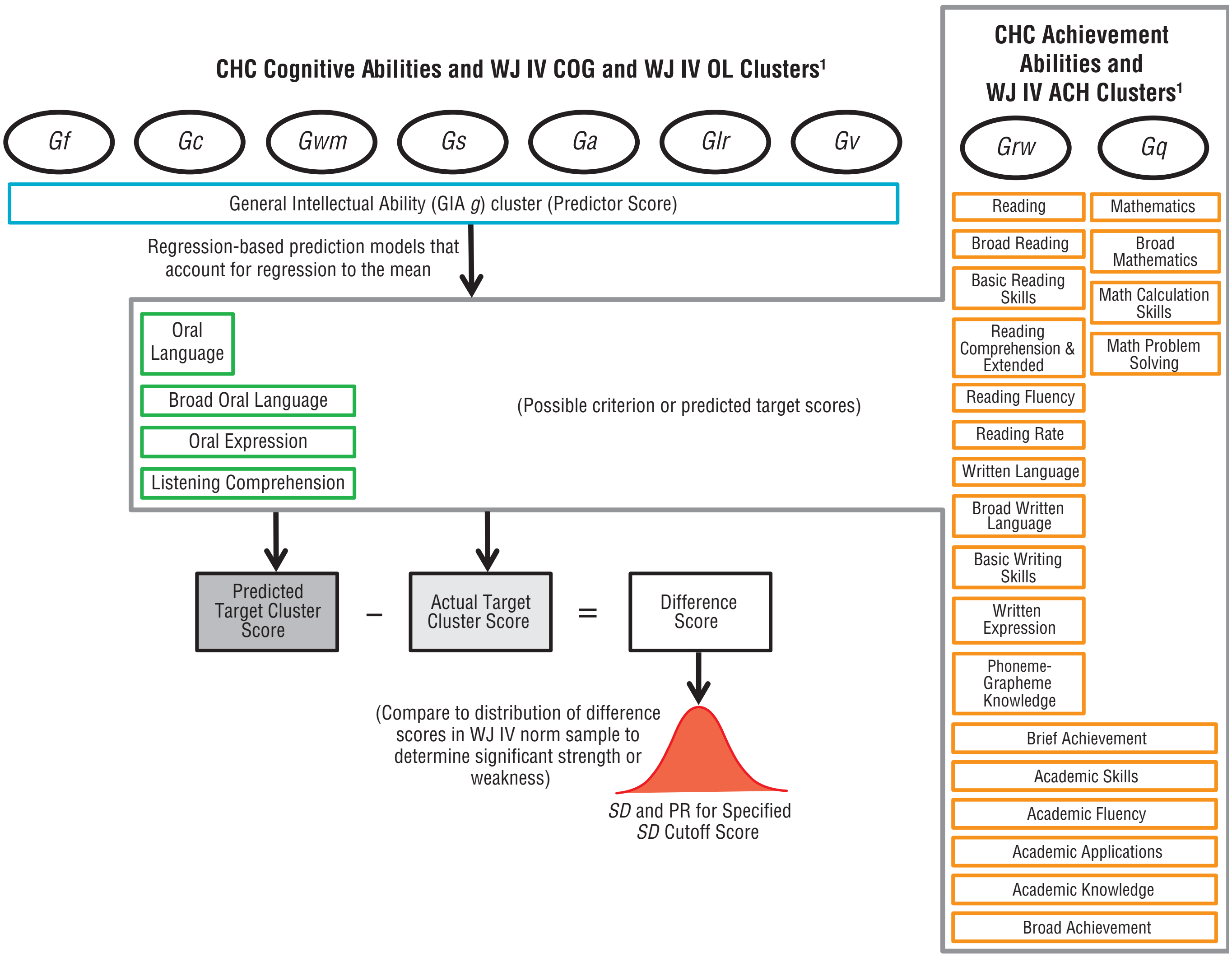
In the WJ IV, ability/achievement discrepancies are calculated from the General Intellectual Ability (GIA) score. To use this comparison procedure, WJ IV COG Tests 1 through 7 must be administered, but only the achievement tests that measure the specific area(s) of interest need to be administered. Table 1-11 lists the seven tests that are required to calculate the GIA score and the achievement measures that can be used in the GIA/Achievement discrepancy procedure. In this procedure, the GIA score yields a predicted score for each targeted area that is based on correction for regression to the mean. One advantage of using the WJ IV GIA/Achievement discrepancy procedure rather than a discrepancy calculation table is that the WJ IV procedure produces actual discrepancy norms based on the co-normed WJ IV tests, rather than the estimates that are produced from a table or statistical formula. A visual schematic conceptual summary of general intellectual ability (GIA)/achievement comparison procedures is presented in Figure 1-5.

***Table 1-11.***
*General Intellectual Ability/ Achievement Discrepancy Procedure: Required Tests and Optional Criterion Measures*

| Predictor Cluster and Required Tests | Achievement Measures That Can Be Used in the GIA/Achievement Discrepancy Procedure |
|---|---|
| General Intellectual Ability (GIA) | Brief Achievement |
| COG 1: Oral Vocabulary | Broad Achievement |
| COG 2: Number Series | |
| COG 3: Verbal Attention | Reading |
| COG 4: Letter-Pattern Matching | Broad Reading |
| COG 5: Phonological Processing | Basic Reading Skills |
| COG 6: Story Recall | Reading Comprehension |
| COG 7: Visualization | Reading Comprehension–Extended |
| | Reading Fluency |
| | Reading Rate |
| | |
| | Mathematics |
| | Broad Mathematics |
| | Math Calculation Skills |
| | Math Problem Solving |
| | |
| | Written Language |
| | Broad Written Language |
| | Basic Writing Skills |
| | Written Expression |
| | |
| | Academic Knowledge |
| | Academic Skills |
| | Academic Fluency |
| | Academic Applications |
| | Phoneme-Grapheme Knowledge |
| | |
| | Oral Language |
| | Broad Oral Language |
| | Oral Expression |
| | Listening Comprehension |

Even though an identified discrepancy may be statistically significant, this type of comparison is rarely appropriate as the sole criterion for determining the existence or nonexistence of a learning disability or for determining eligibility for special services. In fact, the Individuals with Disabilities Education Improvement Act (IDEA, 2004) eliminated an ability/achievement discrepancy as an eligibility requirement for special education services for individuals suspected of having a learning disability. Analyses of other abilities and an understanding of the relationships and interactions among various abilities and skills are important. This is referred to as a pattern of strengths and weaknesses (PSW) under IDEA 2004 and can be accomplished using the WJ IV intra-cognitive (including, when appropriate, selected oral language tests and clusters) and intra-achievement variations procedures or with the WJ IV *Gf-Gc* composite/other ability comparison procedure.

***Figure 1-5.***
*General intellectual ability (GIA)/achievement discrepancy procedure.*




[1] See Table 1-11 for the specific tests and cluster information.

## *Gf-Gc* Composite/Other Ability Comparisons

The WJ IV introduces the *Gf-Gc* composite/other ability comparison procedure as a hybrid model that uses the methodology of a traditional intellectual ability/achievement discrepancy procedure but interprets any observed discrepancies as a profile of intra-individual cognitive, oral language, and achievement strengths and weaknesses. Like all of the WJ IV comparisons, this procedure is based on co-normed measures, and all comparisons are corrected for regression to the mean. It is described as a hybrid model because it combines two interpretive paradigms. First, the analysis allows the examiner to determine if any other included cluster is consistent with or discrepant from what would be expected based on the *Gf-Gc* Composite. Second, if any cluster score is discrepant, the target area is identified as a strength or weakness relative to the *Gf-Gc* Composite. Target clusters that are not significantly discrepant from what would be predicted based on the *Gf-Gc* Composite are interpreted as neither strengths nor weaknesses. Discrepant clusters that are significantly higher than would be predicted by the *Gf-Gc* Composite are interpreted as relative strengths; discrepant clusters that are significantly lower than would be predicted by the *Gf-Gc* Composite are interpreted as relative weaknesses.

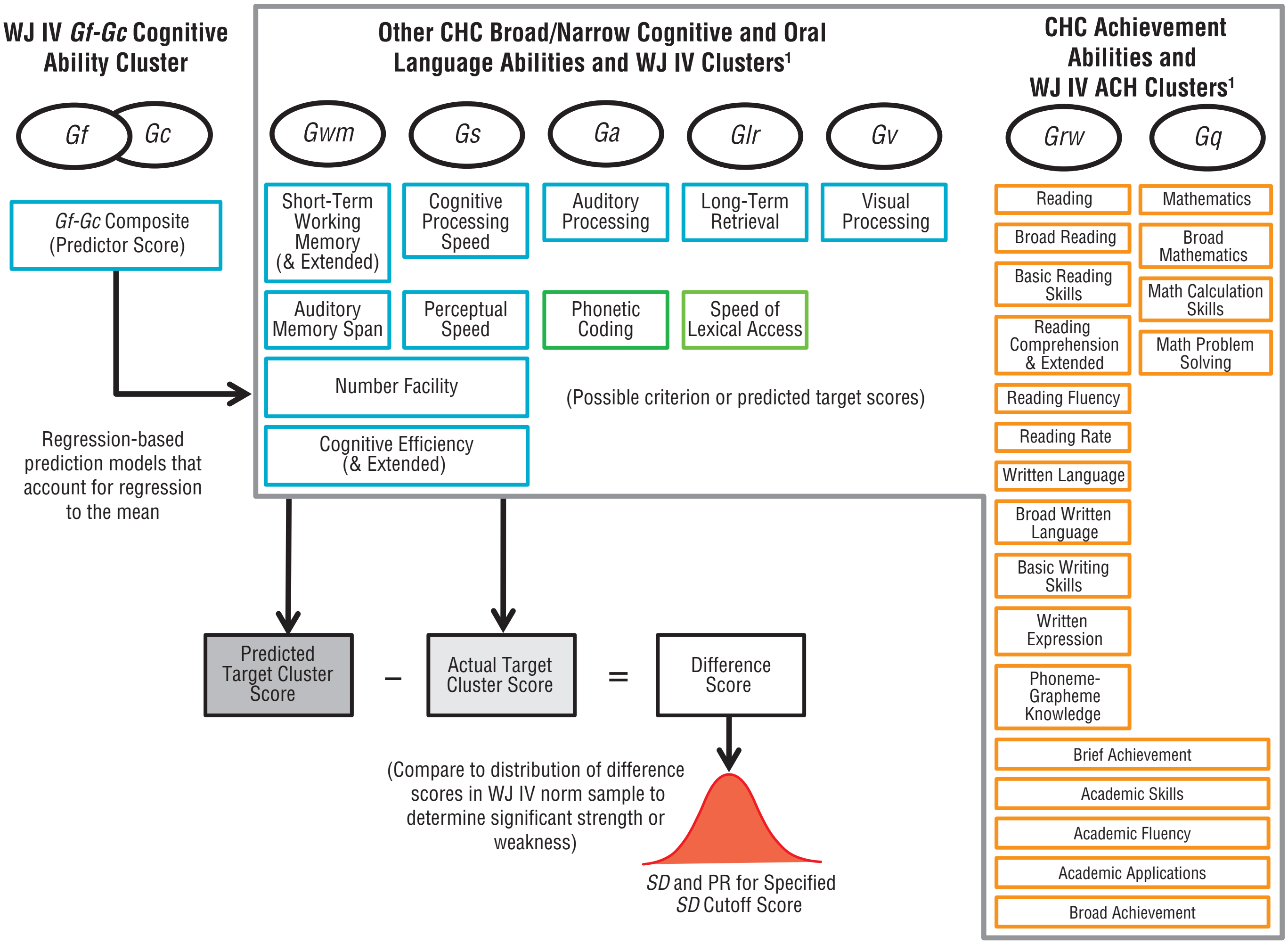
This procedure uses a four-test *Gf-Gc* Composite consisting of two comprehension-knowledge (*Gc*) tests and two fluid reasoning (*Gf*) tests as the basis for comparison to most other abilities across the WJ IV COG, WJ IV OL, and WJ IV ACH. (Other clusters that are primarily identified as *Gf* or *Gc* are not included in the comparison due to shared content with the *Gf-Gc* Composite.) Table 1-12 includes the four tests that compose the *Gf-Gc* Composite and the 34 other cognitive, oral language, or achievement clusters that can be compared to the *Gf-Gc* Composite. A visual schematic conceptual summary of *Gf-Gc* composite/achievement comparison procedures is presented in Figure 1-6.

The *Gf-Gc* composite/other ability comparison procedure allows areas of academic achievement and other cognitive processes and linguistic abilities to emerge as strengths or weaknesses relative to the overall index of crystallized and fluid intellectual abilities in a single analysis. The procedure evaluates domain-specific achievement skills jointly with related cognitive and linguistic abilities. This can help an examiner determine and document both strengths and weaknesses in learning abilities and define how other abilities may be related to any learning difficulties. Relative to the *Gf-Gc* Composite, other cognitive, oral language, and achievement abilities can be viewed as a profile of strengths and weaknesses (PSW) that may suggest a diagnostic pattern or influence the selection of instructional interventions. This procedure can be useful for documenting a specific type of disability, such as a specific learning disability (SLD). This procedure also can be useful for diagnosing intellectual disabilities when the representativeness of the full scale IQ score is in question (McGrew, in press a).

***Table 1-12.***
Gf-Gc *Composite/Other Ability Comparisons: Required Tests and Optional Criterion Measures*

| Predictor Cluster and Required Tests | Measures That Can Be Compared to the *Gf-Gc* Composite |
|---|---|
| *Gf-Gc* Composite | Short-Term Working Memory (*Gwm*) |
| COG 1: Oral Vocabulary | Short-Term Working Memory–Extended |
| COG 2: Number Series | Cognitive Processing Speed (*Gs*) |
| COG 8: General Information | Auditory Processing (*Ga*) |
| COG 9: Concept Formation | Long-Term Retrieval (*Glr*) |
| | Visual Processing (*Gv*) |
| | |
| | Auditory Memory Span (MS) |
| | Number Facility (N) |
| | Perceptual Speed (P) |
| | Cognitive Efficiency |
| | Cognitive Efficiency–Extended |
| | |
| | Phonetic Coding (PC) |
| | Speed of Lexical Access (LA) |
| | |
| | Brief Achievement |
| | Broad Achievement |
| | |
| | Reading |
| | Broad Reading |
| | Basic Reading Skills |
| | Reading Comprehension |
| | Reading Comprehension–Extended |
| | Reading Fluency |
| | Reading Rate |
| | |
| | Mathematics |
| | Broad Mathematics |
| | Math Calculation Skills |
| | Math Problem Solving |
| | |
| | Written Language |
| | Broad Written Language |
| | Basic Writing Skills |
| | Written Expression |
| | |
| | Academic Skills |
| | Academic Fluency |
| | Academic Applications |
| | Phoneme-Grapheme Knowledge |

***Figure 1-6.***
Gf-Gc *hybrid variation/ comparison procedure.*




[1] See Table 1-12 for the specific tests and cluster information.

# Changes in the WJ IV

As discussed earlier in this chapter, the WJ IV represents a significant revision and reorganization of the WJ III. Given the significant changes to the battery, WJ III users in particular will be interested in understanding (a) which WJ III tests have been eliminated, (b) which WJ III tests have been retained but renamed, (c) which tests are new to the WJ IV, and (d) how the composition of clusters in the WJ IV compares to similar clusters in the WJ III. This section provides high-level information about these changes; users also should refer to the three WJ IV Examiner's Manuals for detailed descriptions of the WJ IV tests and clusters to facilitate the transition from the WJ III to the WJ IV.

Tables 1-13, 1-14, and 1-15 provide a comparison of the WJ III and WJ IV tests, clusters, and battery organization.

*Table 1-13.*
*Comparison of WJ III/WJ IV Tests and Corresponding COG Cluster Composition*

| WJ III COG/DS and ACH Tests | CHC Code | WJ IV COG and OL Tests | COG Composites | | | CHC Factors | | | | | | | Narrow Ability & Clinical Clusters | | | | | | WJ IV Scholastic Aptitude Clusters | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GIA | BIA | *Gf-Gc* | *Gc* | *Gf* | *Gwm* | *Gs* | *Ga* | *Glr* | *Gv* | Quantitative Reasoning | Auditory Memory Span | Number Facility | Perceptual Speed | Vocabulary | Cognitive Efficiency | WJ III Predicted Achievement | Reading Aptitude A | Reading Aptitude B | Mathematics Aptitude A | Mathematics Aptitude B | Written Language Aptitude A | Written Language Aptitude B |
| Verbal Comprehension—COG | *Gc* | | □ | □ | | □ | | | | | | | | | | | | | ⊠ | | | | | | |
| ~~Picture Vocabulary~~ | ~~*Gc*~~ | | | | | | | | | | | | | | | | | | | | | | | | |
| Synonyms (Syn) | *Gc* | <u>Oral Vocabulary</u> (Syn+Ant) | ⊡ | ⊡ | ■ | ⊡ | | | | | | | | | | | ■ | | | ■ | ■ | ■ | ■ | ■ | ■ |
| Antonyms (Ant) | *Gc* | | | | | | | | | | | | | | | | | | | | | | | | |
| ~~Verbal Analogies—COG~~ | ~~*Gc/Gf*~~ | | | | | | | | | | | | | | | | | | | | | | | | |
| General Information—COG | *Gc* | General Information | | | | ⊡ | | | | | | | | | | | | | | | | | | | |
| Picture Vocabulary—ACH | *Gc* | *Picture Vocabulary* | | | | | | | | | | | | | | | ■ | | | | | | | | |
| Concept Formation—COG | *Gf* | Concept Formation | □ | □ | ■ | | ⊡ | | | | | | ⊡ | | | | | | ⊠ | ■ | | | | | |
| Analysis-Synthesis—COG | *Gf* | Analysis-Synthesis | | | | | □ | | | | | | ■ | | | | | | | | | | ■ | | |
| Number Series—DS | *Gf* | Number Series | ■ | ■ | ■ | | ■ | | | | | | | | | | | | | | | ■ | | | |
| Number Matrices—DS | *Gf* | | | | | | | | | | | | □ | | | | | | | | | | | | |
| Numbers Reversed—COG | *Gwm* | Numbers Reversed | □ | | | | | ⊡ | | | | | | | ■ | | | ⊡ | ⊠ | | | | ■ | | |
| Memory for Words—COG | *Gwm* | Memory for Words | | | | | | □ | | | | | | ⊡ | | | | | | | | | | | |
| Auditory Working Memory—COG | *Gwm* | <u>Object-Number Sequencing</u> | | | | | | | | | | | | | | | | | | | | | | | |
| | *Gwm* | **Verbal Attention** | ■ | ■ | ■ | | | ■ | | | | | | | | | | | | | ■ | | | | ■ |
| Memory for Sentences—DS | *Gwm* | *<u>Sentence Repetition</u>* | | | | | | | | | | | | ⊡ | | | | | | | | | | | |
| Visual Matching—COG | *Gs* | <u>Number-Pattern Matching</u> | □ | □ | | | | | □ | | | | | | ■ | ⊡ | | □ | ⊠ | ■ | ■ | | | ■ | ■ |
| Pair Cancellation—COG | *Gs*/AC | Pair Cancellation | | | | | | | ■ | | | | | | | | | | | | | ■ | | | |
| | *Gs* | **Letter-Pattern Matching** | ■ | | | | | | ■ | | | | | | | ■ | | ■ | | | | | | | |
| Rapid Picture Naming—COG | *Gs/Glr* | Rapid Picture Naming | | | | | | | | | | | | | | | | | | | | | | | |
| ~~Decision Speed—COG~~ | ~~*Gs*~~ | | | | | | | | ⊟ | | | | | | | | | | | | | | | | |
| ~~Cross Out—DS~~ | ~~*Gs*~~ | | | | | | | | | | | | | | | ⊟ | | | | | | | | | |
| | *Ga* | **Phonological Processing** | ■ | | | | | | | ■ | | | | | | | | | | ■ | ■ | | | ■ | ■ |
| | *Ga* | **Nonword Repetition** | | | | | | | | ■ | | | | | | | | | | | | | | | |
| Sound Blending—COG | *Ga* | *Sound Blending* | □ | | | | | | | □ | | | | | | | | | ⊠ | | | | | | |
| ~~Auditory Attention—COG~~ | ~~*Ga*~~ | | | | | | | | | ⊟ | | | | | | | | | | | | | | | |
| ~~Incomplete Words—COG~~ | ~~*Ga*~~ | | | | | | | | | | | | | | | | | | | | | | | | |
| ~~Sound Patterns-Voice—DS~~ | ~~*Ga*~~ | | | | | | | | | | | | | | | | | | | | | | | | |
| ~~Sound Patterns-Music—DS~~ | ~~*Ga*~~ | | | | | | | | | | | | | | | | | | | | | | | | |
| Visual-Auditory Learning—COG | *Glr* | | □ | | | | | | | | ⊡ | | | | | | | | ⊠ | | | | | | |
| Story Recall—ACH | *Glr* | Story Recall | ■ | | | | | | | | ■ | | | | | | | | | | | | | ■ | |
| Retrieval Fluency—COG | *Glr* | Retrieval Fluency | | | | | | | | | □ | | | | | | | | | | | | | | |
| ~~VAL-Delayed—COG~~ | ~~*Glr*~~ | | | | | | | | | | | | | | | | | | | | | | | | |
| ~~Memory for Names—DS~~ | ~~*Glr*~~ | | | | | | | | | | | | | | | | | | | | | | | | |
| ~~Mem Names-Delayed—DS~~ | ~~*Glr*~~ | | | | | | | | | | | | | | | | | | | | | | | | |
| Spatial Relations—COG | *Gv* | <u>Visualization</u> (SR+BR) | ❖ | | | | | | | | | ❖ | | | | | | | ⊠ | | | ■ | ■ | | |
| Block Rotation—DS | *Gv* | | | | | | | | | | | | | | | | | | | | | | | | |
| Picture Recognition—COG | *Gv* | Picture Recognition | | | | | | | | | | ⊡ | | | | | | | | | | | | | |
| ~~Visual Closure—DS~~ | ~~*Gv*~~ | | | | | | | | | | | | | | | | | | | | | | | | |
| ~~Planning—COG~~ | ~~*Gv/Gf*~~ | | | | | | | | | | | | | | | | | | | | | | | | |

COG = WJ III Cognitive test.

DS = *Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities* (WJ III DS) (Woodcock, McGrew, Mather, & Schrank, 2003).

ACH = OL test in WJ III Achievement.

*Test name in italic* = Test now in WJ IV OL battery.

~~Test name crossed out~~ = Not in WJ IV.

<u>Test name underlined</u> = WJ III test renamed in WJ IV.

**Test name in bold** = New WJ IV test.

□ = WJ III COG cluster included this test; test is not in comparable WJ IV cluster.

⊟ = WJ III COG cluster included this test; test is not in WJ IV battery.

⊡ = WJ III and WJ IV comparable COG clusters include the same test (or subtests).

■ = WJ III cluster does not include this test.

❖ = WJ III cluster included one WJ IV subtest as a standalone test.

⊠ = In WJ III the Predicted ACH (PA) option was conceptually similar to SAPTs; 7 GIA tests had age × ACH domain shifting weights.

(Extended clusters not designated in table; e.g., Fluid Reasoning–Extended)

WJ IV COG tests.

WJ IV OL tests.

WJ IV ACH tests.

***Table 1-14.***
*Comparison of WJ III/WJ IV Tests and Corresponding OL Cluster Composition*

| Select WJ III COG/DS and ACH Tests | CHC Code | WJ IV OL Tests | Oral Language Clusters: Oral Language | Broad Oral Language | Oral Expression | Listening Comprehension | **Phonetic Coding** | **Speed of Lexical Access** |
|---|---|---|---|---|---|---|---|---|
| Picture Vocabulary—ACH | *Gc* | Picture Vocabulary | ■ | ⊡ | ⊡ | | | |
| Oral Comprehension—ACH | *Gc* | Oral Comprehension | ■ | ⊡ | | ⊡ | | |
| Sound Blending—COG | *Ga* | Sound Blending | | | | | ■ | |
| Sound Awareness—ACH | *Ga* | Sound Awareness | | | | | | |
| | *Ga* | **Segmentation** | | | | | ■ | |
| Memory for Sentences—DS | *Gwm* | Sentence Repetition | | | ■ | | | |
| Understanding Directions—ACH | *Gwm* | Understanding Directions | □ | ⊡ | | ⊡ | | |
| Rapid Picture Naming—COG | *Gs/Glr* | Rapid Picture Naming | | | | | | ■ |
| Retrieval Fluency—COG | *Glr* | Retrieval Fluency | | | | | | ■ |
| Story Recall—ACH | *Glr* | Story Recall | □ | □ | □ | | | |

COG = WJ III Cognitive test.

DS = WJ III COG Diagnostic Supplement test.

ACH = WJ III Achievement test.

Test name underlined = WJ III test that has been renamed in WJ IV.

**Test name in bold** = New WJ IV test.

**Cluster name in bold** = New WJ IV cluster not in WJ III.

Cluster name underlined = WJ III cluster renamed in WJ IV.
Oral Language is comparable to Oral Language–Standard in WJ III.
Broad Oral Language is comparable to Oral Language–Extended in WJ III.

□ = WJ III OL cluster included this test; test is not in comparable WJ IV cluster.

⊡ = WJ III and WJ IV comparable OL clusters include the same test (or subtests).

■ = WJ III cluster does not include this test.

WJ IV COG tests.

WJ IV OL tests.

A cursory review of the information presented in Tables 1-13, 1-14, and 1-15 reveals that many of the WJ III and WJ IV clusters are not identical in test composition despite having similar or identical names in the two batteries. In fact, all of the major WJ IV COG cognitive composite clusters and CHC factor clusters are different, to varying degrees, from how they were in the WJ III. This point is critical to understanding differences in similarly named WJ III and WJ IV cluster scores for individuals who have been administered both batteries. The theoretical and practical rationale for the WJ III to WJ IV cluster changes was described earlier in this chapter. Some examples of these changes are described below.

As shown in Table 1-13, the WJ IV Auditory Processing (*Ga*) cluster is composed of two new *Ga* tests (COG Test 5: Phonological Processing and Test 12: Nonword Repetition). The WJ III *Ga* cluster was composed of COG Test 14: Auditory Attention, which has been eliminated from the WJ IV, and COG Test 4: Sound Blending, which has been moved to the WJ IV OL battery. As a result of these changes, the WJ III and WJ IV Auditory Processing (*Ga*) cluster scores are not directly comparable. The two respective WJ III and WJ IV *Ga* clusters represent different mixtures of narrow CHC *Ga* abilities.

Although, to a lesser degree than in the *Ga* clusters, the WJ III and WJ IV Comprehension-Knowledge (*Gc*) clusters also differ in composition. As shown in Table 1-13, the WJ III *Gc* cluster was composed of the COG Test 1: Verbal Comprehension and COG Test 11: General Information. In the WJ IV, COG Test 8: General Information remains in the *Gc* cluster. The second test in the WJ IV *Gc* cluster is COG Test 1: Oral Vocabulary, which is composed of two of the four subtests from the WJ III COG Test 1: Verbal Comprehension. The other two subtests from the WJ III Verbal Comprehension test—Picture Vocabulary (not the same as the standalone Picture Vocabulary test in the WJ III ACH) and Verbal Analogies—were removed from this WJ IV *Gc* measure.

***Table 1-15.***
*Comparison of WJ III/WJ IV Tests and Corresponding ACH Cluster Composition*

| | | | Reading Clusters | | | | | | Mathematics Clusters | | | | Writing Clusters | | | | Cross-Domain Clusters | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WJ III ACH Tests** | **ACH Domain** | **WJ IV ACH Tests** | Reading | Broad Reading | Basic Reading Skills | Reading Comprehension | **Reading Fluency** | **Reading Rate** | Mathematics | Broad Mathematics | Math Calculation Skills | <u>Math Problem Solving</u> | Written Language | Broad Written Language | Basic Writing Skills | Written Expression | Academic Skills | Academic Fluency | Academic Applications | **Academic Knowledge** | Phoneme-Grapheme Knowledge | <u>Brief Achievement</u> | <u>Broad Achievement</u> |
| Letter-Word Identification—ACH | Rdg | Letter-Word Identification | ⊡ | ⊡ | ⊡ | | | | | | | | | | | | ⊡ | | | | | ⊡ | ⊡ |
| Reading Fluency—ACH | Rdg | <u>Sentence Reading Fluency</u> | | ⊡ | | | ■ | ■ | | | | | | | | | | ⊡ | | | | | ⊡ |
| Passage Comprehension—ACH | Rdg | Passage Comprehension | ⊡ | ⊡ | | ⊡ | | | | | | | | | | | | | ⊡ | | | | ⊡ |
| Word Attack—ACH | Rdg | Word Attack | | | ⊡ | | | | | | | | | | | | | | | | ⊡ | | |
| Reading Vocabulary—ACH | Rdg | Reading Vocabulary (Syn+Ant) | | | | □ | | | | | | | | | | | | | | | | | |
| Synonyms | Rdg | | | | | | | | | | | | | | | | | | | | | | |
| Antonyms | Rdg | | | | | | | | | | | | | | | | | | | | | | |
| ~~Analogies~~ | ~~Rdg~~ | | | | | | | | | | | | | | | | | | | | | | |
| | Rdg | **Oral Reading** | | | | | ■ | | | | | | | | | | | | | | | | |
| | Rdg | **Reading Recall** | | | | ■ | | | | | | | | | | | | | | | | | |
| | Rdg | **Word Reading Fluency** | | | | | | ■ | | | | | | | | | | | | | | | |
| Calculation—ACH | Math | Calculation | | | | | | | ⊡ | ⊡ | ⊡ | | | | | | ⊡ | | | | | | ⊡ |
| Math Fluency—ACH | Math | <u>Math Facts Fluency</u> | | | | | | | | ⊡ | ⊡ | | | | | | | ⊡ | | | | | ⊡ |
| Applied Problems—ACH | Math | Applied Problems | | | | | | | ⊡ | ⊡ | | ⊡ | | | | | | | ⊡ | | | ⊡ | ⊡ |
| Number Matrices—DS | Math | Number Matrices | | | | | | | | | | ■ | | | | | | | | | | | |
| ~~Quantitative Concepts—ACH~~ | ~~Math~~ | | | | | | | | | | | ⊟ | | | | | | | | | | | |
| Spelling—ACH | Wr Lng | Spelling | | | | | | | | | | | ⊡ | ⊡ | ⊡ | | ⊡ | | | | | ⊡ | ⊡ |
| Writing Fluency—ACH | Wr Lng | <u>Sentence Writing Fluency</u> | | | | | | | | | | | | ⊡ | | ⊡ | | ⊡ | | | | | ⊡ |
| Writing Samples—ACH | Wr Lng | Writing Samples | | | | | | | | | | | ⊡ | ⊡ | | ⊡ | | | ⊡ | | | | ⊡ |
| Editing—ACH | Wr Lng | Editing | | | | | | | | | | | | | ⊡ | | | | | | | | |
| Spelling of Sounds—ACH | Wr Lng | Spelling of Sounds | | | | | | | | | | | | | | | | | | | ⊡ | | |
| ~~Punctuation & Capitalization—ACH~~ | ~~Wr Lng~~ | | | | | | | | | | | | | | | | | | | | | | |
| ~~Academic Knowledge—ACH~~ | ~~*Gc/Gkn*~~ | | | | | | | | | | | | | | | | | | | | | | |
| Science | *Gc/Gkn* | Science | | | | | | | | | | | | | | | | | | ■ | | | |
| Social Studies | *Gc/Gkn* | Social Studies | | | | | | | | | | | | | | | | | | ■ | | | |
| Humanities | *Gc/Gkn* | Humanities | | | | | | | | | | | | | | | | | | ■ | | | |
| Picture Vocabulary—ACH | *Gc* | *Picture Vocabulary* | | | | | | | | | | | | | | | | | | | | | |
| Oral Comprehension—ACH | *Gc* | *Oral Comprehension* | | | | | | | | | | | | | | | | | | | | | |
| Sound Awareness—ACH | *Ga* | *Sound Awareness* | | | | | | | | | | | | | | | | | | | | | |
| Understanding Directions—ACH | *Gwm* | *Understanding Directions* | | | | | | | | | | | | | | | | | | | | | |
| Story Recall—ACH | *Glr* | *Story Recall* | | | | | | | | | | | | | | | | | | | | | |
| ~~Story Recall–Delayed—ACH~~ | ~~*Glr*~~ | | | | | | | | | | | | | | | | | | | | | | |

ACH = WJ III Achievement test.

DS = WJ III COG Diagnostic Supplement test.

*Test name in italic* = Test now in WJ IV COG or OL battery.

~~Test name crossed out~~ = Not in WJ IV.

<u>Test name underlined</u> = WJ III test that has been renamed in WJ IV.

**Test name in bold** = New WJ IV test.

**Cluster name in bold** = New WJ IV cluster not in WJ III.

<u>Cluster name underlined</u> = WJ III ACH or COG DS cluster renamed in WJ IV. Note that Brief Achievement cluster was the Pre-Academic Skills cluster introduced with the WJ III COG DS. The WJ IV Reading, Math, and Written Language clusters were "brief" clusters in the WJ III COG DS.

□ = WJ III ACH cluster included this test; test is not in comparable WJ IV cluster.

⊟ = WJ III ACH cluster included this test; test is not in WJ IV battery.

⊡ = WJ III and WJ IV comparable ACH clusters include the same test (or subtests).

■ = WJ III cluster does not include this test.

Reading Comprehension-Extended cluster not included in this table. Reading Comprehension-Extended is combination of Passage Comprehension, Reading Recall, and Reading Vocabulary test.

WJ IV COG tests.

WJ IV OL tests.

WJ IV ACH tests.

Both the WJ III and WJ IV *Gv* clusters include the Picture Recognition test. The difference in the *Gv* cluster composition arises from the changes in the Spatial Relations test from WJ III to WJ IV. In the WJ III, COG Test 3: Spatial Relations was a standalone test that contributed to the *Gv* cluster; in the WJ IV, Spatial Relations is now a subtest of COG Test 7: Visualization (designated as ❖) in Table 1-13.

Arguably the most important change from the WJ III to the WJ IV is the composition of the GIA cluster:

- The Oral Vocabulary (*Gc*) and Visualization (*Gv*) tests are the only two WJ IV GIA tests that are common to the WJ III GIA cluster, and these tests themselves are not identical in the two batteries, as described above.
- The Number Series test (from the WJ III Cognitive Diagnostic Supplement) replaces Concept Formation as the *Gf* test in the WJ IV GIA cluster.
- The new Verbal Attention test replaces the Numbers Reversed test as the *Gwm* test in the WJ IV GIA cluster.
- The new Letter-Pattern Matching test replaces the Visual Matching test (now called Number-Pattern Matching) as the *Gs* test in the WJ IV GIA cluster.
- The Sound Blending (*Ga*) test has been replaced with the new Phonological Processing test in the WJ IV GIA cluster.
- The Story Recall test, which was moved from the WJ III ACH to the WJ IV COG, replaces Visual-Auditory Learning as the *Glr* test in the WJ IV GIA cluster.[2]

A review of Table 1-14 reveals that the WJ IV OL clusters are nearly all composed of combinations of tests from the WJ III COG, WJ III DS, or WJ III ACH batteries that have been moved to the WJ IV OL battery. The only exception is the new WJ IV Segmentation test, which is contained in the new Phonetic Coding cluster.

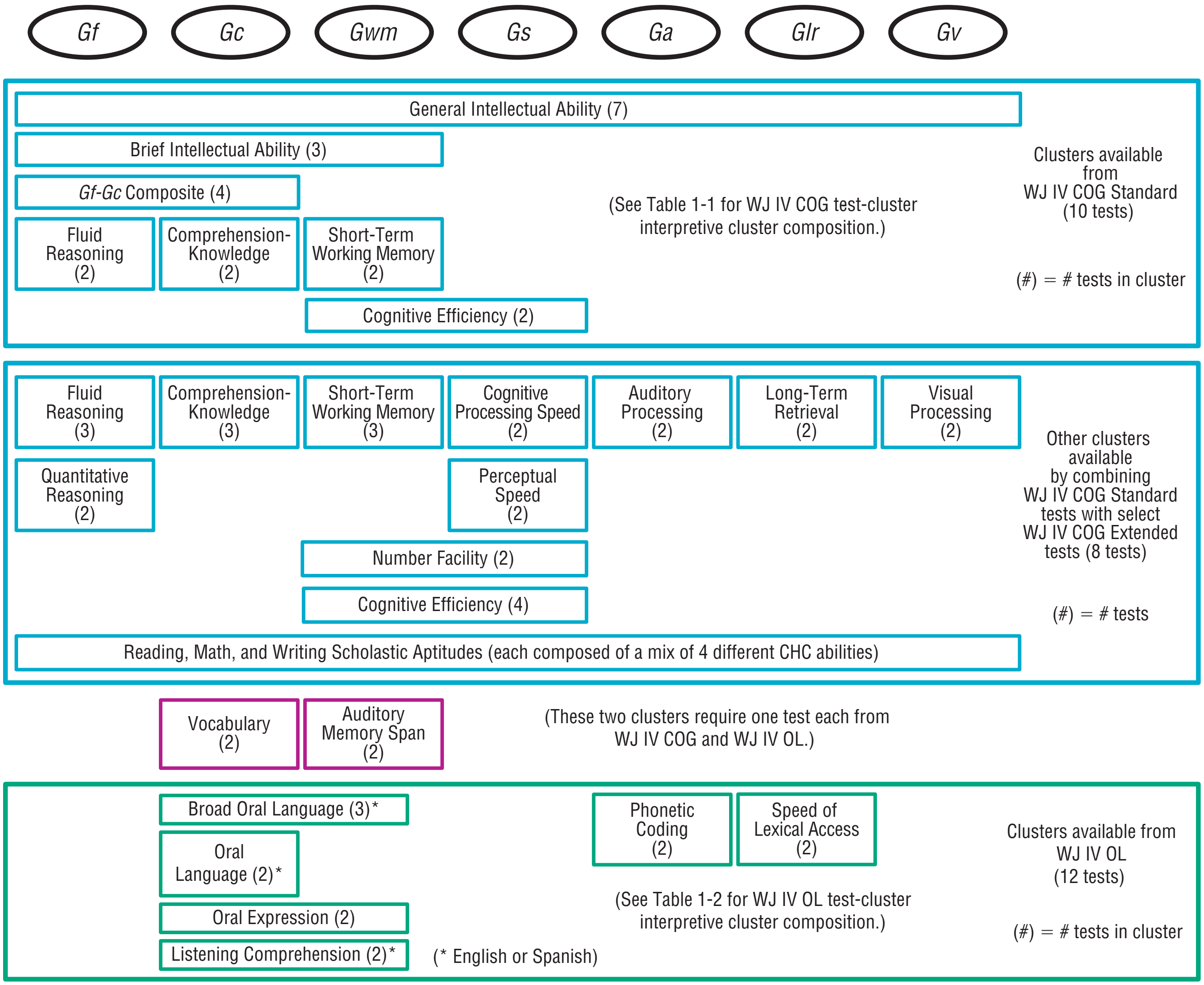
Figure 1-7 expands upon the information in Table 1-14, displaying the organization of the WJ IV COG and OL batteries from a CHC-based interpretive perspective. The ovals along the top of the figure represent the broad CHC abilities measured in the WJ IV COG and OL batteries. The rectangles below the ovals represent interpretive clusters that make up each broad ability. Numbers in parentheses indicate the number of tests in each cluster.

A review of Table 1-15 reveals that most of the WJ III Achievement clusters that have been retained in the WJ IV comprise the same tests in both batteries. For example, Broad Reading includes the same three tests in both the WJ III and the WJ IV: Letter-Word Identification, Passage Comprehension, and Reading Fluency (in WJ III)/Sentence Reading Fluency (in WJ IV). The most significant change in the WJ IV ACH battery is the addition of a number of new clusters, indicated by bold cluster names and square icons (■) for tests in Table 1-15.

Figure 1-8 expands upon the information in Table 1-3, displaying the organization of the WJ IV ACH battery from a CHC-based interpretive perspective. The ovals along the top of the figure represent the broad and narrow CHC abilities measured in the WJ IV ACH battery. The rectangles below the ovals represent interpretive clusters that make up each broad or narrow ability. Numbers in parentheses indicate the number of tests in each cluster.

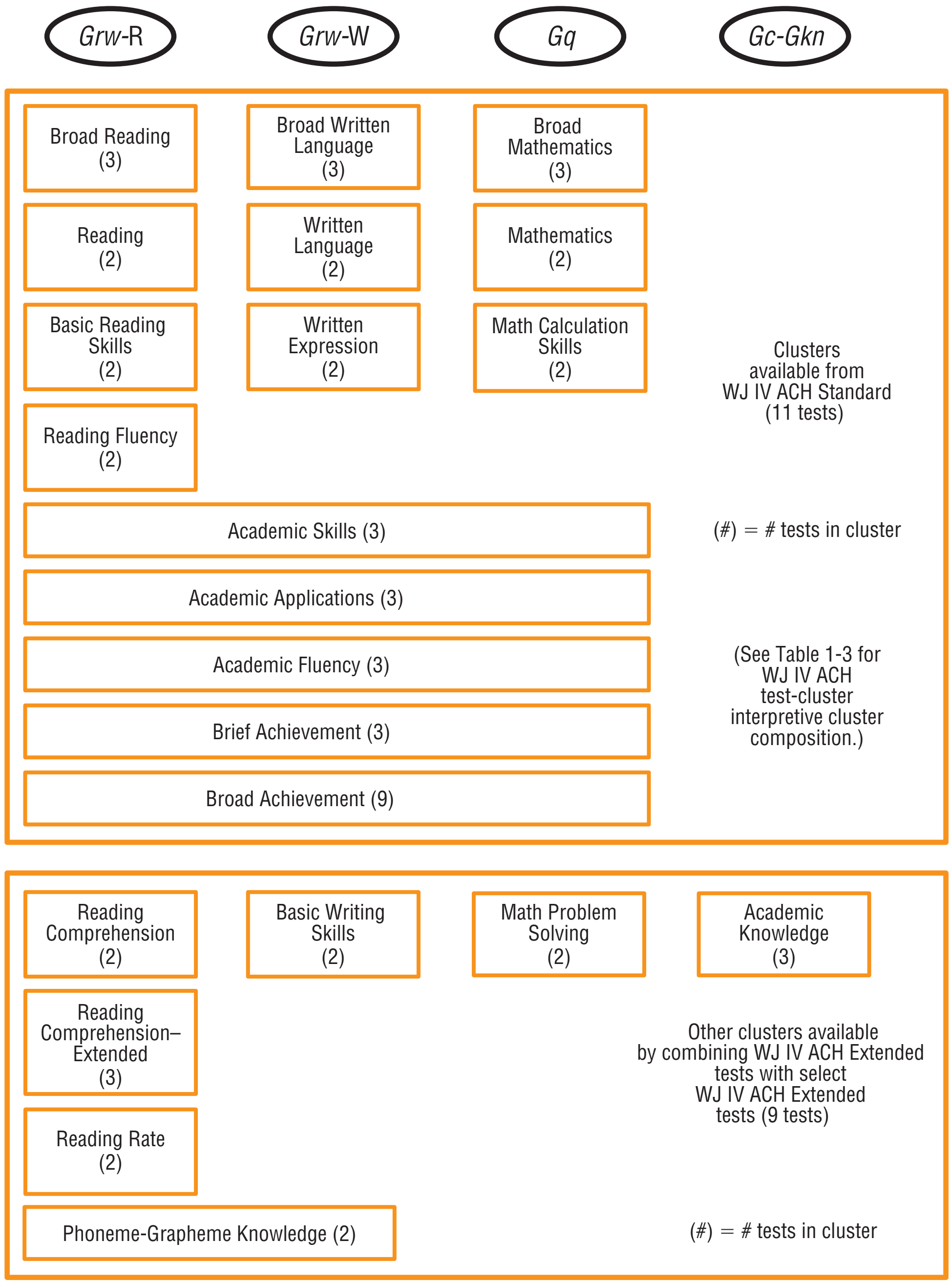
[2] In the WJ III, the Story Recall test was designed to be a COG *Glr* test but was later moved to the WJ III ACH battery to help facilitate the measurement of oral language abilities in the WJ III ACH.

***Figure 1-7.***
*Organization of the WJ IV COG and WJ IV OL batteries.*




Understanding which clusters have changed significantly in content is critical to understanding score differences between the WJ III and WJ IV. Users should exercise caution when interpreting score differences between WJ III and WJ IV clusters due to differences not only in cluster composition but also in WJ III and WJ IV scaling procedures and in the respective norm samples. Also, changes in the composition of many of the clusters, particularly in the WJ IV COG battery, imply that users should not assume that the WJ III validity evidence is relevant for the similarly named clusters in the WJ IV. New evidence for the use and interpretation of these cluster scores is required and is presented in Chapter 5.

**Figure 1-8.**
*Organization of the WJ IV ACH battery.*



# Propositions for the Use and Interpretation of the WJ IV Test Scores

According to the *Standards for Educational and Psychological Testing* (American Educational Research Association [AERA], American Psychological Association [APA], & National Council on Measurement in Education [NCME], 2014) the argument for the validity of test scores should begin during the test development process with a clear statement of the propositions supporting the proposed uses and interpretation of the scores. Then "the validation process evolves as these propositions are articulated and evidence is gathered to evaluate their soundness" (p. 12). The *Standards for Educational and Psychological Testing* contain prescriptions for best practices in test design, development, and interpretation. Adherence to the standards ensures that test developers have carefully thought through the processes and procedures for test design and development and are aware of how these procedures impact the validity of the interpretations made from the test scores. During the design and development of the WJ IV, great care was taken to ensure that all relevant standards were followed. It is through the documentation of the development processes and the technical characteristics of the test that users are able to assess the extent to which the test scores are valid for their particular uses and interpretations. Although adherence to the Standards does not guarantee the validity of the test scores, it does assist users by providing a framework for the evaluation of the validity evidence provided.

Support for the use and interpretation of the WJ IV scores is grounded in the body of validity evidence gathered on the three preceding editions of the test (WJ, WJ-R, and WJ III) and draws from the large body of research related to CHC theory. Additional validity evidence includes documentation of the goals and objectives of the revision and the procedures used for test development, standardization, and norms construction. Support for the use and interpretation of the WJ IV scores also comes from documentation of the technical characteristics of the test, including its internal structure, and from the relationship of the WJ IV scores to other measures. Thus, the *Woodcock-Johnson IV Technical Manual* (McGrew, LaForte, & Schrank, 2014) in its entirety serves as evidence to support the validity of the WJ IV scores for measuring individuals' cognitive abilities, oral language abilities, and academic achievement.

Table 1-16 contains propositions underlying the WJ IV test score interpretations. For each proposition, Table 1-16 directs users to the specific section(s) of this manual that contain empirical evidence and supporting literature that test users may utilize to evaluate the validity of their intended uses and interpretations of the WJ IV test scores.

***Table 1-16.***
*Propositions Underlying the WJ IV Test Score Interpretations*

| Proposition | Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 | Chapter 5 | Technical Manual Section(s) |
|---|---|---|---|---|---|---|
| The WJ IV test structure represents current theory and research on the structure of human cognitive abilities. | ■ | | | | | WJ IV Revision Goals and Design Objectives<br>Evolution of CHC Theory in the WJ IV<br>Organization Into Three Distinct Batteries<br>Changes in the WJ IV<br>Appendix A: Cattell-Horn-Carroll Theory of Cognitive Abilities Definitions |
| | | ■ | | | | Test Specifications Update<br>Development of New WJ IV Tests |
| | | | ■ | | | Appendix D: General Intellectual Ability Average (Smoothed) *g* Weights by Technical Age Groups |
| | | | | | ■ | Representativeness of the WJ IV Test Content, Process, and Construct Coverage<br>Developmental Patterns of WJ IV Ability Clusters<br>Internal Structure of the WJ IV<br>Appendix E: Test Score Intercorrelations<br>Appendix F: Cluster Score Intercorrelations<br>Appendix G: Ward's Cluster Analysis Solutions<br>Appendix H: Exploratory Principal Components Solutions<br>Appendix I: WJ IV MDS Final Exploratory Solutions<br>Appendix J: Comparison of WJ IV CHC Broad Factor ML and SFLS Parameter Estimates |
| WJ IV COG tests provide a representative sampling of the complex set of unique abilities considered to constitute intellectual ability by CHC theory, ranging from lower-level processing to higher-level thinking and reasoning.<br>WJ IV ACH tests provide a broad, representative sampling of core curricular areas and achievement specified in federal legislation.<br>WJ IV OL tests provide a broad, representative sampling of abilities in oral language areas. | ■ | | | | | WJ IV Revision Goals and Design Objectives<br>Evolution of CHC Theory in the WJ IV<br>Organization Into Three Distinct Batteries<br>Changes in the WJ IV<br>Appendix A: Cattell-Horn-Carroll Theory of Cognitive Abilities Definitions |
| | | ■ | | | | Test Specifications Update<br>Development of New WJ IV Tests |
| | | | | | ■ | Representativeness of the WJ IV Test Content, Process, and Construct Coverage<br>Developmental Patterns of WJ IV Ability Clusters<br>Internal Structure of the WJ IV |
| The unique broad and narrow abilities measured by the WJ IV display average score changes that are consistent with the developmental growth and decline of abilities across the life span. | | | | ■ | | Appendix B: Test Summary and Reliability Statistics<br>Appendix C: Cluster Summary and Reliability Statistics |
| | | | | | ■ | Developmental Patterns of WJ IV Ability Clusters |
| Performance on the WJ IV is consistent with other measures of cognitive ability, achievement, and oral language ability. | | | | | ■ | Relationship of WJ IV Scores to Other Measures of Cognitive Abilities, Oral Language, and Achievement |

***Table 1-16.*** *(cont.)*
*Propositions Underlying the WJ IV Test Score Interpretations*

| Proposition | Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 | Chapter 5 | Supporting Evidence Found In: Technical Manual Section(s) |
|---|---|---|---|---|---|---|
| WJ IV ACH test scores are comparable across alternate forms | | ■ | | | | Scale Development<br>Item Pool Development<br>Norming Study<br>Assembly and Evaluation of Final Test Forms |
| | | | | ■ | | Alternate-Forms Equivalence |
| WJ IV test and cluster scores are sufficiently reliable and precise for estimating individuals' abilities across the age span. | | | | ■ | | Reliability Coefficients<br>Appendix B: Test Summary and Reliability Statistics<br>Appendix C: Cluster Summary and Reliability Statistics |
| Normative information from the WJ IV can be used to estimate and evaluate an examinee's performance relative to his or her same age or grade peers. | | ■ | | | | Norming Study |
| | | | ■ | | | General Characteristics of the Norming Sample<br>Norming Study Procedures<br>Planned Incomplete Data Collection Design<br>Norms Construction |
| WJ IV test and cluster scores are sensitive to the detection of individual patterns of strengths and weaknesses. | ■ | | | | | Organization Into Three Distinct Batteries<br>Comparing Abilities Within and Across Batteries |
| | | | ■ | | | Norms Construction |
| | | | | | ■ | Developmental Patterns of WJ IV Ability Clusters |
| WJ IV test and cluster scores are sensitive to the detection of individual patterns of strengths and weaknesses among individuals with learning differences and exceptionalities. | ■ | | | | | Organization Into Three Distinct Batteries<br>Comparing Abilities Within and Across Batteries |
| | | | ■ | | | Norms Construction |
| | | | | | ■ | Developmental Patterns of WJ IV Ability Clusters<br>Performance of Clinical Samples on WJ IV Measures |
| The WJ IV is appropriate for use with individuals from diverse racial and ethnic backgrounds and for both males and females. | | ■ | | | | Expert Content, Sensitivity, and Bias Reviews<br>Norming Study<br>Assembly and Evaluation of Final Test Forms |
| | | | ■ | | | General Characteristics of the Norming Sample<br>Norming Study Procedures<br>Norms Construction |

*Chapter 2*

# Test Design and Development Procedures

The development of the *Woodcock-Johnson IV* (WJ IV) (Schrank, McGrew, & Mather, 2014a) followed traditional planning stages and procedures, including a comprehensive review and update of the test specifications, creation of new tests and items, tryout and psychometric evaluation of new items, scaling of item pools, norming, and selection of the final published test forms. The *Standards for Educational and Psychological Testing* (American Educational Research Association [AERA], American Psychological Association [APA], & National Council on Measurement in Education [NCME], 2014) contain many recommendations for best-practice processes in test development and revision. This chapter serves as documentation that the applicable recommendations were studied and addressed during the test design and development phases for the WJ IV.

## Test Specifications Update

The WJ IV is built on the theoretical, structural, and interpretive framework of the *Woodcock-Johnson III* (WJ III) (Woodcock, McGrew, & Mather, 2001). The revision goals and design objectives for the WJ IV were based on contemporary CHC theory and research, identified professional practice needs, and feedback from WJ III users. These revision goals and objectives are described in Chapter 1 of this manual. The revision goals informed updates to the test specifications, including the creation of several new tests and interpretive clusters and augmentation of several existing tests and interpretive clusters from the WJ III. Some of the new WJ IV tests were developed to meet the design objective for increased ecological and predictive validity of cluster interpretations, while other new tests were intended to augment measures of broad or narrow abilities identified in recent CHC research.

## Development of New WJ IV Tests

Eight new tests were added to the WJ IV: Verbal Attention, Letter-Pattern Matching, Phonological Processing, Nonword Repetition, Segmentation, Oral Reading, Reading Recall, and Word Reading Fluency. A brief description of the rationale, development objectives, and item types for each of these tests follows.

- *Verbal Attention.* This test was developed to be an ecologically valid measure of working memory. The goal was to develop item tasks similar to the types of tasks required of students in a classroom or adults in typical work environments. The stimulus task in Verbal Attention is similar to the items in the Object-Number Sequencing test (Auditory Working Memory in the WJ III). The examinee first listens to a verbally presented series that contains animal names and digits intermingled. Rather than repeating the series or regrouping the items into the animals and the digits (as required by the Object-Number Sequencing test), the examinee must hold the series in immediate memory and then answer a specific question regarding the presented list. The examinee is unaware of the question that will be asked until all items in the sequence have been presented and the examiner provides the item-specific task directions. Item stimuli were developed that ranged from very simple (e.g., a series of one animal and one digit and the examiner asks the examinee to name the animal) through very complex (e.g., a list of nine animal names and digits intermingled and the examiner asks the examinee to recall a specific part of the series).

- *Letter-Pattern Matching.* This test was developed to measure perceptual speed and orthographic processing. Research on orthographic processing and knowledge (Apel, 2011; Barker, Torgesen, & Wagner, 1992; Berninger, 1990; Berninger et al., 2006) has suggested that some strong readers recognize common orthographic patterns with ease, while other individuals who have difficulty reading words quickly have trouble recognizing common spelling patterns. The objective for this test was to develop items that would differentiate individuals who can quickly and easily recognize orthographic patterns from those who do not do so as efficiently. The item format is based on the task from a similar *Gs* test, Number-Pattern Matching (Visual Matching in the WJ III), that measures the speed with which an examinee can make visual number-symbol discriminations. In the new Letter-Pattern Matching test, the task requires examinees to find and circle the two matching letter sequences in a row that includes several distractor combinations. The target (matching) letter sequences are common English spelling patterns, such as *oa* or *sh*. The distractor patterns are impossible or less-frequently used combinations, such as *ao* or *hs*. Letter-Pattern Matching items range from simple, with single-letter targets and distractors, to more difficult items containing four-letter patterns.
- *Phonological Processing.* This test, which is composed of three subtests, was designed to provide a *cognitively complex* (see definition in Chapter 1) measure of phonetic coding or phonological processing abilities. The Phonological Processing test is composed of three parts, or subtests. Subtest C Substitution was included in the WJ III Sound Awareness test. Subtest A Word Access and subtest B Word Fluency were developed for the WJ IV.
    - *Phonological Processing–Word Access.* This subtest was developed to be an ecologically valid test that would tap the cognitive processes required for accessing words based on phonology. This new test is similar to Sound Blending, another WJ IV test. In the Sound Blending test, the examinee listens to a series of syllables or phonemes and then is asked to blend the sounds into a word. In the WJ III, Sound Blending was included in the WJ III GIA clusters. Feedback from users suggested that explicit instruction in blending phonemes into whole words can result in training effects; children who are systematically taught how to identify sounds and then blend them into words tend to improve their scores on Sound Blending. For this reason, as well as to fulfill the objective of including more cognitively complex *Ga* tests in the *Woodcock-Johnson IV Tests of Cognitive Abilities* (WJ IV COG) (Schrank, McGrew, & Mather, 2014b), the decision was made to move Sound Blending to the *Woodcock-Johnson IV Tests of Oral Language* (WJ IV OL) (Schrank, Mather, & McGrew, 2014b) as a complement to the Segmentation test. The objective for the new Word Access subtest was to include items with a wide range of difficulty that would not be as susceptible to the effects of training. The easiest Word Access items require the examinee to point to a picture that has the same starting sound as a word provided by the examiner. The

remaining items require the examinee to access a word from his or her lexicon that contains a specific phonemic element in a specific location, such as at the beginning of a word. Most items are administered using an audio recording.

- *Phonological Processing–Word Fluency*. This subtest was designed to increase the cognitive complexity of the Phonological Processing test, the Auditory Processing (*Ga*) cluster, and the GIA cluster. In this subtest, the examinee is asked to name as many words as possible that begin with a specified sound within a 1-minute time period.
- *Phonological Processing–Substitution.* This was a subtest in the WJ III Sound Awareness test and is included in the WJ IV to increase the cognitive complexity of the Phonological Processing test. In this subtest, the examinee is asked to substitute part of a word to create a new word. For example, the examinee is provided the word *taller* and instructed to change *tall* to *small* to make a new word (*smaller*). Most items are administered using an audio recording.

- *Nonword Repetition.* The addition of the Nonword Repetition test was informed by contemporary research suggesting that the ability to maintain speech sounds in phonological memory is related to learning new words and that this type of task is sensitive to individual differences and disabilities in reading and language development (Archibald & Gathercole, 2006; Baird, Slonims, Simonoff & Dworzynski, 2011; Gathercole & Baddeley, 1989; Gathercole, Willis, Emslie, & Baddeley, 1992, 1994; Nation & Hulme, 2010). The objective for this test was to develop a demanding measure of phonological short-term memory. The item format is based on a similar measure (Sound Mimicry) from the *Goldman-Fristoe-Woodcock Auditory Skills Battery* (Goldman, Fristoe, & Woodcock, 1974). New items were developed that contain nonsense words consisting of regular English phoneme patterns. The examinee listens to the nonword and then is required to repeat it. The items range from very easy (one syllable) to very difficult (seven or more syllables). The simplest one-syllable items are administered by the examiner; the remaining items are administered using an audio recording.
- *Segmentation.* The Segmentation test was added to the WJ IV as a diagnostic counterpart to the Sound Blending test in the formulation of the new Phonetic Coding cluster. Segmentation contributes to a more complete picture of an examinee's ability to analyze and synthesize word sounds as linked to early reading skill acquisition (Bouwmeester, van Rijen, & Sijtsma, 2011). Whereas the task in Sound Blending requires examinees to combine and synthesize phonemes into words, the Segmentation task requires examinees to break apart or deconstruct words into their constituent parts. The easiest items require examinees to listen to a compound word and then name the two parts of the word (e.g., *meatball—meat* and *ball*). The difficult items require the examinee to deconstruct the word into syllables and phonemes. Research has suggested that segmentation tasks require both short-term working memory and speech perception (Bouwmeester et al., 2011).
- *Oral Reading.* The Oral Reading test was added to the WJ IV to provide a more authentic measure of reading fluency. Some practices in reading assessment under response to intervention (RTI) models use simple word reading rate or automaticity tasks that may underrepresent the construct of reading fluency. The WJ IV Oral Reading test measures an examinee's ability to orally read connected text fluently. The task is to read aloud sentences that gradually increase in difficulty. Performance is scored for both accuracy and fluency of expression. Examiners note errors and omissions, including mispronunciations, word substitutions, hesitations, repetitions, transpositions, and punctuation errors.

- *Reading Recall*. The objective for the Reading Recall test is to measure how well an examinee can reconstruct meaningful content that he or she has read. This test was included in the WJ IV to provide users with a more ecologically comprehensive Reading Comprehension cluster. The test is similar to Story Recall in the WJ IV COG, in which examinees are asked to reconstruct meaningful material that is presented to them orally versus reading the material themselves. Performance on the Reading Recall and Story Recall tests can be compared to investigate possible differences in meaningful memory (*Glr*-MM) as a function of an orally presented story versus a written passage that must be read. Examinees are asked to read a story silently and then tell everything they can remember about what they read. Scoring is based on the number of elements that the examinee recalls correctly. The simplest stories include 5 or 6 key elements in a two- or three-sentence story. The difficult stories include 12 or more key elements in stories that are several sentences long. The primary assumption underlying reading recall tests is that "when readers retell a text, they draw on their mental representation of the text read…This mental representation is the product of both lower-level and higher-level processes" (Kendeou, Papadopoulos, & Spanoudis, 2012; p. 356).
- *Word Reading Fluency*. This test was developed to provide users with a Reading Rate cluster that includes a measure of an examinee's ability to read and compare words quickly. In contrast to the Reading Fluency cluster, which includes a measure of oral reading and is often useful for younger examinees, the Reading Rate cluster includes two measures of silent reading that are appropriate measures for older examinees who are referred for reading difficulties. The test was designed as a cognitively complex measure of reading vocabulary knowledge and semantic fluency. Each item consists of a row of four words; examinees must circle the two words in each row that go together (the "target" words). The easiest item rows contain simple words (*mom*, *bag*, *dot*, *dad*), whereas the most difficult item rows contain words that require an examinee to have extensive vocabulary knowledge (*reflection*, *production*, *democracy*, *monarchy*). Examinees are allowed 3 minutes to complete as many items as they can; this test design inherently introduces the element of cognitive processing speed (*Gs*) into the measure.

All items from the new WJ IV tests underwent extensive pilot testing. After each test item pool was developed, project staff first administered the items to a restricted sample to try out the item format and verify that the item instructions were clear. After any necessary modifications were made, each test was administered to a convenience sample of approximately 100 to 200 examinees from a wide range of ages and abilities. The purpose of this round of pilot testing was to obtain preliminary item difficulty estimates and other item statistics to assess whether further item development or modifications were needed prior to the tryout study.

## Augmentation of Item Pools for Existing Tests

In addition to the new WJ IV tests, several existing WJ III tests were targeted for new item development based on the WJ IV test specifications. In most cases, the objective of the new item development was to extend the range of the items in the existing item pool at either the very low or very high difficulty ranges; for some tests, new items were developed at both ends of the scale. In other cases, the new item development was intended to allow replacement of items that had been in use across several editions of the test. For the *Woodcock-Johnson IV Tests of Achievement* (WJ IV ACH) (Schrank, Mather, & McGrew, 2014a), Standard Battery, adding new items served to deepen the item pool and to allow for the selection of three parallel forms of the test in the published WJ IV.

The WJ IV authors wrote new items for the following tests:

- Oral Vocabulary (easy items)
- Numbers Reversed (items across all difficulty levels)
- Object-Number Sequencing (items across all difficulty levels)
- Memory for Words (moderately difficult items)
- Sentence Repetition (difficult items)
- Understanding Directions (very easy items for two picture scenes)
- Sound Blending (items across all difficulty levels)
- Letter-Word Identification (difficult items)
- Spelling (difficult items)
- Calculation (easy items)
- Writing Samples (moderately difficult items)
- Word Attack (items across all difficulty levels)
- Number Matrices (easy to moderately difficult items)
- Spelling of Sounds (difficult items; additionally, audio for all items in the item pool was rerecorded)

All newly developed items were added to the item pools and were included in the tryout study described later in this chapter.

## Expert Content, Sensitivity, and Bias Reviews

During the new test and item development phase of the project, the WJ IV authors consulted with several outside experts, including experienced teachers, university faculty in relevant content areas, and psychologists. A primary goal for the new tests and items was to capture the important aspects of the underlying constructs and cover a wide range of difficulty (construct-representation), while avoiding the measurement of other, confounding abilities (construct-irrelevant variance). Review by content-area experts, especially for the WJ IV ACH domain tests, ensured that the new items covered the breadth of the intended construct and also were appropriately difficult for the range of the scale being targeted.

In addition to the expert content reviews, bias and sensitivity reviews also were conducted as part of the item and test development. Table 2-1 lists the nine individuals who reviewed the WJ IV item pools for potential bias and sensitivity issues. The reviewers examined item content and format for any potential bias or sensitivity issues for women, individuals with certain disabilities, and cultural or linguistic minorities. The reviewers were asked to consider the following questions about each item:

**Table 2-1.**
*WJ IV Content, Bias, and Sensitivity Reviewers*

| Reviewer | Affiliation or Location | Area of Specialization |
|---|---|---|
| Janine Jones, PhD, NCSP<br>Associate Professor, School Psychology | University of Washington<br>Seattle, WA | African American |
| Homer Carter, PhD<br>Chief Academic Officer | Cedar Hill Independent School District<br>Cedar Hill, Texas | African American |
| Carrie Margolin, PhD<br>Faculty, Psychology | The Evergreen State College<br>Olympia, Washington | Gender/Women's Issues |
| Christine Kostrubala<br>Hearing Impairment Specialist | Poulsbo, Washington | Hearing Impairment |
| Servio A. Carroll, EdS, NCSP, LPC<br>School Psychologist | Sheridan County School District<br>Sheridan, Wyoming | Hispanic |
| Ruben Lopez, LEP<br>Bilingual School Psychologist | Moreno Valley Unified School District<br>Moreno Valley, California | Hispanic |
| Jill Davidson, PhD, NCSP<br>School Psychologist | Seattle Public Schools<br>Seattle, Washington | Lesbian, Gay, and Transgender |
| Lynne Jaffe, PhD, Educational Consultant<br>Adjunct Assistant Professor, Department of Disability and Psychoeducational Studies | University of Arizona<br>Tucson, Arizona | Visual Impairment |
| Stephen Hong<br>ESL Instructor | Conant High School<br>Hoffman Estates, Illinois | Asian |

- Does the item contain content or language that might be offensive to any group?
- Does the item reinforce stereotypes of any group?
- Does the item characterize identities, roles, or occupations in an insensitive manner?
- Does the item assume familiarity with concepts or relationships that may not be recognized by all groups?
- Does the item use language or vocabulary that may not be familiar to all groups?
- Does the item use a format that may be more familiar to some groups?
- Does the item contain negative or sensitive material that may be upsetting to some groups and may interfere with their ability to demonstrate knowledge or understanding?
- Does the item show a lack of sensitivity to the way a group has been historically represented?

All reviewer comments were taken into consideration. Typically, if an item was identified as potentially biased, it was eliminated from the item pool or revised prior to the tryout study.

# Scale Development

All WJ IV test item pools were calibrated onto a common scale, called a *W* scale, for use in the construction of the final published tests and development of the norms. This section contains an introduction to the Rasch (Item Response Theory; IRT) measurement model (Bond & Fox, 2007; de Ayala, 2009; Raykov & Marcoulides, 2011; Smith & Smith, 2004; Wright & Stone, 1979), which is the basis for the *W*-score metric, and a description of the procedures used to calibrate the WJ IV item pools.

## Use of the Rasch Model

The WJ IV test development, calibration, item pool equating, and scaling were accomplished through the use of the Rasch single-parameter logistic test model (Rasch, 1960/1980). Danish mathematician Georg Rasch first introduced the use of the logistic function in the analysis of dichotomously scored test items. This model contains two parameters: The ability of the examinee, $B_n$, and the difficulty of the item, $D_i$, and is written as:

$$P_{ni} = \frac{e^{B_n - D_i}}{1 + e^{B_n - D_i}}, \tag{2.1}$$

where $P_{ni}$ is the probability of examinee $n$ correctly responding to item $i$ (Rasch, 1960/1980). Using only these two pieces of information, the model predicts what will happen when an examinee encounters an item. If the examinee's ability is higher than the difficulty of the item (i.e., if $B_n - D_i$ is positive), then $P_{ni}$ will be greater than .5. Conversely, if the examinee's ability is less than the difficulty of the item (i.e., if $B_n - D_i$ is negative), then $P_{ni}$ will be less than .5. Items that are perfectly targeted to an examinee's ability (i.e., $B_n = D_i$) result in a $P_{ni}$ equal to .5.

For polytomously scored items, Wright and Masters (1982) later expanded the dichotomous model to its partial credit form:

$$P_{nik} = \frac{e^{(B_n - D_{ik})}}{1 + e^{(B_n - D_{ik})}}, \ k = 1, 2, \dots m_i, \tag{2.2}$$

where $P_{nik}$ is the probability of examinee $n$ receiving a score in category $k$ for item $i$, and $D_{ik}$ is the difficulty of the $k$th category transition, or the point where a score in category $k$ becomes more probable than a score in category $k - 1$. The partial credit model is appropriate for use with items that have different response categories, and therefore different step difficulties (i.e., different values of $D_{ik}$), such as the Writing Samples items.

With the Rasch model, observed item responses can be used to estimate the difficulties of the items on a test, regardless of the abilities of the particular examinees who have taken the test. This is referred to as *sample-free test calibration*. Likewise, item responses can be used to estimate the abilities of the examinees, regardless of the difficulties of the particular set of items chosen to appear on the test. This means that once a pool of items fitting the model is obtained, any subset of items may be used to construct a test, and the examinee ability scores for such a test will be referenced to the measurement scale on which the total pool of items is scaled. This property is referred to as *item-free measurement*.[1]

Several assumptions about the data must be met before the properties of sample-free test calibration and item-free measurement are realized. One assumption is that the set of test items is *unidimensional*—all the items in a given test measure the same underlying ability. These underlying abilities are referred to as latent traits because they are not directly measurable. A second assumption is that of *local independence*, which means that an examinee's performance on one test item is not influenced by his or her performance on any other test item. If a group of examinees who all have the same ability are administered the same set of test items, there should be no statistical correlation among the items. A third assumption is that the items in a test have *equal discrimination* characteristics. This means that if curves are drawn showing the probability of correct response for each item across the range of ability measured by the test, the obtained "item characteristic curves" (ICCs) will be the same except for horizontal displacement, or differences in item difficulty, along the ability scale.

Once the test developer has confirmed that the data meet these underlying assumptions, the Rasch model provides indices of fit that can be used to determine how well the data fit the model. Items that do not perform as expected under the model are either revised or removed from the item set.

[1] For the item-free measurement property to hold, the particular items chosen to measure a group of examinees must be appropriately targeted to the ability level of the examinees. If, for instance, the items are all much too easy or much too difficult, the precision of the resulting ability measures will be too low to produce meaningful estimates. The possibility for mistargeting of item difficulty and examinee ability is greatly diminished in a test, such as the WJ IV, where items are carefully chosen to cover the entire range of examinee ability.

When items and examinees are calibrated with the Rasch model, the resulting item difficulty estimates and examinee ability estimates are placed onto the same *logit scale*, such that each examinee's ability can be described relative to the difficulty of the items that are below and above the examinee's ability on that scale. This logit scale is an equal-interval scale; the relative distances between ability scores are constant. This means that a difference of one logit at any point along the scale represents the same amount of change in examinee ability or item difficulty. This equal-interval property of the Rasch model underlies many of the score interpretation features of the WJ IV.

## The *W* Scale

The *W* scale underlying the WJ IV tests is a direct transformation of the Rasch logit scale:

$$W = 9.1024 \text{ logits} + 500 \,. \tag{2.3}$$

Developed by Woodcock and Dahl (1971), the *W* scale provides several practical advantages over the Rasch logit scale (Woodcock, 1999):

1. The additive constant centers the scale at $W = 500$, eliminating negative examinee ability and item difficulty values that occur in score scales based on the Rasch logit metric.
2. The signs of the item difficulty and person ability scores are set such that low values imply either low item difficulty or low examinee ability, whereas high values imply either high item difficulty or high examinee ability.
3. The multiplicative scaling constant of 9.1024 produces probability implications that are more convenient to remember and use than distances along the Rasch logit scale.

Through Rasch item calibration and scaling, the WJ IV examinee ability and item difficulty measures are placed on the common *W* scale; the same set of numbers can then be used to describe an examinee's ability and an item's difficulty. As with the Rasch logit scale, the difference between an examinee's ability location and an item's difficulty location along the *W* scale ($W_{A-D}$) has implications for the examinee's probability of success on any test item:

$$P_{A-D} = \frac{e^{W_{A-D}/9.1024}}{1 + e^{W_{A-D}/9.1024}} \,, \tag{2.4}$$

where $P_{A-D}$ is the probability of a correct response associated with a given value of $W_{A-D}$. Figure 2-1 illustrates the relationship between examinee ability and task difficulty on the *W* scale.

In this figure, Examinee A has an ability estimate of $W = 510$. This examinee will experience approximately 50% success on items of difficulty $W = 510$. When items are administered to this examinee that have a difficulty measure lower than 510 on the *W* scale (i.e., when $W_{A-D}$ is positive), the examinee will have greater than 50% chance of success on the items. Likewise, when items are administered that are higher than 510 on the *W* scale (i.e., when $W_{A-D}$ is negative), the examinee will be less than 50% likely to respond correctly. Table 2-2 describes the probability of examinee success for several key values of $W_{A-D}$.

***Figure 2-1.***
*Relationship between an examinee's ability and an item's difficulty on the W scale.*

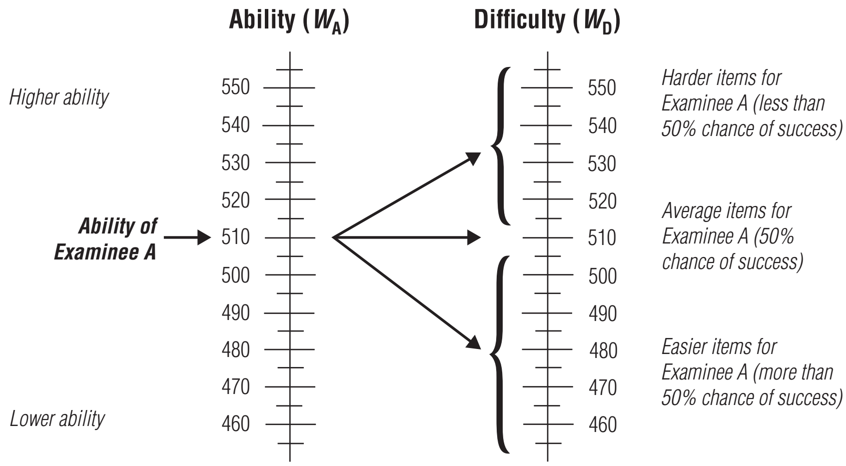



***Table 2-2.***
*Probability of Success for Several Key Values of* $W_{A-D}$

| Examinee Ability Minus Task Difficulty ($W_{A-D}$) | Probability of Success ($P_{A-D}$) | Examinee Ability Minus Task Difficulty ($W_{A-D}$) | Probability of Success ($P_{A-D}$) |
|---|---|---|---|
| +50 | .996 | 0 | .500 |
| +45 | .993 | –5 | .366 |
| +40 | .988 | –10 | .250 |
| +35 | .979 | –15 | .161 |
| +30 | .964 | –20 | .100 |
| +25 | .940 | –25 | .060 |
| +20 | .900 | –30 | .036 |
| +15 | .839 | –35 | .021 |
| +10 | .750 | –40 | .012 |
| +5 | .634 | –45 | .007 |
| 0 | .500 | –50 | .004 |

Like the Rasch logit scale, the *W* scale is an equal interval metric; the distance between two points on the *W* scale has the same interpretation at any ability level measured by the WJ IV tests. This is true whether the difference represents the change in a kindergartener's ability to identify a set of letters or a college student's ability to solve a set of calculus problems. In either case, if an examinee is administered an item that is, for example, 10 points less difficult than his or her ability measure (i.e., $W_{A-D} = +10$), the examinee will have a 75% chance of success on the item.

The probability relationships that exist for $W_{A-D}$ also apply to other situations in which a difference score can be determined. For example, an examinee's ability measure ($W_A$) can be compared to some reference point along the *W* scale (REF *W*), to obtain the difference score *W* DIFF. In the WJ IV, REF *W* points for each age and grade level on each test and cluster were identified through the process of scale norming (see Chapter 3). Standard scores and percentile ranks reported for the WJ IV tests and clusters are derived using these *W* DIFF points. Other interpretive features derived from the WJ IV *W* scale include the relative proficiency index (RPI), instructional zone, and developmental zone, which are discussed in more detail in the WJ IV Examiner's Manuals.

# Item Pool Development

The WJ IV item pool development built upon more than 30 years of research and test development data from prior editions of the Woodcock-Johnson tests. For most tests, large item pools exist that contain data from many thousands of examinees. Using Rasch calibration and equating procedures, these existing data were leveraged to allow the calibration of new items to the existing *W* scale for each test. The processes used to calibrate the item pools, evaluate item calibration invariance, and equate new items to the existing *W* scales are described in this section.

## Item Tryout Study

The goals of the tryout study were: (a) to build item pools for new tests from which norming study forms would be selected, (b) to augment existing item pools for some tests, and (c) to assess the psychometric characteristics of the new test items. For tests that are new in the WJ IV, the tryout study also afforded examiners an opportunity to provide feedback about the clarity of the test instructions, materials, response formats, and scoring.

Tryout forms were assembled for all new tests and for existing WJ III tests for which new items were developed for the WJ IV edition. In the latter case, tryout test forms included not only the newly developed items but also a set of carefully selected linking items from the existing test item pools. This item linkage design provided the necessary data to allow the new item difficulty estimates to be evaluated relative to the existing item pools at the completion of the tryout study. The item difficulty order for each tryout test form was estimated a priori by the test authors using pilot test data and item/stimulus content assessment as guides.

The tryout study forms were administered to convenience samples ranging from 100 to 500 examinees per test. Although emphasis was not placed in the tryout study on obtaining samples that would be representative of the United States population, care was taken to ensure that examinees from all age and ability ranges were included. Basal and ceiling rules for the tryout forms, where applicable, were set generously so that examiners administered more items than they would give in a typical WJ IV test session. This ensured that adequate data from appropriately able examinees would be obtained in the tryout study, even if some items were misplaced in difficulty order on the tryout test forms. At the completion of the tryout study, data were analyzed using Rasch analysis procedures. New items that did not meet minimum criteria for psychometric characteristics, such as item point-measure correlations and Rasch item fit indices, were dropped from further consideration from the item pools.

## Item Pool Calibration

Item pools for all untimed WJ IV tests were then Rasch-calibrated and scaled to the *W*-score metric. Most WJ IV tests contain items that are scored as either correct (1) or incorrect (0); the item pools for these tests were calibrated using the dichotomous Rasch model. The Writing Samples and Oral Reading tests in the WJ IV ACH battery are scored with multiple-point rubrics; the item pools from these tests were calibrated using the partial-credit form of the Rasch model (Wright & Masters, 1982). For WJ III tests included in the WJ IV tryout study, Rasch common-item equating procedures were used to estimate the difficulty of the newly developed test items relative to the difficulty of the items in the existing pools. The item *W* difficulties from the calibrated pools then informed the selection of items for the norming versions of the tests. Because the WJ IV timed tests were not assembled from item pools, those tests were not calibrated at this time. Rather, the norming versions of the timed tests comprised the full set of existing items for each test. The procedures used for calibration of the WJ IV timed tests are described later in this chapter.

# Norming Study

## Assembly of Norming Test Forms

Several guidelines informed the selection of items for the WJ IV norming tests. These guidelines are based on those employed during the development of prior editions of the test and also take into consideration the goals for the revision of the WJ IV outlined in Chapter 1 as well as empirical data gathered during the item development and tryout phases. Some of the test form construction guidelines were general to most tests, including the following:

- Items were selected to cover the range of difficulty for each test as outlined in the test battery specifications. For most tests, it was necessary for the norming form to include items that would be of average difficulty for 2- or 3-year-olds on the low end of the scale and items that would be appropriately challenging for bright adults on the high end of the scale.
- Items were selected to be approximately equally distributed along the *W* difficulty scale, with approximately 2 to 4 *W* points separating each item. Item difficulty values from the pool calibrations informed the selection and ordering of the items on each form.
- Items were selected so that content from one item would not cue examinees to the correct response for another item, both within and between tests.

In addition to the general guidelines, the following specific changes were made to the WJ III versions of some tests for the WJ IV norming, in keeping with the goals of the revision:

- In an effort to extend the difficulty range of several tests for adults with above-average ability, more difficult items were added at the end of some tests.
- Likewise, very easy items were added to several tests to extend the range of measurement for young children.
- For many timed tests, additional items were added to the test to reduce the number of examinees who would finish the test before the time limit.
- The norming versions of the Science, Social Studies, and Humanities tests in the WJ IV ACH battery were included as full-length, standalone tests rather than subtests.

For most tests, following these general and test-specific item selection guidelines resulted in norming forms that contained approximately 10% to 40% more items than were needed for the final WJ IV test forms. All test materials to be encountered by examinees during the norming study were produced in their final form. For example, the norming Test Book pages visible to the examinee contained the final artwork. For tests administered with an audio recording, all test items were recorded in the voice and presentation to be used in the final published test. The norming Test Records were designed as scannable documents to aid in data entry. The Test Records included space for examiners to write actual examinee responses as well as to provide feedback about the test administration for later analysis. Additionally, norming Test Records included space for examiners to note the item number reached at each minute of testing and the total testing time for all timed tests.

The basal and ceiling rules used for the administration of the norming forms generally required examiners to administer more items than would be administered using the final published basal and ceiling rules. The norming administration rules maximized the number of examinee responses to each item and ensured that each examinee would pass all items below the basal and fail all items above the ceiling.

## Norming Data Collection

The WJ IV norming study was conducted during the 25-month period beginning in December of 2009 and ending in January of 2012.[2] Norming data were scanned and quality-control checked when received from examiners. Specially trained project staff checked that all demographic information was entered on the Test Record, verified that examinee responses were accurately scored as correct or incorrect, hand entered examinees' responses from the Response Booklets, and scored the open-ended items in the Writing Samples test. Project staff also tallied item responses that were recorded by the examiners during the data collection; this information later informed the construction of the item keys for the published version of the tests.

Item and test data were analyzed at two intermediate points during the norming data collection. First, after approximately 1,500 norming cases had been gathered, the item data were Rasch-analyzed to check the psychometric characteristics of the items.[3] The results of this preliminary analysis informed minor modifications to some tests. Additionally, this preliminary Rasch analysis revealed gaps in the item difficulty hierarchy of several tests. It was determined that some additional item development and calibration would be necessary so the final WJ IV item pools would contain sufficient numbers of items to ensure the desired uniformity of item distribution across the *W* scale. New items were developed and piloted for several tests:

- Additional easy items were developed for Segmentation, Number Matrices, Sentence Repetition, and Sound Blending.
- Additional difficult items were developed for Passage Comprehension, Calculation, Writing Samples, Science, Social Studies, and Humanities.
- For Word Attack, approximately 50 new items were developed across the entire range of difficulty in anticipation of this test's move into the WJ IV ACH Standard battery, where three published forms would be required.

Additional test forms were assembled that contained the newly developed items. These forms were administered to approximately 1,000 additional examinees. Each examinee was first administered the norming form of the test, and then—if the newly developed items were appropriate for that examinee's specific age or ability range—the additional form of the test also was administered. This study design ensured adequate linkage between the norming items and the new items so that the new items could be placed onto the *W* scale of each test's item pool after the data collection was complete.

A second intermediate analysis of the norming data was conducted after approximately 3,500 cases had been gathered. The results of the second data analysis did not indicate the need for any additional item development.

## Calibration and Equating of Norming Study Data

At the completion of the norming study, data were analyzed using the dichotomous Rasch model for tests with items scored as correct/incorrect. The Rasch partial credit model was used to analyze data from tests containing items scored with multiple-point scoring rubrics. For all tests, data from the norming study were freely calibrated and item *W* difficulties were

[2] This section contains information about the collection of item-level data during the norming study. Chapter 3 contains detailed information about the examiner training, standardization procedures, and sampling methods used during the norming study and information about the development of the WJ IV norms.

[3] Preliminary structural analyses of the battery were also performed; these analyses are described in Chapter 5.

estimated. Extremely misfitting examinee responses were identified through an examination of the Rasch person fit indices and were removed from the item calibration analysis. Extremely unexpected, or "misfitting," responses contribute excessive noise to the data and can degrade the quality of the item calibrations (Linacre, 2002). For most tests, fewer than one tenth of 1% of the total examinee item responses were removed during the item calibration step.

For tests with existing item pools, the following Rasch common-anchor-item equating procedures (Kolen & Brennan, 2010; Linacre, 2012; Wolfe, 2004; and Wright & Stone, 1979) were used to place the items from the norming study onto the *W* scales underlying the item pools. The common-anchor-item equating was performed using the following steps:

1. *Identify stable linking items*. The *Standards for Educational and Psychological Testing* (AERA, APA, NCME, 2014) suggest that test developers "conduct periodic checks of the stability of the scale on which scores are reported" (p. 103). A change in the difficulty of an item over time or across administrations is referred to as *item parameter drift*. A review of the Rasch literature suggests that item parameter drift of .3 to .5 logits in simulation studies has little impact on examinee measurement (Wright & Douglas, 1975; Wright & Stone, 1979), especially if the drift is unidirectional (Babcock & Albano, 2012; Stahl & Muckle, 2007). Because the WJ IV norming study forms contained common linking items selected from the large precalibrated item pools in addition to the newly developed items, the norming item *W* difficulties for these linking items could be compared to the item difficulties from the earlier calibration of the item pool to assess the stability of the item difficulty estimates over time. For these common items, the freely estimated item *W* difficulty calibrations from the norming data were cross-plotted against the item *W* difficulty calibrations from the historical item pools. These plots revealed which items, if any, had significantly different relative difficulty locations (i.e., rank order) in the two data sets. For purposes of this analysis, a difference of roughly 5 *W* points (slightly more than .5 logits) or greater from the item pool calibration to the WJ IV norming calibration (on the scale of the item pool calibration) was considered significant item parameter drift. These items were removed from consideration as linking items for the equating run and were treated as new items in subsequent calibrations. In most tests, the items that were identified as displaying item parameter drift were approximately evenly distributed between positive and negative drift conditions.
2. *Run an anchored calibration on norming data*. After a stable set of common linking items was identified, the item pool *W* difficulties for these items were "anchored" to their item pool difficulty values in a WINSTEPS® (Linacre, 2012) analysis that included all the norming items. This resulted in item difficulty values for all norming items (including newly developed items) being on the *W* scale underlying the item pool.

## Calibration of Timed Tests

For all WJ IV timed tests,[4] a new item calibration procedure was employed that is based on the Rasch rating scale model (Andrich, 1978). The following two-step method was employed for calibrating the timed tests:

1. *Convert raw scores into a rate-based metric*. Examinee raw-score-per-minute data recorded by study examiners were used to convert each examinee's count of correct responses into separate, rate-based scores for each minute of testing time.

[4] *Timed tests* refers to tests or subtests that require examinees to provide responses (written or oral) under a timed administration procedure. In the WJ IV COG battery, the timed tests/subtests are Letter-Pattern Matching, Phonological Processing–Word Fluency, Number-Pattern Matching, and Pair Cancellation. In the WJ IV OL battery, the timed tests are Rapid Picture Naming and Retrieval Fluency. In the WJ IV ACH battery, the timed tests are Sentence Reading Fluency, Math Facts Fluency, Sentence Writing Fluency, and Word Reading Fluency.

2. *Obtain a Rasch difficulty estimate for each minute of testing.* These rate-based scores were analyzed using the Rasch rating scale model. This model is written as:

$$P_{nik} = \frac{e^{(B_n - (D_i + F_k))}}{1 + e^{(B_n - (D_i + F_k))}},\ k = 1, 2, \ldots m_i\,, \tag{2.5}$$

where $P_{nik}$ is the probability of examinee $n$ receiving a score in category $k$ for item $i$, $D_i$ is the difficulty of the $i$th item, and $F_k$ is the location of the category threshold, or the point where it is more probable that an examinee will receive a score in category $k$ than in category $k - 1$. In this application, each minute of testing time is treated as an item in the analysis; category thresholds are the locations on the *W* scale where a rate-based score of $k$ becomes more probable than a rate-based score of $k - 1$. For example, an examinee who took the Sentence Writing Fluency test had scores from seven "items," or minutes, and each score reflects the examinee's rate of correct response within that minute of testing.

The rate-based calibration method for the WJ IV timed tests inherently rewards examinees who work quickly and accurately; in fact, the method eliminates the need for the "bonus points" that were awarded to early-finishing examinees in the WJ III scoring algorithms. Additionally, the rate-based method inherently penalizes examinees who have responded quickly but not cautiously. Although these rate-based data from the WJ IV timed tests do not satisfy the local independence requirement of the Rasch model, the justifications for utilizing the Rasch model to analyze the rate-based data from the WJ IV timed tests outweigh the disadvantages of model violations (McGrew, Werder, & Woodcock, 1991). First, the method produces difficulty and ability estimates on the *W* scale, which can then be combined with *W* scores from other WJ IV tests to produce cluster composite scores. Second, the method discriminates examinees who work *accurately and quickly* from examinees who work accurately but not as quickly by awarding the former examinees higher *W* scores. Finally, the timed tests were calibrated using the data gathered on the WJ IV forms of the tests during the norming study; there are no item "pools" for these tests that would require equating to a common scale. Therefore, these tests do not rely on the test-free measurement property of the Rasch model. Instead, the model was used in this application to obtain ability estimates for the examinees from the norming study to be used in the development of the WJ IV test norms and to produce raw score-to-*W* score conversion tables for the published forms of the timed tests.[5]

## Calibration of Spanish Test Items

Item difficulties from the three Spanish-language tests appearing in the WJ IV OL battery are linked to the *W* scale underlying each corresponding English language test using Rasch

[5] Although the timed tests have been calibrated to the *W*-ability scale for practical reasons, users should be aware of several factors influencing the complexity of interpretation of *W* difference scores and relative proficiency indexes (RPIs) for these tests. The RPI is a criterion-referenced score that provides functional information regarding an examinee's performance. While norm-referenced scores such as standard scores and percentile rank scores describe an examinee's relative standing in a group, the RPI describes the quality of an examinee's performance on assessed skills and abilities compared to the performance of the examinee's age or grade peers in the norming sample. The RPI is determined by the *W* difference score, or the distance of an examinee's score from an age or grade reference point on the *W* scale (see Jaffe [2009] for a more detailed explanation of the RPI and its uses).

Because they provide a different level of information, the *W* difference score and RPI are not expected to have a linear relationship with norm-referenced metrics such as standard scores and percentile rank scores. In fact, depending on the distribution of the trait being measured by a test at a particular age or grade, the *W* difference score and RPI associated with a given standard score or percentile rank score could vary markedly across the age or grade range. This score divergence reflects differences in the growth rate of the trait underlying the test. In general, the examinee ability measures from the rate-based calibration methods used for the WJ IV timed tests show larger standard deviations across the age range than were shown by the timed tests in the WJ III. Additionally, because the new rate-based calibration method produces *W* scales that separate the examinees into many more levels of ability, the WJ IV timed tests have generally larger *SD*s than the untimed tests across the age range. Therefore, there may be a greater divergence between SS/PR scores and RPIs for the WJ IV timed tests, reflecting the sensitivity of the *W* difference scores and RPIs to the underlying growth rate.

common-item equating procedures (Wright & Stone, 1979).[6] These procedures relied on the use of the large Spanish-language item pools from the *Batería III Woodcock-Muñoz®* (Batería III) (Muñoz-Sandoval, Woodcock, McGrew, & Mather, 2004). The Spanish-language item pools contain data from between 400 and 1,100 examinees on between 60 and 110 items gathered during the development of the Batería III.[7] Many of the items in the Spanish-language item pools have reasonably direct counterparts in the calibrated English item pools (e.g., puppy/perro; Point to the bird./Señala el pajaro.); these items served as the common links between the two item pools. The Spanish item difficulties were linked to the English *W* scales using the following procedures:

1. *Calibrate the Spanish item pools*. The Spanish-language item data were Rasch calibrated, and *W* difficulty estimates for all Spanish items were obtained.
2. *Identify stable common linking items*. For each test, the separate Spanish and English item difficulties were cross-plotted. Extreme outliers, identified using a linear regression procedure, revealed items with very different relative *W* difficulty estimates in Spanish and English. These outlier items were removed from the common item linking set.
3. *Apply the scale transformation equation*. For each test, item *W* difficulty means (*M*s) and standard deviations (*SD*s) were computed for the subsets of common items from the Spanish and English item pools. Spanish item difficulty *W* values were then adjusted to the scale of the English WJ IV item pools using the following unit transformation equation:

$$D_{e'} = \frac{SD_e}{SD_s}(D_s - M_s) + M_e , \qquad (2.6)$$

where $D_{e'}$ is the item difficulty of any Spanish item transformed onto the English item difficulty scale, $SD_e$ is the standard deviation of the English common item difficulties, $SD_s$ is the standard deviation of the Spanish common item difficulties, $D_s$ is the difficulty of the Spanish item to be transformed, $M_s$ is the mean of the Spanish common item difficulties, and $M_e$ is the mean of the English common item difficulties. Application of this transformation equation placed the Spanish items onto the scale of the English WJ IV item pools.

## Item Bias Analyses

According to the Standards for Educational and Psychological Testing, "a prime threat to fair and valid interpretation of test scores comes from aspects of the test or testing process that may produce construct-irrelevant variance in scores that systematically lowers or raises scores for identifiable groups of test takers and results in inappropriate score interpretations for intended uses." (AERA, APA, NCME, 2014, p. 54). One such threat is bias in item difficulty, often referred to as *differential item functioning* or DIF. DIF occurs when an item is more difficult for a particular subgroup of examinees, even when the overall ability of those examinees is the same as other groups. For the WJ IV norming items, DIF was evaluated during item calibration using the Rasch iterative-logit method within the WINSTEPS software (Linacre, 2012). In this method, item difficulty calibrations, and their associated standard errors, are estimated for each item and each subgroup individually, while all other

[6] Wolfe (2004) terms this type of equating the "equating constants" method, while Linacre (2012) refers to it as the "Fahrenheit-Celsius" method. This method differs from the common-item-anchor equating design in that in the common-item method, the item difficulty parameters for each data set are estimated separately, and the difficulty measures from one set of items are then transformed onto the other scale *outside of the estimation process*.

[7] The *Batería III Woodcock-Muñoz* data sample included native Spanish speakers from outside the United States and monolingual, or near-monolingual, Spanish speakers from within the United States. Complete information about the sample and data gathering procedures for the Batería III can be found in the Batería III Examiner's Manuals.

item difficulty estimates (and examinee ability estimates) are held constant. The difference between the subgroup item difficulty estimates for each item, or the *DIF contrast*, can then be evaluated using Welch's $t$ statistic for the difference between two means (Linacre, 2012).

All norming items for all WJ IV tests, excluding the timed tests, were evaluated for evidence of DIF by sex, race, and ethnicity. The subgroups evaluated were *male* and *female* for sex, *White* and *non-White* for race, and *Hispanic* and *Not Hispanic* for ethnicity. Items were flagged if the DIF contrast between the two groups was at least 5 $W$ points[8] with a significant ($p < .05$)[9] $t$ test, regardless of the direction of the apparent bias. The percentage of flagged items for each subgroup contrast on each WJ IV untimed norming test are contained in Table 2-3.

***Table 2-3.***
*Percentage of Items Flagged for Potential DIF by Test and Subgroup*

| Test/Subtest Name | Total Number of Norming Items | Percentage of Items More Difficult for: Sex | | Race | | Ethnicity | | Median Percentage Flagged Items |
|---|---|---|---|---|---|---|---|---|
| | | Male | Female | White | Non-White | Not Hispanic | Hispanic | |
| Oral Vocabulary–Synonyms | 36 | 2.8% | 5.6% | 2.8% | 5.6% | 0.0% | 0.0% | 2.8% |
| Oral Vocabulary–Antonyms | 42 | 9.5% | 4.8% | 4.8% | 7.1% | 4.8% | 7.1% | 6.0% |
| Number Series | 45 | 4.4% | 0.0% | 2.2% | 4.4% | 2.2% | 4.4% | 3.3% |
| Verbal Attention | 52 | 1.9% | 0.0% | 1.9% | 0.0% | 0.0% | 7.7% | 1.0% |
| Phonological Processing–Word Access | 28 | 3.6% | 3.6% | 0.0% | 0.0% | 7.1% | 3.6% | 3.6% |
| Phonological Processing–Substitution | 18 | 0.0% | 0.0% | 5.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| Story Recall | 82 | 1.2% | 0.0% | 2.4% | 1.2% | 1.2% | 0.0% | 1.2% |
| Visualization–Spatial Relations | 24 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 4.2% | 0.0% |
| Visualization–Block Rotation | 18 | 5.6% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| General Information–Where | 34 | 14.7% | 17.6% | 5.9% | 11.8% | 0.0% | 2.9% | 8.8% |
| General Information–What | 34 | 11.8% | 5.9% | 8.8% | 5.9% | 2.9% | 5.9% | 5.9% |
| Concept Formation | 40 | 0.0% | 0.0% | 2.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| Numbers Reversed | 34 | 0.0% | 2.9% | 2.9% | 0.0% | 0.0% | 2.9% | 1.5% |
| Nonword Repetition | 46 | 0.0% | 0.0% | 2.2% | 2.2% | 0.0% | 0.0% | 0.0% |
| Visual-Auditory Learning | 109 | 0.0% | 0.0% | 0.0% | 0.0% | 0.9% | 0.9% | 0.0% |
| Picture Recognition | 24 | 4.2% | 4.2% | 0.0% | 4.2% | 0.0% | 4.2% | 4.2% |
| Analysis-Synthesis | 35 | 2.9% | 0.0% | 2.9% | 0.0% | 0.0% | 0.0% | 0.0% |
| Object-Number Sequencing | 31 | 0.0% | 0.0% | 3.2% | 0.0% | 0.0% | 3.2% | 0.0% |
| Memory for Words | 30 | 0.0% | 0.0% | 0.0% | 0.0% | 6.7% | 3.3% | 0.0% |
| Picture Vocabulary | 78 | 9.0% | 12.8% | 1.3% | 3.8% | 3.8% | 1.3% | 3.8% |
| Oral Comprehension | 44 | 9.1% | 6.8% | 9.1% | 4.5% | 2.3% | 4.5% | 5.7% |
| Segmentation | 37 | 0.0% | 0.0% | 0.0% | 0.0% | 2.7% | 5.4% | 0.0% |
| Sentence Repetition | 43 | 0.0% | 2.3% | 0.0% | 2.3% | 2.3% | 0.0% | 1.2% |
| Understanding Directions | 77 | 0.0% | 1.3% | 0.0% | 1.3% | 0.0% | 1.3% | 0.6% |
| Sound Blending | 42 | 0.0% | 0.0% | 0.0% | 7.1% | 2.4% | 7.1% | 1.2% |
| Sound Awareness–Rhyming | 22 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 4.5% | 0.0% |
| Sound Awareness–Deletion | 18 | 0.0% | 0.0% | 5.6% | 0.0% | 0.0% | 0.0% | 0.0% |

[8] A 5 $W$-point difference is equivalent to just over one half of a logit, which is a frequently cited criterion for evaluating DIF contrast within a Rasch framework (Draba, 1977; Paek & Wilson, 2011; Wright & Douglas, 1975).

[9] In a test of 20 items, one would expect one item to exhibit significant DIF by chance ($p < .05$, the Type I error rate). Several authors (Linacre, 2012; Wolfe et al., 2006) suggest the use of the Bonferroni correction to adjust for Type I error when performing multiple statistical tests. Because the purpose of this DIF analysis was exploratory—items exhibiting significant DIF contrast were not rejected outright but rather were flagged for further review—no correction was applied in these analyses. The numbers of pairwise $t$ tests in the analysis of DIF for each test suggests that some unbiased items were likely flagged; however, this potential overidentification was deemed acceptable for the purposes of this DIF study.

**Table 2-3.** *(cont.)*
*Percentage of Items Flagged for Potential DIF by Test and Subgroup*

| Test/Subtest Name | Total Number of Norming Items | Percentage of Items More Difficult for: Sex | | Race | | Ethnicity | | Median Percentage Flagged Items |
|---|---|---|---|---|---|---|---|---|
| | | Male | Female | White | Non-White | Not Hispanic | Hispanic | |
| Letter-Word Identification | 112 | 4.5% | 0.9% | 1.8% | 0.9% | 1.8% | 4.5% | 1.8% |
| Applied Problems | 89 | 0.0% | 0.0% | 3.4% | 0.0% | 1.1% | 4.5% | 0.6% |
| Spelling | 98 | 1.0% | 5.1% | 3.1% | 4.1% | 4.1% | 7.1% | 4.1% |
| Passage Comprehension | 69 | 4.3% | 4.3% | 0.0% | 1.4% | 1.4% | 0.0% | 1.4% |
| Calculation | 63 | 6.3% | 4.8% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Writing Samples | 27 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 3.7% | 0.0% |
| Word Attack | 57 | 5.3% | 1.8% | 0.0% | 3.5% | 5.3% | 1.8% | 2.6% |
| Oral Reading | 96 | 0.0% | 1.0% | 0.0% | 1.0% | 2.1% | 1.0% | 1.0% |
| Reading Recall | 101 | 4.0% | 0.0% | 0.0% | 0.0% | 2.0% | 1.0% | 0.5% |
| Number Matrices | 32 | 3.1% | 3.1% | 3.1% | 0.0% | 3.1% | 12.5% | 3.1% |
| Editing | 50 | 2.0% | 0.0% | 8.0% | 6.0% | 2.0% | 2.0% | 2.0% |
| Spelling of Sounds | 34 | 0.0% | 0.0% | 5.9% | 2.9% | 0.0% | 0.0% | 0.0% |
| Reading Vocabulary–Synonyms | 39 | 5.1% | 2.6% | 5.1% | 2.6% | 0.0% | 2.6% | 2.6% |
| Reading Vocabulary–Antonyms | 40 | 5.0% | 7.5% | 5.0% | 10.0% | 2.5% | 5.0% | 5.0% |
| Science | 48 | 8.3% | 8.3% | 0.0% | 2.1% | 2.1% | 6.3% | 4.2% |
| Social Studies | 41 | 7.3% | 12.2% | 7.3% | 7.3% | 4.9% | 4.9% | 7.3% |
| Humanities | 29 | 13.8% | 20.7% | 3.4% | 6.9% | 10.3% | 6.9% | 8.6% |
| **Median Percentage Flagged Items** | | 2.4% | 1.0% | 2.2% | 1.3% | 1.3% | 3.1% | |

The percentage of flagged items for sex ranges from 0% to 20.7%, for race from 0% to 11.8%, and for ethnicity from 0% to 12.5%. Across all tests in the DIF analysis, the median percentage of total items flagged was slightly higher for males (2.4%) than females (1.0%), slightly higher for White (2.2%) than non-White (1.3%) examinees, and slightly higher for Hispanic (3.1%) than Not Hispanic (1.3%) examinees. As expected, tests that draw upon stores of acquired knowledge (the *Gc* tests; i.e., the WJ IV COG Oral Vocabulary and General Information tests, the WJ IV OL Picture Vocabulary and Oral Comprehension tests, and the WJ IV ACH Reading Vocabulary, Science, Social Studies, and Humanities tests) contained the highest numbers of flagged items, while the tests measuring fluid reasoning (*Gf*) and visual processing (*Gv*) generally had the lowest number of flagged items across subgroups. The largest percentage of items flagged for potential DIF in Table 2-3 were for sex subgroups on the *Gc* tests.

All flagged items were carefully reviewed by the test authors to identify possible sources of bias. In some cases, explanations for subgroup calibration differences were easily identified. For example, in the General Information–Where subtest, the item "Where would you find a carburetor?" was 5.52 *W* points easier for males in the norming sample ($t = 3.58$, $p < .01$), while the item "Where would you find a recipe?" was 5.03 *W* points easier for females ($t = 2.24$, $p < .05$). These examples of sex-based DIF are not unexpected, given traditional cultural gender roles. In other cases, the apparent bias in flagged items was not easily explained through consideration of the items' content within gender, racial, and ethnic cultural contexts. For some of these flagged items, a review of the item data revealed very low counts, especially from the non-White and Hispanic subgroups, for raw scores of 0 on the easiest test items and raw scores of 1 on the most difficult test items. An examination of the person-by-item residuals (Wright, Mead, & Draba, 1976) for each response on these items suggests that many of the items were flagged simply because of a small number of extremely unexpected responses to those items by examinees of one subgroup.

In most cases, flagged items were removed from consideration for the publication forms of the WJ IV. In a few rare cases where item pool depth did not allow for the removal of an item, flagged items were included on final WJ IV test forms only if the apparent DIF could not be explained by the item's content and if the flag appeared to be the result of one or more extremely unexpected (i.e., misfitting) examinee responses.

## Post-Norming Item Revisions

Empirical and qualitative data gathered during the norming study prompted some modifications of individual test items. Item scoring rubrics for Writing Samples were simplified so that the easiest items are now scored as correct or incorrect and the more difficult items are scored as either 0, 1, or 2 points. Similarly, the item scoring rules for the Visualization–Spatial Relations subtest, Picture Recognition, Object-Number Sequencing, and Sentence Repetition tests were simplified (from their multiple point scoring in the WJ III) so that all items are now scored as either correct or incorrect. Prior to assembly of the final test forms, all items from these tests were recalibrated to obtain new item difficulties based on the simplified scoring system.

For some tests, such as Oral Vocabulary and General Information, the correct and incorrect keys accompanying the test items provided the examiners with guides for scoring the item responses during the norming study. Frequently during the norming, however, an examinee would provide a response that could not be scored as correct or incorrect without obtaining further information. The query key provides the examiner with further prompts to elicit another response from the examinee. During the norming study, examiners were instructed to record hard-to-score examinee responses verbatim. These responses were then tallied by project staff at the completion of the study. Project staff made the final scoring decisions on such responses; if necessary, those items were rescored and the items' difficulty values were reestimated. Analysis of these tallied responses were the primary resource for preparing the final correct, incorrect, and query keys for the publication forms.

## Assembly and Evaluation of Final Test Forms

After all test items had been placed onto the item pools' underlying *W* scales, publication forms were assembled for all WJ IV tests. For many tests, such as Concept Formation, Analysis-Synthesis, Visual-Auditory Learning, Numbers Reversed, and all of the timed tests and subtests, the publication forms of the tests were identical to the norming forms. For tests that were assembled from item pools, the same general principles of test construction that were used in the assembly of the norming test forms also were used to select items for the publication forms. A common guideline across all WJ IV tests is that items should be evenly distributed across the *W*-score range of the test, with approximately three to four items per 10 *W* points. This guideline was generally followed in the WJ IV test construction; however, the specific item task requirements of some tests precluded an even distribution of item difficulties across the *W*-score range. For instance, a logical shift in the progression of task requirements between Items 6 and 9 in the Word Attack test resulted in an item difficulty order that was nonmonotonically increasing in that range. Other generally accepted rules of test construction—such as that item content should not cue the correct responses to any other items and that selected items should have acceptable Rasch fit statistics—also were followed in the selection of items for the publication forms.

For the WJ IV ACH Standard Battery tests, three publication forms—A, B, and C—of each test were constructed. Information about the specific guidelines for the assembly of the WJ IV ACH Standard Battery tests, and their equivalence, is contained in Chapter 4. The Spanish-language forms of the WJ IV Oral Comprehension (Comprensión oral) and Understanding Directions (Comprensión de indicaciones) tests were the same as or similar to versions of the test that appeared in the *Batería III Woodcock-Muñoz* (Muñoz-Sandoval et al., 2004). The Spanish-language form of the WJ IV Picture Vocabulary test (Vocabulario sobre dibujos), in contrast, was constructed from the calibrated Spanish-language item pool for that test.

The Sentence Writing Fluency test was shortened from 7 minutes to 5 minutes in the publication version. Analysis of the norming data under the new rate-based calibration procedures for the timed tests revealed that reliable examinee ability estimates for Sentence Writing Fluency could be obtained in a 5-minute testing period; no significant improvement in the precision of the examinee ability scores was realized in the last 2 minutes of the test during norming administration. Feedback from WJ III examiners and WJ IV norming study examiners also supported the shortened time limit for this test as a means to minimize examinee fatigue and allow more efficient use of testing time.

## Test Accommodation and Adaptation Design Considerations

During the design and development of the WJ IV tests, special effort was made to consider the unique needs of individuals with various types of disabilities, such as vision impairment, hearing impairment, or motor delays; individuals from diverse linguistic backgrounds; and individuals of different ages. To ensure that the WJ IV tests are accessible to as many examinees as possible, some general best-practice universal design principles were followed. These include, but are not limited to the following:

- Test instructions are written in clear, concise language without high vocabulary demands, making them appropriate for young children and individuals who are English language learners.
- Examinee stimulus artwork, such as pictures and text, is printed with bold colors and/or lines, increasing its accessibility for visually impaired individuals.
- Where possible without reducing the construct relevance of the test (e.g., on Applied Problems), items are written in clear, simple language to minimize the language load. This makes the test item content more accessible to individuals with certain types of learning disabilities.
- The WJ IV selective testing procedure allows tests to be administered in any order, which provides flexibility for frequent breaks, for planned shifts in task types, or for testing to be broken down into several sessions. This design feature is especially beneficial for individuals with attention, behavior, physical, or sensory impairments.

In addition to these general design guidelines, the WJ IV authors solicited input from several experts who have experience working with individuals with disabilities or from diverse linguistic backgrounds. These experts reviewed the WJ IV tests and provided information about how the tests might be made more accessible. Their suggestions were incorporated into the design of the tests and items whenever possible if the design changes did not interfere with the measured construct. Additionally, these experts provided information about the types of test accommodations that are appropriate when testing individuals with disabilities, individuals from diverse linguistic backgrounds, and individuals of different ages. These accommodations, as well as cautions for interpreting the WJ IV test scores when accommodations are used, are documented in Chapter 3 of each WJ IV Examiner's Manual.

*Chapter 3*

# Standardization and Norm Development Procedures for the WJ IV

This chapter contains information on the *Woodcock-Johnson IV* (WJ IV) (Schrank, McGrew, & Mather, 2014a) norming study and the calculation of the norm-based scores for all WJ IV tests and clusters. Following the recommendations outlined in the *Standards for Educational and Psychological Testing* (American Educational Research Association [AERA], American Psychological Association [APA], & National Council on Measurement in Education [NCME], 2014), this chapter provides a description of the norming study sample and its representativeness of the U.S. population, the processes followed to gather the norming data, and the statistical methods used to derive the norm-based scores. The information in this chapter serves as evidence supporting the proposition that the WJ IV norm-based scores can be used to describe an examinee's cognitive abilities, oral language abilities, and achievement relative to the U.S. population and that the WJ IV scores are accurate measures of these abilities from preschool through the geriatric age.

## General Characteristics of the Norming Sample

Adequate selection and measurement of a norming sample is one of the more difficult, yet crucial, tasks in the development of a test. The *Standards for Educational and Psychological Testing* (AERA, APA, NCME, 2014) state, "The validity of norm-referenced interpretations depends in part on the appropriateness of the reference group to which test scores are compared" (p. 97).

The WJ IV norming study was conducted between December 2009 and January 2012. During this 25-month period, data were collected from 7,416 individuals from geographically diverse communities representing 46 U.S. states and the District of Columbia. The preschool sample was composed of 664 children ages 2 through 5 years who were not enrolled in kindergarten. The kindergarten through 12th-grade sample contained 3,891 examinees. The college/university sample was composed of 775 undergraduate and graduate students. The adult sample contained 2,086 examinees. Table 3-1 displays the distribution of the norming sample by age and by grade. The higher density of examinees in the school-age population reflects the need to collect more concentrated data on examinees during the period of time when the abilities measured by the WJ IV undergo the greatest rate of growth.

***Table 3-1.***
*Distribution of the WJ IV Norming Sample by Age and Grade*

| Age | Number | Grade | Number |
|---|---|---|---|
| 2 | 173 | Kindergarten | 308 |
| 3 | 203 | 1 | 334 |
| 4 | 223 | 2 | 303 |
| 5 | 205 | 3 | 312 |
| 6 | 308 | 4 | 327 |
| 7 | 310 | 5 | 328 |
| 8 | 336 | 6 | 330 |
| 9 | 306 | 7 | 294 |
| 10 | 314 | 8 | 313 |
| 11 | 329 | 9 | 289 |
| 12 | 317 | 10 | 269 |
| 13 | 307 | 11 | 256 |
| 14 | 299 | 12 | 228 |
| 15 | 277 | | |
| 16 | 284 | College and University | |
| 17 | 254 | 13 | 205 |
| 18 | 276 | 14 | 190 |
| 19 | 295 | 15 | 104 |
| 20–29 | 759 | 16 | 104 |
| 30–39 | 492 | 17+ (graduate students) | 172 |
| 40–49 | 462 | | |
| 50–59 | 274 | | |
| 60–69 | 164 | | |
| 70–79 | 132 | | |
| 80+ | 117 | | |
| **Total** | 7,416 | **Total** | 4,666 |

The norming sample was selected to be representative, within practical limits, of the U.S. population from ages 24 months to 90 years and older. Examinees were randomly selected within a stratified sampling design that controlled for the following community and examinee variables:

- *Census region*—Northeast, Midwest, South, West
- *Sex*—male, female
- *Country of birth*—United States, other
- *Race*—White; Black; American Indian or Alaska Native (AIANAT); Asian, Native Hawaiian, or Other Pacific Islander (ASIPAC); Other
- *Ethnicity*—Hispanic, Not Hispanic
- *Community type* (preschool, K–12, and adult samples only)—Metropolitan (areas with population ≥ 50,000 plus adjacent outlying counties), Micropolitan (areas with population between 10,000 and 49,999 plus adjacent outlying counties), Rural (population < 10,000)
- *Parent education* (preschool and K–12 samples only)—less than high school diploma, high school diploma, greater than high school diploma
- *Type of school* (K–12 sample only)—public, private, home
- *Type of college*—public 2-year, public 4-year, private 2-year, private 4-year
- *Educational attainment* (adult sample only)—less than 9th grade, less than high school diploma, high school diploma, 1 to 3 years of college, Bachelor's degree, Master's degree or higher
- *Employment status* (adult sample only)—employed, unemployed, not in the labor force

- *Occupational level of adults in the labor force*—management/professional; service occupations; sales and office occupations; natural resources, construction, and maintenance occupations; production, transportation, and material moving occupations

Tables 3-2 through 3-5 contain the sampling variables and their distribution, both in the U.S. population according to the 2010 census projections and in the WJ IV norming sample. This information is included for the major levels of the norming sample (preschool, Kindergarten through grade 12, college, and adult); the examinees in the college sample also were included in the adult sample. All variables were not relevant at all levels of the norming sample. For example, occupational information was applied only to the adult sample, and type of college was applied only to the college sample. The race and ethnicity variables are not orthogonal (i.e., the distribution of race is not the same within both categories of the ethnicity variable in the U.S. population), so these two variables were combined for all sampling groups. Additionally, the variables sex, country of birth, and educational attainment for the adult sample were stratified by age (see Table 3-5), because the distribution of the variables varies with age. For example, it is well known that the ratio of males to females changes as the population gets older.

***Table 3-2.***
*Distribution of Sampling Variables in the U.S. Population and in the WJ IV Norming Sample–Preschool*

| Sampling Variable | Percentage in U.S. Population | Number Obtained | Percentage in Norm Sample | Partial Examinee Weight |
|---|---|---|---|---|
| **Census Region** | | | | |
| Northeast | 15.6 | 113 | 17.0 | 0.914 |
| Midwest | 21.5 | 167 | 25.2 | 0.854 |
| South | 37.2 | 219 | 33.0 | 1.127 |
| West | 25.8 | 165 | 24.8 | 1.038 |
| **Community Type** | | | | |
| Metropolitan | 83.7 | 551 | 83.0 | 1.008 |
| Micropolitan | 10.0 | 86 | 13.0 | 0.774 |
| Rural | 6.3 | 27 | 4.1 | 1.552 |
| **Sex** | | | | |
| Male | 51.1 | 332 | 50.0 | 1.022 |
| Female | 48.9 | 332 | 50.0 | 0.970 |
| **Country of Birth** | | | | |
| United States | 98.7 | 661 | 99.5 | 0.992 |
| Other | 1.3 | 3 | 0.5 | 2.809 |
| **Race/Ethnicity** | | | | |
| White, Not Hispanic | 63.7 | 427 | 64.3 | 0.975 |
| Black, Not Hispanic | 12.5 | 96 | 14.5 | 0.852 |
| AIANAT, Not Hispanic | —[a] | — | — | — |
| ASIPAC, Not Hispanic | 5.2 | 23 | 3.5 | 1.483 |
| Other, Not Hispanic | —[a] | 2 | 0.3 | 1.000[b] |
| White, Hispanic | 16.6 | 102 | 15.4 | 1.067 |
| Black, Hispanic | 0.7 | 4 | 0.6 | 1.138 |
| AIANAT, Hispanic | 0.3 | 1 | 0.2 | 1.894 |
| ASIPAC, Hispanic | 0.2 | 1 | 0.2 | 1.131 |
| Other, Hispanic | —[a] | 8 | 1.2 | 1.000[b] |
| **Parent Education** | | | | |
| < High School | 13.9 | 94 | 14.2 | 0.984 |
| High School | 23.6 | 181 | 27.3 | 0.865 |
| > High School | 62.5 | 389 | 58.6 | 1.067 |

[a] No reliable population information could be obtained.

[b] Null partial weights of 1.000 were assigned to cells for which reliable population information could not be obtained or for which the sample counts were so low that they inappropriately skewed examinees' overall weights.

***Table 3-3.***
*Distribution of Sampling Variables in the U.S. Population and in the WJ IV Norming Sample–Grades K Through 12*

| Sampling Variable | Percentage in U.S. Population | Number Obtained | Percentage in Norm Sample | Partial Examinee Weight |
|---|---|---|---|---|
| **Census Region** | | | | |
| Northeast | 17.4 | 652 | 16.8 | 1.039 |
| Midwest | 21.8 | 991 | 25.5 | 0.854 |
| South | 37.2 | 1,246 | 32.0 | 1.163 |
| West | 23.6 | 1,002 | 25.8 | 0.916 |
| **Community Type** | | | | |
| Metropolitan | 83.7 | 3,323 | 85.4 | 0.980 |
| Micropolitan | 10.0 | 372 | 9.6 | 1.048 |
| Rural | 6.3 | 196 | 5.0 | 1.253 |
| **Sex** | | | | |
| Male | 51.0 | 1,924 | 49.4 | 1.032 |
| Female | 49.0 | 1,967 | 50.6 | 0.969 |
| **Country of Birth** | | | | |
| United States | 95.0 | 3,802 | 97.7 | 0.972 |
| Other | 5.0 | 88 | 2.3 | 2.209 |
| **Race/Ethnicity** | | | | |
| White, Not Hispanic | 63.7 | 2,460 | 63.2 | 0.984 |
| Black, Not Hispanic | 12.5 | 537 | 13.8 | 0.886 |
| AIANAT, Not Hispanic | 0.8 | 21 | 0.5 | 1.446 |
| ASIPAC, Not Hispanic | 5.2 | 164 | 4.2 | 1.209 |
| Other, Not Hispanic | —[a] | 7 | 0.2 | 1.000[b] |
| White, Hispanic | 16.6 | 591 | 15.2 | 1.071 |
| Black, Hispanic | 0.7 | 12 | 0.3 | 2.205 |
| AIANAT, Hispanic | 0.3 | 6 | 0.2 | 1.835 |
| ASIPAC, Hispanic | 0.2 | 11 | 0.3 | 0.598 |
| Other, Hispanic | —[a] | 82 | 2.1 | 1.000[b] |
| **Parent Education** | | | | |
| < High School | 13.7 | 502 | 12.9 | 1.060 |
| High School | 22.7 | 1,179 | 30.3 | 0.747 |
| > High School | 63.6 | 2,198 | 56.5 | 1.122 |
| **School Type** | | | | |
| Public | 85.7 | 3,483 | 89.5 | 0.957 |
| Private | 11.4 | 314 | 8.1 | 1.413 |
| Home | 2.9 | 92 | 2.4 | 1.227 |

[a] No reliable population information could be obtained.

[b] Null partial weights of 1.000 were assigned to cells for which reliable population information could not be obtained or for which the sample counts were so low that they inappropriately skewed examinees' overall weights.

**Table 3-4.**
*Distribution of Sampling Variables in the U.S. Population and in the WJ IV Norming Sample–College and University*

| Sampling Variable | Percentage in U.S. Population | Number Obtained | Percentage in Norm Sample | Partial Examinee Weight |
|---|---|---|---|---|
| **Census Region** | | | | |
| Northeast | 17.9 | 149 | 19.2 | 0.931 |
| Midwest | 21.7 | 157 | 20.3 | 1.069 |
| South | 37.1 | 242 | 31.2 | 1.189 |
| West | 23.3 | 227 | 29.3 | 0.796 |
| **Sex** | | | | |
| Male | 43.0 | 347 | 44.8 | 0.961 |
| Female | 57.0 | 428 | 55.2 | 1.031 |
| **Country of Birth** | | | | |
| United States | 87.6 | 738 | 95.2 | 0.920 |
| Other | 12.4 | 37 | 4.8 | 2.604 |
| **Race/Ethnicity** | | | | |
| White, Not Hispanic | 63.7 | 524 | 67.6 | 0.928 |
| Black, Not Hispanic | 12.5 | 108 | 13.9 | 0.885 |
| AIANAT, Not Hispanic | 0.8 | 4 | 0.5 | 1.525 |
| ASIPAC, Not Hispanic | 5.2 | 31 | 4.0 | 1.285 |
| Other, Not Hispanic | —[a] | 1 | 0.1 | 1.000[b] |
| White, Hispanic | 16.6 | 92 | 11.9 | 1.382 |
| Black, Hispanic | 0.7 | 3 | 0.4 | 1.773 |
| AIANAT, Hispanic | 0.0 | 1 | 0.1 | 2.212 |
| ASIPAC, Hispanic | 0.2 | 1 | 0.1 | 1.322 |
| Other, Hispanic | —[a] | 10 | 1.3 | 1.000[b] |
| **College Type** | | | | |
| Public 2-Year | 34.3 | 164 | 22.2 | 1.548 |
| Private 2-Year | 2.2 | 3 | 0.4 | 5.425 |
| Public 4-Year | 37.7 | 333 | 45.1 | 0.837 |
| Private 4-Year | 25.7 | 239 | 32.3 | 0.796 |

[a] No reliable population information could be obtained.

[b] Null partial weights of 1.000 were assigned to cells for which reliable population information could not be obtained or for which the sample counts were so low that they inappropriately skewed examinees' overall weights.

***Table 3-5.***
*Distribution of Sampling Variables in the U.S. Population and in the WJ IV Norming Sample–Adults*

| Sampling Variable | Percentage in U.S. Population | Number Obtained | Percentage in Norm Sample | Partial Examinee Weight |
|---|---|---|---|---|
| **Census Region** | | | | |
| Northeast | 17.9 | 513 | 17.9 | 0.998 |
| Midwest | 21.7 | 665 | 23.2 | 0.931 |
| South | 37.1 | 902 | 31.5 | 1.178 |
| West | 23.3 | 781 | 27.3 | 0.854 |
| **Community Type** | | | | |
| Metropolitan | 83.7 | 2,445 | 85.5 | 0.979 |
| Micropolitan | 10.0 | 289 | 10.1 | 0.992 |
| Rural | 6.3 | 127 | 4.4 | 1.422 |
| **Sex** | | | | |
| **18–24 years** | | | | |
| Male | 51.0 | 397 | 45.4 | 1.122 |
| Female | 49.0 | 477 | 54.6 | 0.898 |
| **25–44 years** | | | | |
| Male | 50.5 | 512 | 47.3 | 1.067 |
| Female | 49.5 | 571 | 52.7 | 0.940 |
| **45–64 years** | | | | |
| Male | 48.8 | 262 | 44.0 | 1.111 |
| Female | 51.2 | 334 | 56.0 | 0.913 |
| **65+ years** | | | | |
| Male | 43.9 | 153 | 49.8 | 1.119 |
| Female | 56.1 | 154 | 50.2 | 0.880 |
| **Country of Birth** | | | | |
| **Under 20 Years** | | | | |
| United States | 93.2 | 445 | 96.5 | 0.965 |
| Other | 6.8 | 16 | 3.5 | 1.962 |
| **20–29 Years** | | | | |
| United States | 86.2 | 713 | 93.9 | 0.917 |
| Other | 13.8 | 46 | 6.1 | 2.283 |
| **30–39 Years** | | | | |
| United States | 78.4 | 450 | 91.5 | 0.858 |
| Other | 21.6 | 42 | 8.5 | 2.526 |
| **40–49 Years** | | | | |
| United States | 81.9 | 425 | 92.0 | 0.890 |
| Other | 18.1 | 37 | 80.0 | 2.265 |
| **50–59 Years** | | | | |
| United States | 86.7 | 249 | 90.9 | 0.955 |
| Other | 13.3 | 25 | 9.1 | 1.454 |
| **60–69 Years** | | | | |
| United States | 87.9 | 151 | 92.1 | 0.955 |
| Other | 12.1 | 13 | 7.9 | 1.528 |
| **70+ Years** | | | | |
| United States | 88.1 | 227 | 91.2 | 0.967 |
| Other | 11.9 | 22 | 8.8 | 1.342 |

***Table 3-5.*** *(cont.)*
*Distribution of Sampling Variables in the U.S. Population and in the WJ IV Norming Sample–Adults*

| Sampling Variable | Percentage in U.S. Population | Number Obtained | Percentage in Norm Sample | Partial Examinee Weight |
|---|---|---|---|---|
| **Race/Ethnicity** | | | | |
| White, Not Hispanic | 63.7 | 1,926 | 67.3 | 0.935 |
| Black, Not Hispanic | 12.5 | 401 | 14.0 | 0.882 |
| AIANAT, Not Hispanic | 0.8 | 21 | 0.7 | 1.075 |
| ASIPAC, Not Hispanic | 5.2 | 106 | 3.7 | 1.391 |
| Other, Not Hispanic | —[a] | 2 | 0.1 | 1.000[b] |
| White, Hispanic | 16.6 | 359 | 12.5 | 1.310 |
| Black, Hispanic | 0.7 | 6 | 0.2 | 3.279 |
| AIANAT, Hispanic | 0.3 | 3 | 0.1 | 2.729 |
| ASIPAC, Hispanic | 0.2 | 5 | 0.2 | 0.978 |
| Other, Hispanic | —[a] | 32 | 1.1 | 1.000[b] |
| **Employment Status** | | | | |
| Employed | 58.4 | 1,705 | 59.6 | 0.980 |
| Unemployed | 5.7 | 292 | 10.2 | 0.562 |
| Not in Labor Force | 35.9 | 864 | 30.2 | 1.188 |
| **Occupational Level** | | | | |
| Management/Professional | 37.6 | 750 | 43.9 | 0.855 |
| Service | 17.7 | 330 | 19.3 | 0.917 |
| Sales/Office | 23.6 | 443 | 26.0 | 0.911 |
| Natural Resources/ Construction/Maintenance | 9.3 | 80 | 4.7 | 1.985 |
| Production/Transportation/ Material Moving | 11.8 | 104 | 6.1 | 1.932 |
| **Educational Attainment** | | | | |
| **18–19 Years** | | | | |
| < 9th Grade | 1.7 | 1 | 0.2 | 1.000[b] |
| < High School | 42.0 | 31 | 6.7 | 6.171 |
| High School | 26.0 | 234 | 50.9 | 0.506 |
| Some College | 30.0 | 190 | 41.3 | 0.720 |
| Bachelor's Degree | 0.3 | — | — | — |
| Master's Degree or Higher | — | — | — | — |
| **20–29 Years** | | | | |
| < 9th Grade | 2.5 | 2 | 0.3 | 1.000[b] |
| < High School | 8.2 | 49 | 6.5 | 1.269 |
| High School | 28.1 | 87 | 11.5 | 2.442 |
| Some College | 38.6 | 368 | 48.5 | 0.794 |
| Bachelor's Degree | 18.7 | 157 | 20.7 | 0.901 |
| Master's Degree or Higher | 3.8 | 93 | 12.3 | 0.309 |
| **30–39 Years** | | | | |
| < 9th Grade | 4.1 | 3 | 0.6 | 1.000[b] |
| < High School | 6.9 | 63 | 12.8 | 0.539 |
| High School | 26.9 | 162 | 32.9 | 0.817 |
| Some College | 27.8 | 61 | 12.4 | 2.239 |
| Bachelor's Degree | 22.6 | 89 | 18.1 | 1.252 |
| Master's Degree or Higher | 11.7 | 114 | 23.2 | 0.506 |

**Table 3-5.** *(cont.)*
*Distribution of Sampling Variables in the U.S. Population and in the WJ IV Norming Sample–Adults*

| Sampling Variable | Percentage in U.S. Population | Number Obtained | Percentage in Norm Sample | Partial Examinee Weight |
|---|---|---|---|---|
| **Educational Attainment** | | | | |
| **40–49 Years** | | | | |
| < 9th Grade | 4.0 | 2 | 0.4 | 1.000[b] |
| < High School | 6.8 | 50 | 10.8 | 0.630 |
| High School | 30.0 | 180 | 39.0 | 0.770 |
| Some College | 27.0 | 53 | 11.5 | 2.352 |
| Bachelor's Degree | 20.9 | 88 | 19.0 | 1.098 |
| Master's Degree or Higher | 11.3 | 89 | 19.3 | 0.586 |
| **50–59 Years** | | | | |
| < 9th Grade | 4.0 | 3 | 1.1 | 1.000[b] |
| < High School | 6.4 | 31 | 11.3 | 0.562 |
| High School | 31.8 | 88 | 32.1 | 0.989 |
| Some College | 27.3 | 51 | 18.6 | 1.469 |
| Bachelor's Degree | 19.2 | 44 | 16.1 | 1.196 |
| Master's Degree or Higher | 11.3 | 57 | 20.8 | 0.544 |
| **60–64 Years** | | | | |
| < 9th Grade | 4.6 | 1 | 0.9 | 1.000[b] |
| < High School | 6.0 | 14 | 13.2 | 0.458 |
| High School | 30.7 | 32 | 30.2 | 1.018 |
| Some College | 27.4 | 22 | 20.8 | 1.321 |
| Bachelor's Degree | 17.6 | 17 | 16.0 | 1.097 |
| Master's Degree or Higher | 13.6 | 20 | 18.9 | 0.720 |
| **65 Years+** | | | | |
| < 9th Grade | 9.8 | 11 | 3.6 | 1.000[b] |
| < High School | 9.6 | 26 | 8.5 | 1.131 |
| High School | 36.3 | 110 | 35.8 | 1.013 |
| Some College | 21.1 | 67 | 21.8 | 0.968 |
| Bachelor's Degree | 12.8 | 44 | 14.3 | 0.892 |
| Master's Degree or Higher | 10.4 | 49 | 16.0 | 0.651 |

[a] No reliable population information could be obtained.

[b] Null partial weights of 1.000 were assigned to cells for which reliable population information could not be obtained or for which the sample counts were so low that they inappropriately skewed examinees' overall weights.

The demographic characteristics of the sample were carefully tracked during the norming study to ensure that the distributions of each demographic characteristic in the sample matched those in the U.S. population as closely as possible. The population and sample percentages in Tables 3-2 through 3-5 show a close match for most sampling variables; however, to ensure that the WJ IV norms are representative of the exact demographic distributions in the U.S. population, examinee weighting was used. The examinee weighting procedures are described in the norms construction section later in this chapter.

# Norming Study Procedures

Most norming study data were collected by trained professional examiners. At the outset of the study, project staff at Riverside recruited examiners via e-mail and postcard mailing targeted to *Woodcock-Johnson III* (WJ III) (Woodcock, McGrew, & Mather, 2001) customer databases, the member database from the National Association of School Psychologists, and individuals designated as school psychologists in a subscription-based educational database.

All professional WJ IV norming examiners completed a 5-hour online training course consisting of test-by-test video modules with embedded practice exercises and summative quiz questions. Examiners were required to achieve a minimum passing score on each end-of-module quiz to be approved for participation. After completion of online training, each examiner completed three practice test administrations. Practice administration protocols were reviewed by project staff to ensure that examiners were proficient in administration and scoring of all norming tests. Project staff at Riverside provided feedback to examiners on any issues or concerns that were noted on the three practice cases.

After the three practice cases were approved, examiners were permitted to begin recruiting and testing norming study participants. All examiners were provided access to the WJ IV project website, which allowed them to search for available norming cases by region, age, and other demographic characteristics. When an examiner identified a potential norming study participant, the examiner could search the WJ IV project website to determine if the potential examinee met the requirements of the WJ IV norming sampling plan. If a match was identified, the examiner "reserved" the case, administered the norming test to the norming study participant, and submitted the completed protocol to Riverside. Project staff reviewed all submitted protocols for completion and accuracy of administration procedures (e.g., adherence to basal and ceiling rules and administration of the appropriate tests for the examinee's age). Approved protocols were scanned and item data were added to the master norming data files.

Throughout the norming study, project staff continuously monitored the sample acquisition to ensure adherence to the demographic variable distributions of the sampling plan. Certain demographic subgroups (i.e., adult examinees with less than high school education and examinees from rural communities) were generally more difficult to locate and recruit for participation. To overcome this challenge, two additional approaches to sample acquisition were initiated approximately halfway through the norming study. First, a market research firm was retained to assist in identifying potential examinees with specific demographic characteristics. Second, additional paraprofessional examiners were recruited and trained to accommodate the influx of potential examinees identified by the market research firm.

Paraprofessional examiners were recruited via postings on job boards and websites in targeted locations through the United States. Qualified paraprofessional examiners had a bachelor's degree in education or a related field but were not required to have experience administering clinical assessments. All paraprofessional examiners completed a 1-week, in-person training program on WJ IV test administration. After completion of the in-person training, paraprofessional examiners were required to complete the online training program, obtain a minimal passing score on each summative quiz, and submit three practice cases for review and approval before they were allowed to gather norming data.

## Planned Incomplete Data Collection Design

It was not practical for all WJ IV norming study participants to be administered all 51 tests (18 cognitive tests, 9 oral language tests, 20 achievement tests, and 4 research tests) in the norming edition. Gathering accurate data for 51 tests on a large nationally representative sample presented a number of logistical design constraints. A balance was needed between the competing goals of reasonable testing time for each norming study participant (to minimize examinee response burden) and completeness of data for all tests (National Research Council, 2013; Thomas, Raghunathan, Schenker, Katzoff, & Johnson, 2006). Lengthy surveys or test batteries have been known to have adverse effects on data acquisition and quality due to individuals refusing to participate, increased examinee fatigue and boredom, decreased examinee motivation and concentration, and examinee attrition over multiple testing sessions (Gonzalez & Eltinge, 2007; National Research Council, 2013; Wolf, 2006). Although the primary concern arising from examinee response burden is the potential for introducing bias or error into measurement precision of the test norms, complete or near complete test data collection also would substantially increase the costs of test development; those costs would ultimately be passed on to the end user. For these reasons, a planned incomplete data collection design was used in the WJ IV norming study. Planned incomplete (missing) data collection methods (Graham, Taylor, Olchowski, & Cumsille, 2006; McArdle, 1994; McKnight, McKnight, Sidani, & Figueredo, 2007; Rhemtulla & Little, 2012; Schafer, 1997; Wolf, 2006) have been developed as a statistically sound method for gathering data given these design constraints.

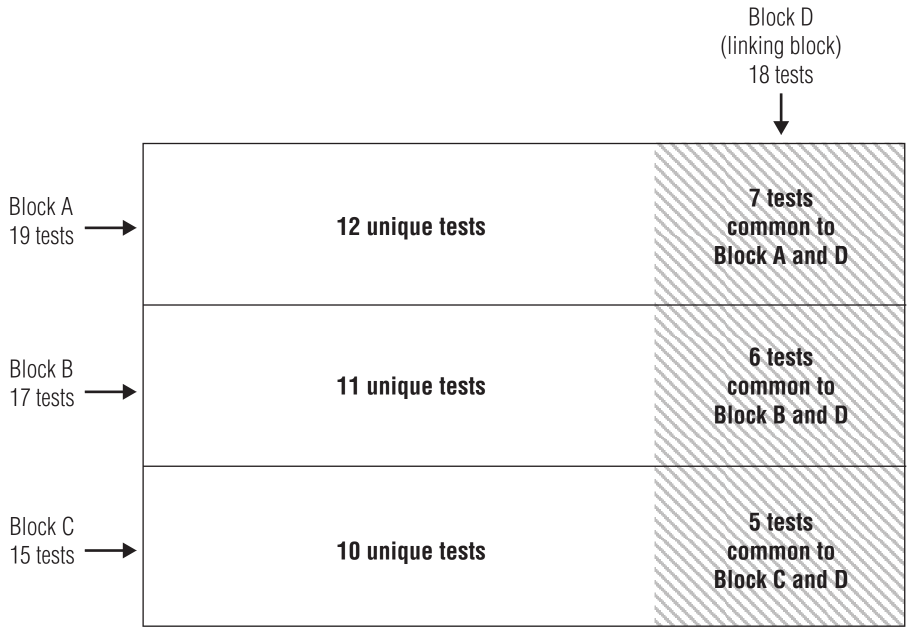
## Multiple Matrix Sampling Design

Applied measurement specialists recognized these constraint-driven design decisions as early as 1920. Chapin (1920) stated, in the context of survey completion, that "… the questions should be as few as possible, because in most questionnaires the informant's answer is voluntary and a bulky list will appear more formidable than it really is, thus discouraging replies" (p. 188). Fortunately, measurement specialists, led by a group of researchers at Educational Testing Service (ETS) (Gonzalez & Eltinge, 2007), started developing and evaluating applied solutions to these test design and data gathering issues in the 1950s and 1960s. The multiple matrix sampling[1] (MMS) approach to test or survey design, where different parts of a larger complete set of test items or tests are administered to different random subsamples of the total norming sample, was proposed and evaluated by Hooke (1956a, 1956b) and Lord (1962, 1965). Shoemaker (1971) published the first book on matrix sampling. The primary goal of MMS is to reduce response burden and insure the collection of unbiased efficient estimates of the population parameters (e.g., means, variances, and covariances).

MMS is one of a number of designs under the umbrella term of planned incomplete (missing) data collection (Graham et al., 2006; McArdle, 1994; Rhemtulla & Little, 2012; Wolf, 2006). Different versions of MMS have been used in large scale national data collection programs such as the National Assessment of Educational Progress (NAEP) and the National Educational Longitudinal Study of 1988 (NELS:88), major U.S. surveys (e.g., Consumer Expenditure Quarterly Interview Survey [CEQ], National Health and Nutrition Examination Survey [NHANES], National Health Interview Survey [HIS], the U.S. Census), and health and business research (Bokossa & Huang, 2001; Johnson, 1992; Mislevy, Beaton, Kaplan, & Sheehan, 1992; National Research Council, 2013; Thomas et al., 2006). Figure 3-1 presents the MMS design used in collecting data for the WJ IV norming sample. This particular MMS planned incomplete data design is considered a partial matrix sampling plan (Anigbo, 2011; Childs, Dings, & Kingston, 2002) where a common or core set of tests is administered to all norming study participants and the remaining tests are matrix sampled. The common or core set of tests serves as an "anchor" to improve comparability of examinee results across all examinees and tests, while the matrix-sampled sets of tests increase the efficacy of coverage per testing time (Anigbo, 2011).

[1] A number of different planned incomplete (missing) data designs have been proposed and used in the test development and research literature (e.g., balanced incomplete blocks; fractional block design; 3-form design; split questionnaire survey design; and simple, genuine, and partial MMS). Only MMS is discussed here because it was the method used to gather the WJ IV norming data. See Anigbo (2011); Childs, Dings, Kingston (2002); Graham et al. (2006); McArdle (1994); and Wolf (2006) for additional information regarding other designs.

**Figure 3-1.**
*WJ IV multiple matrix sampling (MSS) plan.*




*Note.* Total sample sizes for tests unique to Blocks A, B, or C were 1,500 to 2,200. Total sample sizes for tests in Block D were 3,400 to 3,800.

When properly designed and paired with "modern" plausible data value generation techniques (Baraldi & Enders, 2010; Enders, 2006; Graham et al., 2006; McKnight et al., 2007; Peugh & Enders, 2004; Rubin, 1987; Schafer, 1997), research has found that MMS designs increase participation rates, provide more accurate data, and provide efficient, unbiased, and accurate estimates of the critical parameters (i.e., means, variances and covariances) needed for the construction of test norms (Anigbo, 2011; Garg, Boss, & Carlson, 1986; Goldstein & James, 1983; Gonzalez & Eltinge, 2007; National Research Council, 2013; Shoemaker, 1971; Wolf, 2006).

The WJ IV standardization sample consists of 7,416 individuals. As illustrated in Figure 3-1, the 51 tests in the WJ IV standardization battery were divided into three unique sets, or blocks. Block A contained 19 tests, Block B contained 17 tests, and Block C contained 15 tests. A fourth block, Block D (linking block), was composed of a subset of 7 tests from Block A, 6 tests from Block B, and 5 tests from Block C, for a total of 18 tests. This type of block design increases the efficacy of coverage per testing time (Anigbo, 2011). The set of Block D linking tests serves as an "anchor" to improve comparability of examinee results across all examinees and tests. The 7,416 examinees in the norming sample were randomly assigned to Block A, Block B, Block C, or Block D administration. Tests that were unique to either Block A, Block B, or Block C were administered to approximately 1,500 to 2,200 examinees in the norming, with total sample sizes for each test varying according to the age range appropriate for each test. Because each test in Block D was common to one other block, the Block D tests were administered to a larger sample that ranged from 3,400 to 3,800 examinees.

## MMS Design Criteria

The success of a large-scale MMS data collection design hinges on a combination of statistical, logical, and practical considerations. The following were the primary design considerations used in the WJ IV MMS norming data collection.

- The precision of the final "complete record" WJ IV data file for the 7,416 norming study participants was the most important design consideration. As suggested by prior planned incomplete data collection research, the 18 tests selected for inclusion in the

WJ IV core linking battery were optimal predictors of all other WJ IV tests. Based on prior *Woodcock-Johnson Psycho-Educational Battery–Revised* (WJ-R) research (McGrew, Werder, & Woodcock, 1991) and WJ III (McGrew & Woodcock, 2001) research, the 18 core linking tests also had to be strong indicators of all seven CHC factors and the domains of reading, math, and writing to be measured by the WJ IV. The 18 selected tests also were the cognitive factor and achievement domain tests that were intended to be featured as the primary tests for the main WJ IV clusters (e.g., General Intellectual Ability, Comprehension-Knowledge, Broad Reading).

- To reduce norming study participant response burden, tests were distributed across Blocks A, B, C, and D such that each examinee's testing time would not exceed approximately 3 hours. In addition, to the extent possible given the primary statistical design considerations listed above, certain types of similarly administered tests (e.g., controlled learning tests, tests administered from an audio recording, speeded tests) were dispersed across the blocks so examinees would not experience a task-specific type of testing fatigue.
- WJ IV tests that were significantly revised versions of their WJ III counterparts, as well as new WJ IV tests, were spread across the blocks.

## Generation of "Complete Record" WJ IV Norming Data Records

The *W* scores (see Chapter 2) for each test were used for the calculation of test and cluster norms. Best practice approaches to generating plausible *W* scores for tests not taken by norming study participants (e.g., *W* scores for tests in Blocks B and C for norming study participants who took Block A) were utilized to generate a "complete record"[2] for all 7,416 norming study participants. According to Baraldi and Enders (2010), as well as others (Allison, 2002; Enders, 2006; Schafer & Graham, 2002; Schafer & Olsen, 1998), "state of the art" plausible value generation methods utilize maximum likelihood (ML) estimation and multiple imputation (MI) methods. These methods produce unbiased estimates of parameter values under the most common planned incomplete data designs.

It is beyond the scope of this manual to describe the detailed nuances of these methods. The NORM (version 2) (Schafer, 1999a) software program for incomplete multivariate data was used to generate the complete WJ IV norming study participant records. The two-step EM (expectation maximization)+DA (data augmentation) NORM procedures were used as described by Darmawan (2002), Peugh & Enders (2004), and Schafer (1999b). As described by Wolf (2006), this two-step NORM method is a form of Bayesian Multiple Imputation "in which initial parameters are estimated via the EM-algorithm, imputations are derived using the DA-algorithm, and population quantities are estimated using the principles of repeated-imputation inference" (p. 77). This is considered best practice, as "all resulting population estimates for the vast majority of statistical models (and not just linear ones) are unbiased and efficient, yet not overconfident in terms of their standard errors and test statistics" (Wolf, 2006, p. 77). The final DA MI step used 10,000 iterations to generate 10 multiple imputed data sets (each data set was generated after 1,000 iterations). One of the 10 resultant MI imputed data sets was randomly selected to serve as the basis for the calculation of the WJ IV norms and psychometric statistics. This process resulted in a data set that included *W* scores for 51 tests (47 WJ IV tests and 4 research tests; see Table 5-10 in Chapter 5) from between

[2] Although contemporary "modern" plausible values data imputation produced test scores for all WJ IV tests not administered to a norming study participant in a specific MMS block, the statistical machinery of these procedures does not recognize "out of bounds" (i.e., implausible) values for the WJ IV tests. For example, in the data imputation process, test scores for the Writing Samples test would be generated for preschool examinees, even though this test is not developmentally appropriate for these young examinees. In addition, in some cases an imputed plausible score was below the minimum or above the maximum *W* score provided by each test's raw score-to-*W* score conversion (see Chapter 2). The plausible value imputation steps described here were followed by a "filtering" process, in which implausible (out-of-bounds) scores were set to missing data. Thus, a "complete record" for a norming study participant included *W* scores for tests actually administered to the examinee plus plausible imputed *W* scores that remained after the filtering process.

6,637 and 7,416 norming study participants. The use of the NORM EM+DA methods in the construction of the final WJ IV norm file is consistent with the recommendation of Baraldi and Enders (2010), within the context of the field of school psychology research, that:

> Given the widespread availability of missing data software and the ease with which maximum likelihood and multiple imputation can be implemented, we strongly recommend that school psychology researchers abandon old standby procedures in favor of these modern approaches. This recommendation has strong theoretical and empirical support from the methodological literature and also is consistent with recent recommendations from the American Psychological Association (Wilkinson, 1999; p. 33–34).

# Norms Construction

Data from the 7,416 norming study participants are summarized for each test and cluster in Appendices B and C. Individual examinee weights were applied during the WJ IV norming data construction process to insure that the test, cluster, and difference score norms were based on a sample with characteristics proportional to the U.S. population distribution. The innovative *bootstrap resampling* procedures (Efron & Tibshirani, 1993), first implemented and described for the *Woodcock-Johnson III Normative Update* (McGrew, Dailey, & Schrank, 2007),[3] were used to calculate the WJ IV norms. The use of bootstrap resampling procedures allows for the incorporation of estimates of uncertainty and potential bias (in the sample data) in the calculation of the WJ IV norms. When compared to more traditional norm development procedures (such as those used in the *Woodcock-Johnson Psycho-Educational Battery* [WJ] [Woodcock & Johnson, 1977], WJ-R, WJ III, and most other individually administered cognitive, language, and achievement batteries), the bootstrap-based procedures used to calculate the WJ IV norms produce more precise estimates of an examinee's ability. This section explains the procedures and calculations used in preparing the WJ IV test, cluster, and comparison/variation norms.

## Test and Cluster Summary Statistics

Summary statistics and reliabilities for the *Woodcock-Johnson IV Tests of Cognitive Abilities* (WJ IV COG) (Schrank, McGrew, & Mather, 2014b), *Woodcock-Johnson IV Tests of Oral Language* (WJ IV OL) (Schrank, Mather, & McGrew, 2014b), and *Woodcock-Johnson IV Tests of Achievement* (WJ IV ACH) (Schrank, Mather, & McGrew, 2014a) are presented for 25 technical age groups in Appendix B. Summary statistics and reliabilities for the WJ IV COG, WJ IV OL, and WJ IV ACH clusters are presented for the same 25 technical age groups in Appendix C. In both sets of tables, the unweighted means and standard deviations reported are in units of the *W*-score scale. Also included in the tables are the test and cluster reliabilities, standard errors of measurement (*SEM*s) of the *W* scores, and the *SEM*s of the standard scores for each age group.

## Weighting of Examinees

Although the distribution of norming study participants closely approximated the U.S. population distribution for most community and individual sampling variables,

[3] A copy of this document can be obtained at the following URL: http://www.riverpub.com/products/wjIIIComplete/pdf/WJIII_ASB9.pdf

examinee weighting was applied during the construction of the norms[4] to account for any discrepancies. The use of participant weighting adjustments during construction of the norms removes any potential bias effects that might result from having approximate, rather than exact, representation in each cell of the sampling design. Each norming study participant was assigned a weight based on that examinee's required contribution to the database.

The weight for each norming study participant was obtained by calculating the product of several partial weights, each corresponding to a demographic variable for the applicable sampling group (Preschool, Kindergarten through Grade 12, College, or Adult). For each demographic variable, if an examinee belonged to a category of the variable that was overrepresented in the norming study sample, the examinee's partial weight for that variable was less than 1.0. Likewise, if the examinee belonged to a category of the variable that was underrepresented in the norming study sample, the examinee's partial weight for that variable was greater than 1.0. Tables 3-2 through 3-5 contain the partial weights assigned for each demographic variable value within each sample of examinees. If demographic information was missing for a particular examinee on a particular variable, that examinee was assigned a null (1.00) partial weight for that variable. A partial weight of 1.00 is considered "null" because when it is multiplied together with the other partial weights to compute a total norming study participant weight, a value of 1.00 has no effect on the overall weight. For some variables (indicated with superscript *b* in Tables 3-2 through 3-5), null partial weights of 1.0 also were assigned to cells for which reliable population information could not be obtained or for which the sample counts were so low that they inappropriately skewed examinees' overall weights (e.g., the "< 9th Grade" values of the educational attainment variable in the Adult sample).

## Development and Calculation of WJ IV Cluster Scores

With the exception of the WJ IV COG General Intellectual Ability (GIA) cluster, all WJ IV COG, WJ IV OL, and WJ IV ACH cluster scores are based on the arithmetic average of the *W* scores of the tests that contribute to the cluster score. For example, an examinee's *W* score for the WJ IV Reading cluster, which is composed of the Letter-Word Identification and Passage Comprehension tests, is calculated as:

$$\frac{\text{Letter-Word Identification } W \text{ score} + \text{Passage Comprehension } W \text{ score}}{2}.$$

## Calculation of Differentially Weighted GIA Cluster Score

The WJ IV COG General Intellectual Ability (GIA) cluster score is a differentially weighted score. Principal component analysis was used to obtain differential *g* weights across the complete range of the norming sample for the tests that contribute to the GIA score. The differential weights are used by the Woodcock-Johnson online scoring and reporting program (Schrank & Dailey, 2014) to calculate GIA scores for individual examinees.

The WJ IV GIA score is the general intelligence (*g*) score; it represents the first principal component obtained from principal component analyses (PCA). The use of PCA-determined GIA weights was first introduced in the original WJ Broad Cognitive Ability (BCA) cluster score (Woodcock, 1978). Equally weighted BCA cluster scores were used in the WJ-R (McGrew et al., 1991). PCA-determined GIA weights were reintroduced in the WJ III battery (McGrew & Woodcock, 2001). In PCA, the optimal weighted combination of tests that account for the largest proportion of the variance in a collection of tests is extracted as the

[4] Calculation of the norming study participant weights is described here. For more information about how the weights were applied during the norming process, see the "Construction of WJ IV Norms and Derived Scores" section later in this chapter.

first component (similar to a factor in factor analysis). Using PCA weights ensures that all individual test weights in the GIA are optimal. In contrast, other tests of cognitive abilities (including the Wechsler intelligence scales and the WJ-R) weight all tests in the general intelligence (*g*) score equally. Using PCA of cognitive measures as a basis for prescribing different test weights gives the best statistical estimate of general intelligence (Jensen, 1998).

Bootstrap resampling[5] procedures were used in the calculation of the GIA test weights to obtain statistical estimates of *g* loadings bounded by confidence bands (at the 25th and 75th percentiles), which were then smoothed across the complete age range of the WJ IV norming sample. In simple terms, age-sorted blocks of samples of 100 examinees were each resampled 250 times. PCA *g* loadings were calculated for each of the 250 resamples. The ranges of the *g* loadings (from the 25th to the 75th percentile) were plotted for each age-sorted block. Next the complete set of PCA *g* loadings for each of the seven tests was individually smoothed using polynomial curve-fitting procedures to provide the best fit to the sample parameters across the age range of the WJ IV norming sample. The smoothed PCA loadings for each test were then transformed to component test score weights, which are proportional to the PCA loadings (as a function of the PCA eigenvalue). These differential *g* weights were used to calculate GIA cluster scores for all norming sample study participants. Finally, age- and grade-based norms for these cluster scores were calculated using the procedures described later in this chapter.

Appendix D presents the average GIA weights by the 25 technical age groups. A review of the weights in Appendix D reveals that the weights for the individual tests fluctuate little as a function of age. For example, the GIA weights for Number Series range from .15 to .18. The WJ IV tests that measure *Gc* (Oral Vocabulary; median *g* weight = .18), *Gf* (Number Series; median *g* weight = .17), and Ga (Phonological Processing; median *g* weight = .17) are among the highest *g*-weighted tests. The high *Gc* and *Gf* weights are consistent with the extant factor-analytic research on *g* (Carroll, 1993). The test with the consistently lowest *g* weight is Letter-Pattern Matching (median *g* weight = .11).

## Scholastic Aptitude Cluster Scores

A major function of the WJ IV is to provide statements regarding a person's predicted performance in different achievement domains (see Table 1-10 and Figure 1-7 in Chapter 1), and to make comparisons between predicted and actual achievement within these domains. The six WJ IV Scholastic Aptitude (SAPT) cluster scores (two for each achievement domain) are designed to provide optimal and efficient prediction of expected achievement in each domain. Although based on the arithmetic averaging of tests composing each SAPT, the statistical procedures used to construct the SAPT clusters warrant additional description.

Each SAPT cluster score is based on a combination of four tests that together produce the most efficient and strongest prediction for the selected achievement area. Although SAPTs were included in the WJ and the WJ-R, the WJ IV SAPTs represent an advance over those from the earlier batteries because they differ by academic areas, providing the best prediction of achievement skills (see Table 1-10 and Figure 1-4 in Chapter 1). For example, Basic Reading Skills has a different combination of predictor tasks (Reading Aptitude B) than does Reading Comprehension (Reading Aptitude A), Basic Math Calculation Skills (Math Aptitude A) has a different combination of predictor tasks than does Math Problem Solving (Math Aptitude B), and Basic Writing Skills (Written Language Aptitude B) has a different combination of predictor tasks than does Written Expression (Written Language Aptitude A). These advances were incorporated into the WJ IV SAPT clusters based on research indicating that predictor tasks vary within broad achievement areas, and that these predictors change

[5] Bootstrap resampling methods are described in detail in the "Construction of the WJ IV Norms and Derived Scores" section later in this chapter.

developmentally (McGrew, 2012; McGrew & Wendling, 2010; Schneider & McGrew, 2012). Tests with content very similar to the achievement cluster to be predicted were not included in the predictor score (e.g., a reading test was not used to predict reading). The combination of WJ IV COG tests that was most highly correlated with each curricular area was identified statistically; consideration also was given to relevant theory and the extant research literature. The following steps were used to construct the WJ IV SAPT clusters.

Phase 1: Identify the pool of best predictor COG tests across all ages. All WJ IV COG tests were entered into stepwise multiple regression analyses to predict each of the achievement cluster scores across the entire WJ IV norming sample data file (ages 6 and above). Age-based standard scores based on the final WJ IV norms were used for the predictor and criterion measures. The following logic and guidelines were followed in the completion of these analyses.

- Number Series was eliminated from consideration as a predictor in reading, writing, and one math SAPT cluster (Math Aptitude B) to eliminate predictor-criterion contamination. One of the tests in the Math Problem Solving cluster is Number Matrices, which is a very similar measure of *Gf*-RQ (quantitative reasoning) to Number Series. Number Series was considered an appropriate predictor for all other math achievement clusters.
- It was decided that the SAPT clusters should not contain more than one test from each respective CHC domain. Instead, each SAPT cluster would sample from four different CHC domains, and the composition of the clusters should be consistent with theory and research. Only the strongest within-CHC domain predictors identified during the multiple regression analyses were included in the pool of potential predictor tests.
- Initial multiple regression models were constructed using a seven-test stopping rule (i.e., no more than seven tests were allowed to enter the regression model). The results were inspected to identify tests with negative weights (i.e., suppressors). Additionally, note was made of tests that did not enter the model at any step but were close to entering (based on the partial correlations after each step).
- Tests with negative weights were removed and the seven-step model was rerun. Tests with very small weights were eliminated one at a time. These steps occurred in an iterative fashion.
- A final five-step multiple regression model was completed to identify the five best predictor tests for each achievement domain.
- Using the five-test predictor test pool, various four-test SAPT cluster combinations were analyzed with multiple regressions. This typically produced a pool of two to three possible SAPT cluster combinations for each achievement domain cluster. The multiple $R$ and $R$-squared values were inspected. Typically, the $R$ and $R$-squared values only differed to the second decimal place, so all possible SAPT clusters for predicting a specific achievement cluster were retained as possibilities.

Phase 2: Construction and evaluation of the potential SAPTs by age groups.

- All possible SAPTs for each achievement domain were constructed as *W*-score–based clusters within the WJ IV norming sample data file. Correlations between the candidate SAPT clusters and the relevant achievement domain clusters were calculated for five age groups (6 through 8 years, 9 through 13 years, 14 through 19 years, 20 through 39 years, 40 through 90+ years).[6]
- The predictive efficiency of the potential SAPT clusters within each achievement domain, across all ages, was evaluated. It was observed that the various SAPT cluster

[6] Given the wide age-based developmental period spanned by each age group, chronological age (in months) variance was partialed out of the *W* scores prior to the analyses.

correlations were very similar across candidate SAPT clusters, typically differing only to the second decimal place. The final selection of SAPT clusters within each achievement domain was based on the following set of guidelines:

- SAPT clusters that consistently demonstrated the highest correlations across ages and clusters within an achievement domain, even if not statistically significantly different from other possible SAPT clusters, were given strong consideration.
- SAPT clusters that made the most theoretical, research, and logical sense were given strong consideration.
- To minimize complexity of the WJ IV battery, a maximum of two SAPT clusters were developed within each broad achievement domain (reading, math, and writing).

## Construction of the WJ IV Norms and Derived Scores

As described in the *Woodcock-Johnson III Technical Manual* (McGrew & Woodcock, 2001) and the *Woodcock-Johnson III Normative Update* (WJ III NU) *Technical Manual* (McGrew, Schrank, & Woodcock, 2007), the development of test norms and derived scores requires the establishment of the "normative" (average) score for each measure for individuals at each specific age (age norms) or grade (grade and college norms) where normative interpretations are intended. In the WJ family of instruments, this normative score is called the *Reference* W *score* (REF *W*). When plotted as a function of chronological age (or grade), the REF *W* scores assume the characteristics of developmental growth curves (see cluster growth curves in Chapter 5). These test and cluster REF *W* curves are visual-graphic representations of the average performance of norming study participants at every age (or grade) for the effective use of the specific measure.

The REF *W* curves serve as the foundation for the age- and grade-equivalent scores, relative proficiency index (RPI), and instructional range interpretation features in the WJ IV. In addition, when the standard deviations (*SD*s) of the scores at each age are plotted as a function of age or grade, the resultant curves represent the *SD* values that, when combined with the REF *W* values, provide the foundation for the calculation of all other norm-referenced score metrics (e.g., standard scores and percentile ranks).

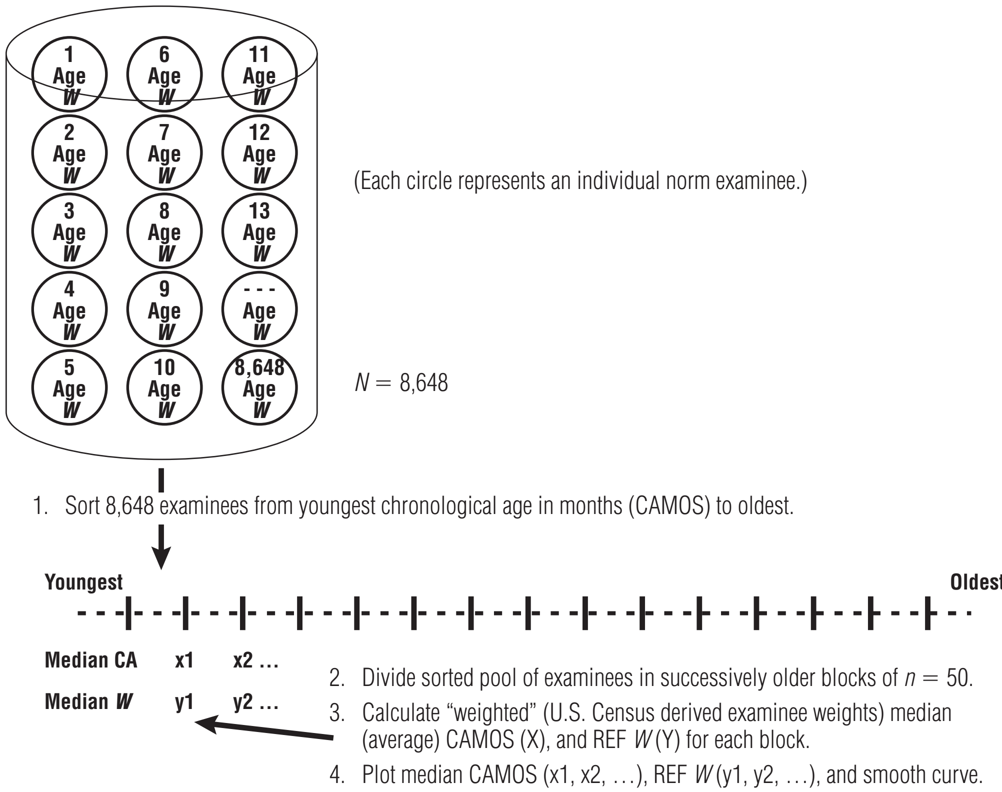
The procedures used to construct the WJ IV norms mirrored those used for the WJ III NU. These innovative procedures, which introduced the methodology of bootstrap resampling to the construction of test norms, were described in detail by McGrew, Dailey, and Schrank (2007).[7] The following description and figures, including the presentation of results for the Letter-Word Identification test, are from that 2007 document. The traditional methods for calculating REF *W* values for the Woodcock family of instruments are briefly described first (see McGrew & Woodcock, 2001), followed by the presentation of the bootstrap-based methods used for the WJ III NU and WJ IV. Finally, the advantages of the newer method are explained.

### *Traditional Norm Calculation Description*

In the WJ III and prior editions, REF *W* values for each measure were obtained from smoothed curves passing through sample-based data points that represent the average REF *W* values for successively ordered (by age or grade) groups or blocks of 50 norming study participants. This traditional (nonbootstrap) process used in the calculation of the WJ III norms is documented in Figures 3-2 and 3-3 using the Letter-Word Identification test as an example.

[7] A copy of this document can be obtained at the following URL: http://www.riverpub.com/products/wjIIIComplete/pdf/WJIII_ASB9.pdf

***Figure 3-2.***
*WJ III (traditional) norm calculation procedures example for Letter-Word Identification—Steps 1 through 4.*



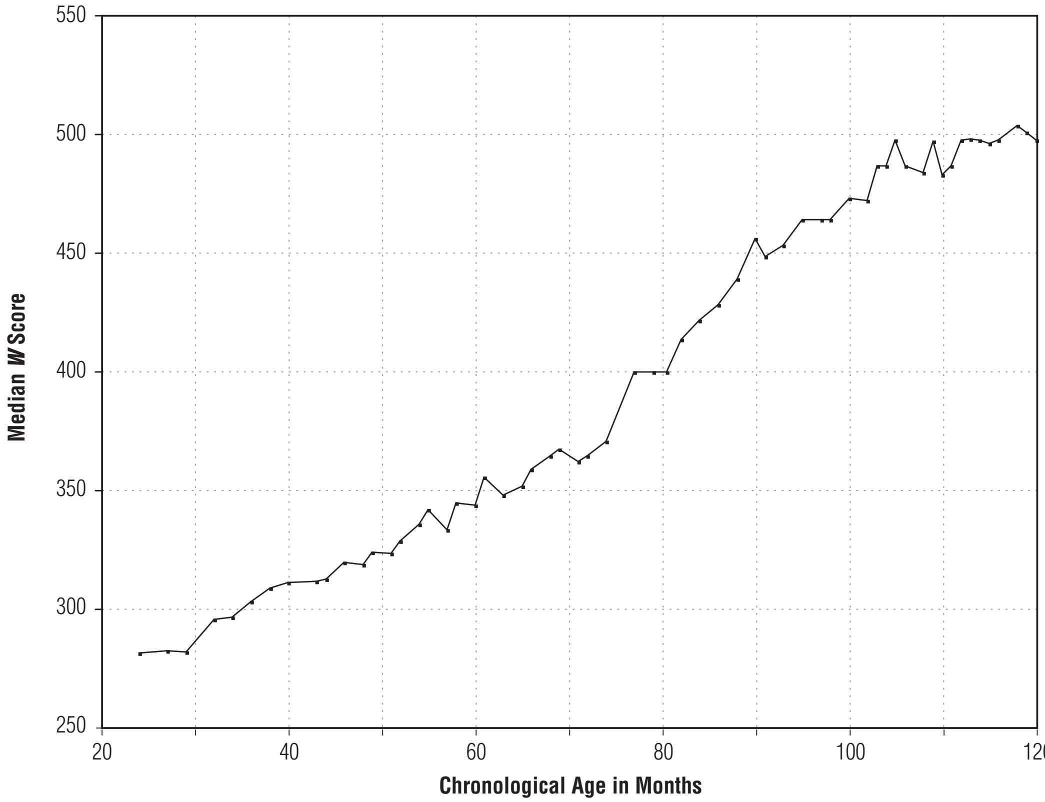

*Note.* The total sample size (8,648) in this figure represents the WJ III norming sample.

The first step represented in Figure 3-2 is the sorting, by chronological age, of all 8,648 WJ III norming study participants with Letter-Word Identification scores—represented by the cylinder. This is portrayed in Figure 3-2 via the visual line representation where norming study participants are arranged from youngest (left end of dashed horizontal line) to oldest (right end of dashed horizontal line). The next step is the division of the sorted set of norming study participants into successive groups or blocks of 50 individuals (in Figure 3-2, each block is visually represented by the area between adjacent vertical hash marks on the dashed horizontal line). Thus, the first demarcated set of the youngest examinees is at the far left end of the dashed line representing the 8,648 age-sorted WJ III examinees. The end result is a set of blocks, or groups of 50 norming study participants, successively ordered from youngest to oldest.

The third step in Figure 3-2 is the calculation of the *weighted* chronological age (in months) and Letter-Word Identification *W* score for each block, using examinee weights calculated according to the procedures described earlier in this chapter. These pairs of age and *W*-score values for all blocks serve as the raw material for the plotting and calculation of the REF *W* curve for Letter-Word Identification (see Figure 3-3).[8]

[8] For illustrative purposes, age-by-Reference *W* block data points are presented only for ages 20 through 120 months in Figure 3-3. In practice, the age-by-Reference *W* curves are plotted across the complete age range of the norms for a test.

***Figure 3-3.***
*Plot of select (ages 20 to 120 months only) WJ III Letter-Word Identification age-by-*W *score sorted block values (from Step 3).*

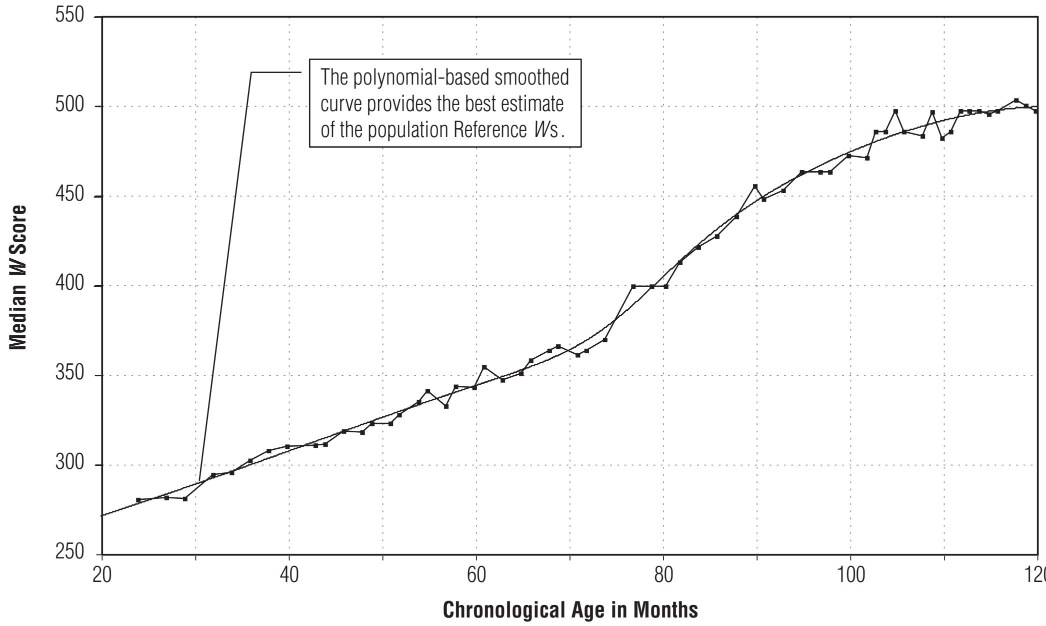



As seen in the Figure 3-3, although the REF *W* values demonstrate a consistent developmental trend, there is "noise" or "bounce" in the trend due to sampling error (Woodcock, 1994). To remove the error from the sample-based data, special software-based polynomial curve-fitting procedures are employed to produce a "smoothed" solution that best approximates the population REF *W* parameter values (McGrew & Wrightson, 1997; Woodcock, 1994). Figure 3-4 presents the result of the polynomial curve-fitting procedures when applied to the WJ III Letter-Word Identification data points presented in Figure 3-3. The smoothed curve provides the normative REF *W* values that were used in the derivation of WJ III scores (e.g., age and grade equivalents, RPIs, standard scores, and percentile ranks).[9] The plotting and smoothing process is then repeated for the sample-based standard deviations.[10]

9 The smoothed norm curve in Figure 3-4 is illustrative and is not the final WJ III age norm curve used for the Letter-Word Identification test.

10 Sources that provide explanations of norm construction via curve-fitting procedures can be found in Daniel (1997), Gorsuch & Zachary (1985), McGrew & Woodcock (2001), McGrew & Wrightson (1997), and Woodcock (1994).

**Figure 3-4.**
*Smoothed polynomial curve solution for raw age by* W *score Letter-Word Identification sample-based data presented in Figure 3-3.*




*Note.* A similar process is completed with the standard deviations (*SD*s) for Letter-Word Identification.

## Bootstrap Resampling-Based WJ IV Norm Calculation Description

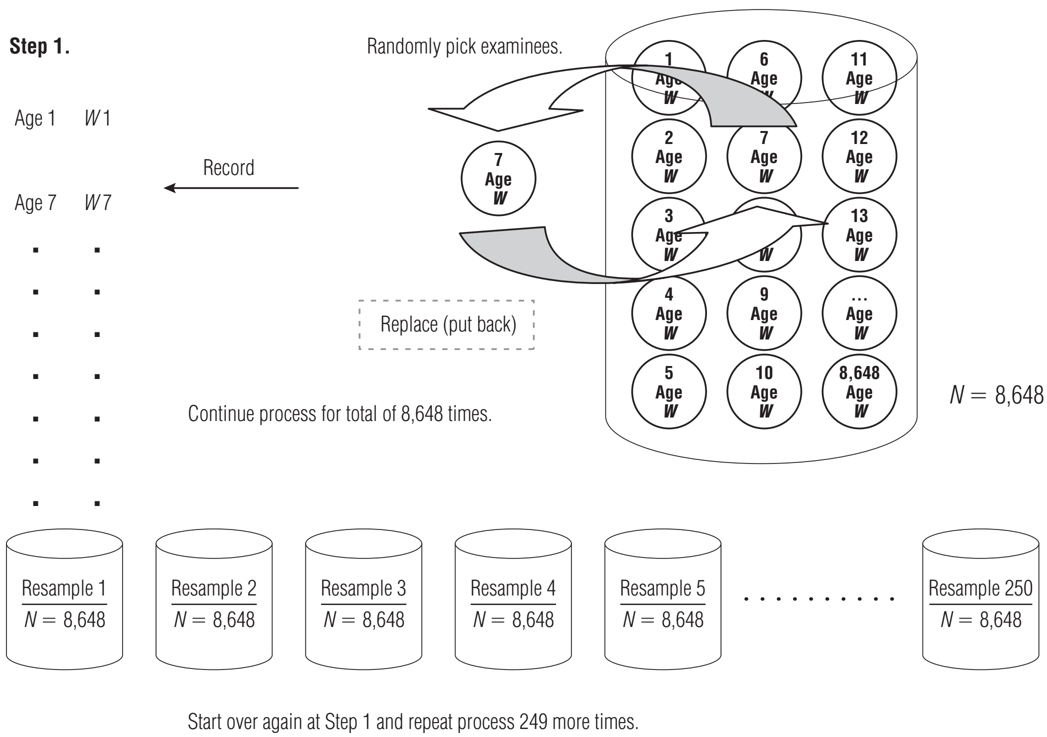
As described above, the use of polynomial curve-fitting procedures in the calculation of the smoothed REF *W* scores and *SD*s for all WJ III measures provided norms based on the most state-of-the art statistical population estimation procedures available for calculating derived scores at the time the WJ III was published (Daniel, 1997; Gorsuch & Zachary, 1985; Woodcock, 1994). However, these traditional procedures did not allow for the estimation of the uncertainty that underlies the raw data points used in the norm curve-fitting procedures. For the calculation of the WJ III NU and WJ IV norms, it was determined that the degree of certainty of the raw data points used to generate norm curves (see Figure 3-4) could be estimated. This parameter estimate certainty could then be incorporated into the selection of the optimal norm curve solution for all measures via the use of a statistical technique known as the *bootstrap procedure*.

The bootstrap procedure (Efron & Tibshirani, 1993) is a method for assigning measures of accuracy to statistical estimates. According to the *APA Dictionary of Psychology* (VandenBos, 2007), *bootstrap* is "a computational method for estimating the precision of an estimate of a (statistic) parameter. A random sample of *n* observations is taken, and from this a number of other samples of equal size are obtained by sampling with replacement" (p. 129). Bootstrap procedures can be used to estimate the uncertainty of a statistic via the provision of a bootstrap *standard error (confidence band)*. This feature is useful in estimating the variability and possible bias in sample statistics—in this case, the sample data used for constructing test norms.

The bootstrap method works by constructing an empirical distribution of a statistic calculated for a sample of individuals drawn from a population. The variability of the statistic within this distribution can be interpreted as a range in which the true value of the statistic would fall if the entire population were to be measured. In simple terms, the bootstrap process, when applied to the calculation of the age and *W*-score data points used for curve fitting, produces a confidence interval, or band, around each plotted data point, much like the standard error or confidence band examiners use to bound individual test scores. The empirical distribution of the statistic is constructed by repeatedly resampling from the obtained norming sample and recalculating the desired statistic or statistics for each resample.

In the case of the WJ IV (and WJ III NU) norm calculation procedures, 250 resamples of the norming sample study participants were taken.[11] A *resample* is a sample—with replacement—of the same size as the norming sample. Figure 3-5 shows how this resampling was conducted for the Letter-Word Identification test in the WJ III NU norming study. Imagine that each of the 8,648 WJ III NU norming study participant's (7,416 for the WJ IV) age and *W* scores is printed on a Ping-Pong® ball and placed into a "selecting machine," represented by the cylinder in Figure 3-5. One of the balls (i.e., norming study participants) is randomly selected. The age and *W* score for the individual are recorded, and the ball is put back into the machine (i.e., replaced) before another ball is selected. This process is repeated 8,648 times for the WJ III NU (7,416 times for the WJ IV) to produce *one resample*. The participants in each of the resamples are placed into age-sorted blocks of 50 examinees, and median chronological age and *W* scores are calculated for each of the blocks, similar to the process described above for the traditional norm calculation procedures used in the WJ III. This entire process is then repeated 250 times. Figures 3-5 and 3-6 summarize these steps.

***Figure 3-5.***
*Creation of 250 WJ III NU Letter-Word Identification resamples via random selection of examinees with replacement (bootstrap method).*




At this stage, there are 250 paired values of median chronological ages and median *W* scores that have been calculated at each group from the resamples (see Figure 3-6). From the distribution of median *W* scores within each age group, the 25th and 75th percentiles are calculated; this range represents the middle 50% of the generated sample statistics. This window or band provides an empirical estimate of the degree of certainty in the sample statistics that are used for norm curve generation. If a line is drawn from the point defined by the 25th percentile of the chronological age and the 25th percentile of the median *W* score

[11] According to Efron and Tibshirani (1993), 50 bootstrap resamples are often sufficient to provide accurate estimates of the standard error of the statistic. With each increase in the number of bootstrap resamples, the amount of improvement in the statistical estimates becomes less. In the WJ IV norming, 250 resamples were selected to insure a high degree of confidence in the estimates of the standard error of the block-level statistics.

to the point defined by the 75th percentile of each respective statistic, the result, for each of the age-sorted blocks of examinees, is a "stick" or "window" through which smoothed norm curves are fit. That is, instead of fitting norm curves to single data points as illustrated in Figure 3-4, norm curves are now fit to confidence band windows as shown in Figure 3-7.

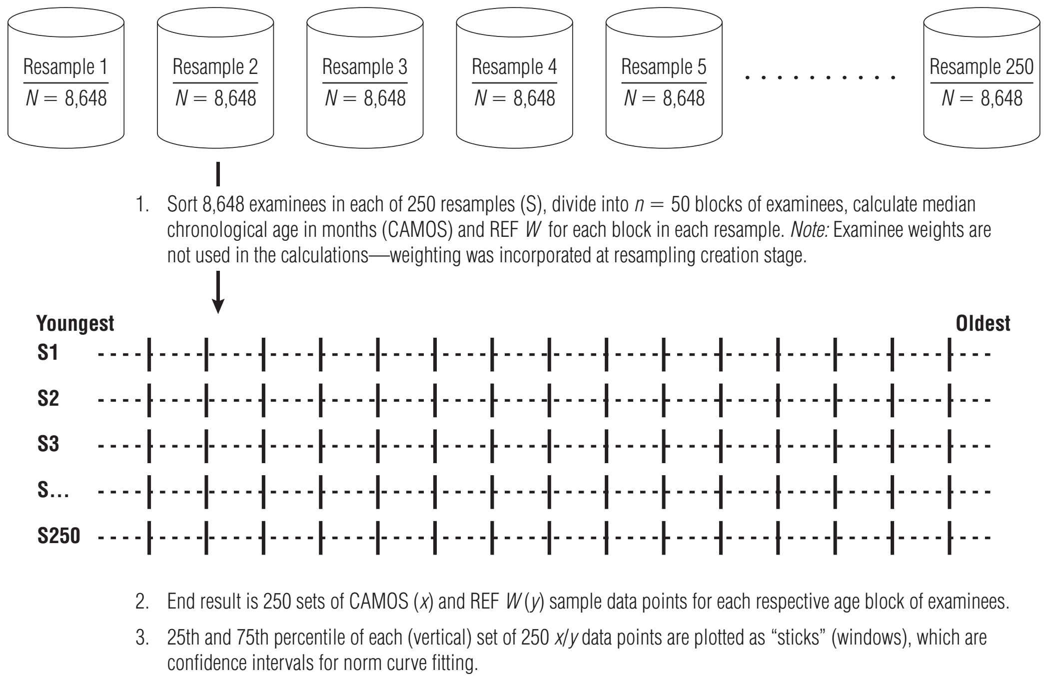
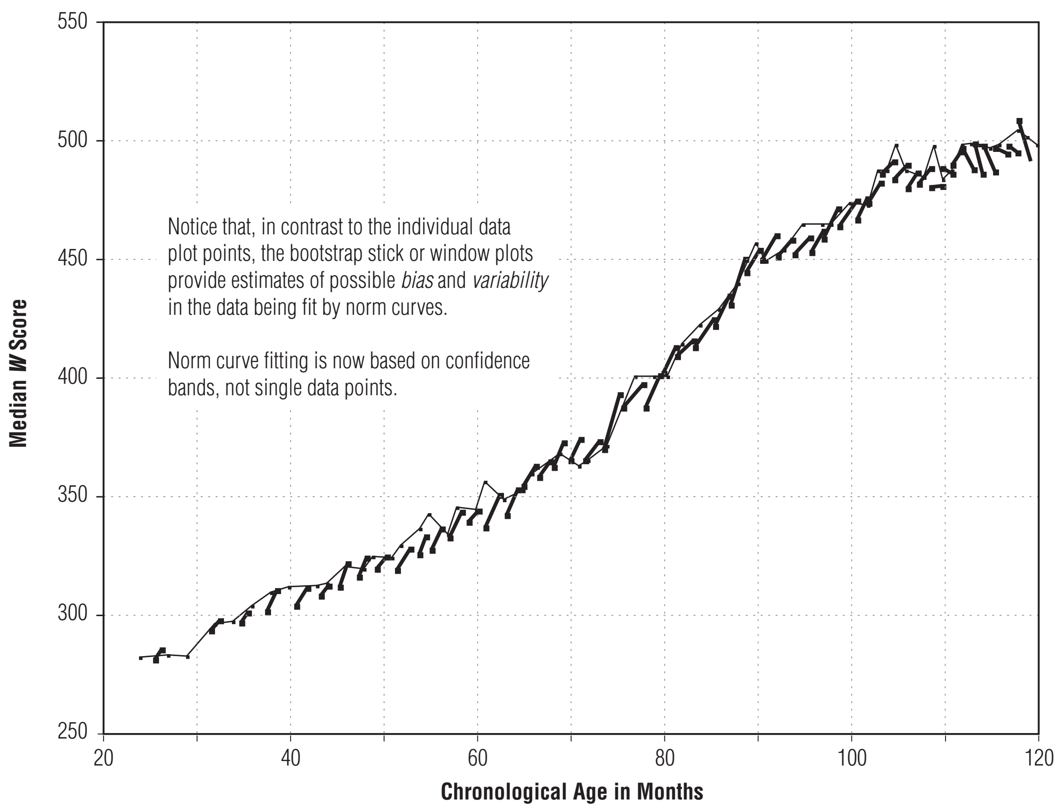



***Figure 3-6.***
*Calculation of bootstrap-generated sample statistic (see Figure 3-5) confidence band windows (25th to 75th percentile).*




*Note.* Top and bottom of sticks are slightly offset to allow plotting on the same graph.

***Figure 3-7.***
*Comparison of WJ III Letter-Word Identification REF* W *raw data "points" and WJ III NU bootstrap "sticks" or "windows."*

Aside from the generation of bootstrap resamples, the WJ IV and WJ III NU norm development procedures also differ from those used in the WJ III in the use of the norming study participant weights. The WJ IV and WJ III NU bootstrap resampling procedure does not require that each norming study participant be as likely to be selected as every other norming study participant. In fact, in the WJ III NU and WJ IV, examinee weights were converted to *selection probabilities*, such that norming sample participants with higher weights had a higher chance for selection and inclusion in any given resample. In fact, some examinees were selected many more times than others, balancing the demographic characteristics in the norming sample with respect to the reference population.

### Advantages of the Newer Method of Calculating REF W Values

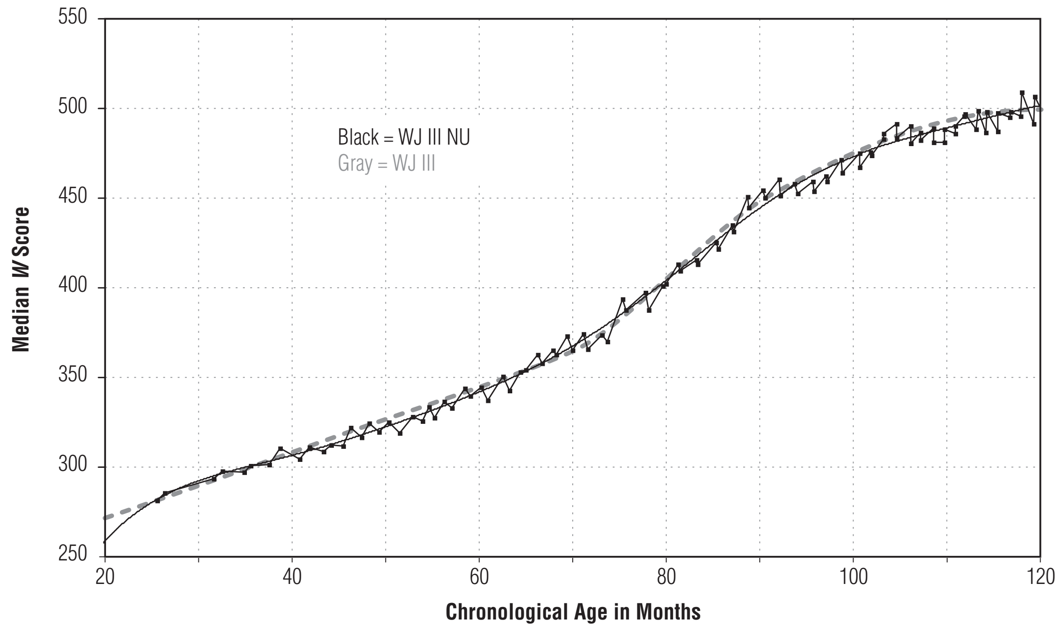
There are distinct advantages of the resampling procedures used for the WJ III NU and WJ IV norm calculation procedures. First, within each resample, the calculation of statistics for each block or group of 50 norming study participants is simplified because examinee weights are no longer part of the calculation. Instead, the norming study participant weights are incorporated in the probability of including a particular norming study participant in each resample. This makes the calculation of more complex statistics (beyond the median *W* score) easily possible.

Second, and more importantly, the norm curve-fitting process involves choosing a path through a series of confidence bands (sticks or windows) instead of a series of single data points (see Figure 3-7). At any given age, there is a range of values (with a known degree of certainty) that might be acceptable smoothed norm REF *W* values. When norm curves are fit to a series of individual data points as in the traditional method used in the WJ, WJ-R, and WJ III, there is a tendency to focus on curve solutions that miss as few data points as possible. By fitting a curve through confidence band windows, the uncertainty inherent in the sampling process (as in any sampling process) is acknowledged and visibly observable, thereby reducing the tendency for norm curves to "chase individual data points"—a practice that may result in less precise norm curves. This advantage can be seen in Figure 3-7, where the WJ III NU Letter-Word Identification bootstrap confidence bands are superimposed over the single data points from the WJ III Letter-Word Identification test that were shown in Figure 3-3.

In Figure 3-8, the most obvious differences between the REF *W*s displayed as single data points and those displayed as confidence bands are visible between approximately 35 to 65 months of age. The confidence bands are consistently lower than the corresponding single data points, suggesting that the single-point (WJ III) REF *W* values in this age range are biased upward. When a norm curve is fitted to these upwardly biased data points, it will track upward, resulting in less precise norm curve REF *W* estimates. Although the curve fitted to the single data points appeared to be an optimal solution in Figure 3-4,[12] when compared to the REF *W* curve fitted using the confidence bands in Figure 3-8, the former curve "runs high" between 35 to 65 months of age. Given the quantification of the variability in the range of sample estimates for these specific age blocks (as represented by the sticks or windows), it is clear that the more precise norm curve tracks lower at these ages. The two REF *W* curves for Letter-Word Identification in Figure 3-8 also are noticeably different from approximately 20 to 30 months. The WJ III point-based curve solution trends noticeably higher than the WJ III NU curve in this age range.

[12] Adequate fit also was suggested by the various polynomial curve-fitting fit statistics associated with the solution in Figure 3-4.

**Figure 3-8.**
*Comparison of possible WJ III (gray) and WJ III NU (black) Letter-Word Identification REF* W *norm curves.*




*Note.* Connected data points are actually connected bootstrap sticks or windows (see unconnected sticks or windows in Figure 3-7).

It is well known among applied psychometricians that it is the most challenging to fit norm curves at the youngest and oldest ages due to the lack of data points below the youngest age and above the highest age in the distribution. When norm curves are fit to a set of continuous data points surrounded by other data points (e.g., the data points between 60 and 80 months in Figure 3-3), the curve fitting algorithms use not only the specific data point values within this range, but also information from the data points immediately prior to and immediately following those points. In contrast, as shown in Figure 3-3, the data point at 24 months has no preceding or prior data points to contribute curve-fitting information through this first point. Similarly (although not shown in Figure 3-3), the challenge at the highest end of the age range is that there is no empirical data beyond the last data point to aid in the curve fitting through that point. As a result, there is considerable uncertainty surrounding the values of the sample statistics and the shape of the fitted norm curves at the youngest and oldest ages. In practice, psychometricians typically extrapolate norm curves slightly beyond the extreme empirical data points available, which can result in a curve-fitting approach that is more art than science at the extreme age ranges. However, as shown in Figure 3-8, when bootstrap-based confidence bands are the source data for curve fitting, the general trends of the sample statistics at the extreme ages are more apparent. In the case of the WJ III NU Letter-Word Identification example presented in Figure 3-8, greater certainty is placed in the lower norm curve solution between 20 and approximately 36 months.

A review of both the illustrative WJ III and WJ III NU curves in Figure 3-8 demonstrates that the bootstrap method represents a methodological improvement for norm curve generation. Greater confidence can be placed in the bootstrap-based norm curves when compared to the traditional norm curves used in WJ editions prior to the WJ III NU.

## Calculation of Age- and Grade-Equivalent Scores

In the WJ IV, bootstrap-based smoothed curves from the entire age range for a test or cluster were used to generate the age- and grade-equivalent scores that are reported by the online scoring program. An age-equivalent score was obtained for each *W* score (from the *y*-axis of the fitted curve) by identifying the corresponding age (in months) along the *x*-axis. Grade-equivalent scores were obtained in the same manner, except that the smoothed curves were based on bootstrap samples of norming study participants sorted in order by grade placement (to the tenth of each grade). Points along these curves represent the median *W* score (REF *W*) of students at each tenth-of-grade placement. A grade-equivalent score was then obtained for each REF *W* score (from the *y*-axis of the fitted curve) by identifying the corresponding grade (in tenths of a year) along the *x*-axis.

## Calculation of Percentile Rank and Standard Score Norms

The WJ IV standard scores are calculated using a special procedure that combines features of both area and linear transformations of the distribution of scores (McGrew et al., 1991; McGrew & Woodcock, 2001). The percentile rank and standard score norms for the WJ IV were constructed as follows.

1. The WJ IV, as in prior editions of the test, employs a unique procedure for maintaining the real-world skew of score distributions. Different standard deviations (*SD*s) are estimated for the two halves of the score distribution (High *SD* and Low *SD* value) above the median REF *W* at different ages.[13]
2. For each normative comparison (age- or grade-based) for each test and cluster, the mathematical algorithms representing the REF *W* score equations and either the High *SD* or Low *SD* are used to calculate the percentile rank and corresponding standard scores for each individual's obtained score.[14] The standard score scale is based on a mean of 100 and standard deviation of 15.

## Calculation of the WJ IV Difference Score Norms

Difference scores allow users to make data-based predictions and comparisons among selected test or cluster scores derived from the WJ IV batteries, which can then be used to describe performance patterns that may be useful for diagnostic decision making and educational planning. The two most common uses for difference scores in assessment practice follow:

1. To determine if an examinee's relative standing in a group on an individual test or cluster (e.g., WJ IV COG Number Series) is statistically significantly different from the examinee's relative standing in the same group on another individual test or cluster (e.g., WJ IV COG Visualization).
2. To determine if an examinee's score on an individual test or cluster is significantly different from what would be expected or predicted, given his or her score on some "predictor" test or cluster.

The first example above is a *standard score/percentile rank profile difference*. The second example above relies on the distribution of actual differences between *predictor* and *criterion* scores in the norming study group. The development of the norms for these types of difference scores is described next.

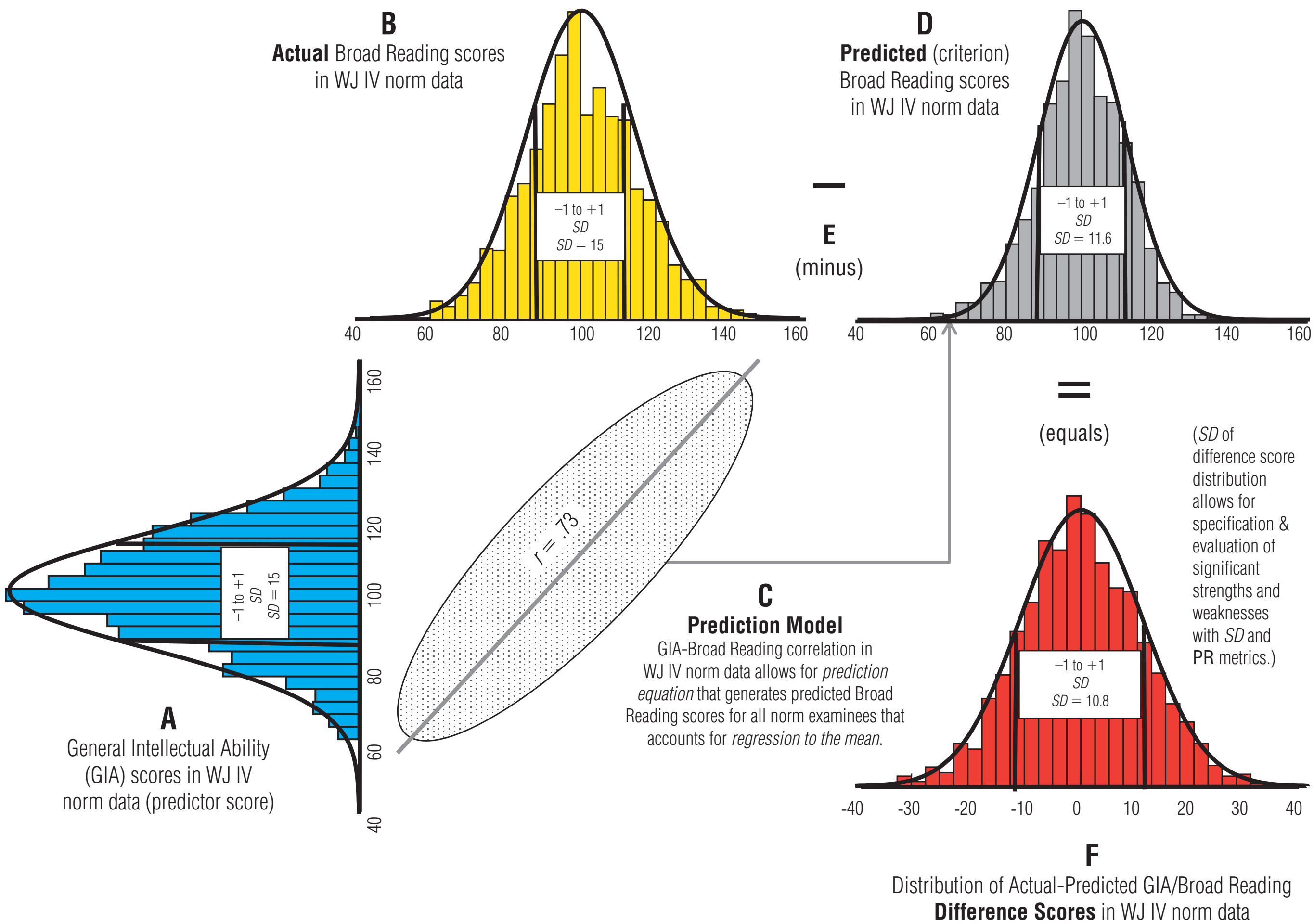
One benefit of co-norming the WJ IV COG, WJ IV OL, and WJ IV ACH batteries is that it allows computation of actual differences between predictor and criterion variables for each individual in the norming sample, which can then be used to model these differences in the population. In the WJ IV, this type of difference score takes two forms: *variations* and *comparisons*. All WJ IV comparison and variation procedures are based on a common statistical model, which is visually demonstrated in Figure 3-9. What distinguishes variations and comparisons from each other is the score that is used as the predictor in the model (the A in Figure 3-9). While variations rely on a predictor score that is an average of the

[13] See McGrew and Woodcock (2001) for a more detailed description.

[14] PR and SS values are derived from the calculation of the $z$ score based on the REF $W$ and the appropriate $SD$: $z = (\text{observed } W - \text{REF } W)/SD$.

(noncriterion) scores from a pool of tests that excludes the criterion measure, comparisons rely on a single predictor, such as the GIA or *Gf-Gc* Composite cluster score. The scoring algorithms for these WJ IV difference-based variations and comparisons were constructed using a regression-based procedure similar to that previously described for the discrepancies[15] used in the WJ-R and WJ III batteries (McGrew et al., 1991; McGrew & Woodcock, 2001).

***Figure 3-9.***
*Illustration of procedures used to develop all WJ IV variation/comparison difference score (standard score) norms (GIA/Broad Reading ACH example).*




*Note.* All score distributions represent real scores for all 9- through 13-year-old norming examinees from WJ IV co-normed sample. Actual prediction models vary by age or grade (developmentally shifting prediction models).
The *SD* of predicted and difference score distributions are not 15. They would only be 15 if the GIA/Broad Reading correlation was perfect (1.0).

The procedures portrayed in Figure 3-9 were identical for the development of all WJ IV comparison and variation procedures. In each case, a predictor score (A) was used to generate the target predicted (criterion) score (D), which was based on the correlation between

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[15] The term *discrepancy score* is not used here given its accumulated surplus meaning as a result of the original *ability/achievement discrepancy* model when used in specific learning disability (SLD) identification. Although a discrepancy score is a form of difference score, difference scores may differ in their method of calculation and intended use and interpretation.

the predictor scores (A) and the actual obtained scores (B) from participants in the WJ IV norming sample. In this example, the correlation between the predictor score (A) and the obtained score (B) is .73, but in reality, the correlations shift developmentally (by age or grade) via a complex polynomial regression-based statistical prediction model[16] (C). The actual scores (B) minus the predicted scores (D) produces the difference scores (F) for all norming study participants. In the example in Figure 3-9, the GIA score (A), which has a correlation with Broad Reading (B) of .73 for this age group, was entered into a regression-based statistical prediction model (C) to generate predicted Broad Reading (D) scores for all WJ IV norming study participants in this age group. Then, those norming study participants' predicted Broad Reading scores (D) were subtracted from their actual GIA/Broad Reading scores (B) to generate a distribution of "actual minus predicted" Broad Reading difference scores (F) for this age group.

The distribution of these difference scores in the norming sample (F) provided the data for computing difference standard deviations (*SD*s) and percentile ranks (PRs) using the WJ IV norm construction procedures described previously. These scores are identified in the online scoring program as discrepancy *SD* and discrepancy PR. A discrepancy *SD* score is a standardized *z* score that reports (in standard deviation units) the difference between an individual's difference score and the average difference score for individuals at the same age or grade level in the norming sample who had the same predictor score. This *SD* is used to determine the statistical significance of an individual's difference score when it differs from the mean difference score of others with the same predictor score who are at the same age or grade level. The discrepancy PR reports this information as the examinee's location in the distribution of difference scores from the examinee's same age or grade reference group in the norming sample.

It is important to recognize that while the predictor (A) and actual standard scores (B) have score distributions with means of 100 and *SD*s of 15, the distribution of the predicted (D) and difference (F) scores *do not*. As illustrated in the example in Figure 3-9, the mean of the distribution of the predicted Broad Reading (D) scores is 100, but the *SD* equals 11.6 (not 15). The *SD* of 11.6 reflects the impact of regression to the mean due to the less-than-perfect correlation between the predictor (A) and actual (B) scores. The only instance in which the predicted score distribution (D) would have an *SD* of 15 is if the predictor (A) and actual (B) scores were perfectly correlated ($r = 1.0$). This means that users should not interpret the predicted scores reported by the online scoring program as having the same meaning as standard scores based on a scale with a mean of 100 and an *SD* of 15. In the GIA/Broad Reading example in Figure 3-9, if an examiner were to mistakenly interpret a predicted Broad Reading score of 85 as being 1 *SD* below the mean, the examiner would be significantly overestimating the true predicted Broad Reading score; with a real *SD* of 11.6, a predicted Broad Reading score of 85 would actually be 1.29 *SD*s below the mean ($100 - 85 = 15$; $15/11.6 = 1.29$ *SD*s).

Finally, the difference score distribution (F) will always have a mean of zero and a unique *SD* that will *not equal 15*. In the example in Figure 3-9, given a correlation of .73 between GIA and Broad Reading for WJ IV norming study participants between the ages of 9 and 13, the *SD* of the difference score distribution is 10.8. If an examiner or agency determines that a GIA/Broad Reading difference score must be $\leq -1.5$ *SD* to be considered significant for diagnostic or classification purposes, then a difference score of approximately $-17.5$ ($10.8 \times -1.5 = 17.49$) would be required to meet this criterion. If the examiner mistakenly believes that the *SD* of the distribution is 15 points (so that $-1.5$ *SD* would equal a difference

[16] The regression-based statistical prediction models, which account for regression to the mean, are similar to those previously described for the discrepancies used in the WJ-R and WJ III batteries (McGrew et al., 1991; McGrew & Woodcock, 2001).

score of approximately −22 or −23 points), the examiner would inadvertently fail to identify a significant score difference when one exists. The online scoring program removes this potential for error by designating whether a comparison or variation difference score is significant at the user's preselected criterion level (e.g., 1.5 *SD*s).

## Advantages of the WJ IV Difference Score Norms

When examiners do not use a co-normed instrument that includes actual difference score norms, they must estimate the relationship between the predictor and criterion measures by using a regression equation or a table based on the equation. In practice, these equations are typically based on a limited number of correlation coefficients based on relatively small samples and do not cover the entire developmental range for which they are used. In contrast, the procedure used in the WJ IV is based on a large, nationally representative sample of 7,416 norming study participants with scores from the WJ IV COG, WJ IV OL, and WJ IV ACH batteries. Furthermore, because all tests in the WJ IV are co-normed, the comparison and variation difference scores do not contain error that is inherent when using measures based on different samples.

Another advantage of the WJ IV comparison and variation difference norms is that examiners can evaluate the significance of a difference in the population by inspecting either the percentile rank of the difference score (discrepancy PR) or the difference between the achievement score and the predicted achievement score in standard error of estimate units (discrepancy *SD*). This feature allows a professional, school district, or state to define a criterion of significance in terms of either the standard error of the estimate or the discrepancy percentile rank. The standard error of the estimate allows the criterion to be defined in terms of the distance of an individual's score from the average score for that subgroup of the norming sample (i.e., individuals of the same age or same grade). The discrepancy percentile rank allows the criterion to be defined in terms of the percentage of the population identified as possessing a discrepancy of a specified direction and magnitude.

## Chapter 4

# Reliability

Reliability refers to the precision of a test score. High reliability indicates that an individual's measure on a test would be unlikely to change if he or she were retested under similar conditions. Reliability is a necessary, but not sufficient, condition for validity. While high reliability does not necessarily imply that a test score is valid for a specific purpose, reliability is an important element of the overall validity argument for a test. This chapter (and its associated Appendices B and C) contains evidence demonstrating that the *Woodcock-Johnson IV* (WJ IV) (Schrank, McGrew, & Mather, 2014a) test and cluster scores are sufficiently reliable and precise for measuring an individual's cognitive ability, oral language ability, and achievement across the majority of the age span. First, the chapter reviews some basic reliability and measurement error concepts. Then it provides descriptions of several different types of reliability analyses performed for the WJ IV tests and clusters and reports their results. Finally, it presents results of additional reliability studies conducted with the WJ IV tests.

## Reliability Concepts

Because no test provides a perfect measure of a trait, all test scores contain some degree of error. This error component is assumed to be unsystematic and randomly distributed around zero. In classical test theory (CTT) (de Ayala, 2009; Raykov & Marcoulides, 2011), an individual's observed score is understood to be composed of two components: the true score, or the score that would be obtained on a hypothetical "perfect" test, and the error component:

$$X_{observed} = X_{true} + X_{error}\ , \tag{4.1}$$

where $X_{true}$ and $X_{error}$ are independent and uncorrelated. Over a large number of individual scores, the relationship between the means of these distributions takes this form:

$$\overline{X}_{observed} = \overline{X}_{true} + \overline{X}_{error}\ , \tag{4.2}$$

where $\overline{X}_{error}$ is equal to zero. The relationship of the variances takes this form:

$$SD^2_{observed} = SD^2_{true} + SD^2_{error}\ . \tag{4.3}$$

The reliability ($r_{11}$) of a test is defined as the ratio of true score variance to observed score variance:

$$r_{11} = \frac{SD^2_{true}}{SD^2_{observed}}\ , \tag{4.4}$$

or, equivalently,

$$r_{11} = 1 - \frac{SD^2_{error}}{SD^2_{observed}} . \tag{4.5}$$

This last equation provides an expression for test reliability that utilizes the statistics of observed score variance and error score variance.

# Error of Measurement

The square root of the error variance term in Equation 4.5 (i.e., $SD_{error}$, or the standard deviation (*SD*) of the differences between observed scores and true scores) is called the *standard error of measurement*, or *SEM*. Substituting *SEM* into Equation 4.5, we see that

$$r_{11} = 1 - \frac{SEM^2}{SD^2_{observed}} . \tag{4.6}$$

The *SEM* is frequently used as an index of the precision of an individual score, or the accuracy with which the underlying true score can be located on a scale. There exists an inverse relationship between reliability and *SEM*; as *SEM* decreases, reliability increases. Errors of measurement for the WJ IV tests can be calculated in *W*-scale units based on a traditional formula relating the reliability coefficient and standard deviation for a set of test scores:

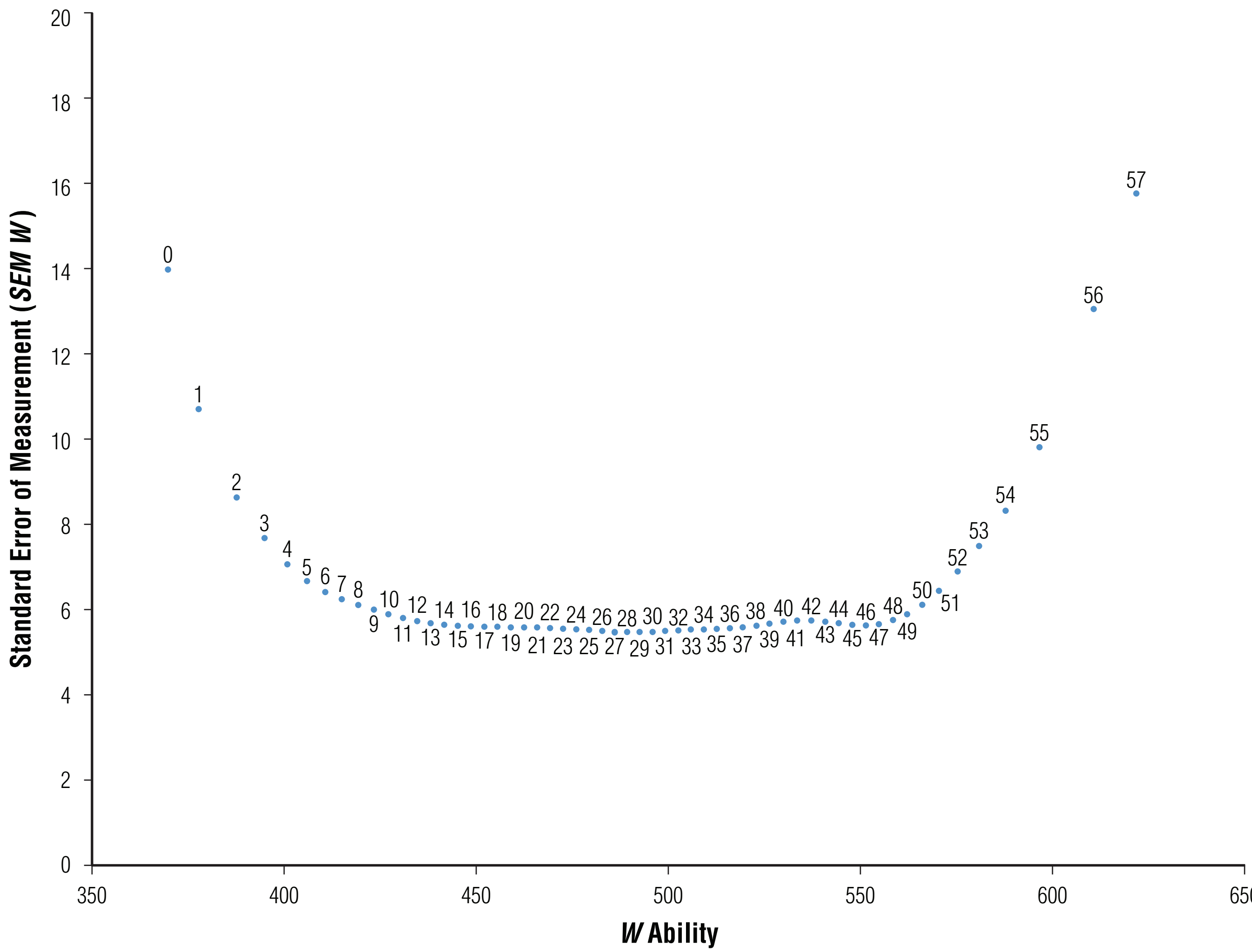
$$SEM = SD_{observed}\sqrt{1 - r_{11}} . \tag{4.7}$$

These *SEM* values are group statistics and can be interpreted as the average *SEM*s for individual *W* scores at a given age or grade level.

Unlike classical test theory reliability estimates that assume constant precision across the range of ability measured by the test, the item response theory (IRT) (de Ayala, 2009; Raykov & Marcoulides, 2011) based Rasch analysis procedures that underlie the *W* scale provide a unique estimate of the *SEM* for the ability score associated with each raw score. As such, using the Rasch model and the *W* scale allows WJ IV test users to compare *SEM* values on a common scale across all tests and levels. For example, if the *SEM* for one test at age 5 is 6.0 and the *SEM* for a second test at age 8 is 3.0, then scores on the second test at age 8 are twice as precise as scores on the first test at age 5. Given a test with a uniform item density (i.e., equal spacing of items along the *W* difficulty scale), the *SEM* estimates, when expressed in *W* units, are smaller in the center region of the test and larger at the extremes. The exact *SEM* value in any region of a test is a function of the number of items and density of the items in that region.

Figure 4-1 illustrates the typical relationship between error of measurement and ability across the entire range of a test on the *W* scale. The dots in Figure 4-1 represent raw scores on *Woodcock-Johnson IV Tests of Achievement* (WJ IV ACH) (Schrank, Mather, & McGrew, 2014a) Standard Battery Test 5: Calculation, Form A that start at 0 (W score = 369.73) and progress to 57 (*W* score = 621.70). Note that the error of measurement increases rapidly in size at the tail ends of the raw score distribution. Also note the almost equidistant spacing of raw scores between the *W*-ability values of 415.06 (raw score = 7) and 566.04 (raw score = 50). This equal *W*-ability spacing results from the inclusion of items with relatively uniform *W* difficulty spacing across the entire range of the test. When items have uniform *W* difficulty spacing, raw scores and *W*-ability scores will be approximately linearly related, except at the extreme upper and lower ends of the test. This relationship is especially true in wide-range tests, such as those in the WJ IV.

***Figure 4-1.***
*Relationship of measurement error to* W *ability across the range of examinee* W *scores for WJ IV ACH Test 5: Calculation, Form A.*




# Reliability Coefficients

The reliability coefficient can be thought of as an index of the precision with which relative standing or position in a group is measured. High reliability implies that an individual's relative standing in the group would be similar across repeated administrations of the test. If we examine the component parts of Equation 4.6, we see that high reliability can result from either a small *SEM* (i.e., good score precision), or a large value of $SD^2_{observed}$ (i.e., wider variability of test scores in a group). Conversely, larger values of *SEM* and/or limited variability of test scores within a group can cause deflation of the reliability coefficient.

It is possible for a test to have good precision of scores, as reflected by a small *SEM*, but to have poor precision for relative standings in a group when the group has a limited range of scores on the trait being measured. A limited range of scores and a resulting low $r_{11}$ can occur when the group selected to provide data for the reliability analysis has a small range among scores (e.g., a group having mostly zero and very low scores or a group having mostly perfect and very high scores), or when the trait being measured has limited variability in the population at a particular level (McGrew, Schrank, & Woodcock, 2007).

In cases where a low reliability coefficient is due to limited variability in the sample or population, to claim that the test is "unreliable" (with the implication being that it is poor) is analogous to concluding that a particular yardstick is not a reliable measuring instrument because everything you measure happens to be about 36 inches long (McGrew et al., 2007). Table 4-1 illustrates this point for the WJ IV. This table includes *SEM*, *SD*, and $r_{11}$ data for ages 11 and 50 through 59 on *Woodcock-Johnson IV Tests of Cognitive Ability* (WJ IV COG) (Schrank, McGrew, & Mather, 2014b) Test 5: Phonological Processing. Note that the reliability coefficient for this test is relatively low at age 11 (.78) compared with age 50 through 59 (.90). Further study of Table 4-1 reveals that the precision of the test scores, as indicated by the *SEM*s, is about the same for both ages (4.60 and 4.58, respectively). The difference in the reliability coefficients is due to the larger spread of ability (*SD*) on this test at age 50 through 59 (14.49) compared with the spread of ability at age 11 (9.81). The test itself is just as precise at age 11 as it is at age 50 through 59, but the apparent precision of relative standings is not as good at age 11 because there is a smaller range of individual differences in the population at this age. Therefore, the relatively low reliability coefficient at age 11 is a function of the sample, not of the test.

***Table 4-1.***
*Selected Reliability Data From WJ IV COG Test 5: Phonological Processing*

| Statistic | Age 11 | Ages 50–59 |
|---|---|---|
| *SEM* | 4.60 | 4.58 |
| *SD* | 9.81 | 14.49 |
| $r_{11}$ | 0.78 | 0.90 |

## Test Reliabilities

Reliability statistics were calculated for all WJ IV tests across the age ranges of intended use. Reliability calculations for the nonspeeded tests included data from all norming examinees tested at each technical age level.[1]

The standard error of the reliability coefficient provides a confidence band within which the true reliability coefficient would be expected to fall. Table 4-2 reports the 68% confidence band for several typical reliabilities and sample sizes. The confidence bands were determined by first transforming the reliabilities into Fisher $z'$ values using standard statistical tables. Then the standard errors of the $z'$ values were estimated using the following equation:

$$SE_{z'} = \sqrt{\frac{1}{N - 3}}\ . \qquad (4.8)$$

These standard error values were used to determine confidence bands for the $z'$ values. Finally, these values were transformed back into the reliability scale for Table 4-2.

[1] The technical age levels for the reliability analyses are < 5 years, 5–6 years, 7–8 years, 9–10 years, 11–12 years, 13–14 years, 15–16 years, 17–19 years, 20–29 years, 30–39 years, 40–49 years, 50–69 years, and 70+ years.

**Table 4-2.**
*±1 SEM Confidence Bands for Selected Values of Reliability and Sample Size*

| Reliability | Sample Size | | |
|---|---|---|---|
| | 100 | 200 | 300 |
| .80 | .760–.835 | .773–.824 | .782–.815 |
| .90 | .879–.918 | .886–.912 | .890–.909 |
| .95 | .939–.959 | .942–.957 | .945–.954 |

## Tests and Subtests With Dichotomously Scored Items

Internal-consistency reliabilities for all untimed tests and subtests with dichotomously scored items were calculated using the split-half procedure. Raw scores were computed for the norming examinees based on the odd and even items in these tests. Correlations were then computed between the two item sets. The basal-ceiling rules used during the norming study were stringent enough that the probability of an examinee failing an item below the basal or passing an item above the ceiling was very low. Therefore, all item responses below an examinee's basal level were assumed to be correct, and all responses above the examinee's ceiling level were assumed to be incorrect. These coefficients were then corrected for published test length using the Spearman-Brown correction formula.

## Tests With Multiple-Point Scoring

Because the split-half procedure is inappropriate[2] for speeded tests and subtests (e.g., Phonological Processing–Word Fluency and Retrieval Fluency subtests) and tests containing multiple-point items (e.g., Writing Samples and Oral Reading), the reliabilities for these tests and subtests were calculated using information provided by the Rasch model. The Rasch model underlying the *W* scale provides a standard error of measurement (*SEM*) associated with the ability estimate for every person in the norm sample. The observed score variance ($SD^2_{observed}$) and mean-square error values were calculated across all norming examinees in a technical age group and inserted into Equation 4.6 to calculate reliabilities.

The use of mean-squared-error values is justified as follows. Equation 4.6 is reproduced here for convenience:

$$r_{11} = 1 - \frac{SEM^2}{SD^2_{observed}} . \tag{4.9}$$

where the *SEM* is equivalent to the $SD_{error}$ term, as previously discussed. Now consider the general formula for calculating variances:

$$SD^2_Y = \frac{N\Sigma Y^2 - (\Sigma Y)^2}{N(N-1)} . \tag{4.10}$$

Taking *Y* to be the error term, observe that because the error terms are randomly distributed around zero, the sum of the error terms is itself zero. Therefore,

$$SD^2_Y = \frac{\Sigma Y^2}{(N-1)} , \tag{4.11}$$

which approaches the mean-squared-error value as *N* becomes sufficiently large. The

[2] Internal consistency reliability methods, such as the split-half procedure, assume that the average correlation between items within a test is the same as the average correlation between items from the hypothetical alternative forms created by splitting the test into two smaller tests (e.g., odd and even items). This assumption is violated when tests contain items that produce a different range of scores for each item (as in the WJ IV tests with multiple-point item scoring). In this case, splitting the test in half may produce tests that are no longer equivalent; the items on one half of the test may have a higher maximum possible total score than the items on the other half.

differences between the error score variance and the mean-squared error are small enough to be negligible for the purposes of calculating these reliabilities. The mean-squared error, as the numerator of the term in the reliability formula, could be made exactly equivalent to the error score variance by multiplying by a factor of $(N - 1)/N$.

## Tests With Subtests

The WJ IV Oral Vocabulary, Phonological Processing, Visualization, General Information, Sound Awareness, and Reading Vocabulary tests are all composed of two or three subtests. Reliability of composite scores can be calculated by the following equation (Mosier, 1943):

$$r_{cc} = 1 - \frac{\Sigma SD_j^2 - \Sigma SD_j^2 r_{jj}}{\Sigma SD_j^2 + 2\Sigma SD_j SD_k r_{jk}}, \tag{4.12}$$

where $r_{cc}$ is the reliability of a composite test, $SD_j$ is the standard deviation of examinee ability scores on test $j$, $SD_k$ is the standard deviation of examinee ability scores on test $k$, $r_{jj}$ is the reliability of test $j$, and $r_{jk}$ is the correlation between tests $j$ and $k$. Equation 4.12 was used to calculate the unweighted reliabilities for tests with subtests. The reliabilities for the subtests were those obtained using either the split-half or the Rasch reliability procedures reported earlier.

Appendix B reports the reliability coefficients ($r_{11}$) and the standard errors of measurement (*SEM*) for all nonspeeded WJ IV tests across 25 age groups. The *SEM*s are reported in both *W* scale and standard score (SS) units. The Appendix B tables also report *W* scale mean and standard deviation statistics for all tests.

A review of the median reliabilities reported for each test in Appendix B reveals the extent to which the test reliabilities fall at the desired level of .80 or higher. Of the 39 median test reliabilities reported, 38 are .80 or higher and 17 are .90 or higher. Although these are strong reliabilities for individual tests, the WJ IV cluster scores are recommended for interpretation, particularly when the scores are used in making important decisions about an individual. Cluster scores are based on combinations of two or more tests and, as a result, possess consistently higher reliabilities.

## Speeded Tests

As described in Chapter 2, the WJ IV speeded tests (Letter-Pattern Matching, Phonological Processing–Word Fluency, Number-Pattern Matching, Pair Cancellation, Rapid Picture Naming, Retrieval Fluency, Sentence Reading Fluency, Math Facts Fluency, Sentence Writing Fluency, and Word Reading Fluency) were calibrated using a rate-based metric. While this rate-based metric is useful for calibrating items and rank-ordering examinees, it provides inflated standard errors for ability measures due to the limited number of possible scores for each time interval. For this reason, the procedures for calculating Rasch-based reliability that were used for the tests with multiple-point items were not appropriate for the speeded tests. Instead, a test-retest study was conducted for all speeded tests. Examinees in three separate age groups were administered the norming form of each speeded test, followed by a second administration of the same form of the test 1 day later. The retest interval in this study was intentionally short to minimize changes in test scores due to changes in the examinee's state or latent trait. Correlations between the first and second administrations were computed, and a correction was applied for restriction of range in the study samples (Sackett & Yang, 2000).

Table 4-3 contains summary statistics and test-retest reliability coefficients from the speeded test-retest study.[3] With the exception of the .79 and .76 test-retest correlations for Rapid Picture Naming and Sentence Writing Fluency, respectively, in the 14 through 17 age group, all test-retest correlations in Table 4-3 are in the .80 to .90 range. The median reliabilities across tests for the three different age groups (.91, .88, .92) provide evidence of strong test-retest stability; these test-retest correlations provide evidence that the speeded test scores rank order examinees in a similar manner across repeated administrations.

Table 4-3 also contains mean *W*-score differences between the first and second administration and the associated change in standard deviation (of the first test administration) units. While test-retest *SD*-unit difference score information is often interpreted as the change due to a "practice effect,"[4] these relatively large *SD* differences are likely due to the 1-day test-retest interval employed in this study. On the first administration, the eight speeded test tasks in Table 4-3 are *novel* for most individuals, particularly for the cognitive tests. The second time the tests are administered (only 1 day later), memory and experience remove the element of novelty, resulting in improved scores. The average improvement in scores across all tests for the three age groups is .36, .82 and .46 *SD* units, respectively. Users are cautioned *not* to use the information summarized in Table 4-3 to make decisions about WJ IV practice effects over a longer test-retest interval—information that is often used to determine how long a period of time should pass before a test score is not likely to be influenced by practice effects.[5]

## Cluster Reliabilities

The reliabilities of the WJ IV cluster scores were computed using Mosier's (1943) unweighted composite from Equation 4.12. The relationship among cluster reliability, standard deviation, and the standard error of measurement can be shown by:

$$r_{\mathrm{cc}} = 1 - \frac{SEM^2_{cluster}}{SD^2_{cluster}} . \tag{4.13}$$

Notice that Equation 4.13 parallels Equation 4.6.

Appendix C reports means, standard deviations, cluster score reliabilities, and standard errors of measurement for the WJ IV clusters across their range of intended use at each technical age level. The *SEM* values are presented in both *W* and standard score (SS) units. A review of the median reliabilities for each cluster reveals that most are .90 or higher.

[3] Test-retest correlations are sometimes referred to as *coefficients of stability*.

[4] The *APA Dictionary of Psychology* (VandenBos, 2007) defines *practice effect* as "any change or improvement that results from practice or repetition of task items or activities" (p. 719).

[5] The impact of practice effects on intelligence test scores generated by repeated testing with the same tests is well documented in the scientific and professional intelligence testing literature (Kaufman, 2009). Researcher-based professional guidelines recommend that the same test not be administered if the time elapsed from the first administration is less than 12 months (American Association on Intellectual and Developmental Disabilities, 2010; Kaufman & Lichtenberger, 2002). If retesting is necessary, the WJ IV battery includes alternate forms for the tests in the ACH Standard Battery.

***Table 4-3.***
*Summary Statistics and Test-Retest Reliability Coefficients for the WJ IV Speeded Test-Retest Study*

| **Ages 7–11** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Mean** | | **Standard Deviation** | | | | |
| **Test** | ***n*** | **Test** | **Retest** | **Test** | **Retest** | $r_{12}$ | **Mean Difference** | **Difference in *SD* units** |
| Letter-Pattern Matching | 47 | 506.73 | 513.92 | 23.55 | 27.48 | 0.91 | 7.19 | 0.31 |
| Number-Pattern Matching | 47 | 442.59 | 450.35 | 36.06 | 32.93 | 0.85 | 7.76 | 0.22 |
| Pair Cancellation | 47 | 498.03 | 515.28 | 29.44 | 30.61 | 0.89 | 17.25 | 0.59 |
| Rapid Picture Naming | 47 | 501.53 | 504.12 | 14.52 | 16.29 | 0.90 | 2.59 | 0.18 |
| Sentence Reading Fluency | 47 | 487.42 | 504.93 | 41.96 | 49.90 | 0.95 | 17.51 | 0.42 |
| Math Facts Fluency | 47 | 492.23 | 499.27 | 27.53 | 30.29 | 0.95 | 7.04 | 0.26 |
| Sentence Writing Fluency | 46 | 518.84 | 525.71 | 15.86 | 19.72 | 0.83 | 6.87 | 0.43 |
| Word Reading Fluency | 47 | 480.85 | 502.34 | 46.40 | 50.09 | 0.92 | 21.49 | 0.46 |
| **Median** | | | | | | 0.91 | 7.47 | 0.36 |
| **Ages 14–17** | | | | | | | | |
| | | **Mean** | | **Standard Deviation** | | | | |
| **Test** | ***n*** | **Test** | **Retest** | **Test** | **Retest** | $r_{12}$ | **Mean Difference** | **Difference in *SD* units** |
| Letter-Pattern Matching | 49 | 554.40 | 564.41 | 10.13 | 11.65 | 0.88 | 10.01 | 0.99 |
| Number-Pattern Matching | 49 | 491.91 | 496.32 | 11.20 | 13.22 | 0.84 | 4.41 | 0.39 |
| Pair Cancellation | 49 | 550.94 | 563.87 | 18.33 | 16.32 | 0.89 | 12.93 | 0.71 |
| Rapid Picture Naming | 49 | 535.09 | 544.08 | 21.58 | 20.69 | 0.79 | 8.99 | 0.42 |
| Sentence Reading Fluency | 49 | 560.39 | 583.19 | 23.78 | 33.23 | 0.93 | 22.80 | 0.96 |
| Math Facts Fluency | 49 | 540.69 | 545.88 | 18.38 | 19.98 | 0.97 | 5.19 | 0.28 |
| Sentence Writing Fluency | 49 | 547.15 | 557.92 | 11.58 | 15.73 | 0.76 | 10.77 | 0.93 |
| Word Reading Fluency | 49 | 550.38 | 573.82 | 21.93 | 22.30 | 0.91 | 23.44 | 1.07 |
| **Median** | | | | | | 0.88 | 10.39 | 0.82 |
| **Ages 26–79** | | | | | | | | |
| | | **Mean** | | **Standard Deviation** | | | | |
| **Test** | ***n*** | **Test** | **Retest** | **Test** | **Retest** | $r_{12}$ | **Mean Difference** | **Difference in *SD* units** |
| Letter-Pattern Matching | 50 | 546.95 | 555.27 | 18.40 | 19.30 | 0.91 | 8.32 | 0.45 |
| Number-Pattern Matching | 50 | 489.21 | 494.98 | 16.05 | 16.78 | 0.88 | 5.77 | 0.36 |
| Pair Cancellation | 50 | 542.68 | 558.19 | 19.79 | 20.28 | 0.95 | 15.51 | 0.78 |
| Rapid Picture Naming | 50 | 539.66 | 548.93 | 19.55 | 20.97 | 0.90 | 9.27 | 0.47 |
| Sentence Reading Fluency | 50 | 552.07 | 570.31 | 25.75 | 30.94 | 0.93 | 18.24 | 0.71 |
| Math Facts Fluency | 50 | 546.17 | 552.04 | 19.20 | 20.63 | 0.95 | 5.87 | 0.31 |
| Sentence Writing Fluency | 50 | 545.41 | 552.17 | 16.25 | 17.04 | 0.88 | 6.76 | 0.42 |
| Word Reading Fluency | 50 | 548.21 | 586.61 | 32.29 | 29.72 | 0.93 | 38.40 | 1.19 |
| **Median** | | | | | | 0.92 | 8.79 | 0.46 |

*Note.* Means and standard deviations are reported in the *W* score metric. The difference in *SD* units was calculated by dividing the mean change from the first to the second administration by the standard deviation of the first administration, in *W* units.

## Alternate-Forms Equivalence

The WJ IV ACH Standard Test Book is available in three unique, parallel forms (A, B, and C). The fundamental questions in the evaluation of the equivalence of alternate test forms are: (a) Do the items on the alternate forms measure the same construct? and (b) Is the precision of measurement on alternate forms similar? In other words, form equivalence implies that examinees' scores on different forms of the test can be compared and interpreted in the same way. This section describes the procedures used to construct the three unique forms of the WJ IV ACH Standard tests. Empirical evidence is presented that supports the equivalence of the alternate forms.

### *Nonspeeded WJ IV ACH Standard Tests*

The three forms of WJ IV ACH Standard Tests 1 through 8 were constructed from large, Rasch-calibrated item pools. The item pools for ACH tests 1 through 7 typically included from 100 to 600 items and contained data from between 15,000 and 25,000 people collected over the course of the WJ IV norming study and the development of prior editions of the Woodcock-Johnson tests. Test 8: Oral Reading is a new test in the WJ IV; thus, the item pool for the 100 Oral Reading items included data from approximately 2,500 people. Using Rasch item banking and equating methodology described in Chapter 2, items in each of these pools were calibrated and placed onto a common *W* difficulty scale. Items were selected from the item pools to appear on the published test forms using the following guidelines.

#### Guideline 1: Equivalence of Item Difficulties

Items were selected for each form so that the item difficulty gradient, or number of items per 10 *W* points, was approximately equal for each form.[6] This guideline ensures that there are no obvious gaps in item difficulty on any of the test forms, which might disadvantage an examinee who is administered a specific form of the test.

Figures 4-2 through 4-9 present evidence that the first guideline in the construction of equivalent forms was met. These figures plot the *W* difficulties of the items, in serial (test administration) order, for Forms A, B, and C of the WJ IV ACH Standard Tests 1 through 8. In almost all forms of Tests 1 through 7, the number of items per 10 *W* points is equivalent across the entire range of *W* ability covered by the test. Exceptions are at the very bottom (i.e., easy) ends for some tests where there are large increases in the difficulty of items representing the underlying trait measured by the first several test items. An example of such an item difficulty gap is found in Test 4: Passage Comprehension (see Figure 4-5). In this test, the first four items require an examinee to point to a rebus that represents a larger picture. These items do not require the examinee to read. On Item 5, however, the examinee must match a picture to its written description. There is an item difficulty increase of about 150 *W* points between Items 4 and 5 on all forms of Passage Comprehension where this task requirement change occurs.

[6] *Item difficulty gradient* is sometimes called *item density*.

***Figure 4-2.***
*Plot of item W difficulties across three forms of WJ IV ACH Test 1: Letter-Word Identification.*

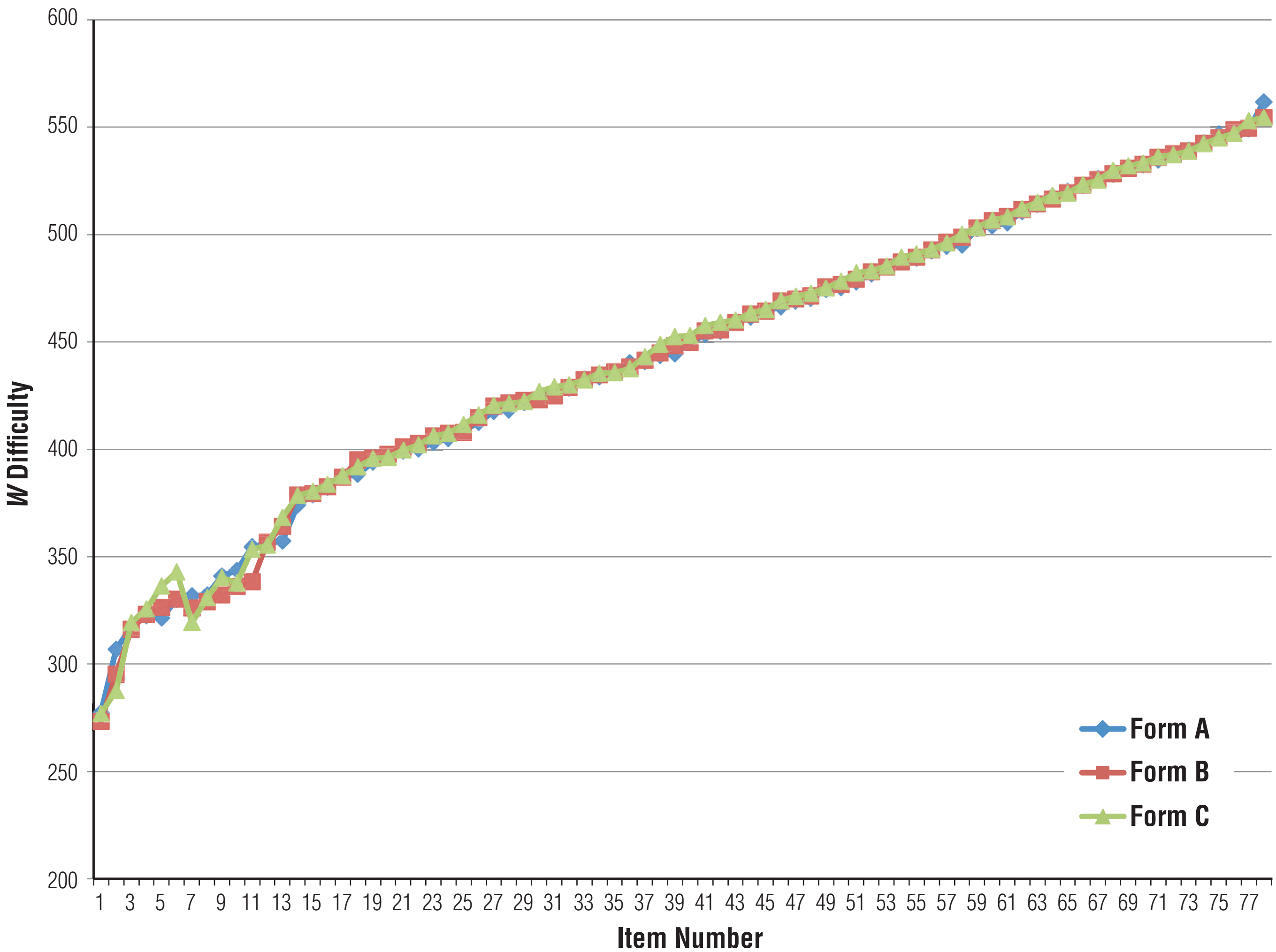


***Figure 4-3.***
*Plot of item W difficulties across three forms of WJ IV ACH Test 2: Applied Problems.*

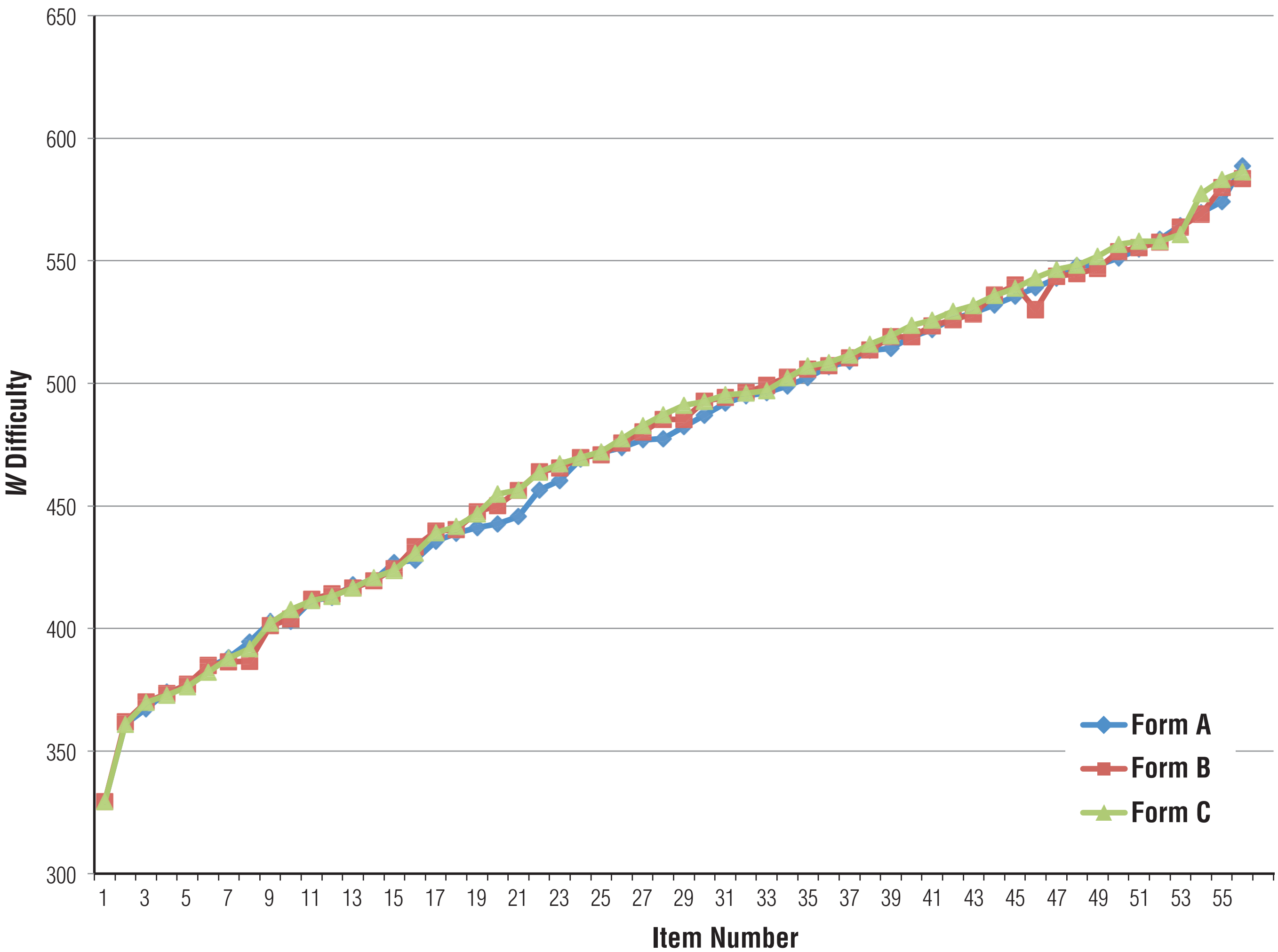


***Figure 4-4.***
*Plot of item W difficulties across three forms of WJ IV ACH Test 3: Spelling.*

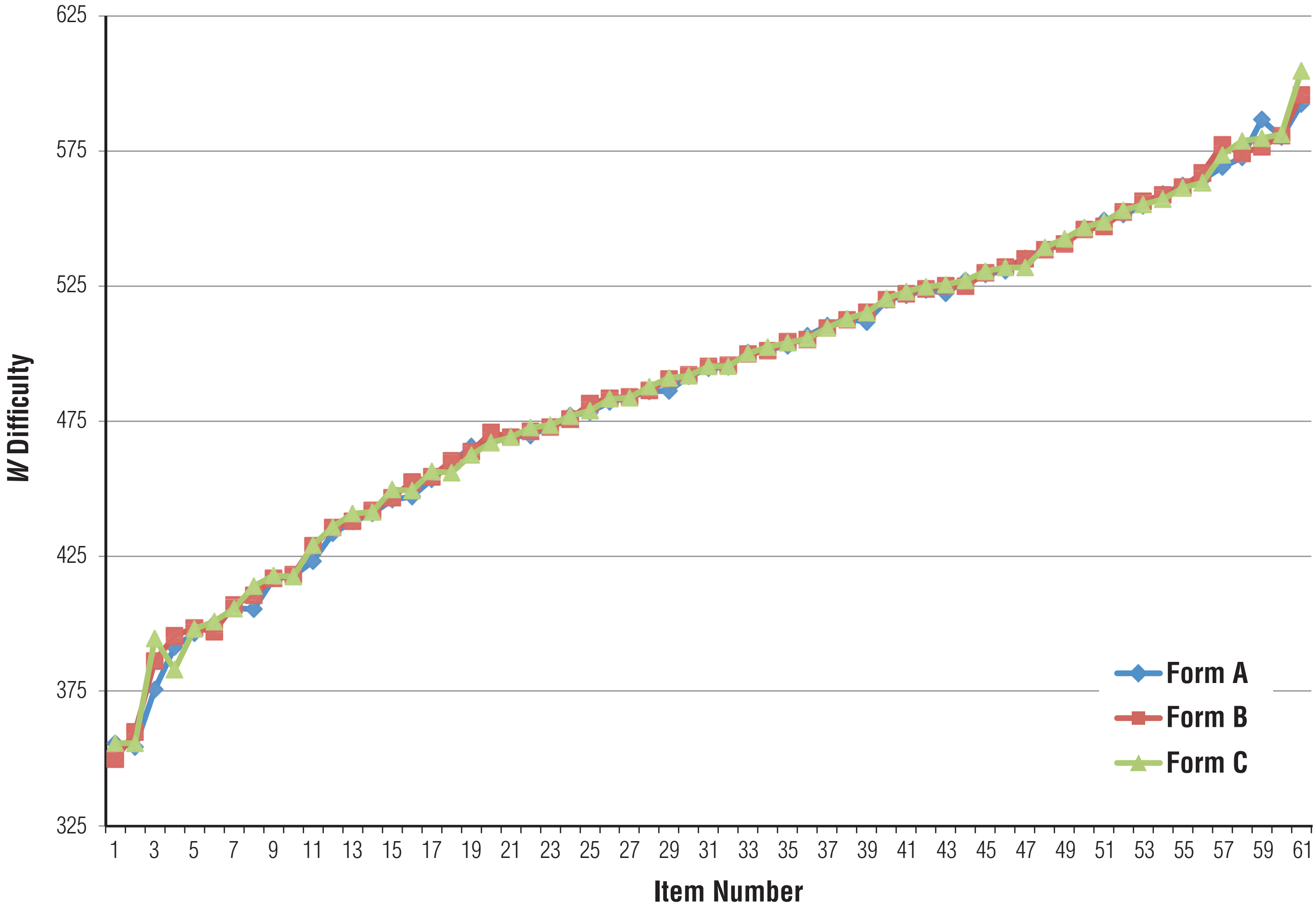


***Figure 4-5.***
*Plot of item W difficulties across three forms of WJ IV ACH Test 4: Passage Comprehension.*

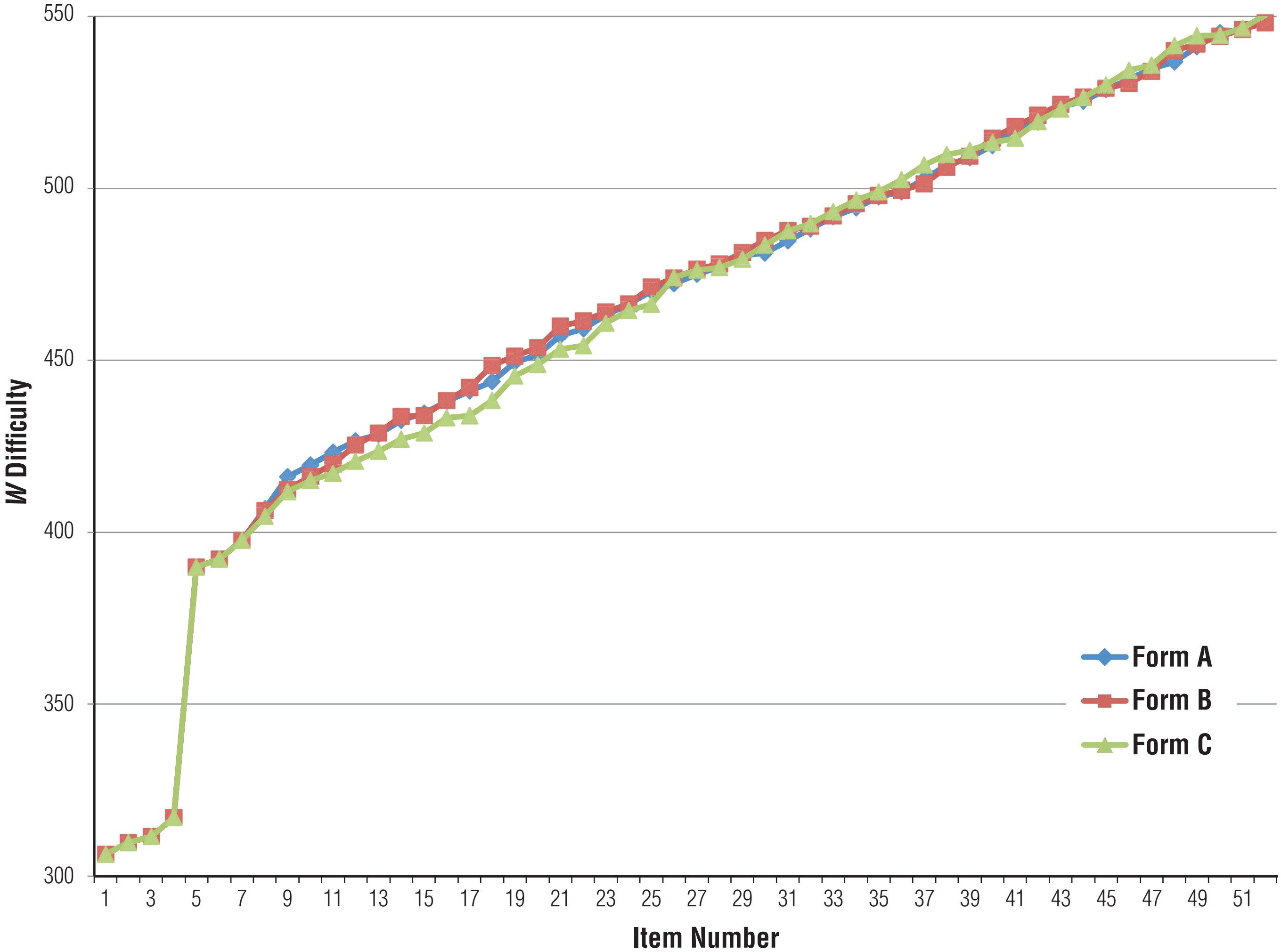


***Figure 4-6.***
*Plot of item W difficulties across three forms of WJ IV ACH Test 5: Calculation.*

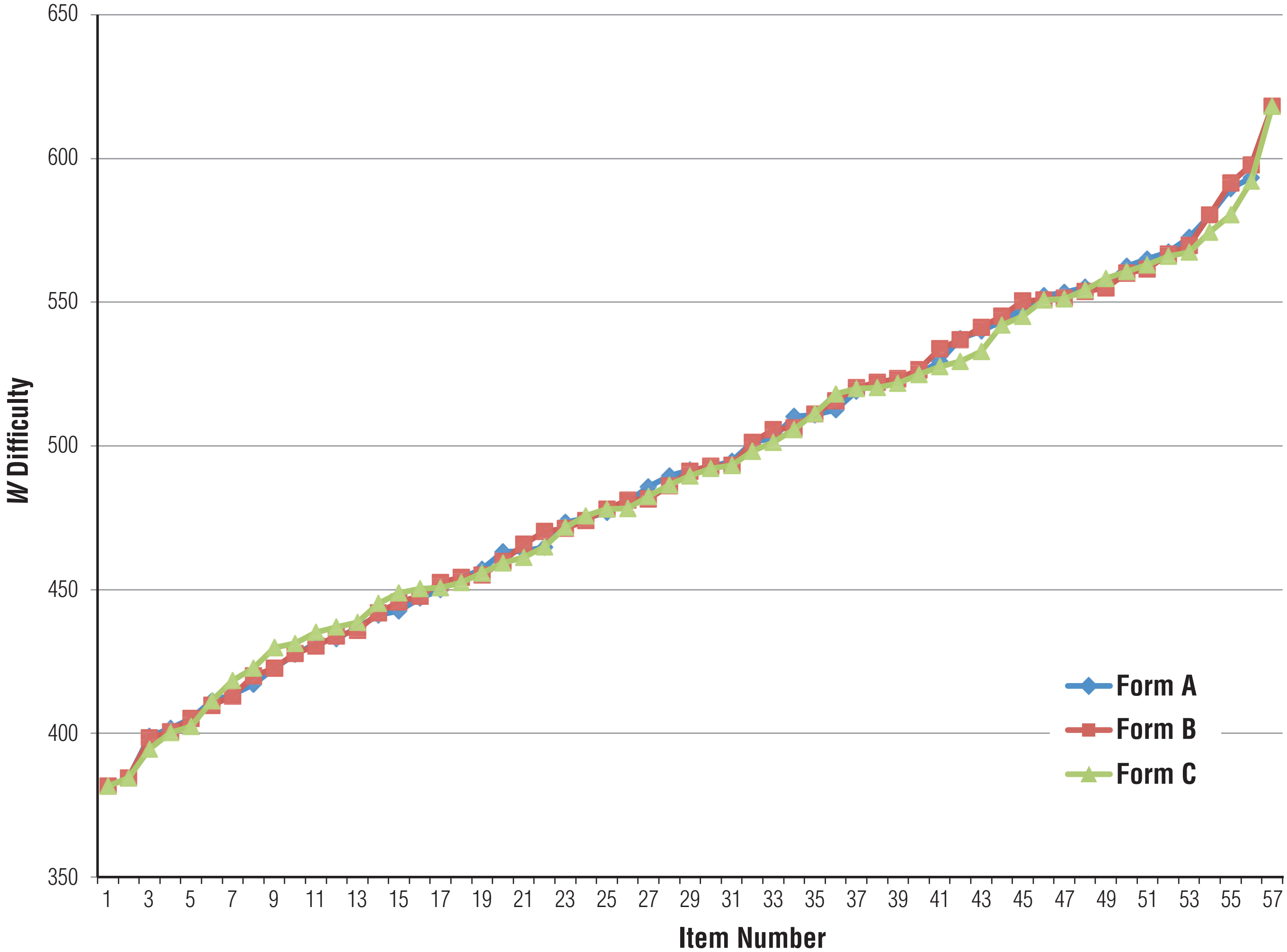


***Figure 4-7.***
*Plot of item W difficulties across three forms of WJ IV ACH Test 6: Writing Samples.*

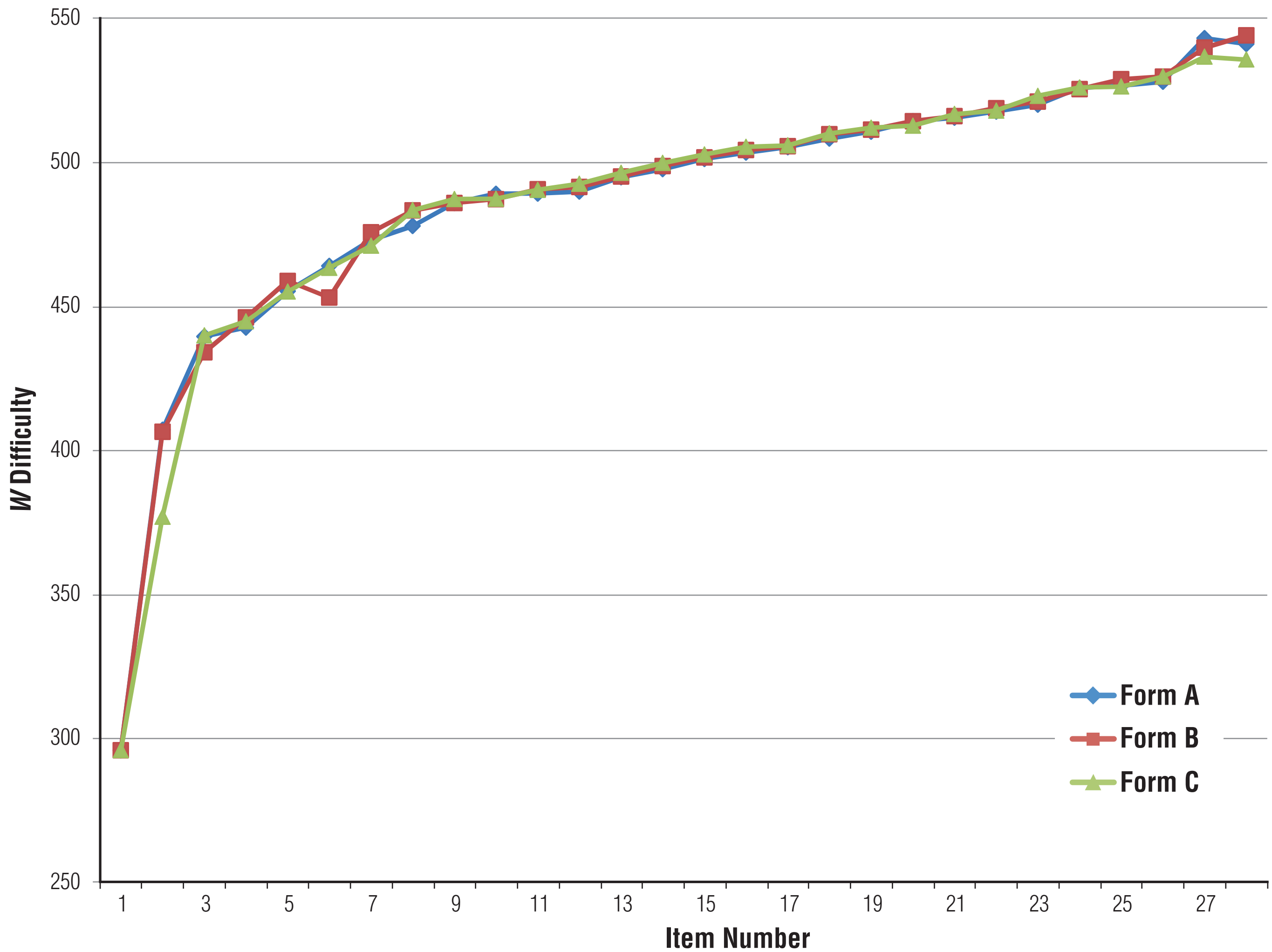
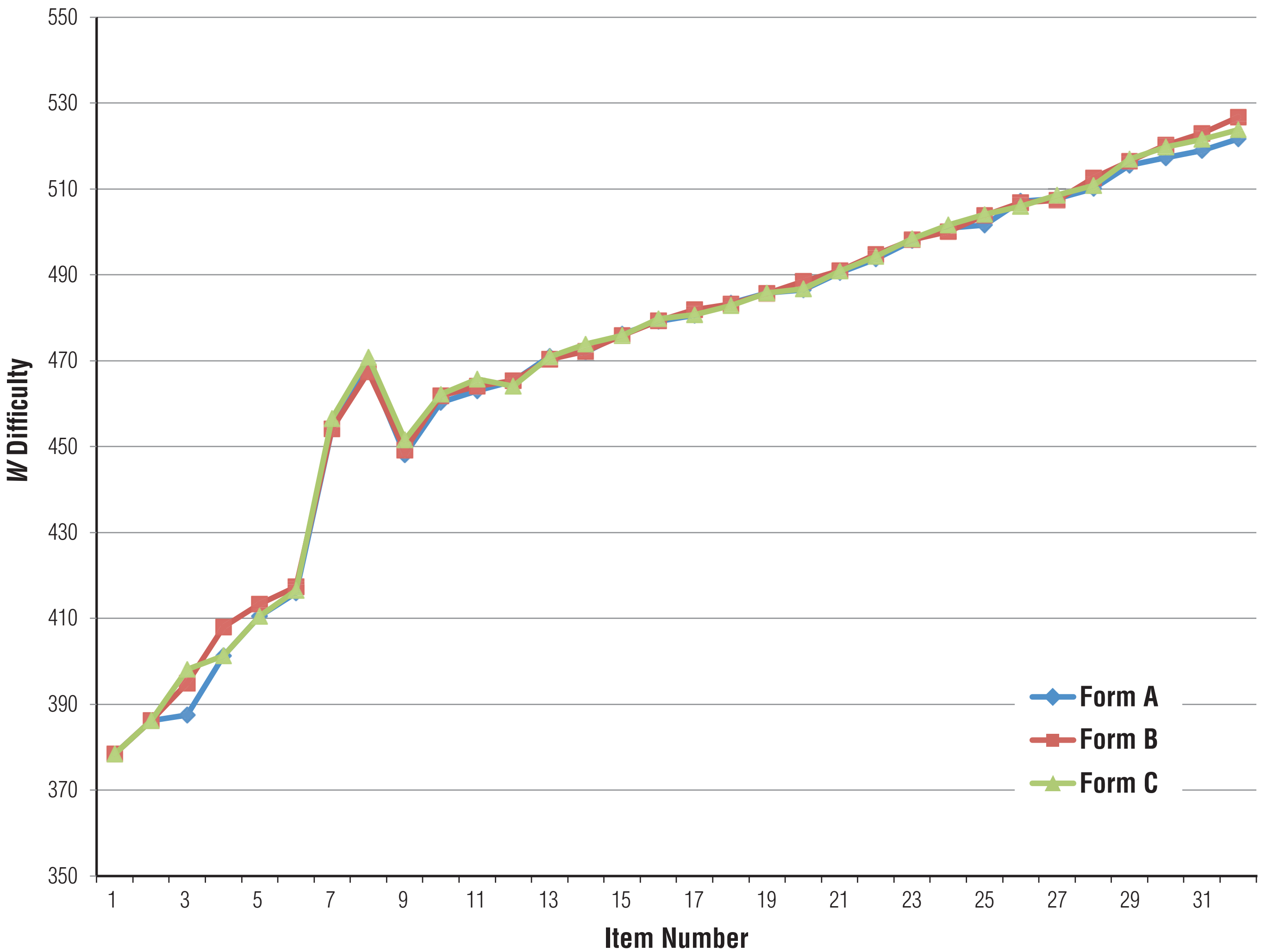


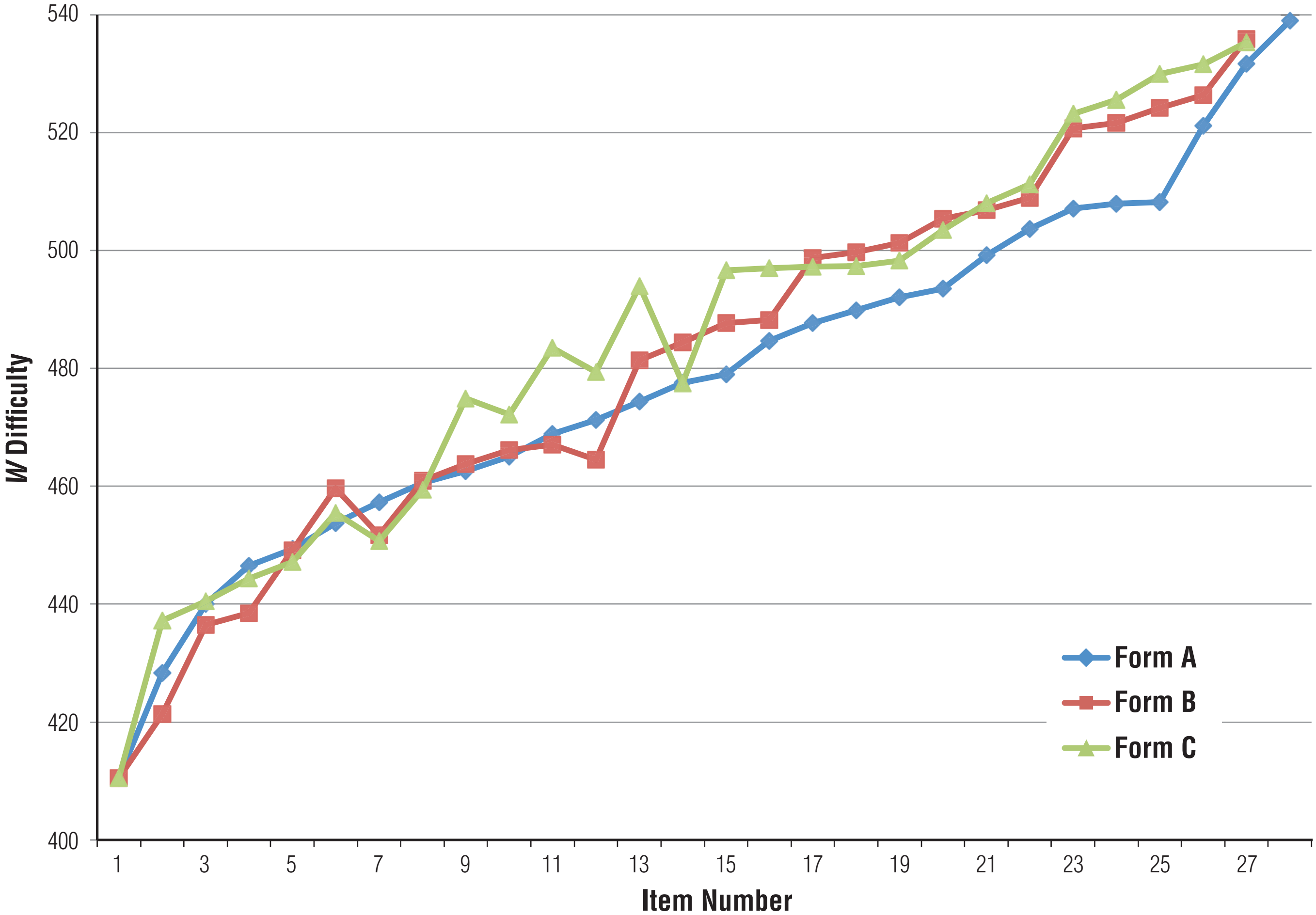
**Figure 4-8.**
*Plot of item W difficulties across three forms of WJ IV ACH Test 7: Word Attack.*




Another example of a nonuniform gradient in item difficulty due to the changes in task representation of the underlying trait is the raw score range of 6 to 9 on Test 7: Word Attack (see Figure 4-8). On this test, the initial items require the examinee to point to pictures that begin with the letter sounds shown or to produce the sounds for single letters. At Item 7, the task changes and the examinee is asked to read aloud nonsense letter combinations that are phonically consistent or regular patterns in English. At Item 9, the stimulus changes again to be nonsense whole words. At this point, there is a noticeable decrease in item difficulty across all three forms that allows for the logical flow of the task presentation in the test.

In addition to equivalent item gradients across alternate forms, most corresponding item difficulties are equivalent within 2 *W* points across forms. There are a few instances of item difficulty differences between forms. For example, at the raw score range 19 to 23 in Test 2: Applied Problems (see Figure 4-3), Form A contains items that are slightly easier than the corresponding items in Forms B and C. Also, at the raw score range 12 to 22 in Test 4:

***Figure 4-9.***
*Plot of item W difficulties across three forms of WJ IV ACH Test 8: Oral Reading.*




Passage Comprehension (see Figure 4-5), Form C contains items that are slightly easier than the corresponding items in Forms A and B. In these cases, although great care was taken to ensure equivalence in form difficulty, small tradeoffs in item difficulty difference are made to maintain the equivalence and breadth of the item types across the three forms.

Test 8: Oral Reading is administered in item sets; in each form of the test, sets of items together form meaningful "stories." The items in this test are calibrated onto a common scale in the same manner as the items on the other WJ IV tests are. However, because the items are administered in sets, or stories, the item pool underlying the Oral Reading test contains a limited number of items. For this reason, the items on the three forms of Oral Reading are expected to vary in difficulty more than the items on Tests 1 through 7 do because Tests 1 through 7 are constructed from much larger pools of standalone items. This slight variation in item difficulty between forms is visible in Figure 4-9.

The equivalent item gradient and item difficulty across three forms of the WJ IV ACH Standard tests ensure that no form will be significantly easier or significantly more difficult for examinees at any level of ability and provide evidence to support the equivalence of the alternate forms.

### Guideline 2: Equivalence of Item Content

Items were selected so that each form contained equal representation of the intended breadth of content for that test. Content-area curriculum experts provided consultation on the comparability of the item types across the three WJ IV ACH Standard forms for key criteria in the Letter-Word Identification, Applied Problems, Spelling, Calculation, and Word Attack tests. For example, a content-area expert reviewed all three forms of Test 3: Spelling to ensure that the forms contained equivalence in the numbers of items that included different types of phonetic components, such as vowel digraphs, *r*-controlled blends, silent letters, doubling consonants, etc. In a similar manner, a mathematics curriculum expert verified that each form of Test 5: Calculation contained approximately equal numbers of items measuring basic math concepts such as addition, subtraction, multiplication, and division as well as more advanced concepts such as fractions, algebra, geometry, trigonometry, and factorials. Where necessary, adjustments were made to item selections to ensure content equivalence across forms.

Table 4-4 contains an example of the application of Guideline 2 in the development of Test 5: Calculation. This table shows the distribution of item types for each form of the test. Each form contains equal, or nearly equal, numbers of items representing the entire breadth of the item pool for this test. Adherence to the guideline of equivalence of item content ensures that no examinee will encounter more or less of a certain item type than examinees who take other forms of the test. This is further evidence for the equivalence of the WJ IV ACH Standard test forms.

***Table 4-4.***
*Frequency of Item Types Across Three Forms of WJ IV ACH Test 5: Calculation*

| | Number of Items per Form | | |
|---|---|---|---|
| **Item Type** | **Form A** | **Form B** | **Form C** |
| Basic Addition | 12 | 10 | 10 |
| Basic Subtraction | 6 | 8 | 8 |
| Basic Multiplication | 4 | 4 | 4 |
| Basic Division | 2 | 3 | 2 |
| Advanced Addition | 3 | 3 | 4 |
| Advanced Subtraction | 1 | 1 | 2 |
| Advanced Multiplication | 3 | 3 | 4 |
| Advanced Division | 2 | 2 | 2 |
| Advanced Math | 1 | 1 | 1 |
| Algebra | 5 | 4 | 4 |
| Derivatives | 2 | 2 | 2 |
| Factorials | 1 | 1 | 1 |
| Fractions | 4 | 4 | 4 |
| Geometry | 1 | 1 | 1 |
| Integrals | 2 | 3 | 3 |
| Logarithms | 1 | 1 | 1 |
| Matrices & Determinants | 1 | 1 | 1 |
| Percentages | 2 | 1 | 1 |
| Powers & Roots | 2 | 2 | 1 |
| Trigonometry | 2 | 2 | 1 |

After parallel test forms are constructed through careful item selection, their equivalence can be evaluated by comparing the *test characteristic curves*, or raw score-to-*W*-ability ogives, for the multiple forms of each test. If the same raw score yields a similar *W*-ability measure across the three forms of a test, then the difficulty of the test forms are equivalent across the range of ability. Figures 4-10 through 4-17 contain plots showing the relationship of raw score to *W*-ability for each form of the WJ IV ACH Standard Tests 1 through 8. The raw score-to-*W* ability ogives are nearly identical for Tests 1 through 7; in places where they differ slightly, the differences can be attributed to small variations in the item difficulties between forms near those locations on the *W* scale. Examples of these small differences due to item content constraints were discussed earlier. For Test 8: Oral Reading in Figure 4-17, the raw score-to-*W* ability ogives are more variable across forms. This variation is due to the item-set–based administration for the Oral Reading test discussed earlier. The equivalence of the test characteristic curves in Figures 4-10 through 4-17 provides further empirical evidence that the alternate forms of the WJ IV ACH Standard tests are equivalent in difficulty.

***Figure 4-10.***
*Relationship between raw score and* W *ability across three forms of WJ IV ACH Test 1: Letter-Word Identification.*

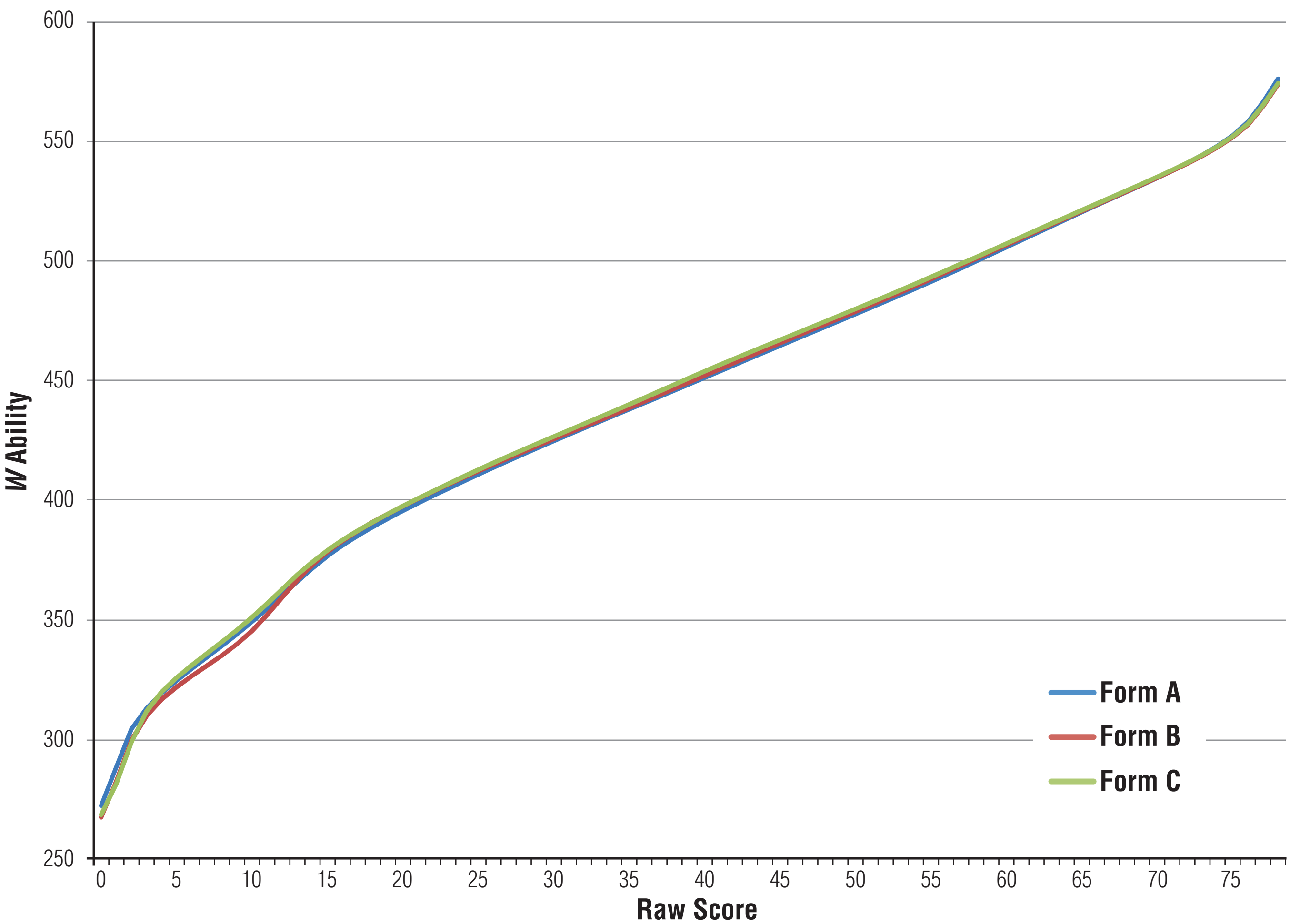


***Figure 4-11.***
*Relationship between raw score and* W *ability across three forms of WJ IV ACH Test 2: Applied Problems.*

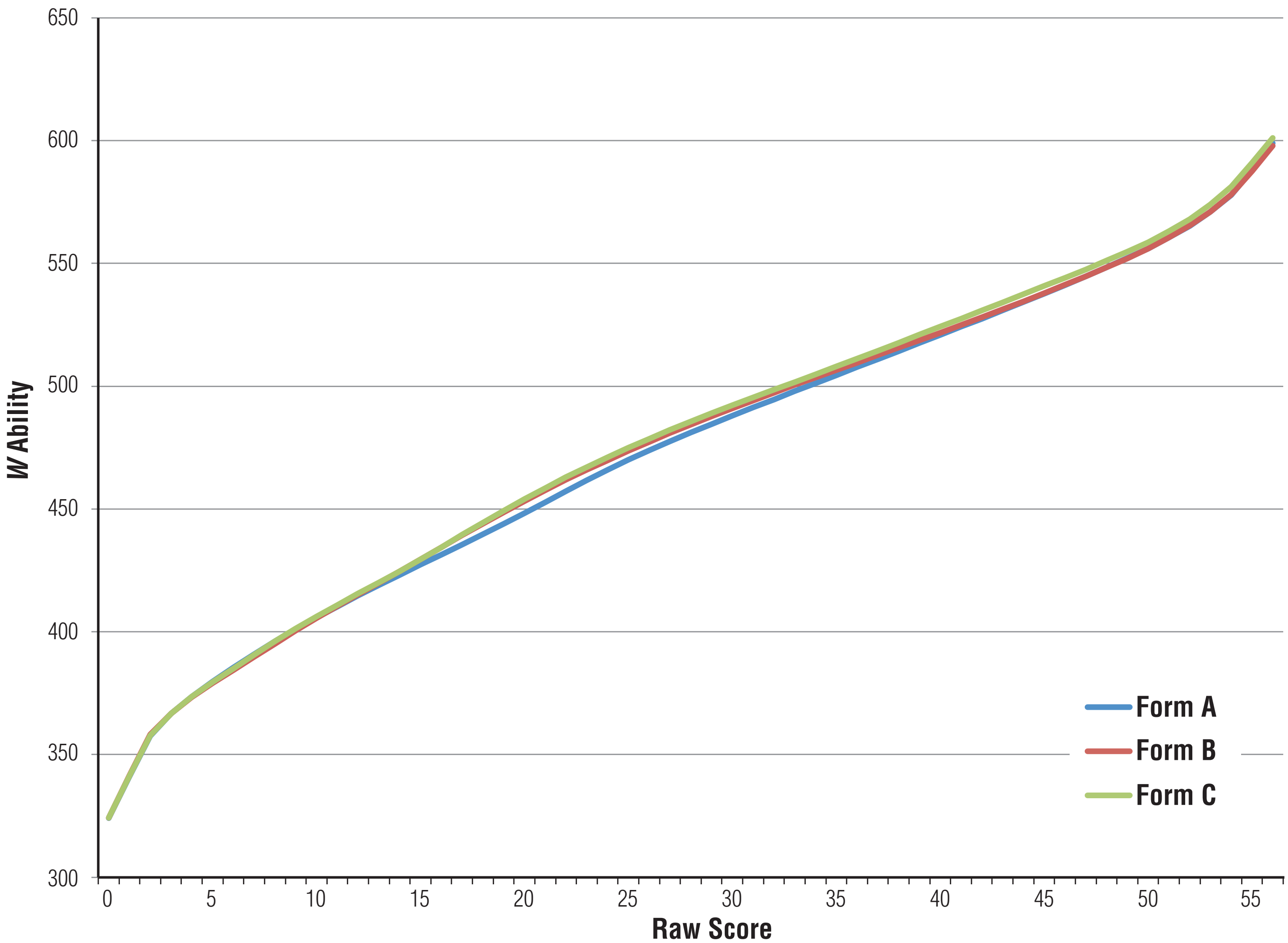


***Figure 4-12.***
*Relationship between raw score and W ability across three forms of WJ IV ACH Test 3: Spelling.*

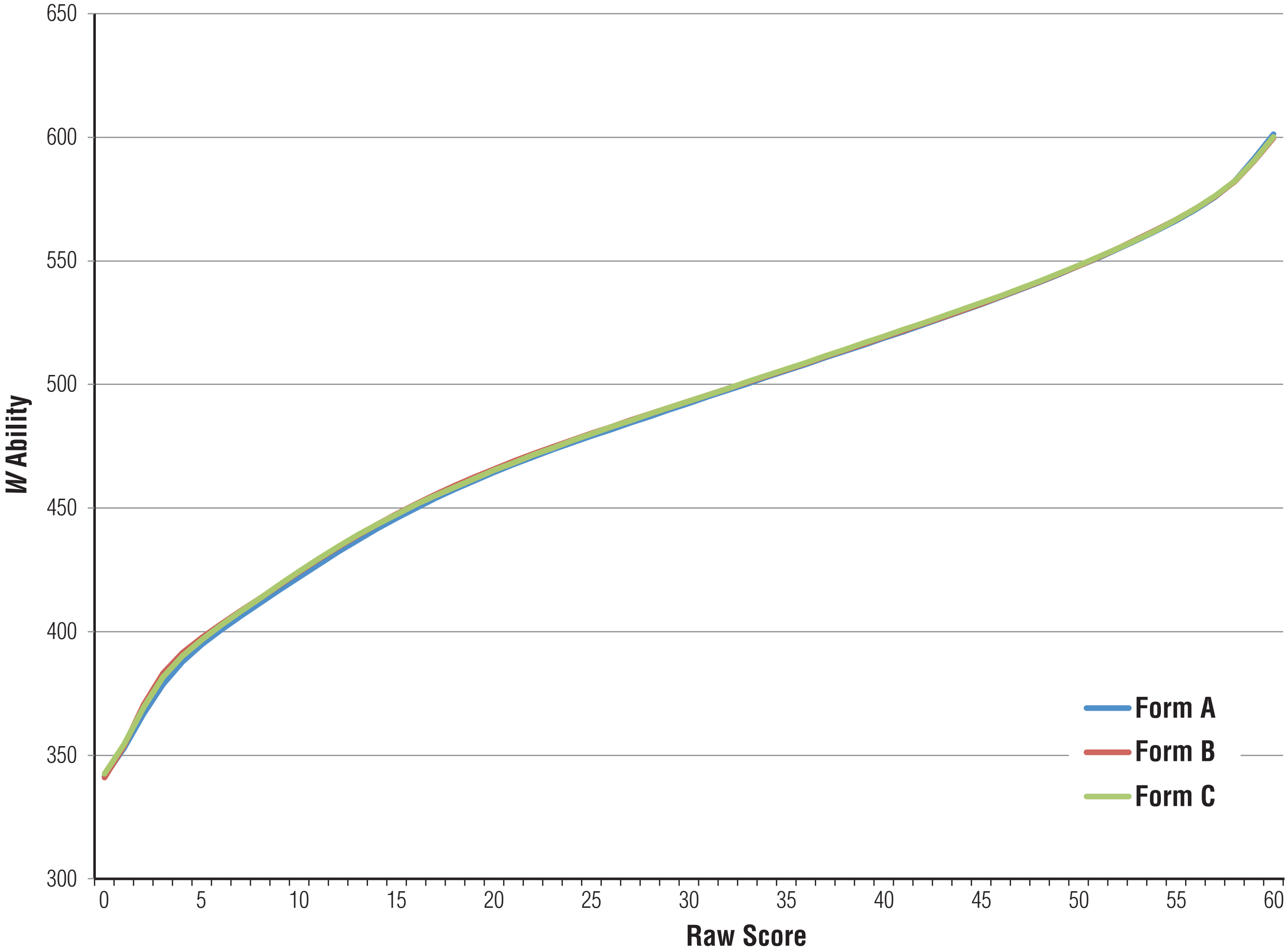


***Figure 4-13.***
*Relationship between raw score and* W *ability across three forms of WJ IV ACH Test 4: Passage Comprehension.*

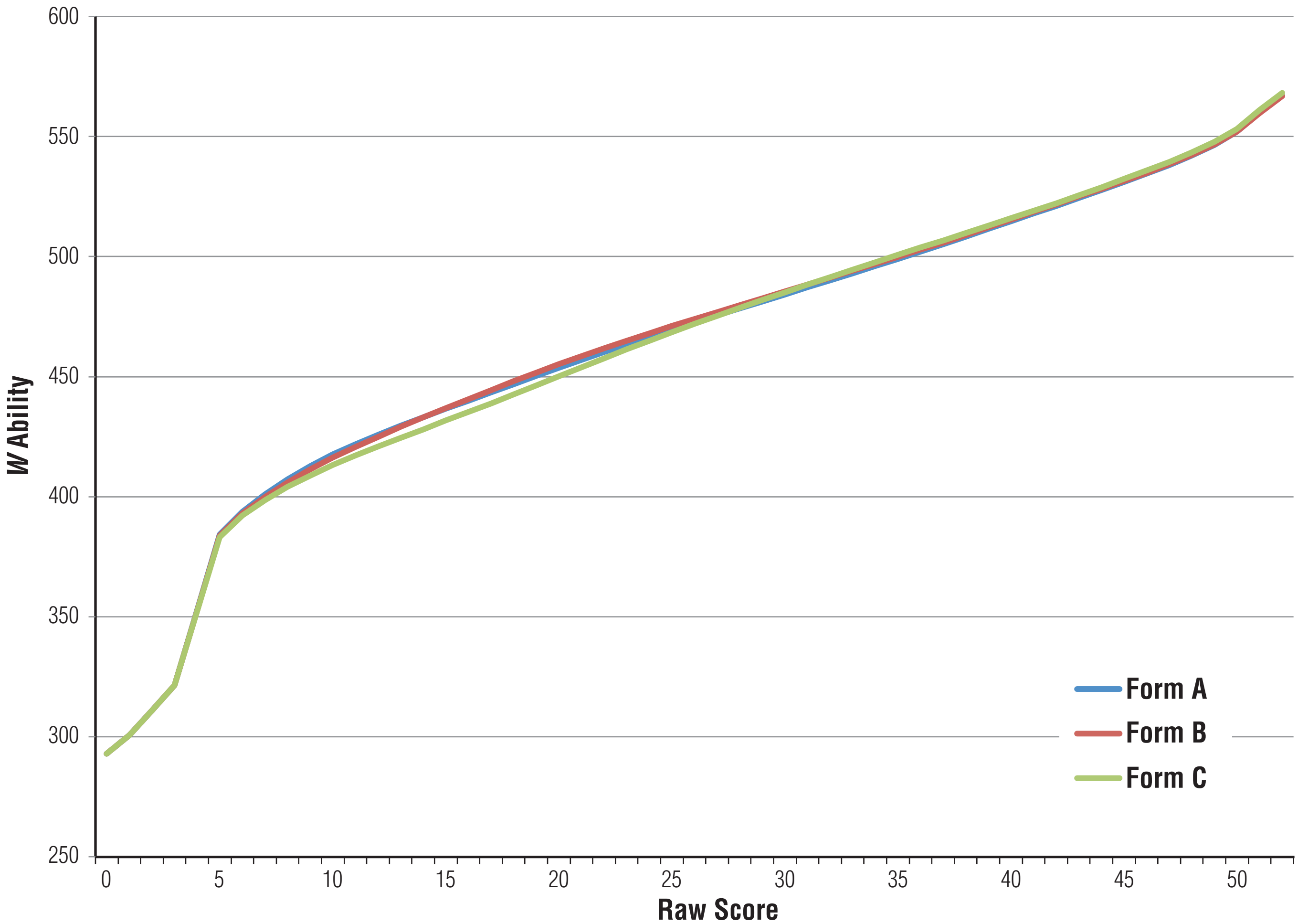


***Figure 4-14.***
*Relationship between raw score and* W *ability across three forms of WJ IV ACH Test 5: Calculation.*

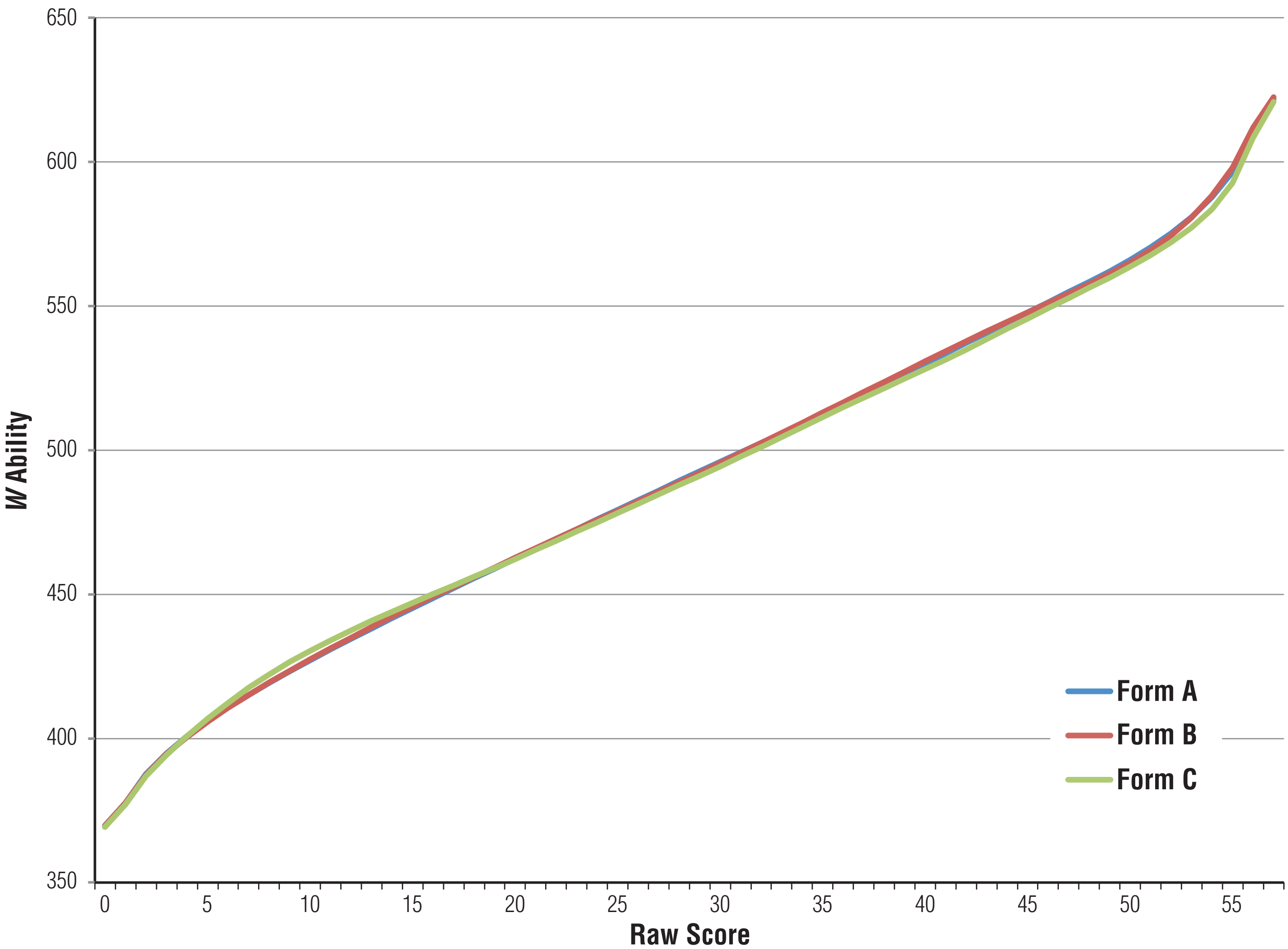


***Figure 4-15.***
*Relationship between raw score and* W *ability across three forms of WJ IV ACH Test 6: Writing Samples.*

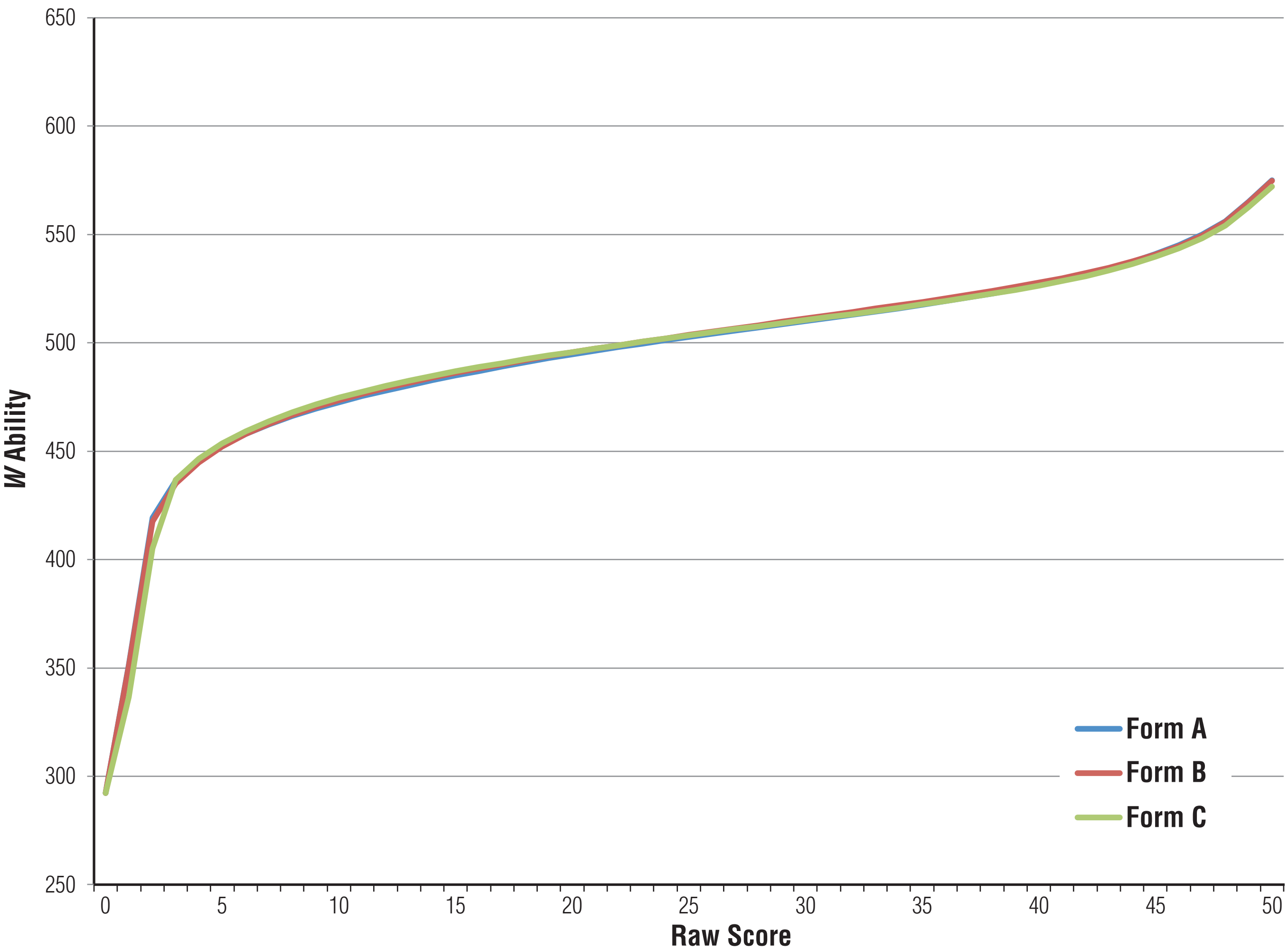


**Figure 4-16.**
*Relationship between raw score and* W *ability across three forms of WJ IV ACH Test 7: Word Attack.*

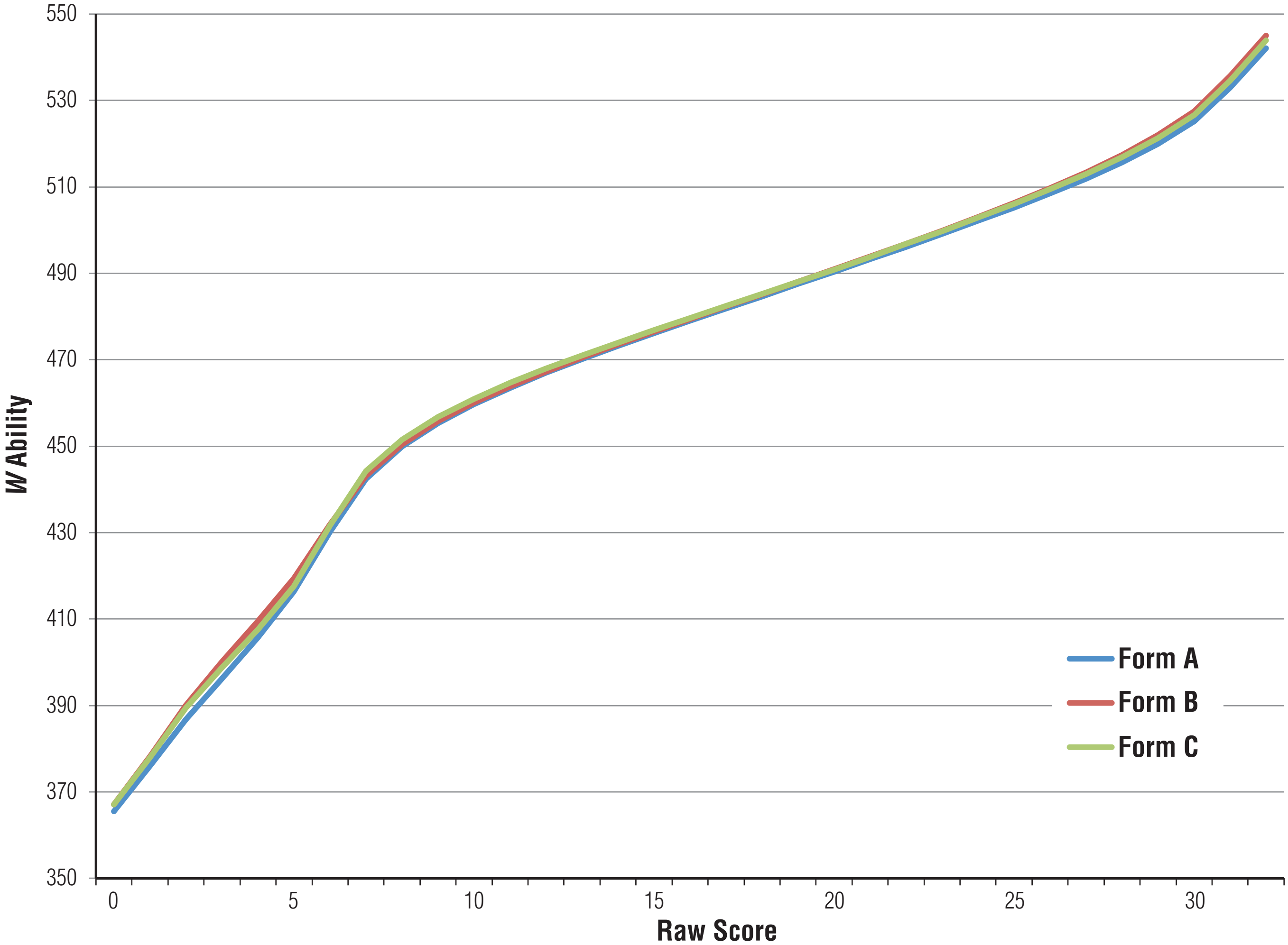
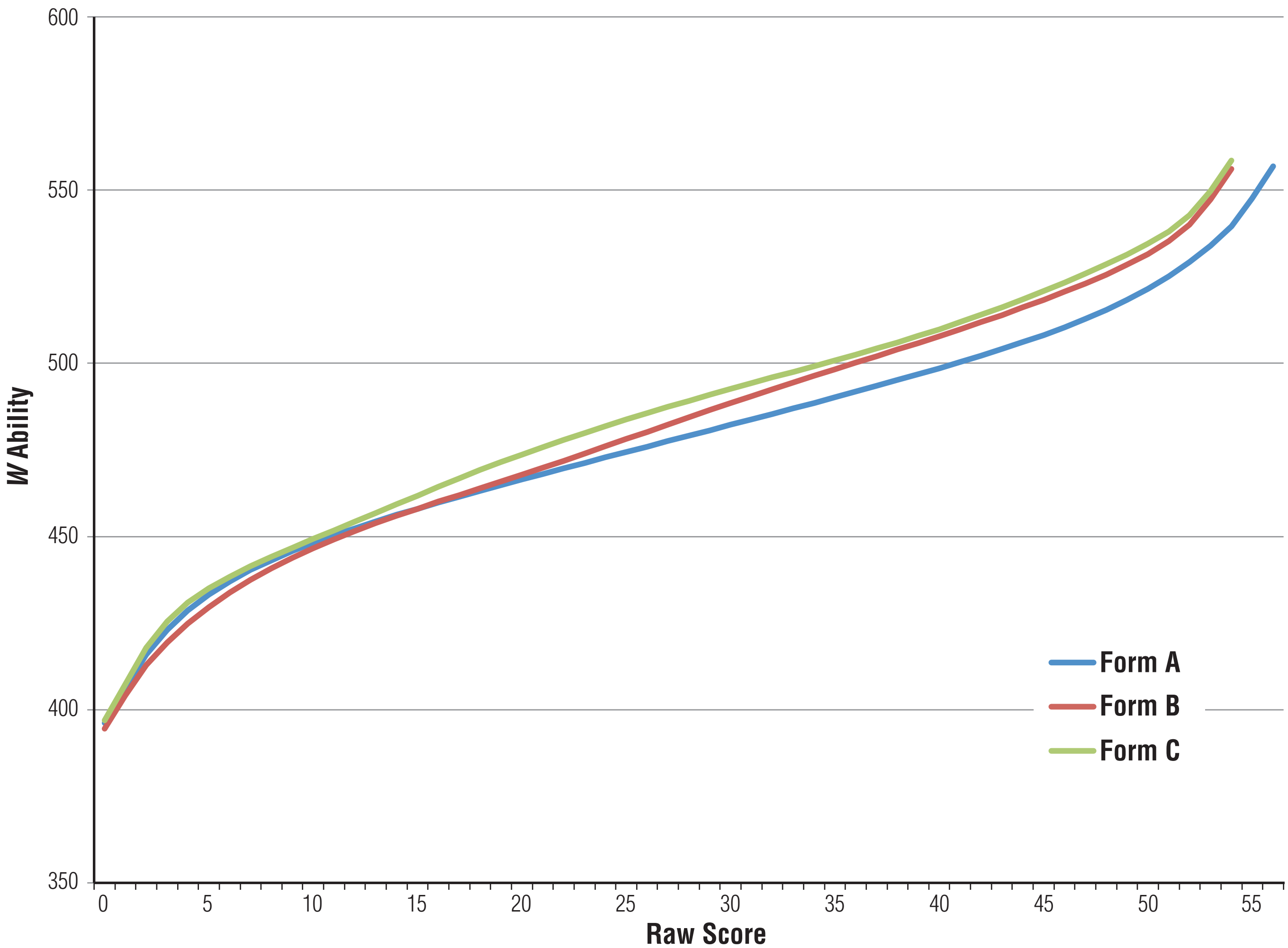


***Figure 4-17.***
*Relationship between raw score and W ability across three forms of WJ IV ACH Test 8: Oral Reading.*




Another means of assessing the equivalence of alternate forms is to determine whether the forms measure with the same degree of precision across the range of ability. As described earlier in this chapter, the *SEM* can be used as an index of the precision of scores, or the accuracy with which the underlying true score can be located on a scale. Figures 4-18 through 4-25 show the relationship between *SEM* and *W* ability for each form of the WJ IV ACH Standard tests. A study of these plots shows that the *SEM*s are comparable across the entire range of ability for each of the tests.[7]

[7] The notable exception is for Test 6: Writing Samples. Item 1 on all three forms of Writing Samples is identical; however, Item 2 on Form C is notably easier than Item 2 on Forms A and B (see Figure 4-7). The effect of the relatively large gap in item difficulty between Items 1 and 2 on Forms A and B is a larger standard error of measurement—i.e., less measurement *precision*—at that point along the *W*-ability scale. This will be apparent to test users as a large standard error band for raw scores of 1 or 2 on Forms A and B of the Writing Samples test. This between-form difference in measurement precision is a function of the item pool depth, and is only perceptible for raw scores of 1 and 2 on the Writing Samples test.

**Figure 4-18.**
*Relationship between* SEM *and* W *ability across three forms of WJ IV ACH Test 1: Letter-Word Identification.*

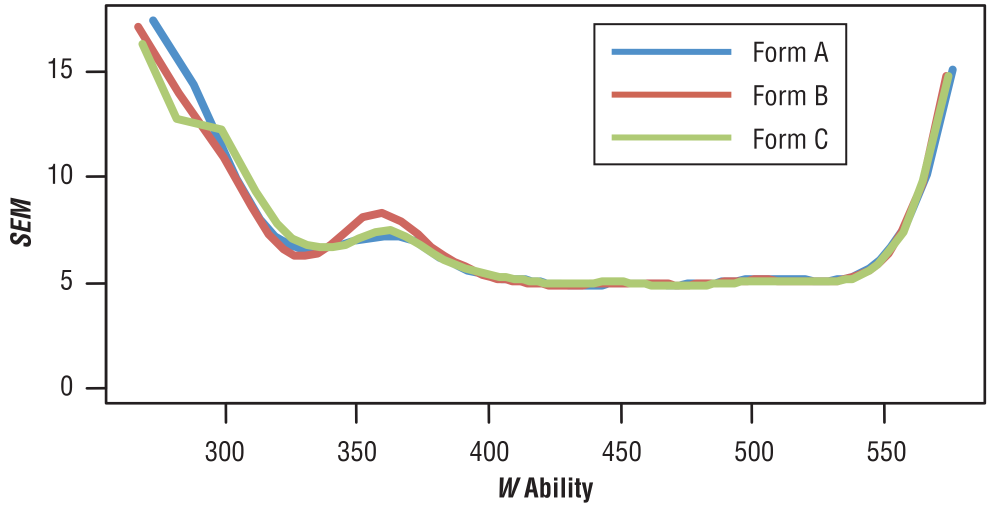



**Figure 4-19.**
*Relationship between* SEM *and* W *ability across three forms of WJ IV ACH Test 2: Applied Problems.*

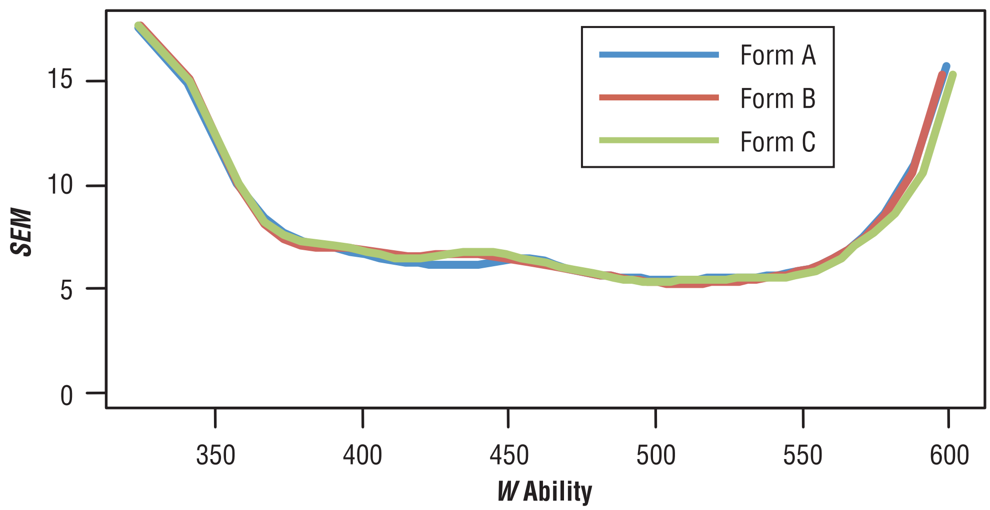



**Figure 4-20.**
*Relationship between* SEM *and* W *ability across three forms of WJ IV ACH Test 3: Spelling.*

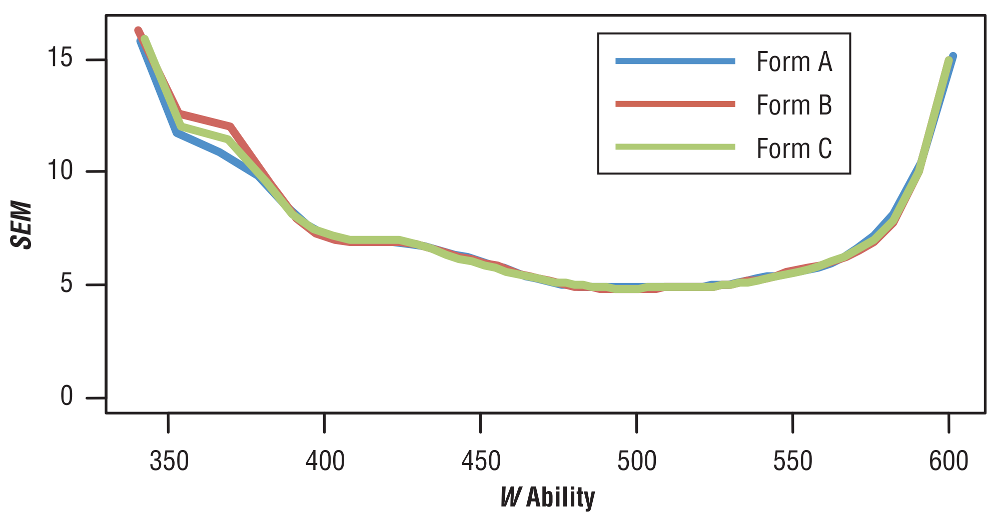


**Figure 4-21.**
*Relationship between* SEM *and* W *ability across three forms of WJ IV ACH Test 4: Passage Comprehension.*

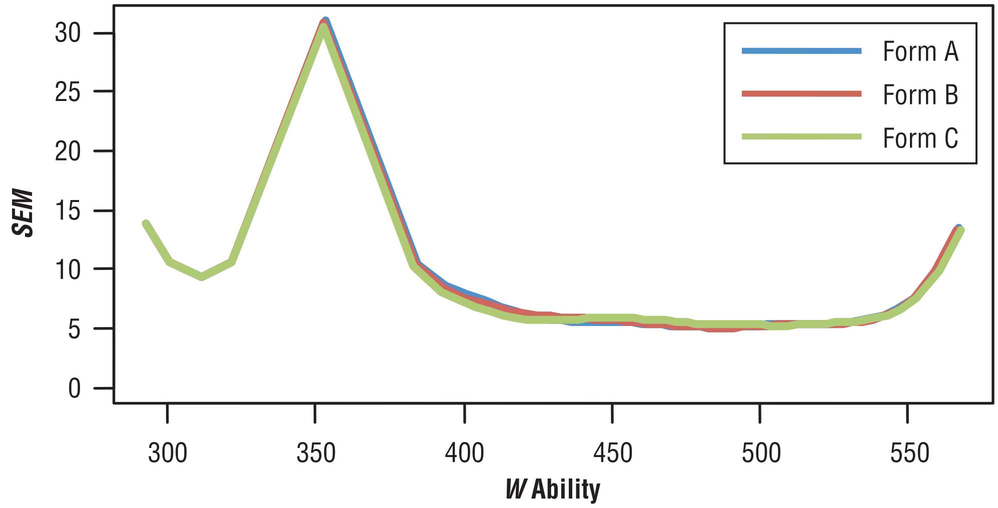



**Figure 4-22.**
*Relationship between* SEM *and* W *ability across three forms of WJ IV ACH Test 5: Calculation.*

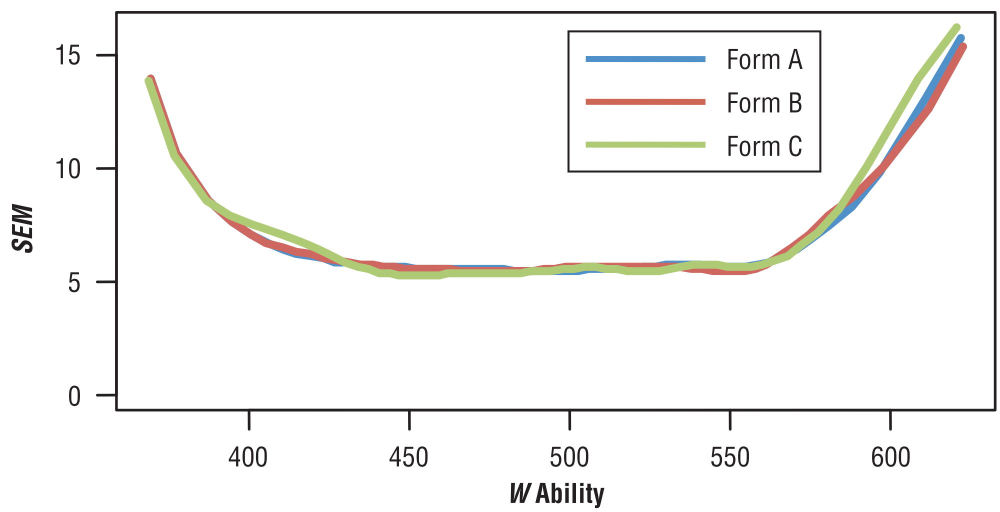



**Figure 4-23.**
*Relationship between* SEM *and* W *ability across three forms of WJ IV ACH Test 6: Writing Samples.*

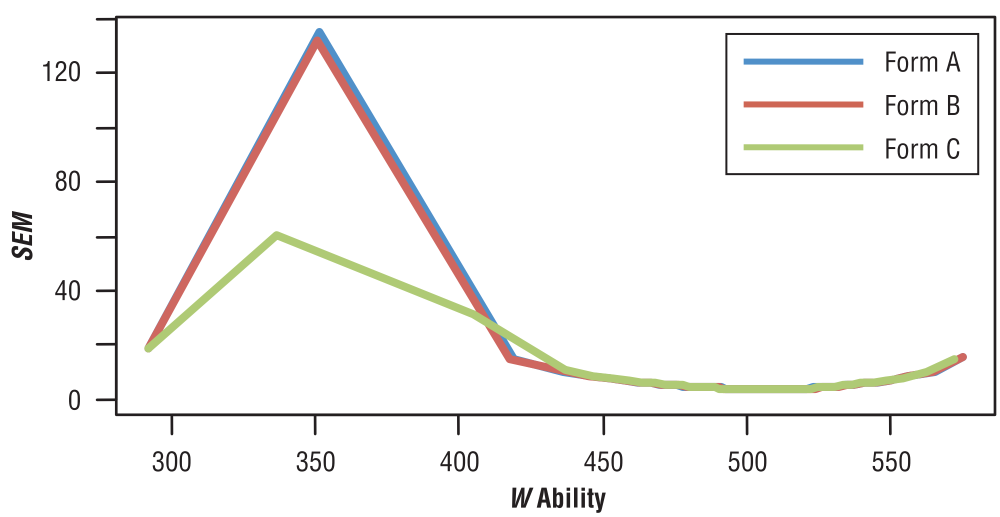


**Figure 4-24.**
*Relationship between SEM and W ability across three forms of WJ IV ACH Test 7: Word Attack.*

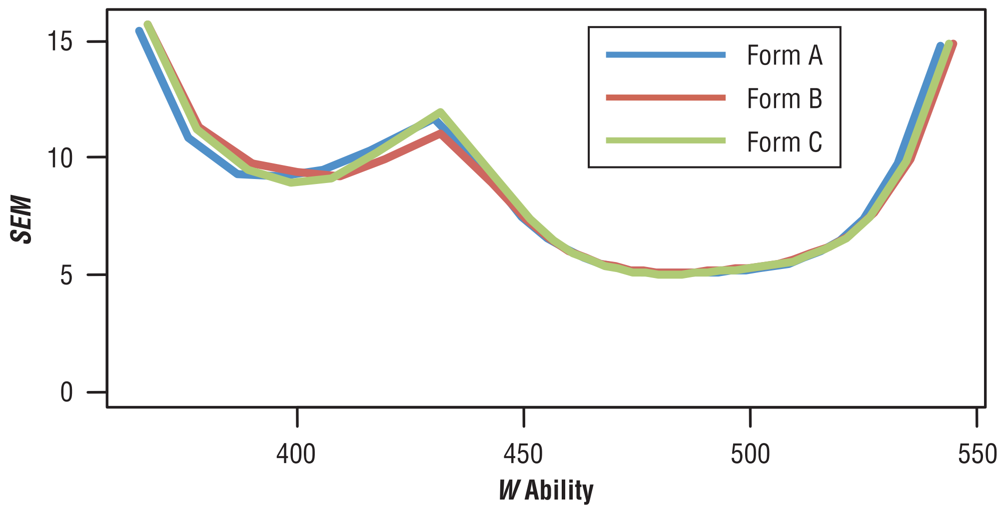
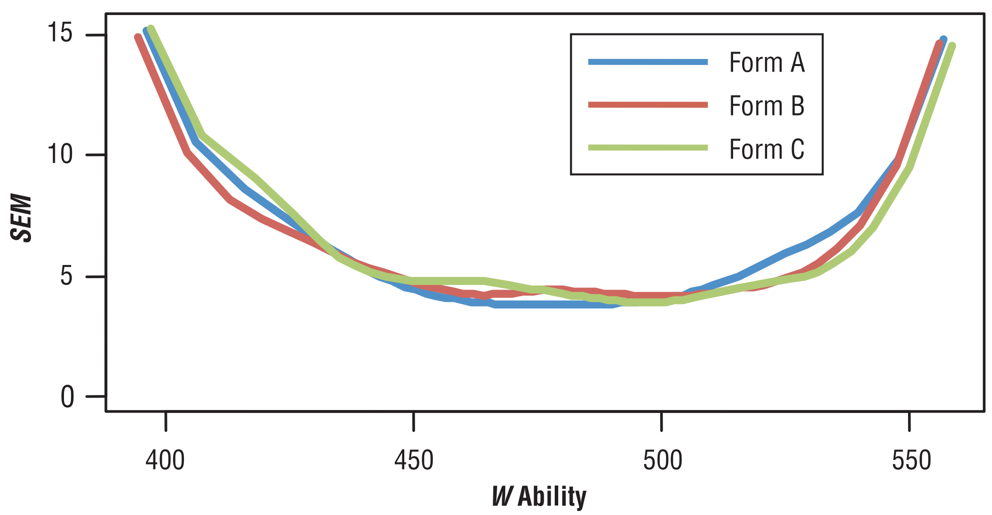



**Figure 4-25.**
*Relationship between SEM and W ability across three forms of WJ IV ACH Test 8: Oral Reading.*




## Speeded WJ IV ACH Standard Tests

All speeded tests in the WJ IV, including the three ACH Standard speeded tests—Test 9: Sentence Reading Fluency, Test 10: Math Facts Fluency, and Test 11: Sentence Writing Fluency—were constructed and calibrated to the *W* scale using a rate-based metric (see Chapter 2). This method of scoring inherently combines information about the examinee's speed and accuracy of response. The per-minute rate scores were input to construct the score scale for each speeded test, and each minute of testing was treated as a separate "item." When these items were calibrated, the first minute of each test (when examinees were typically working most quickly and accurately, resulting in a higher rate of correct response) was easier than the later minutes (when examinees tended to slow down, become less accurate, or reach the time limit, resulting in a lower rate of correct response). In practice, the rate-based scoring method requires as input both a total count of correct responses and a total testing time.

The rate-based scoring method makes two assumptions about the difficulty of the items on each test. First, the average difficulty of the items on the form is more relevant to the overall examinee score than is the difficulty of any one individual item. Second, it follows that for alternate forms of these tests, it is more important for the average difficulty of the items on each form to be equivalent, rather than for there to be a one-to-one correspondence of item difficulty by item position (as on the nonspeeded alternate forms of the ACH Standard tests).

A study was conducted to determine whether the average item difficulty on each form of the three WJ IV ACH Standard speeded tests is equivalent. If the three forms of a speeded test are equivalent, then examinees' rates of correct response should be approximately equal across forms. To determine whether this was the case, the three forms of Test 9: Sentence Reading Fluency, Test 10: Math Facts Fluency, and Test 11: Sentence Writing Fluency were administered to examinees in three different age groups in a counterbalanced manner. Table 4-5 contains the distribution of examinees in the alternate forms speeded test study.

***Table 4-5.***
*Distribution of Examinees in Alternate Forms Speeded Test Study by Age Group and Administration Order*

| | Test Administration Order | Grades 3–4 | Grades 9–12 | Adult | Total |
|---|---|---|---|---|---|
| Test 9: | A-B-C | 40 | 44 | 50 | 134 |
| Sentence Reading Fluency | B-C-A | 40 | 46 | 48 | 134 |
| | C-A-B | 40 | 43 | 51 | 134 |
| | **Total** | 120 | 133 | 149 | 402 |
| Test 10: | A-B-C | 40 | 44 | 51 | 135 |
| Math Facts Fluency | B-C-A | 40 | 45 | 42 | 127 |
| | C-A-B | 40 | 42 | 53 | 135 |
| | **Total** | 120 | 131 | 146 | 397 |
| Test 11: | A-B | 19 | 21 | 26 | 66 |
| Sentence Writing Fluency | B-A | 20 | 18 | 26 | 64 |
| | B-C | 19 | 24 | 21 | 64 |
| | C-B | 20 | 22 | 26 | 68 |
| | C-A | 19 | 22 | 28 | 69 |
| | A-C | 20 | 24 | 26 | 70 |
| | **Total** | 117 | 131 | 153 | 401 |

Study participants were administered all three forms of Test 9: Sentence Reading Fluency and Test 10: Math Facts Fluency but only two forms of Test 11: Sentence Writing Fluency. This design allowed for sufficient counterbalancing to ensure that any significant differences between forms were not due to fatigue or practice effects, while also minimizing the chance of examinee fatigue on the sentence writing task.

Table 4-6 contains summary statistics for each form of the speeded tests. For ease of interpretation, the means and *SD*s in Table 4-6 are presented in a rate-based metric, which is related to the examinee rate of correct response per minute of testing.[8]

Mean examinee scores and standard deviations were consistent across all tests and age groups (see Table 4-6), providing evidence that the difficulties of the items on each form are, on average, approximately equal. Mean scores on Test 11: Sentence Writing Fluency show larger between-form differences than the other tests do. However, because each examinee

[8] During the calibration of the WJ IV speeded tests, scaling constants were introduced to account for the length of each test and to be consistent with the data collected from administration of the tests during the norming study. So, although the rate-based scores reported in Table 4-6 can be described as rates of correct response within each minute of testing, they should not be strictly interpreted as "the number of correct responses per minute." In the Woodcock-Johnson online scoring and reporting program (Schrank & Dailey, 2014), the calculation of the rate score and the subsequent conversion to a *W* score is handled by the software; the rate-based data are provided in Table 4-6 simply to assist the user in interpreting the comparison of examinee performance across forms.

took only two of the three forms of Sentence Writing Fluency, the summary statistics reported in Table 4-6 for that test are not from completely matched samples. In other words, the slight differences in examinee mean scores on Sentence Writing Fluency may be due to differences in the ability of the examinees who took each form rather than differences in item difficulty between the forms.

Correlations for Sentence Reading Fluency and Math Facts Fluency are strong, supporting the notion that the three forms of each test would rank order the examinees in the same way. Correlations for the three forms of Sentence Writing Fluency are slightly lower but are still in the moderate to strong range. Collectively, the alternative forms speeded tests study results support the reliability of the three speeded WJ IV ACH tests.

***Table 4-6.***
*Summary Statistics and Correlations for Three Forms of WJ IV ACH Speeded Tests*

| Test | Age Group | Form | Mean | *SD* | $r_{AB}$ | $r_{AC}$ | $r_{BC}$ |
|---|---|---|---|---|---|---|---|
| Test 9: | Grades 3–4 | A | 7.22 | 1.99 | 0.87 | 0.87 | 0.88 |
| Sentence Reading Fluency | | B | 7.25 | 2.03 | | | |
| | | C | 6.87 | 2.00 | | | |
| | Grades 9–12 | A | 12.18 | 2.67 | 0.85 | 0.88 | 0.85 |
| | | B | 12.53 | 2.69 | | | |
| | | C | 11.97 | 2.52 | | | |
| | Adult | A | 14.27 | 3.05 | 0.82 | 0.87 | 0.88 |
| | | B | 14.36 | 3.30 | | | |
| | | C | 14.09 | 3.00 | | | |
| Test 10: | Grades 3–4 | A | 9.16 | 3.36 | 0.95 | 0.94 | 0.95 |
| Math Facts Fluency | | B | 9.03 | 3.38 | | | |
| | | C | 9.25 | 3.37 | | | |
| | Grades 9–12 | A | 17.34 | 3.99 | 0.92 | 0.93 | 0.94 |
| | | B | 17.43 | 4.07 | | | |
| | | C | 17.48 | 4.17 | | | |
| | Adult | A | 22.06 | 5.45 | 0.96 | 0.95 | 0.95 |
| | | B | 21.97 | 5.46 | | | |
| | | C | 21.93 | 5.48 | | | |
| Test 11: | Grades 3–4 | A | 16.01 | 4.43 | 0.84 | 0.84 | 0.91 |
| Sentence Writing Fluency | | B | 17.03 | 4.62 | | | |
| | | C | 16.54 | 4.82 | | | |
| | Grades 9–12 | A | 28.16 | 7.16 | 0.82 | 0.89 | 0.76 |
| | | B | 28.18 | 5.64 | | | |
| | | C | 30.71 | 6.27 | | | |
| | Adult | A | 30.20 | 5.77 | 0.87 | 0.91 | 0.79 |
| | | B | 30.30 | 5.20 | | | |
| | | C | 32.07 | 5.22 | | | |

*Chapter 5*

# Validity Evidence for the WJ IV

Chapter 1 contained an outline of the propositions underlying the recommended *Woodcock-Johnson IV* (WJ IV) (Schrank, McGrew, & Mather, 2014a) test score uses and interpretations. This chapter contains several types of evidence to support these propositions. The evidence is presented in a framework consistent with that outlined in the *Standards for Educational and Psychological Testing* (American Educational Research Association [AERA], American Psychological Association [APA], & National Council on Measurement in Education [NCME], 2014); it subsumes other classic validity frameworks that specify the need for substantive, internal, and external validity evidence (Benson, 1998; Cronbach, 1971; Cronbach & Meehl, 1955, Loevinger, 1957; Messick, 1989; Nunnally, 1978); and it provides an additional framework that addresses the unique contributions of the Rasch model to the validity argument (Wolfe & Smith, 2007). While much of the evidence presented in this chapter directly addresses the validity propositions in Chapter 1, this manual and the accompanying WJ IV Examiner's Manuals (Mather & Wendling, 2014a, 2014b, 2014c) provide supporting evidence for the validity of the WJ IV test score interpretations because the manuals contain important information about the development, administration, scoring, and interpretation of the WJ IV.

## Representativeness of the WJ IV Test Content, Process, and Construct Coverage

The WJ IV includes tests measuring a complex set of unique abilities constituting intellectual ability, oral language ability, and achievement under CHC theory. Evidence to support this proposition, often termed *content validity* or *substantive validity* evidence, for the WJ IV test scores is provided via the specification of test and cluster content according to contemporary CHC research and theory.[1] This aspect of the WJ IV validity argument builds upon the theories contained in the three prior editions of the battery—the *Woodcock-Johnson Psycho-Educational Battery* (WJ) (Woodcock & Johnson, 1977), the *Woodcock-Johnson Psycho-Educational Battery–Revised* (WJ-R) (Woodcock & Johnson, 1989), and the *Woodcock-Johnson III* (WJ III) (Woodcock, McGrew, & Mather, 2001). The WJ-R and the WJ III were based on successive revisions to the Cattell-Horn Extended *Gf-Gc* and Cattell-Horn-Carroll (CHC) theories of cognitive abilities (McGrew, 2005, 2009; Schneider & McGrew, 2012). In an independent review, Braden and Niebling (2012) judged the quality of the WJ III content validity evidence, upon which the WJ IV continues to build, as near the strong end of their rating scale. In their review, they assigned the WJ III a global rating of 4 on a "quality of

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[1] Refer to Chapter 1 and Appendix A for a description of contemporary CHC theory and the tests and clusters contained in the WJ IV.

validity evidence" scale that ranged from 0 to 5, with 1 indicating weak and 5 indicating strong quality. This rating reflected the inclusion of (a) a detailed description of the CHC theory upon which test content was developed; (b) the use of multiple tests to measure each CHC broad ability domain; (c) the use of the item response theory (IRT) Rasch model to ensure that each test represented a unidimensional measure of a single narrow ability; (d) the inclusion of items that ranged from lower-level processing to higher-level thinking and reasoning; (e) the use of an expert panel to review item content; and (f) the use of nine reviewers to identify items that are potentially biased against women, individuals with disabilities, and cultural or linguistic minorities. This manual provides similar forms of evidence for the content validity of the WJ IV.

## CHC Theory Content Coverage

The WJ IV test design blueprint pushes the design of tests "beyond CHC theory" (McGrew, 2012; Schneider & McGrew, 2012) as CHC theory was defined in the WJ III. In addition to its reliance on contemporary CHC theory as the basis for the overarching test battery design blueprint, the WJ IV plan was influenced by the incorporation of contemporary findings from neurocognitive, neuropsychological, and developmental research. A description of the theoretical foundation of the WJ IV battery is presented in Chapter 1 and Appendix A. For the *Woodcock-Johnson IV Tests of Oral Language* (WJ IV OL) (Schrank, Mather, & McGrew, 2014b) and the *Woodcock-Johnson IV Tests of Achievement* (WJ IV ACH) (Schrank, Mather, & McGrew, 2014a), test and cluster content were designed to cover core curricular areas and areas of oral language competency and achievement specified in federal legislation.

The distinction between broad and narrow abilities is an important concept in CHC theory. It played a key role in the design of the WJ III and has been prominent in the test design blueprints and interpretation of most other major intelligence test batteries (Flanagan, Alfonso, & Ortiz, 2012; Flanagan, Ortiz, & Alfonso, 2013; Keith & Reynolds, 2010; Schneider & McGrew, 2012). As in the WJ III, most of the WJ IV tests were designed to measure one narrow ability. This CHC-based test design approach, first operationalized in the WJ III, focuses on increasing CHC construct representation and decreasing construct-irrelevant variance in tests (Benson, 1998; McGrew & Flanagan, 1998; Messick, 1995). To increase breadth, WJ III clusters were constructed to subsume two or more qualitatively different narrow abilities. The principle of cluster interpretation was adopted to improve the content validity of measures for broad abilities such as reading, fluid reasoning, or general intelligence.

The design blueprint for the WJ IV is similar in many respects to the WJ III blueprint, but it differs significantly in the fundamental design emphasis. While the WJ III principle of constructing relatively pure, broad, CHC-based cognitive clusters was used in the design of the WJ IV, the organization of the test battery test books, particularly the two *Woodcock-Johnson IV Tests of Cognitive Abilities* (WJ IV COG) (Schrank, McGrew, & Mather, 2014b) Test Books, was based on what McGrew (2012) described as a "hybrid broad plus narrow" approach to intelligence battery organization. This approach is based on a review of 20 years of CHC research on the relationship between cognitive abilities and academic achievement (McGrew & Wendling, 2010) that suggested that the majority of the important cognitive abilities for understanding school achievement are narrow abilities. McGrew (2012) subsequently expanded upon this conclusion, noting that the cognitive complexity processing demands of the measures, rather than the breadth of measures, may be the most important feature for understanding school achievement.

The seven broad CHC factors measured in the WJ IV COG include fluid reasoning (*Gf*), comprehension-knowledge (*Gc*), short-term working memory (*Gwm*), cognitive processing speed (*Gs*), auditory processing (*Ga*), long-term retrieval (*Glr*), and visual processing (*Gv*) (see Chapter 1 and Appendix A). Two-test narrow clusters are available for the CHC abilities of quantitative reasoning (RQ), auditory memory span (MS), number facility (N), perceptual speed (P), and lexical knowledge (VL).[2] Cognitive efficiency, which represents the amalgam of processing speed (*Gs*) and short-term working memory (*Gwm*), is represented by two- and four-test clusters.

The WJ IV OL includes 12 tests that also measure abilities in the broad CHC domains of comprehension-knowledge (*Gc*), auditory processing (*Ga*), long-term retrieval (*Glr*), and short-term working memory (*Gwm*). The WJ IV OL tests were developed to measure the most important aspects of oral language ability, including oral expression, listening comprehension (LS), phonetic coding (PC), speed of lexical access (LA), vocabulary (VL/LD), and auditory memory span (MS).

The WJ IV ACH contains 20 tests that tap two other identified CHC cognitive abilities described in Appendix A—quantitative knowledge (*Gq*) and reading and writing ability (*Grw*). The WJ IV ACH also includes additional measures of comprehension-knowledge (*Gc*), long-term retrieval (*Glr*), and auditory processing (*Ga*). The 20 WJ IV ACH tests were developed to measure the major aspects of academic achievement, including reading, mathematics, written language, and curricular knowledge. The specification of item content in these tests was based primarily on the goal of providing a broad sampling of achievement areas rather than an in-depth assessment of a relatively narrow area.

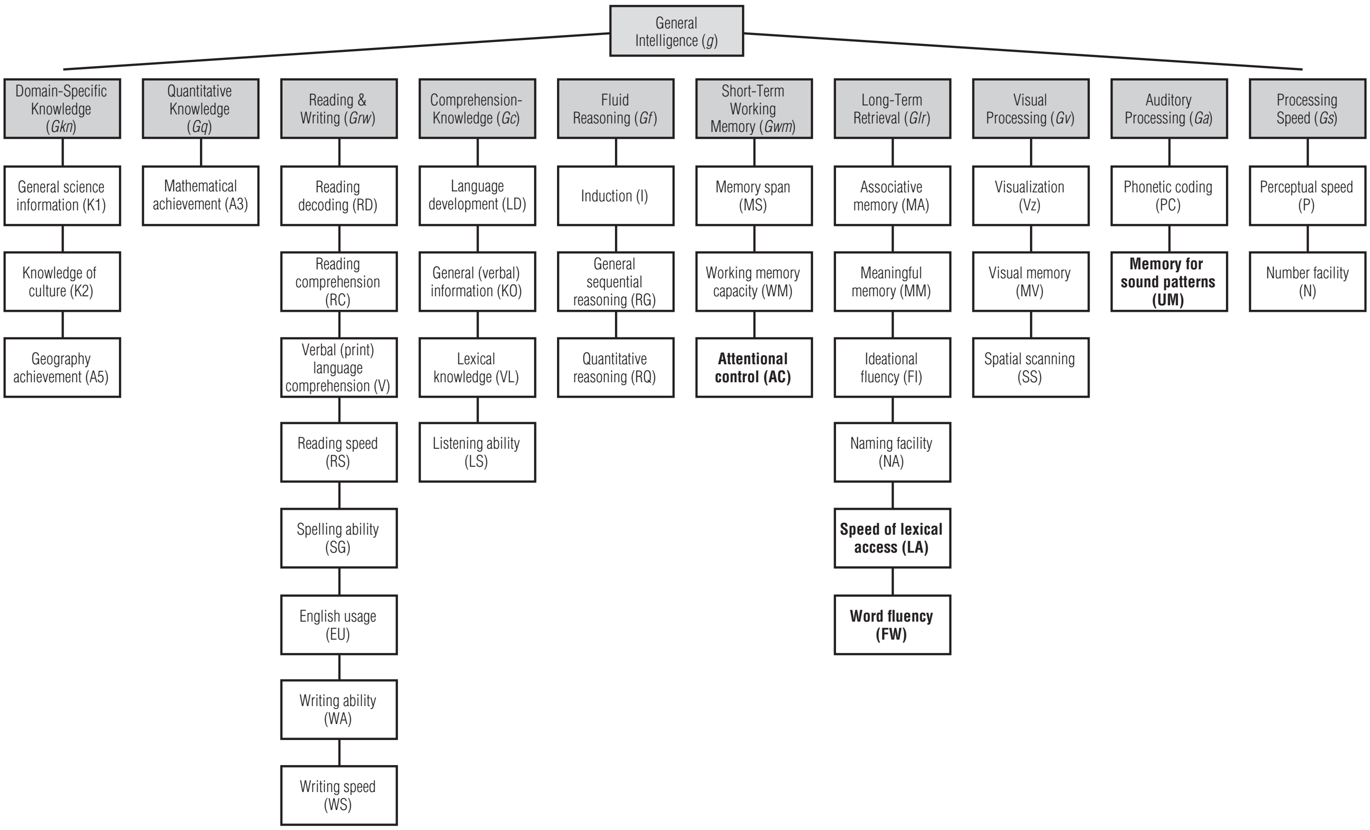
## Construct, Process, and Content Coverage

Figure 5-1 presents a mapping of the broad and narrow CHC abilities measured by the complete WJ IV.

The WJ IV CHC mapping in Figure 5-1 was created by the WJ IV authors. All broad CHC abilities are represented by at least one narrow CHC ability; most are represented by measures of two to seven narrow abilities. For the majority of WJ III tests that have been retained in the WJ IV, independent support for the CHC content classifications has been provided by multiple iterations of cross-battery CHC expert consensus (Flanagan, Ortiz, & Alfonso, 2007, 2013; Flanagan, Ortiz, Alfonso, & Mascolo, 2006; McGrew, 1997; McGrew & Flanagan, 1998). A summary and comparison of the WJ IV author and independent source classifications is presented in Table 5-1.

[2] The Vocabulary cluster (VL/LD) requires combining one test each from the WJ IV COG and WJ IV OL batteries.

***Figure 5-1.***
*Contemporary CHC broad and narrow ability content coverage by WJ IV COG, WJ IV OL, and WJ IV ACH.*




*Note.* Bold font indicates narrow abilities that reflect modified definitions in CHC theory or proposed abilities based on results presented in this manual (see Chapter 1 and Appendix A). The material in this figure is adapted from Schneider, W. J., & McGrew, K. S. (2012). The Cattell-Horn-Carroll model of intelligence. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary Intellectual Assessment: Theories, Tests, and Issues* (3rd ed.) (p. 99–144). New York, NY: Guilford Press. Copyright Guilford Press. Reprinted with the permission of the Guilford Press.

**Table 5-1.**
*Comparison of WJ IV Author and Independent Broad and Narrow CHC Classifications of WJ III Tests Retained in the WJ IV and Author Broad and Narrow CHC Classifications of New WJ IV Tests*

| Battery/Test Name | WJ IV Author Classifications | | Independent Classifications | |
|---|---|---|---|---|
| | Broad | Narrow | Broad | Narrow |
| **Tests of Cognitive Abilities** | | | | |
| 1: Oral Vocabulary | *Gc* | VL/LD | *Gc* | VL |
| 2: Number Series | *Gf* | RQ, I | *Gf* | RQ |
| 3: Verbal Attention | *Gwm* | WM, AC | — | — |
| 4: Letter-Pattern Matching | *Gs* | P | — | — |
| 5: Phonological Processing | *Ga/Glr* | PC/LA, FW | — | — |
| 6: Story Recall | *Glr/Gc* | MM/LS | *Glr* | MM |
| 7: Visualization | *Gv* | Vz | *Gv* | Vz |
| 8: General Information | *Gc* | K0 | *Gc* | K0 |
| 9: Concept Formation | *Gf* | I | *Gf* | I |
| 10: Numbers Reversed | *Gwm* | WM/AC | *Gwm* | WM |
| 11: Number-Pattern Matching | *Gs* | P | *Gs* | P |
| 12: Nonword Repetition | *Ga/Gwm* | PC, UM/MS | — | — |
| 13: Visual-Auditory Learning | *Glr* | MA | *Glr* | MA |
| 14: Picture Recognition | *Gv* | MV | *Gv* | MV |
| 15: Analysis-Synthesis | *Gf* | RG | *Gf* | RG |
| 16: Object-Number Sequencing | *Gwm* | WM | *Gwm* | WM |
| 17: Pair Cancellation | *Gs/Gwm/Gv* | P/AC/SS | *Gs* | P |
| 18: Memory for Words | *Gwm* | MS | *Gwm* | MS |
| **Tests of Oral Language** | | | | |
| 1: Picture Vocabulary | *Gc* | VL/LD | *Gc* | VL |
| 2: Oral Comprehension | *Gc* | LS | *Gc* | LS |
| 3: Segmentation | *Ga* | PC | — | — |
| 4: Rapid Picture Naming | *Glr* | NA, LA | *Glr* | NA |
| 5: Sentence Repetition | *Gwm/Gc* | MS/LS | *Gwm* | MS |
| 6: Understanding Directions | *Gwm/Gc* | WM/LS | *Gc/Gwm* | LS/WM |
| 7: Sound Blending | *Ga* | PC | *Ga* | PC |
| 8: Retrieval Fluency | *Glr* | FI, LA | *Glr* | FI |
| 9: Sound Awareness | *Ga* | PC | *Ga* | PC |
| **Tests of Achievement** | | | | |
| 1: Letter-Word Identification | *Grw* | RD | *Grw* | RD |
| 2: Applied Problems | *Gq/Gf* | A3/RQ | *Gq/Gf* | A3/RQ |
| 3: Spelling | *Grw* | SG | *Grw* | SG |
| 4: Passage Comprehension | *Grw* | RC | *Grw* | RC |
| 5: Calculation | *Gq* | A3 | *Gq* | A3 |
| 6: Writing Samples | *Grw* | WA | *Grw* | WA |
| 7: Word Attack | *Grw/Ga* | RD/PC | *Grw/Ga* | RD/PC |
| 8: Oral Reading | *Grw* | RD/V | — | — |
| 9: Sentence Reading Fluency | *Grw/Gs* | RC/RS | *Grw* | RS |
| 10: Math Facts Fluency | *Gq/Gs* | A3/N | *Gq/Gs* | A3/N |
| 11: Sentence Writing Fluency | *Grw/Gs* | WA/WS | *Grw/Gs* | WA/R9 |
| 12: Reading Recall | *Grw/Glr* | RC/MM | — | — |
| 13: Number Matrices | *Gf* | RQ | *Gf* | RQ |
| 14: Editing | *Grw* | EU | *Grw* | EU |
| 15: Word Reading Fluency | *Grw/Gs* | RC/RS | — | — |
| 16: Spelling of Sounds | *Grw/Ga* | SG/PC | *Grw/Ga* | SG/PC |
| 17: Reading Vocabulary | *Grw/Gc* | RC/VL | *Grw/Gc* | V/VL |
| 18: Science | *Gkn/Gc* | K0/K1 | *Gc/Gkn* | K0/K2 |
| 19: Social Studies | *Gkn/Gc* | K0/K2/A5 | *Gc/Gkn* | K0/K2 |
| 20: Humanities | *Gkn/Gc* | K0/K2 | *Gc/Gkn* | K0/K2 |

*Note.* Independent classifications are based on Flanagan, Ortiz, and Alfonso (2013) and Flanagan et al. (2006). *Gsm*/MW abbreviations reported by independent sources are converted to *Gwm*/WM as described in Chapter 1. Blanks designate WJ IV tests not yet classified by independent sources.

Tables 5-2, 5-3, and 5-4 provide further descriptions of the broad and narrow constructs measured by the WJ IV COG, OL, and ACH tests, respectively, as well as stimulus and response characteristics, task requirements, and inferred cognitive processes.

***Table 5-2.***
*WJ IV COG Test Content, Process, and Construct Descriptions*

| Cognitive Test | Primary Broad CHC Ability *Narrow Ability* | Stimuli | Task Requirements | Cognitive Processes | Response |
|---|---|---|---|---|---|
| 1: Oral Vocabulary<br>A: Synonyms<br>B: Antonyms | Comprehension-Knowledge (*Gc*)<br>*Lexical knowledge* (VL)<br>*Language development* (LD) | Auditory (words) | Listening to a word and providing a synonym; listening to a word and providing an antonym | Semantic activation, access, and matching | Oral (words) |
| 2: Number Series | Fluid Reasoning (*Gf*)<br>*Quantitative reasoning* (RQ)<br>*Induction* (I) | Visual (numeric) | Determining a numerical sequence | Representation and manipulation of points on a mental number line; identifying and applying an underlying rule/principle to complete a numerical sequence | Oral (numbers) |
| 3: Verbal Attention | Short-Term Working Memory (*Gwm*)<br>*Working memory capacity* (WM)<br>*Attentional control* (AC) | Auditory (words, numbers) | Listening to a series of numbers and animals intermingled and answering a specific question regarding the sequence | Controlled executive function; working memory capacity; recoding of acoustic, verbalized stimuli held in immediate awareness; selective auditory attention; attentional control | Oral (words) |
| 4: Letter-Pattern Matching | Processing Speed (*Gs*)<br>*Perceptual speed* (P) | Visual (letters) | Rapidly locating and circling identical letters or letter patterns | Speeded visual perception and matching; visual discrimination; orthographic processing; divided attention | Motoric (circling) |
| 5: Phonological Processing<br>A: Word Access<br>B: Word Fluency<br>C: Substitution | Auditory Processing (*Ga*)<br>*Phonetic coding* (PC)<br>*Word fluency* (*Glr*-FW)<br>*Speed of lexical access* (*Glr*-LA) | Auditory (words) | Providing a word with a specific phonic element; naming as many words as possible that begin with a specified sound; substituting part of a word to make a new word | Semantic activation, access; speed of lexical access | Oral (words) |
| 6: Story Recall | Long-Term Retrieval (*Glr*)<br>*Meaningful memory* (MM)<br>*Listening ability* (*Gc*-LS) | Auditory (text) | Listening to and recalling details of stories | Construction of propositional representations and recoding | Oral (passages) |
| 7: Visualization<br>A: Spatial Relations<br>B: Block Rotation | Visual Processing (*Gv*)<br>*Visualization* (Vz) | Visual (shapes, designs) | Identifying two-dimensional pieces that form a shape; identifying two three-dimensional rotated block patterns that match a target | Visual feature detection; manipulation (mental rotation) of visual images in space; matching | Oral (letters) or Motoric (pointing) |
| 8: General Information<br>A: Where<br>B: What | Comprehension-Knowledge (*Gc*)<br>*General (verbal) information* (K0) | Auditory (questions) | Identifying where an object is found and what people typically do with an object | Semantic activation and access to declarative generic knowledge | Oral (phrases, sentences) |
| 9: Concept Formation | Fluid Reasoning (*Gf*)<br>*Induction* (I) | Visual (drawings) | Identifying, categorizing, and determining rules | Rule-based categorization; rule switching; induction/inference | Oral (words) |
| 10: Numbers Reversed | Short-Term Working Memory (*Gwm*)<br>*Working memory capacity* (WM)<br>*Attentional control* (AC) | Auditory (numbers) | Listening to and recalling a sequence of digits in reversed order | Span of apprehension and recoding in working memory; working memory capacity, attentional capacity | Oral (numbers) |

***Table 5-2.*** *(cont.)*
*WJ IV COG Test Content, Process, and Construct Descriptions*

| Cognitive Test | Primary Broad CHC Ability *Narrow Ability* | Stimuli | Task Requirements | Cognitive Processes | Response |
|---|---|---|---|---|---|
| 11: Number-Pattern Matching | Processing Speed (*Gs*) *Perceptual speed* (P) | Visual (numbers) | Rapidly locating and circling identical numerals from a defined set | Speeded visual perception and matching; visual discrimination; divided attention | Motoric (circling) |
| 12: Nonword Repetition | Auditory Processing (*Ga*) *Phonetic coding* (PC) *Memory for sound patterns* (UM) *Memory span* (*Gwm*-MS) | Auditory (nonsense words) | Listening to a nonsense word and repeating it exactly | Analysis of a sequence of acoustic phonological elements in immediate awareness; efficiency of the phonological loop | Oral (words) |
| 13: Visual-Auditory Learning | Long-Term Retrieval (*Glr*) *Associative memory* (MA) | Visual (rebuses) Auditory (words) | Learning and recalling pictographic representations of words | Paired-associative encoding via directed spotlight attention; storage and retrieval | Oral (sentences) |
| 14: Picture Recognition | Visual Processing (*Gv*) *Visual memory* (MV) | Visual (pictures) | Recognizing a subset of previously presented pictures within a field of similar distracting pictures | Formation of iconic memories and matching of visual stimuli to stored visual representations | Oral (words) or Motoric (pointing) |
| 15: Analysis-Synthesis | Fluid Reasoning (*Gf*) *General sequential reasoning* (RG) | Visual (drawings) | Analyzing puzzles (using symbolic formulations) to determine missing components | Algorithmic reasoning; deduction | Oral (words) |
| 16: Object-Number Sequencing | Short-Term Working Memory (*Gwm*) *Working memory capacity* (WM) | Auditory (words, numbers) | Listening to a series of numbers and words intermingled and recalling in two reordered sequences | Recoding of acoustic, verbalized stimuli held in immediate awareness; working memory capacity | Oral (words, numbers) |
| 17: Pair Cancellation | Processing Speed (*Gs*) *Perceptual speed* (P) *Spatial scanning* (*Gv*-SS) *Attentional control* (*Gwm*-AC) | Visual (drawings) | Rapidly locating and marking a repeated pattern | Executive processing; attentional control; inhibition and interference control; sustained attention | Motoric (circling) |
| 18: Memory for Words | Short-Term Working Memory (*Gwm*) *Memory span* (MS) | Auditory (words) | Listening to and repeating a sequence of unrelated words | Formation of echoic memories and verbalizable span of echoic store | Oral (words) |

***Table 5-3.***
*WJ IV OL Test Content, Process, and Construct Descriptions*

| Oral Language Test | Primary Broad CHC Ability *Narrow Ability* | Stimuli | Task Requirements | Cognitive Processes | Response |
|---|---|---|---|---|---|
| 1: Picture Vocabulary (*10: Vocabulario sobre dibujos)* | Comprehension-Knowledge (*Gc*) *Lexical knowledge* (VL) *Language development* (LD) | Visual (pictures) | Identifying objects | Object recognition; lexical access and retrieval | Oral (words) |
| 2: Oral Comprehension (*11: Comprensión oral*) | Comprehension-Knowledge (*Gc*) *Listening ability* (LS) | Auditory (text) | Listening to an oral passage and identifying a missing key word that makes sense | Construction of propositional representations through syntactic and semantic integration of orally presented passages in real time | Oral (words) |
| 3: Segmentation | Auditory Processing (*Ga*) *Phonetic coding* (PC) | Auditory (words) | Listening to a word and breaking it into syllables or phonemes | Analysis of acoustic, phonological elements in immediate awareness | Oral (word parts, phonemes) |
| 4: Rapid Picture Naming | Long-Term Retrieval (*Glr*) *Naming facility* (NA) *Speed of lexical access* (LA) | Visual (pictures) | Recognizing objects, then retrieving and articulating their names rapidly | Speed/fluency of retrieval and oral production of recognized objects; speeded serial naming; rapid object recognition | Oral (words) |
| 5: Sentence Repetition | Short-Term Working Memory (*Gwm*) *Memory span* (MS)<br><br>Comprehension-Knowledge (*Gc*) *Listening ability* (LS) | Auditory (words, sentences) | Listening to and repeating words, phrases, or sentences in the correct sequence | Formation of echoic memories aided by a semantic, meaning-based code | Oral (words, sentences) |
| 6: Understanding Directions (*12: Comprensión de indicaciones*) | Short-Term Working Memory (*Gwm*) *Working memory capacity* (WM)<br><br>Comprehension-Knowledge (*Gc*) *Listening ability* (LS) | Visual (pictures) Auditory (text) | Studying a picture, then listening to a sequence of instructions and following the directions by pointing to items in the picture | Construction of a mental structure in immediate awareness and modification of the structure via mapping | Motoric (pointing) |
| 7: Sound Blending | Auditory Processing (*Ga*) *Phonetic coding* (PC) | Auditory (phonemes) | Synthesizing language sounds (phonemes) to say a word | Synthesis of acoustic, phonological elements in immediate awareness; matching the sequence of elements to stored lexical entries; lexical activation and access | Oral (words) |
| 8: Retrieval Fluency | Long-Term Retrieval (*Glr*) *Speed of lexical access* (LA) *Ideational fluency* (FI) | Auditory (directions only) | Naming as many examples as possible in a given category within 1 minute | Recognition, fluent retrieval, and oral production of examples of a semantic category; activation of semantic network; speeded name generation | Oral (words) |
| 9: Sound Awareness | Auditory Processing (*Ga*) *Phonetic coding* (PC) | Auditory (questions, words) | Providing a rhyming word; removing parts of words to make a new word | Access, retrieval, and application of the rules of English phonology | Oral (words) |

*Note.* Test name in italics signifies the Spanish version of the English test.

***Table 5-4.***
*WJ IV ACH Test Content, Process, and Construct Descriptions*

| **Achievement Test** | **Primary Broad CHC Ability** *Narrow Ability* | **Stimuli** | **Task Requirements** | **Cognitive Processes** | **Response** |
|---|---|---|---|---|---|
| 1: Letter-Word Identification | Reading & Writing Ability (*Grw*)<br>*Reading decoding* (RD) | Visual (text) | Identifying printed letters and words | Feature detection and analysis (for letters) and recognition of visual word forms from a phonological lexicon; access of pronunciations associated with visual word forms | Oral (letter names, words) |
| 2: Applied Problems | Quantitative Knowledge (*Gq*)<br>*Mathematical achievement* (A3)<br><br>Fluid Reasoning (*Gf*)<br>*Quantitative reasoning* (RQ) | Auditory (questions)<br>Visual (numeric, text) | Performing math calculations in response to orally presented problems | Construction of mental models via language comprehension, application of calculation and/or quantitative reasoning; formation of insight | Oral (numbers, words) |
| 3: Spelling | Reading & Writing Ability (*Grw*)<br>*Spelling ability* (SG) | Auditory (words) | Spelling orally presented words | Access to and application of knowledge of orthography of word forms by mapping whole-word phonology onto whole-word orthography, by translating phonological segments into graphemic units, or by activating spellings of words from the semantic lexicon | Motoric (writing) |
| 4: Passage Comprehension | Reading & Writing Ability (*Grw*)<br>*Reading comprehension* (RC) | Visual (text) | Identifying a missing key word that makes sense in the context of a written passage | Construction of propositional representations; integration of syntactic and semantic properties of printed words and sentences into a representation of the whole passage | Oral (words) |
| 5: Calculation | Quantitative Knowledge (*Gq*)<br>*Mathematical achievement* (A3) | Visual (numeric) | Performing various mathematical calculations | Access to and application of knowledge of numbers and calculation procedures; verbal associations between numbers represented as strings of words | Motoric (writing) |
| 6: Writing Samples | Reading & Writing Ability (*Grw*)<br>*Writing ability* (WA) | Auditory (text)<br>Visual (text) | Writing meaningful sentences for a given purpose | Retrieval of word meanings; application of psycholinguistic rules of case, grammar, and syntax; planning and construction of bridging inferences in immediate awareness (auditory and/or visual buffer) | Motoric (writing) |
| 7: Word Attack | Reading & Writing Ability (*Grw*)<br>*Reading decoding* (RD)<br><br>Auditory Processing (*Ga*)<br>*Phonetic coding* (PC) | Visual (word) | Reading phonically regular nonwords | Grapheme-to-phoneme translation and accessing pronunciations of pseudowords not contained in the mental lexicon | Oral (words) |

***Table 5-4.*** *(cont.)*
*WJ IV ACH Test Content, Process, and Construct Descriptions*

| Achievement Test | Primary Broad CHC Ability *Narrow Ability* | Stimuli | Task Requirements | Cognitive Processes | Response |
|---|---|---|---|---|---|
| 8: Oral Reading | Reading & Writing Ability (*Grw*)<br>*Reading comprehension* (RC)<br>*Verbal (print) language comprehension* (V) | Visual (text) | Reading sentences orally with accuracy and fluency | Integration of orthographic, phonological, and semantic processes; articulatory planning and motor execution | Oral (sentences) |
| 9: Sentence Reading Fluency | Reading & Writing Ability (*Grw*)<br>*Reading comprehension* (RC)<br>*Reading speed* (RS)<br><br>Processing Speed (*Gs*) | Visual (text) | Reading printed statements rapidly and responding true or false (yes or no) | Speeded semantic decision making requiring reading ability and generic knowledge | Motoric (circling) |
| 10: Math Facts Fluency | Quantitative Knowledge (*Gq*)<br>*Mathematical achievement* (A3)<br><br>Processing Speed (*Gs*)<br>*Number facility* (N) | Visual (numeric) | Adding, subtracting, and multiplying rapidly | Speeded access to and application of digit-symbol arithmetic procedures | Motoric (writing) |
| 11: Sentence Writing Fluency | Reading & Writing Ability (*Grw*)<br>*Writing ability* (WA)<br>*Writing speed* (WS)<br><br>Processing Speed (*Gs*) | Visual (words with pictures) | Formulating and writing simple sentences rapidly | Speeded formation of constituent sentence structures requiring fluent access to semantic and syntactic knowledge | Motoric (writing) |
| 12: Reading Recall | Reading & Writing Ability (*Grw*)<br>*Reading comprehension* (RC)<br><br>Long-Term Retrieval (*Glr*)<br>*Meaningful memory* (MM) | Visual (text) | Reading and recalling details of stories | Construction of propositional representations and recoding | Oral (passages) |
| 13: Number Matrices | Fluid Reasoning (*Gf*)<br>*Quantitative reasoning* (RQ) | Visual (numeric) | Determining a two-dimensional numerical pattern | Access to verbal-visual numeric codes; transcoding verbal and/or visual representations of numeric information into analogical representations; determining the relationship between/among numbers on the first part of the structure and mapping (projecting) the structure to complete the analogy | Oral (numbers) |
| 14: Editing | Reading & Writing Ability (*Grw*)<br>*English usage* (EU) | Visual (text) | Identifying and correcting errors in written passages | Access and application of lexical and syntactic information about details of word forms and writing conventions | Oral (sentences) |
| 15: Word Reading Fluency | Reading & Writing Ability (*Grw*)<br>*Reading comprehension* (RC)<br>*Reading speed* (RS)<br><br>Processing Speed (*Gs*) | Visual (words) | Rapidly reading words and marking the two in each row that are semantically related | Speeded semantic decision making requiring reading ability | Motoric (slash marks) |

***Table 5-4.*** *(cont.)*
*WJ IV ACH Test Content, Process, and Construct Descriptions*

| Achievement Test | Primary Broad CHC Ability *Narrow Ability* | Stimuli | Task Requirements | Cognitive Processes | Response |
|---|---|---|---|---|---|
| 16: Spelling of Sounds | Reading & Writing Ability (*Grw*)<br>*Spelling ability* (SG)<br><br>Auditory Processing (*Ga*)<br>*Phonetic coding* (PC) | Auditory (letters, words) | Spelling letter patterns that are regular patterns in written English | Translating spoken elements of nonwords into graphemic units; phonologically mediated mapping of orthography | Motoric (writing) |
| 17: Reading Vocabulary | Reading & Writing Ability (*Grw*)<br>*Reading comprehension* (RC)<br><br>Comprehension-Knowledge (*Gc*)<br>*Lexical knowledge* (VL) | Visual (words) | Reading words and providing an appropriate synonym or antonym | Recognition of visual word forms; semantic access and activation; semantic matching | Oral (words) |
| 18: Science | Domain-Specific Knowledge (*Gkn*)<br>*General science information* (K1)<br><br>Comprehension-Knowledge (*Gc*)<br>*General (verbal) information* (K0) | Auditory (questions)<br>Visual (text, pictures) | Responding to questions about science | Implicit, declarative category-specific memory | Oral (words, sentences) |
| 19: Social Studies | Domain-Specific Knowledge (*Gkn*)<br>*Knowledge of culture* (K2)<br>*Geography achievement* (A5)<br><br>Comprehension-Knowledge (*Gc*)<br>*General (verbal) information* (K0) | Auditory (questions)<br>Visual (text, pictures) | Responding to questions about social studies | Implicit, declarative category-specific memory | Oral (words, sentences) |
| 20: Humanities | Domain-Specific Knowledge (*Gkn*)<br>*Knowledge of culture* (K2)<br><br>Comprehension-Knowledge (*Gc*)<br>*General (verbal) information* (K0) | Auditory (questions)<br>Visual (text, pictures) | Responding to questions about humanities | Implicit, declarative category-specific memory | Oral (words, sentences) |

## Empirical Evaluation of Test Content Characteristics

Most content validity evidence "usually takes the form of consensual professional judgments about the relevance of item content to the specified domain and about the representativeness with which the test content covers the domain content" (Messick, 1989, p. 36). Recent research has demonstrated, within academic curriculum domains, the potential for evaluating content validity via empirical methods. Li and Sireci (2013) demonstrated the potential value of using *multidimensional scaling* (MDS), augmented by cluster analysis and correlation analysis, to evaluate the correspondence between empirically identified content dimensions and professional judgment.

MDS is a complimentary or alternative method to factor analysis when dealing with large multidimensional data sets. As defined in the *APA Dictionary of Psychology* (VandenBos, 2007), MDS is "a scaling method that represents perceived similarities among stimuli by arranging similar stimuli in spatial proximity to one another, while disparate stimuli are represented far apart from one another" (p. 599). This statistical method helps users understand relationships between and among variables through the use of visual-spatial "maps." The input for an MDS analysis is a matrix of correlations among a set of variables; the output is a visual-spatial figure, or map, in which the relationship between the variables is represented by distances and dimensions on the map. These maps help users understand the key dimensions among the variables. In contrast to factor analysis, interpretation of MDS is more qualitative and subjective. However, MDS has particular potential in the context of content validity because it provides information about "both the *content* and *processes* underlying performance on diverse cognitive tasks" (McGrew, 2005, p. 172).

When MDS methods have been applied to data sets previously analyzed by exploratory or confirmatory factor analysis methods, "new insights into the characteristics of tests and constructs previously obscured by the strong statistical machinery of factor analysis emerge" (Schneider & McGrew, 2012, p. 110).[3] Examples include Marshalek, Lohman, and Snow's (1983) classic two-dimensional MDS analysis of over 30 cognitive tests (including the *Wechsler Adult Intelligence Scale®* [WAIS] [Wechsler, 1955] subtests), Cohen, Fiorello, and Farley's (2006) three-dimensional cylindrical MDS interpretation of the *Wechsler Intelligence Scale for Children®–Fourth Edition* (WISC®-IV) (Wechsler, 2003) subtests, McGrew's (2012) two-dimensional MDS of WJ-R cognitive and achievement cluster scores, and Tucker-Drob and Salthouse's (2009) sophisticated factor and MDS analysis of 16 cognitive variables across 38 aggregated studies ($n = 8{,}813$).

As stated in Chapter 1, one goal of the WJ IV is to contribute to the field of applied test development by employing contemporary, innovative models for data collection and processing. Following is a brief description of how MDS scaling was employed in the WJ IV development as an empirical tool for supplementing WJ IV author and other expert judgments regarding content validity.

The correlations between the 51 WJ IV standardization and research tests were analyzed with a Guttman Radex two-dimensional MDS procedure at each of five WJ IV age groups.[4] The radex model of intelligence postulates that cognitive abilities can be organized to form a radial order of complexity (or radex). As described in the *APA Dictionary of Psychology* (VandenBos, 2007):

> The radex comprises two parts: (a) a simplex, which is the relative distance from the center of a circle, with abilities that are closer to the center of the circle therefore being closer to the construct of general intelligence, which is at dead center; and (b) a circumplex which is the relative distance around the circle, with abilities that are more highly correlated therefore being located closer to each other. Thus the system identifies abilities through a set of polar coordinates (rather than Cartesian coordinates used by other systems). (p. 765)

This chapter contains detailed results for the 9 through 13 age group; the complete results of the MDS analyses for the five other age groups (3 through 5, 6 through 8, 14 through 19, 20 through 39, and 40 through 90+) are presented in Appendix I.

In the current context, the mass of information visually portrayed in Figure 5-2 should be overlooked in favor of a big picture understanding. The important point here is that the tests that share a common dimension are typically in close spatial proximity in the map (often represented by circles or ovals or connected as a shape via lines). Tests that are in

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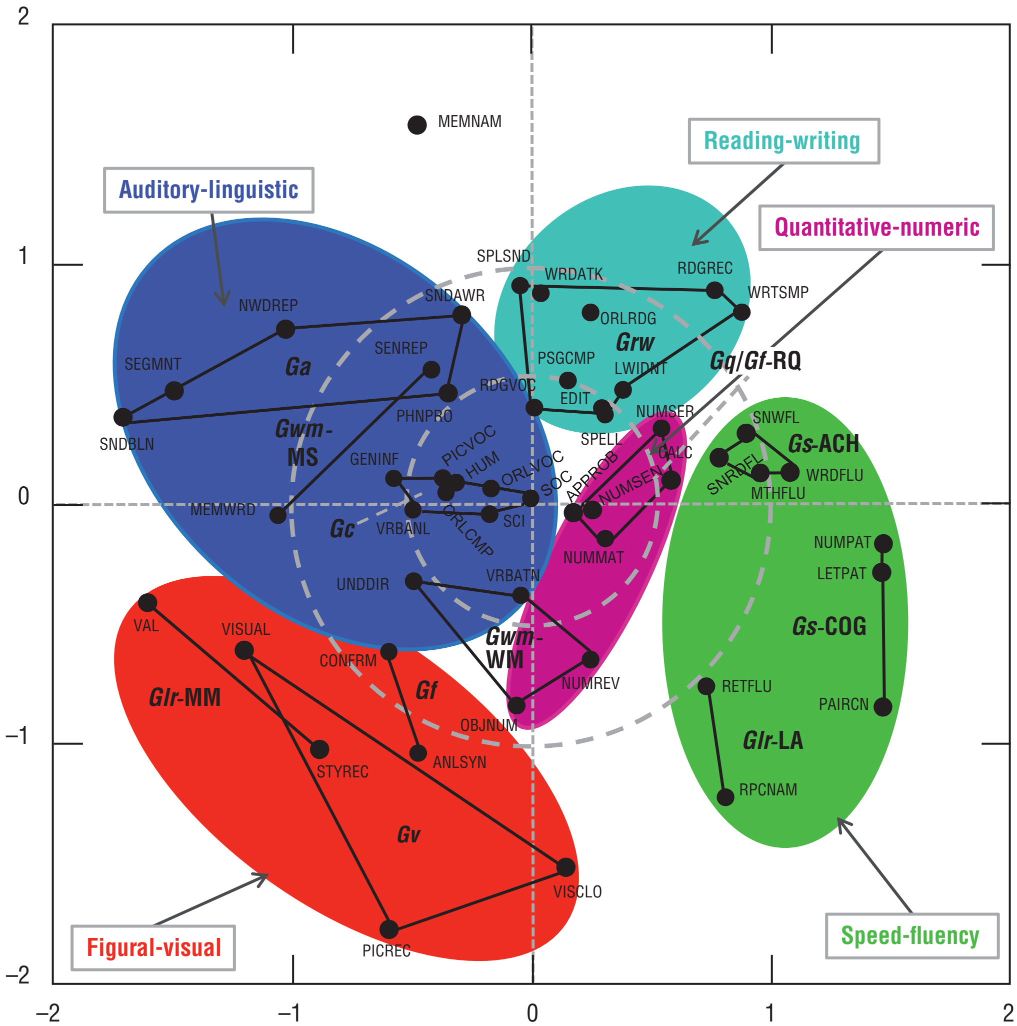
[3] See Cohen et al., (2006); Süß and Beauducel (2005); Tucker-Drob and Salthouse (2009); and Wilhelm (2005) for excellent descriptions and applications of MDS methods.

[4] The construction of these age-differentiated samples and correlation matrices is explained later in this chapter. In addition, more detail regarding the interpretation of the MDS methods and results is discussed later in this chapter. The 51 WJ IV norming and research tests and test name abbreviations are presented in Table 5-10.

close proximity are interpreted as measuring similar cognitive operations or sharing common stimulus or content features. The five large shaded ovals are relevant to this discussion.

***Figure 5-2.***
*MDS (Guttman Radex) content validity interpretation of WJ IV ages 9 through 13 model-development sample A (n = 785)*




Based on an analysis of the test item content, three of the shaded ovals in Figure 5-2 are characterized as sharing an *auditory-linguistic* content dimension (primarily *Ga*, *Gc*, and select *Gwm* tests), a *figural-visual* content dimension (primarily *Gv*, and select *Gf* and *Glr* tests), and a *quantitative-numeric* content dimension (primarily *Gq/Gf*-RQ and select *Gwm* tests). Although these three dimensions are very similar to the verbal, figural, and numeric content facets of the *Berlin Model of Intelligence Structure* (BIS) (Süß & Beauducel, 2005),[5] which has made extensive use of MDS methods, research on the BIS framework has not included auditory tasks. In Figure 5-2 the WJ IV auditory tests group with the verbal tests, forming a broader oral language, or auditory-linguistic dimension. This finding suggests the possibility that the BIS verbal content dimension might need to be expanded to represent a broader oral language dimension. Alternatively, the auditory-linguistic dimension found in the WJ IV collection of tests could be split into separate auditory and verbal content dimensions, thus expanding the number of BIS content dimensions to four (auditory,

[5] The BIS model is a heuristic framework, derived from both factor analysis and MDS facet analysis, for the classification of performance on different tasks and is not to be considered a traitlike structural model of intelligence as exemplified by the factor-based CHC theory. Nevertheless, Guttman Radex MDS models often show strong parallels to hierarchical factor-based models based on the same set of variables (Süß & Beauducel, 2005; Tucker-Drob & Salthouse, 2009).

verbal, figural, quantitative). The BIS research also has not typically included reading and writing achievement tests. The emergence of the new reading-writing content dimension in the WJ IV tests may reflect another missing piece of the BIS framework—a sixth content dimension (reading and writing). Finally, the speed-fluency grouping in the WJ IV tests appears to be more of a cognitive operations (vs. content) dimension, although the speeded reading, writing, and math tests do show close proximity to the respective reading-writing and quantitative-numeric content dimensions. In all likelihood, a clearer differentiation of *cognitive content versus cognitive operations* dimensions would emerge if a three-dimensional MDS analysis (see Cohen et al., 2006; Tucker-Drob & Salthouse, 2009) were completed with the WJ IV norming data.

Although preliminary, this wide-lens MDS analysis of the WJ IV test groupings provides empirical support for four broad types of shared stimulus content characteristics (namely, auditory-linguistic or auditory and verbal, figural-visual, quantitative-numeric, and reading-writing). Table 5-5 summarizes the classification of WJ IV tests across five of the six age-group samples (included in Appendix H) on which the MDS analyses were completed.

***Table 5-5.***
*Broad MDS-Based Stimulus Content Characteristic Classifications of WJ IV Tests by Five Age Groups*

| Battery/Test Name | Test Name Abbreviation | Age Group | | | | |
|---|---|---|---|---|---|---|
| | | 6–8 | 9–13 | 14–19 | 20–39 | 40–90+ |
| **Tests of Cognitive Abilities** | | | | | | |
| 1: Oral Vocabulary | ORLVOC | AL | AL | AL | AL | AL |
| 2: Number Series | NUMSER | QN | QN | QN | QN | QN |
| 3: Verbal Attention | VRBATN | | AL | AL | AL | AL |
| 4: Letter-Pattern Matching[a] | LETPAT | | | | | |
| 5: Phonological Processing | PHNPRO | AL | AL | AL | AL | AL |
| 6: Story Recall | STYREC | AL | | | AL | AL |
| 7: Visualization | VISUAL | FV | FV | FV | FV | FV |
| 8: General Information | GENINF | AL | AL | AL | AL | AL |
| 9: Concept Formation | CONFRM | FV | FV | FV | FV | FV |
| 10: Numbers Reversed | NUMREV | | QN | FV | AL | FV |
| 11: Number-Pattern Matching[a] | NUMPAT | | | | | |
| 12: Nonword Repetition | NWDREP | | AL | AL | AL | AL |
| 13: Visual-Auditory Learning | VAL | FV | FV | | FV | |
| 14: Picture Recognition | PICREC | FV | FV | FV | FV | FV |
| 15: Analysis-Synthesis | ANLSYN | | FV | FV | FV | FV |
| 16: Object-Number Sequencing | OBJNUM | | QN | FV | FV | FV |
| 17: Pair Cancellation[a] | PAIRCN | | | | | |
| 18: Memory for Words | MEMWRD | | AL | AL | AL | |
| **Tests of Oral Language** | | | | | | |
| 1: Picture Vocabulary | PICVOC | AL | AL | AL | AL | AL |
| 2: Oral Comprehension | ORLCMP | AL | AL | AL | AL | AL |
| 3: Segmentation | SEGMNT | AL | AL | AL | AL | AL |
| 4: Rapid Picture Naming[a] | RPCNAM | | | | | |
| 5: Sentence Repetition | SENREP | AL | AL | AL | AL | AL |
| 6: Understanding Directions | UNDDIR | AL | AL | AL | | AL |
| 7: Sound Blending | SNDBLN | | AL | AL | AL | AL |
| 8: Retrieval Fluency[a] | RETFLU | | | | | |
| 9: Sound Awareness | SNDAWR | AL | AL | AL | AL | AL |

***Table 5-5.*** *(cont.)*
*Broad MDS-Based Stimulus Content Characteristic Classifications of WJ IV Tests by Five Age Groups*

| Battery/Test Name | Test Name Abbreviation | Age Group | | | | |
|---|---|---|---|---|---|---|
| | | 6–8 | 9–13 | 14–19 | 20–39 | 40–90+ |
| **Tests of Achievement** | | | | | | |
| 1: Letter-Word Identification | LWIDNT | RW | RW | RW | RW | RW |
| 2: Applied Problems | APPROB | QN | QN | QN | QN | QN |
| 3: Spelling | SPELL | RW | RW | RW | RW | RW |
| 4: Passage Comprehension | PSGCMP | RW | RW | RW | RW | RW |
| 5: Calculation | CALC | QN | QN | QN | QN | QN |
| 6: Writing Samples | WRTSMP | RW | RW | RW | RW | RW |
| 7: Word Attack | WRDATK | RW | RW | RW | RW | RW |
| 8: Oral Reading | ORLRDG | RW | RW | RW | RW | RW |
| 9: Sentence Reading Fluency | SNRDFL | *RW* | *RW* | *RW* | *RW* | *RW* |
| 10: Math Facts Fluency | MTHFLU | *QN* | *QN* | *QN* | *QN* | *QN* |
| 11: Sentence Writing Fluency | SNWRFL | *RW* | *RW* | *RW* | *RW* | *RW* |
| 12: Reading Recall | RDGREC | RW | RW | RW | RW | RW |
| 13: Number Matrices | NUMMAT | QN | QN | QN | QN | QN |
| 14: Editing | EDIT | RW | RW | RW | RW | RW |
| 15: Word Reading Fluency | WRDFLU | *RW* | *RW* | *RW* | *RW* | *RW* |
| 16: Spelling of Sounds | SPLSND | | RW | RW | | |
| 17: Reading Vocabulary | RDGVOC | RW | RW | RW | RW | RW |
| 18: Science | SCI | AL | AL | AL | AL | AL |
| 19: Social Studies | SOC | AL | AL | AL | AL | AL |
| 20: Humanities | HUM | AL | AL | AL | AL | AL |

*Note.* AL = auditory-linguistic; FV = figural-visual; QN = quantitative-numeric; RW = reading-writing. Blank cell for tests other than speeded tests indicates tests that fell in a broad content classification that was not consistent with the stimulus characteristics of the test. Italic *RW* and *QN* indicate tests in the speed-fluency grouping with very close proximity to *Grw* and QN achievement groupings. Shading designates tests with consistent content classifications in four or five age groups.

[a] The speeded tests are not classified in this content validity summary table because in the MDS analyses those tests did not group in the broad content dimensions, but instead grouped together in a cognitive speed-fluency dimension (see Figure 5-2).

Many tests (e.g., Oral Vocabulary, Number Series, and Phonological Processing) show very consistent content classifications across the age groups. Other tests (e.g., Numbers Reversed) show less consistency in content classification across the age groups, which suggests that there are either developmental shifts in the nature of the tasks included in these tests, or more likely, the current analysis, which may be clouded by cognitive operations variance, is still an incomplete picture of the content features of the tests. These apparent content classification inconsistencies for some tests may be better understood through the use of three-dimensional MDS models.

Of particular interest is how the tests in the separate WJ IV COG, WJ IV OL, and WJ IV ACH batteries tend to cluster together—providing a broad form of content validity evidence for the three-battery WJ IV organization. The auditory-linguistic grouping shown in the upper left MDS quadrant of Figure 5-2 includes all the nonspeeded WJ IV OL tests. The upper right MDS quadrant in that figure is composed exclusively of WJ IV ACH tests from the *Grw* and *Gq* domains. The one exception is Number Series, which is clearly a cognitive *Gf* measure.[6] All WJ IV COG tests are either in the upper left (auditory-linguistic), lower right (primarily *Gs* and *Gwm* cognitive efficiency tests), or lower left (primarily figural-visual and *Gwm* tests) of Figure 5-2. With the previously discussed exception and explanation of Number Series, it is important to note that none of the WJ IV COG tests are in the upper right, "achievement" quadrant.

[6] We predict that in a three-dimensional MDS analysis of the WJ IV tests there would be a cleaner separation of content and cognitive classification of tests. Number series tests have a long history in intelligence testing of being strong indicators of quantitative reasoning under *Gf* (Carroll, 1993). Support for this interpretation is presented in the internal structural validity section of this chapter.

The current MDS-based category content validity evidence presented here supports the broad content structure of the WJ IV clusters and batteries. These analyses and interpretations are preliminary and require more extensive analyses of the WJ IV standardization sample, particularly more complex mixed-method (factor and three-dimensional MDS) analysis as demonstrated by Tucker-Drob and Salthouse (2009). Others are encouraged to pursue such research.

## Cognitive Complexity of Test Content and Operations

As described in Chapter 1, an important goal of the WJ IV revision plan was to increase the *cognitive complexity* demands of certain WJ IV tests. Two different approaches were taken to achieve this goal. The first approach, which is a common approach in applied test development, is to design factorially complex CHC tests, or tests that deliberately include the influence of two or more narrow abilities. This approach is exemplified by Kaufman and Kaufman (2004a) in the development of the *Kaufman Assessment Battery for Children–Second Edition* (KABC-II), where:

> the authors did not strive to develop "pure" tasks for measuring the five CHC broad abilities. In theory, *Gv* tasks should exclude *Gf* or *Gs*, for example, and tests of other broad abilities, like *Gc* or *Glr*, should only measure that ability and no other abilities. In practice, however, the goal of comprehensive tests of cognitive abilities like the KABC-II is to measure problem solving in different contexts and under different conditions, with *complexity* being necessary to assess high-level functioning. (p. 16; italic emphasis added)

In this approach to test development, construct-irrelevant variance is not deliberately minimized or eliminated (Benson, 1998; Messick, 1995), and although tests that measure more than one narrow CHC ability typically tend to have lower validity as indicators of CHC abilities, they tend to lend support to other types of validity evidence (e.g., higher predictive validity).

The second approach to enhancing the complexity of select WJ IV tests is by maintaining the CHC factor purity of tests or clusters as much as possible while deliberately increasing the complexity of information processing demands of the tests within the specific broad or narrow CHC domain (McGrew, 2012). As described by Lohman and Lakin (2011), the cognitive complexity of the abilities measured by tests can be achieved through increasing either: (a) the number of cognitive component processes, (b) the accumulation of differences in speed of component processing, (c) the number of more important component processes (e.g., inference), (d) the demands of attentional control and working memory, or (e) the demands on adaptive functions (assembly, control, and monitoring). This second form of cognitive complexity, not to be confused with factorial complexity, is defined in Chapter 1 as tasks that place greater demands on cognitive information processing (cognitive load), that require greater allocation of key cognitive resources (working memory or attentional control), and that invoke the involvement of more cognitive control or executive functions. Per this second form of cognitive complexity, the design objective is to make a test more cognitively complex within a CHC domain, not to deliberately make it a mixed measure of two or more CHC abilities.

Two forms of evidence can be used to support the high cognitive complexity demands of the WJ IV tests. First, in Guttman Radex MDS models, tests closest to the center of the 2-dimensional plots are interpreted as being more cognitively complex (Cohen et al., 2006; Marshalek et al., 1983; Tucker-Drob & Salthouse, 2009). (A test has less cognitive complexity the further away it is from the center of an MDS plot.) In Figure 5-2, the tests within the smallest dashed circle near the center of the plot would be considered the most cognitively complex. These include most of the *Gc* tests, the Applied Problems (*Gq*) and Number Matrices (*Gf*) tests, the research tests of Verbal Analogies (*Gc/Gf*) and Number Sense (*Gq*), the reading and writing (*Grw*) tests of Reading Vocabulary, Editing, Spelling, and Passage Comprehension, and the Verbal Attention test (*Gwm*). Examples of WJ IV tests with relatively lower cognitive complexity demands are select *Ga* tests (Sound Blending, Segmentation) and *Gv* tests (Picture Recognition).[7]

The preliminary MDS analysis of the WJ IV tests reported in this manual is not appropriate for accurately classifying the degree of cognitive complexity of the WJ IV tests. Twenty of the 51 tests (approximately 40%) included in the MDS analysis reported in Figure 5-2 are from the WJ IV ACH battery. The inclusion of such a large number of reading, writing, and math achievement tests in the current MDS analysis biases the MDS toward academic achievement. Future MDS research including the WJ IV COG and WJ IV OL tests alone, or with a balanced set of indicators from each respective battery, is necessary to make assertions about the degree of cognitive complexity in those tests.

A more commonly accepted method for analyzing the cognitive complexity of tests is to examine each test's loading on a single general intelligence (*g*) factor extracted from the collection of tests; this classic interpretation is attributed to Arthur Jensen. Jensen (1998) proposed that the cognitive complexity of a test could be operationally quantified according to the test's loading on the first unrotated factor in a factor analysis or principal axis analysis. The rationale is that tests that are more cognitively complex require abstract reasoning and problem solving and invoke a wider range of elementary cognitive processes (Jensen, 1998; Stankov, 2000, 2005), which in turn is reflected in high g loadings. Typically, but not with 100% congruence, factor analysis results-based test g classifications correspond to cognitive complexity as determined by MDS methods (Marshalek et al., 1983). To determine whether this is true for the WJ IV tests, and given that *g* loadings are most frequently associated with cognitive tests, 18 WJ IV COG tests were analyzed with principal axis analyses at each of five broad age groups. Each test's loading on the first unrotated factor by age group is presented in Table 5-6.[8]

***Table 5-6.***
*WJ IV COG g loadings on First Unrotated Common Principal Axis Factor*

| Test | CHC Factor | Age Group 6–8 $n = 823$ | 9–13 $n = 1{,}572$ | 14–19 $n = 1{,}685$ | 20–39 $n = 1{,}251$ | 40–90+ $n = 1{,}145$ | Median |
|---|---|---|---|---|---|---|---|
| Object-Number Sequencing | *Gwm* | 0.72 | 0.69 | 0.74 | 0.75 | 0.79 | 0.74 |
| **Oral Vocabulary** | ***Gc*** | **0.66** | **0.67** | **0.72** | **0.75** | **0.75** | **0.72** |
| **Phonological Processing** | ***Ga*** | **0.73** | **0.63** | **0.68** | **0.71** | **0.77** | **0.71** |
| Concept Formation | *Gf* | 0.63 | 0.62 | 0.66 | 0.70 | 0.67 | 0.66 |
| Numbers Reversed | *Gwm* | 0.63 | 0.59 | 0.65 | 0.67 | 0.69 | 0.65 |
| Analysis-Synthesis | *Gf* | 0.64 | 0.63 | 0.64 | 0.67 | 0.70 | 0.64 |
| **Verbal Attention** | ***Gwm*** | **0.61** | **0.62** | **0.64** | **0.65** | **0.70** | **0.64** |
| **Number Series** | ***Gf*** | **0.62** | **0.61** | **0.64** | **0.59** | **0.65** | **0.62** |
| Memory for Words | *Gwm* | 0.60 | 0.58 | 0.61 | 0.64 | 0.66 | 0.61 |
| **Visualization** | ***Gv*** | **0.60** | **0.57** | **0.61** | **0.66** | **0.67** | **0.61** |

7 It is important to note that the degree of cognitive complexity is relative to the WJ IV collection of tests. The only way to evaluate the relative cognitive complexity of the WJ IV tests with reference to other test batteries (e.g., the Wechsler tests—WPPSI-III, WISC-IV, WAIS-IV [Wechsler, 2002, 2003, 2008], SB5 [Roid, 2003a], KABC-II [Kaufman & Kaufman, 2004a]) would be to gather data on examinees who are administered both the WJ IV tests and the other test batteries.

8 Similar to the MDS cognitive complexity classifications, the g loadings in Table 5-6 should be interpreted only as the degree of association with g within the WJ IV. Joint analysis with other intelligence test batteries (e.g., the Wechsler tests—WPPSI-III, WISC-IV, WAIS-IV [Wechsler, 2002, 2003, 2008], SB5 [Roid, 2003a], KABC-II [Kaufman & Kaufman, 2004a]) would be necessary to make comparisons across intelligence batteries.

***Table 5-6.*** *(cont.)*
*WJ IV COG g loadings on First Unrotated Common Principal Axis Factor*

| Test | CHC Factor | Age Group 6–8 $n = 823$ | 9–13 $n = 1,572$ | 14–19 $n = 1,685$ | 20–39 $n = 1,251$ | 40–90+ $n = 1,145$ | Median |
|---|---|---|---|---|---|---|---|
| General Information | *Gc* | 0.44 | 0.52 | 0.59 | 0.63 | 0.65 | 0.59 |
| **Story Recall** | ***Glr*** | **0.58** | **0.53** | **0.58** | **0.54** | **0.62** | **0.58** |
| **Letter-Pattern Matching** | ***Gs*** | **0.57** | **0.55** | **0.60** | **0.57** | **0.65** | **0.57** |
| Number-Pattern Matching | *Gs* | 0.56 | 0.53 | 0.54 | 0.53 | 0.59 | 0.54 |
| Nonword Repetition | *Ga* | 0.55 | 0.51 | 0.52 | 0.51 | 0.56 | 0.52 |
| Visual-Auditory Learning | *Glr* | 0.52 | 0.47 | 0.49 | 0.59 | 0.60 | 0.52 |
| Pair Cancellation | *Gs* | 0.45 | 0.47 | 0.52 | 0.51 | 0.54 | 0.51 |
| Picture Recognition | *Gv* | 0.52 | 0.43 | 0.36 | 0.45 | 0.47 | 0.45 |

*Note.* Bold indicates tests in COG GIA cluster. Tests are sorted and listed in descending order of the median *g*-loading values.

The magnitude of the *g* loadings presented in Table 5-6 can be used to evaluate the relative cognitive complexity of each of the WJ III COG tests. For example, Oral Vocabulary (*Mdn* $g = .72$) is clearly the most cognitively complex measure of *Gc*. General Information (*Gc*) has a much lower average *g* loading (*Mdn* $g = .59$). In *Gv*, Visualization (*Mdn* $g = .61$) would be classified as more cognitively complex than Picture Recognition (*Mdn* $g = .45$).

The domain of auditory processing (*Ga*) is a particularly illuminating example. As described in Chapter 1 of the *Woodcock-Johnson IV Tests of Cognitive Abilities Examiner's Manual* (Mather & Wending, 2014b), the new WJ IV Phonological Processing test is designed to require more complex cognitive processing of multiple phonetic coding functions (*Ga*-PC). The results of the principal axis analyses show that Phonological Processing is a much more cognitively complex measure (*Mdn* $g = .71$) than, for example, Nonword Repetition (*Mdn* $g = .52$). In fact, Phonological Processing is one of the three highest *g*-loading tests in the WJ IV COG. The results of the principal axis analyses indicate that the design objective of increasing the cognitive complexity of select WJ IV tests, without necessarily increasing CHC factorial complexity, was attained.

## Developmental Patterns of WJ IV Ability Clusters

A review of the WJ IV summary descriptive statistics in Appendices B and C reveals that all WJ IV tests and clusters display average score changes consistent with the developmental growth and decline of cognitive and achievement abilities across the life span. Divergent growth curves provide evidence for the existence of distinct, unique abilities (Carroll, 1993). Figures 5-3 and 5-4 present examples of growth curves from ages 6 to 90 for the principle WJ IV COG clusters. The growth curves illustrate that the unique abilities measured by the WJ IV follow different developmental courses or trajectories over the age span from childhood to geriatric levels. The examples were constructed using age 6 years, 0 months (6-0) as a starting point and subtracting the norm-based Reference *W* (REF *W*)[9] score for age 6-0 for each cluster from all other REF *W*s for that cluster through age 90+.[10] This procedure produced growth curves all starting with an assigned common origin of zero. Age 6-0 was selected as the starting point because all WJ IV clusters have normative REF *W* scores at and above this age. At any given age, the curves in Figures 5-3 through 5-8 are all based on scores from the same examinees.

[9] Reference *W* scores are defined in Chapter 3.

[10] When two versions of a WJ IV cluster are available (e.g., Oral Language and Broad Oral Language, Reading and Broad Reading), only the two-test cluster is reported here.

**Figure 5-3.**
*Plot of WJ IV COG GIA, seven CHC factor clusters, and the* Gf-Gc *Composite* W *score difference curves by age.*

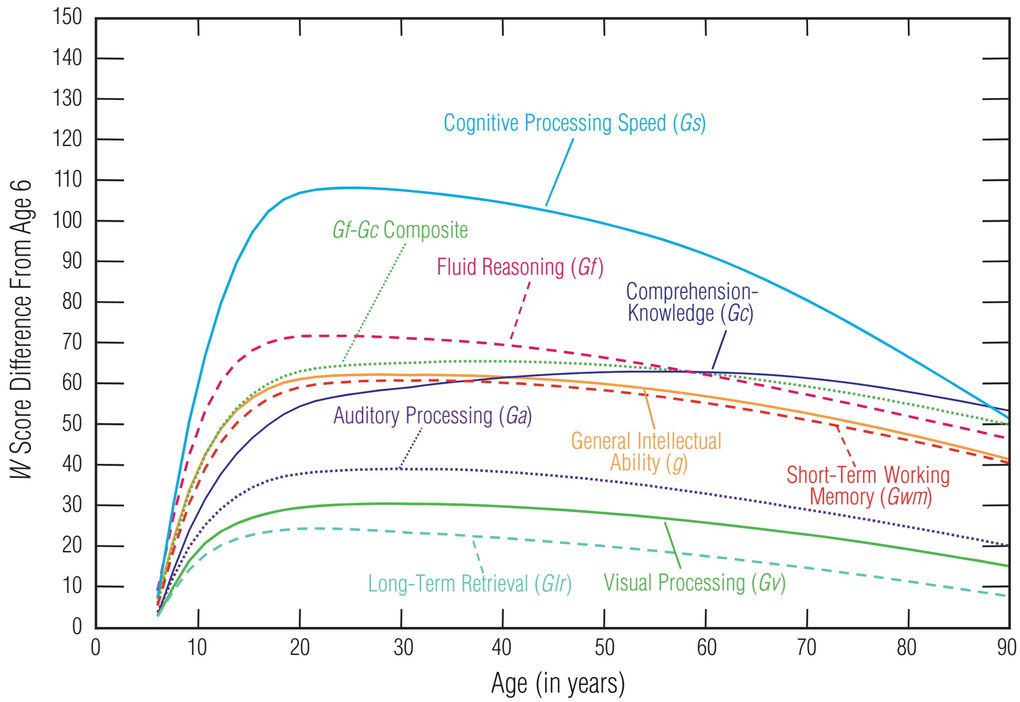
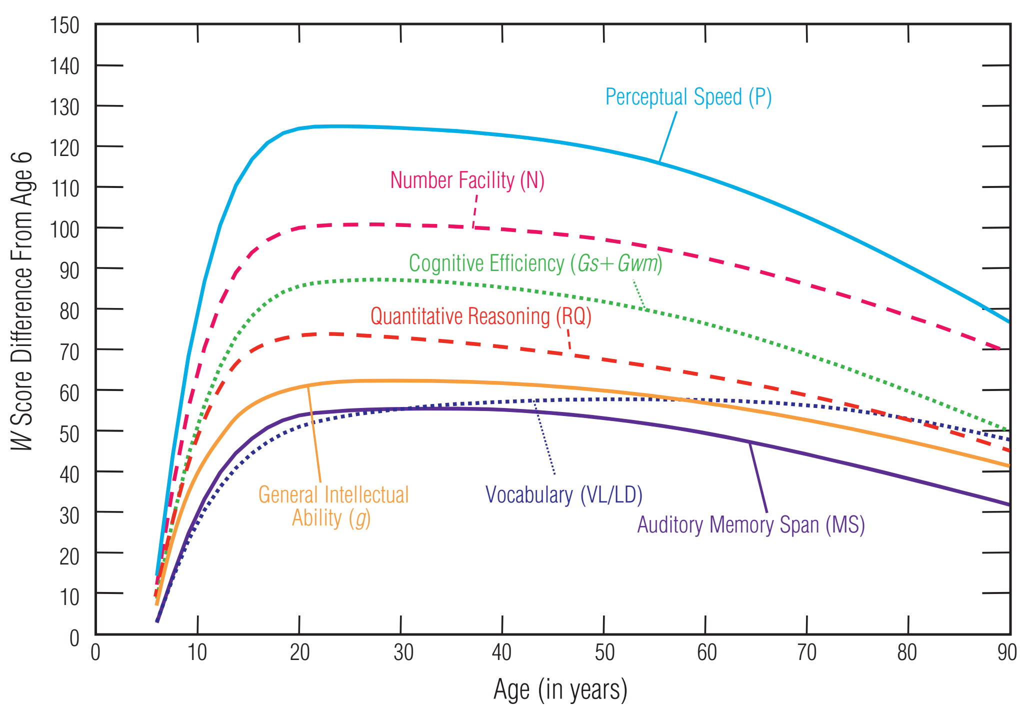



**Figure 5-4.**
*Plot of WJ IV COG GIA and six narrow cognitive ability and other clinical cluster* W *score difference curves by age.*



The existence of unique developmental patterns for most of the WJ IV broad and narrow abilities, across and within CHC domains, is one form of evidence that, combined with information about the test's content, structure, and relationship to other variables (presented later in this chapter), supports the validity of the WJ IV scores for measuring an individual's cognitive, oral language, and achievement abilities. A word of caution is in order about the interpretation of the plots presented in this section. Although the plots are referred to as *growth curves*, they are based on cross-sectional data, not longitudinal data. They portray the rise and decline of median performance across age for the general population at the time the WJ IV was normed, not a progression of the same cohort of examinees over time.

## General (*g*), Broad, and Narrow WJ IV COG Clusters

Growth curves for the General Intellectual Ability (GIA, *g*), *Gf-Gc* Composite, and seven CHC cognitive factor clusters[11] are presented in Figure 5-3. The patterns of growth and decline of the seven WJ IV CHC cognitive factor clusters differ markedly, providing evidence to support the existence of distinct abilities. The Long-Term Retrieval (*Glr*) factor cluster demonstrates less developmental change than any of the other WJ IV COG abilities. The *Glr* factor cluster growth curve is typical of cognitive ability tests where performance is based on a processing ability that is less influenced by formal training and learning. The growth curve for *Glr* (and, to some extent, the curves for *Ga* and *Gv*) is consistent with abilities that develop more as a function of informal and indirect learning experiences, which typically demonstrate relatively little change with age. In contrast, the growth curve for the Comprehension-Knowledge (*Gc*) factor cluster is an example of a measure in which direct and more formalized past learning is an important factor. The *Gc* factor cluster demonstrates continual growth well into adulthood (through ages 55 to 70); the *Glr* factor cluster score reaches its peak much earlier at approximately age 20. In addition, the *Gc* curve shows much less decline during late adulthood than does the *Glr* curve, which demonstrates more rapid decline starting at a much earlier age (approximately age 30 and beyond). The *Gc* curve represents a cognitive ability that is more consistently maintained over the life span than the abilities represented by the *Glr*, *Gv*, and *Ga* cluster curves.

Also note the steep rise in the Processing Speed (*Gs*) factor cluster shown in Figure 5-3. This ability reaches a pronounced asymptote between ages 20 and 30, and then steadily declines throughout the remainder of the age span.[12] The Short-Term Working Memory (*Gwm*) and Fluid Reasoning (*Gf*) factor clusters reach their highest levels between ages 20 and 30 and demonstrate similar rates of decline throughout the rest of the age span.

As expected given the inclusion of one test from each of the seven CHC cognitive domains, the GIA (*g*) factor cluster growth curve falls approximately in the middle of the other curves presented in Figure 5-3. General intelligence (*g*), as measured by the WJ IV GIA factor cluster, peaks between ages 20 and 30. The *Gf-Gc* Composite cluster, which also measures more than one broad CHC ability domain, demonstrates a pattern of early growth that is similar to GIA (*g*) but that diverges upward at approximately age 20, exhibiting a longer period of growth than does GIA. This longer period of score growth throughout adulthood reflects the inclusion of the *Gc* abilities in the *Gf-Gc* Composite.

[11] Throughout this chapter the related terms *cluster* and *factor* are used. It is important to define what each means. When the term *cluster* is used, it refers to the manifest or obtained WJ IV cluster composite score. When the term *factor* is used, it refers to the latent CHC construct or dimension that a cluster is intended to represent. The phrase *factor cluster* refers to the WJ IV cluster (observed or obtained score) that represents a latent factor or ability per CHC theory (see Chapter 1 and Appendix A).

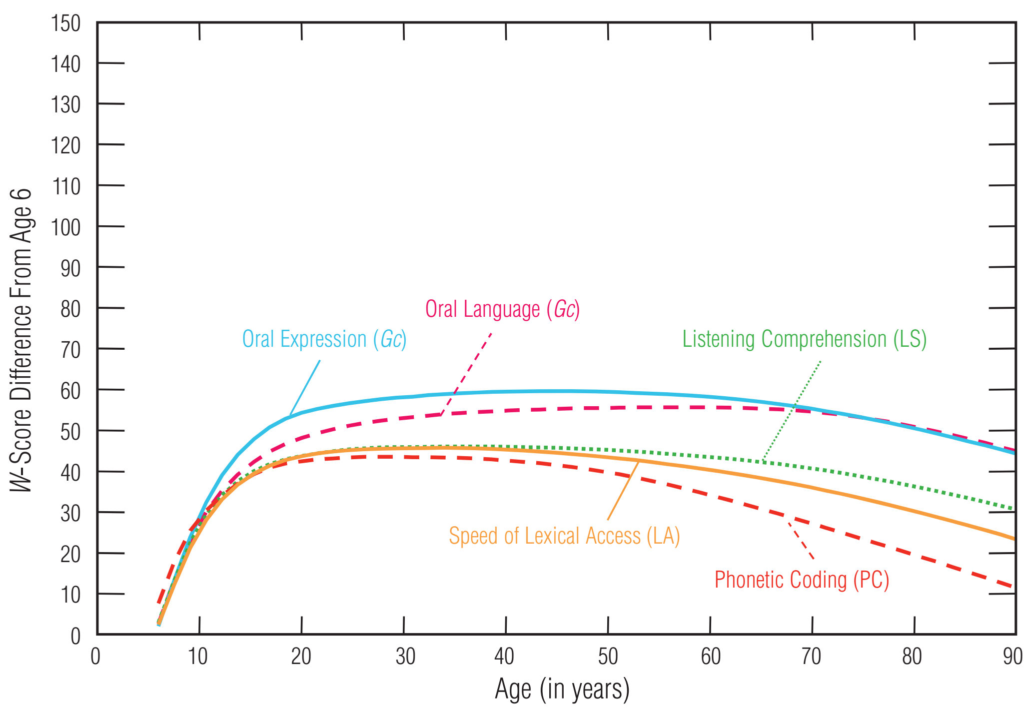
[12] The timed tests have generally wider ranges of examinee *W* ability, and larger standard deviations, than the untimed tests. This large *W*-ability range is reflected in the relatively steep growth curves for clusters containing one or more timed tests (such as *Gs*). Users should refer to Chapter 2, "Calibration of Timed Tests" for more information on how to interpret scores from the timed tests and from the clusters containing timed tests, Also see McGrew, Werder, & Woodcock (1991) for further discussion.

Figure 5-4 demonstrates the existence of distinct patterns of growth and decline among the abilities measured by the WJ IV COG narrow ability factor and clinical clusters of Auditory Memory Span (MS), Vocabulary (VL/LD), Quantitative Reasoning (RQ), Cognitive Efficiency (*Gs*+*Gwm*), Number Facility (N), and Perceptual Speed (P). The GIA (*g*) curve is included for comparison purposes. As expected, the Auditory Memory Span (MS) and Vocabulary (VL/LD) curves are similar to their respective broad *Gwm* and *Gc* curves in Figure 5-3. The Quantitative Reasoning (RQ) curve also is similar to the broad *Gf* curve in Figure 5-3. Finally, given the inclusion of speeded tests in these clusters, the higher peaks and faster rates of decline for the Cognitive Efficiency (*Gs*+*Gwm*), Number Facility (N), and Perceptual Speed (P) curves are consistent with the broad *Gs* curve in Figure 5-3.

## Broad and Narrow WJ IV OL Clusters

Five WJ IV OL cluster growth curves are presented in Figure 5-5. Given that the WJ IV OL clusters contain tests from the broad CHC domains of *Gc*, *Ga*, and *Glr*, the similarity of the WJ IV OL cluster curves to the corresponding CHC domain curves in Figure 5-3 supports the validity of these WJ IV OL cluster scores for measuring key language-related cognitive abilities. The Oral Expression (*Gc*) and Oral Language (*Gc*) cluster growth curves are very similar to the *Gc* curve in Figure 5-3 in their pattern of growth and decline. However, these two WJ IV OL *Gc* cluster curves do not reach the same absolute level of growth as the WJ IV COG *Gc* factor cluster curve, which includes the General Information test—a measure of acquired cultural verbal knowledge (K0) that exhibits continued growth later in the life span. As expected, the Phonetic Coding (PC) cluster growth curve is similar to the broad WJ IV COG *Ga* factor cluster curve in Figure 5-3.

**Figure 5-5.**
*Plot of five WJ IV OL cluster W score difference curves by age.*




It is notable that the Speed of Lexical Access (LA) cluster curve has a much steeper and longer period of initial growth, and higher absolute growth, than its corresponding broad COG *Glr* factor cluster curve in Figure 5-3. This difference is most likely because the COG *Glr* factor cluster is composed of two nonspeeded tests (Story Recall and Visual-

Auditory Learning—Carroll [1993] called these “level” tests—while the two LA tests are either explicitly timed [Rapid Picture Naming] or place an emphasis on fluency of response [Retrieval Fluency]—Carroll called these “rate” tests). The difference in the growth trajectories of the COG *Glr* factor cluster and the OL LA cluster supports the proposition that the *Glr* and LA clusters are measuring different cognitive and language ability constructs. This is commensurate with Schneider and McGrew’s (2012) distinction between the *learning efficiency* and *retrieval fluency* aspects of memory abilities (see Appendix A).

## Broad, Narrow, and Cross-Domain WJ IV ACH Clusters

Growth curves for the 13 broad and narrow WJ IV ACH clusters and 7 cross-domain WJ IV ACH clusters are presented in Figures 5-6 and 5-7, respectively. Close examination of these ACH curves reveals developmental patterns of interest. The most obvious differences among all the achievement curves are between Academic Knowledge (*Gkn*, *Gc*; see Figure 5-7) and the other curves representing the traditional areas of academic instruction (reading, writing, and math). This difference supports the interpretation of the Academic Knowledge cluster score as a measure of *Gkn* or *Gc*. The Academic Knowledge cluster curve is similar in shape to the WJ IV COG *Gc* factor cluster curve in Figure 5-3.

***Figure 5-6.***
*Plot of 13 WJ IV ACH cluster* W *score difference curves by age.*

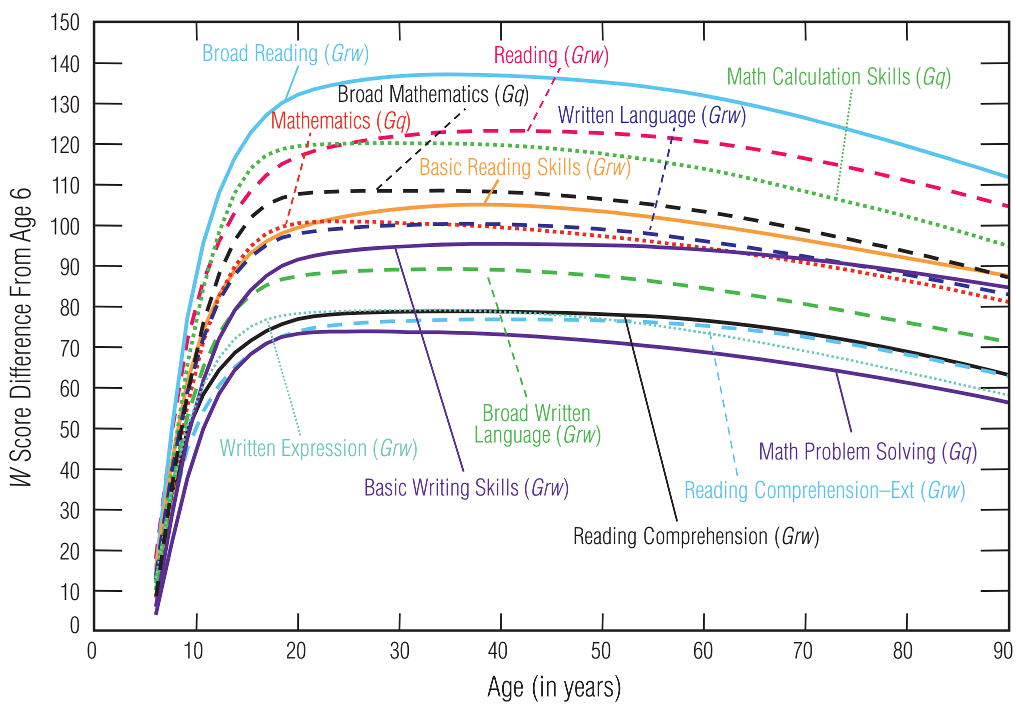
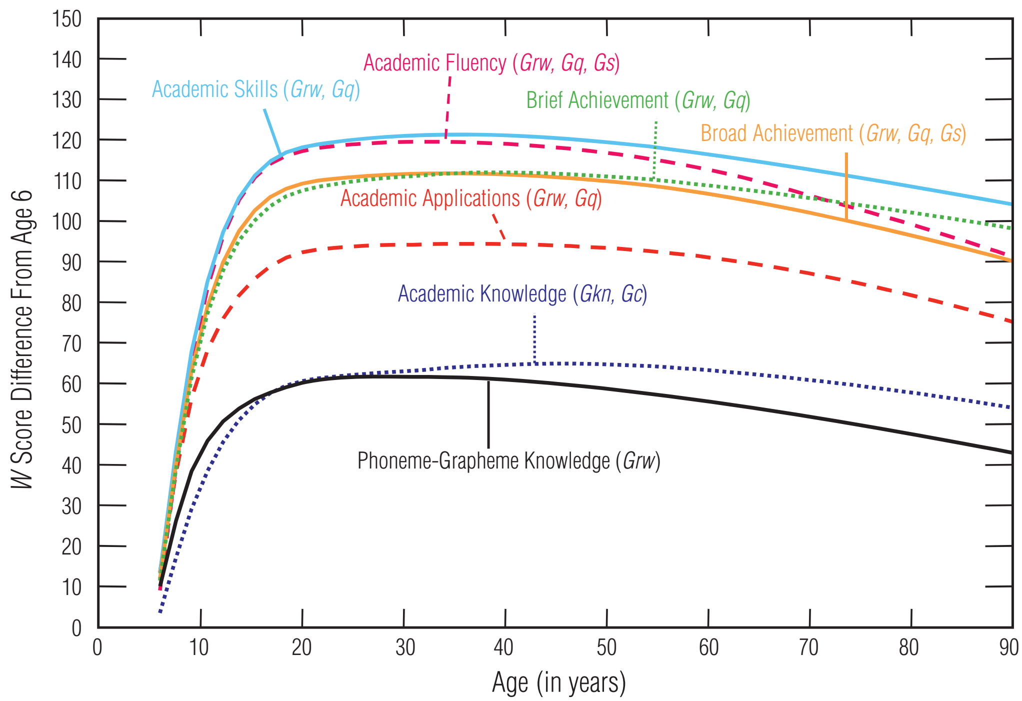


***Figure 5-7.***
*Plot of WJ IV ACH cross-domain cluster* W *score difference curves by age.*




In Figures 5-6 and 5-7, a number of points regarding achievement cluster measures are apparent. First, a majority of the WJ IV ACH clusters show rapid acceleration of growth from age 6 through approximately 15 years. Second, the majority of achievement abilities peak at a much higher level relative to their origin (in this case, 6 years) than the cognitive abilities do.[13] Third, most achievement abilities do not demonstrate as much absolute decline across the age span as the cognitive abilities do; the achievement abilities are generally maintained at higher levels into the older age ranges. These three features distinguish the achievement cluster curves from most all cognitive growth curves. Even *Gc*—the cognitive growth curve that most closely resembles the achievement curves—peaks at a relatively lower level, and much later in the life span, than the achievement curves do. Although some researchers (Shinn, Algozzine, Marston, & Ysseldyke, 1982) have argued that measures of *Gc*, or crystallized intelligence, are indistinguishable from measures of school achievement on intelligence tests, the evidence here supports the existence of ACH growth curves that measure different types of acquired knowledge distinct from *Gc*.

A number of specific WJ IV ACH growth curve comparisons demonstrate the value of examining the developmental patterns of constructs to support the validity of measures that are often difficult to disentangle via other validation methods (e.g., internal structure validity evidence based on factor analysis procedures). The growth curves in Figure 5-6 show that reading decoding abilities (represented by the Basic Reading Skills cluster) grow and are retained at a higher level throughout the life span than reading comprehension abilities are (represented by the Reading Comprehension cluster). Similarly, the curve representing basic math calculation and fluency skills (Math Calculation Skills cluster) grows more rapidly and maintains a higher level than the curve representing the application of mathematics and reasoning within mathematics (Math Problem Solving cluster). Finally, the same skill versus application differentiation is observed within the area of writing achievement. In Figure 5-6, the curve representing the basic writing skills of spelling and editing (Basic Writing Skills

[13] The exception to this is the cognitive *Gs* factor cluster, which peaks at a much higher level than the other cognitive abilities do.

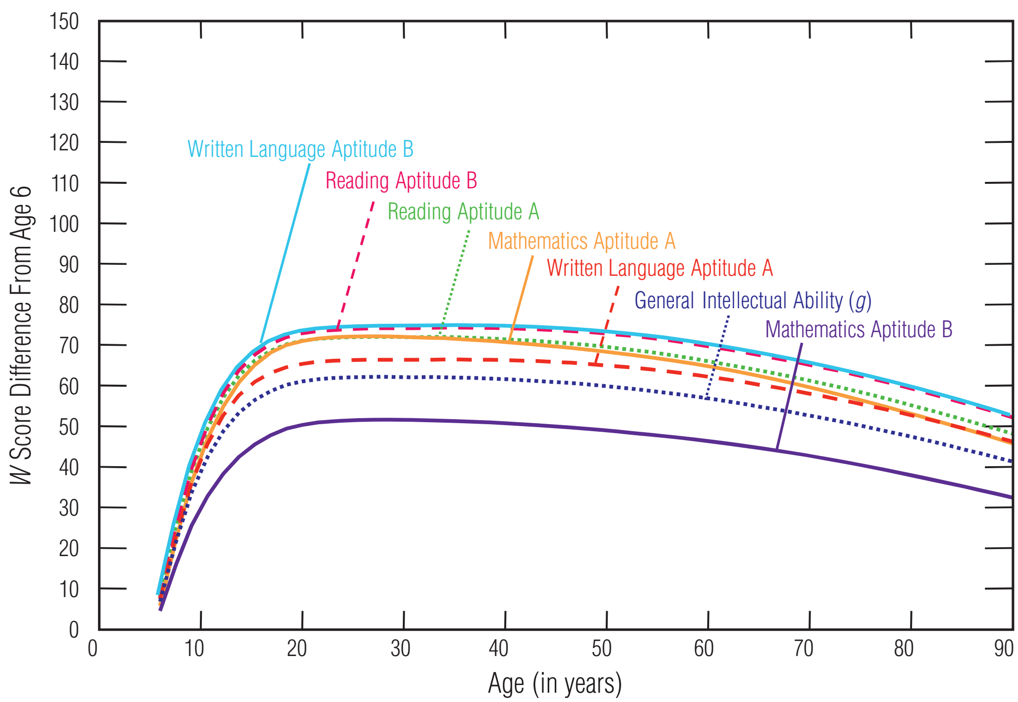
cluster) accelerates at a faster rate and maintains a higher level than the curve representing the ability to write with clarity of thought, organization, and good sentence structure (Written Expression cluster).

All curves except Academic Knowledge in Figure 5-7 represent cross-domain WJ IV ACH clusters composed of tests from reading, mathematics, and writing. It is not surprising, then, given the characterization of the primary features of WJ IV ACH growth curves described above, that the Academic Applications, Academic Skills, Academic Fluency, Brief Achievement, and Broad Achievement clusters are similar to most of the broad and narrow WJ IV ACH clusters in Figure 5-6.

## General (*g*) Scholastic Aptitude Clusters

As will be presented later in this chapter, the WJ IV COG Scholastic Aptitude clusters (SAPTs), which provide achievement domain-specific predictions of expected achievement (see Chapter 1), are highly intercorrelated and highly correlated with the WJ IV GIA (*g*) cluster. However, a review of the SAPT cluster growth curves (Figure 5-8) provides evidence to support the differential growth curves of the within-achievement domain-related SAPTs.

***Figure 5-8.***
*Plot of WJ IV COG GIA and six Scholastic Aptitude cluster* W *score difference curves by age.*




Although the SAPT cluster curves in Figure 5-8[14] are all similar in shape to each other and to the GIA (*g*) cluster curve, the SAPT cluster curves for Reading Aptitude Group A and Reading Aptitude Group B do diverge after approximately ages 15 to 20, and the distance between the curves increases with age. The difference between the SAPT cluster curves for Written Language Group A and Written Language Group B is even more pronounced after approximately age 10. The curves representing the Math Aptitude Group A and Math Aptitude Group B SAPTs are the most divergent clusters within any academic domain shown in Figure 5-8; the Math Aptitude Group B curve shows a slower rate of growth and a much

[14] It is important to note that two of the SAPTs plotted in Figure 5-8 are identical. Reading Aptitude B and Written Language Aptitude B are based on the same combination of the Oral Vocabulary, Verbal Attention, Phonological Processing, and Number-Pattern Matching tests.

lower curve than the Math Aptitude Group A curve does. The within-achievement-area SAPT cluster growth curve differences described here suggest that, despite high intercorrelations, the Group A and Group B SAPT clusters prescribed for use within each academic domain are not measuring identical scholastic aptitude abilities.

Finally, the correspondence between the general shape of the SAPT cluster curves and the GIA (*g*) cluster curve supports the interpretation of the SAPT clusters as analogous to "miniature measures" of domain-specific g within each academic domain (McGrew, 1986, 1994).[15] More important, the differences in magnitude between the SAPT cluster curves and the GIA (*g*) cluster curve suggest that although these clusters are measures of cognitive ability mixtures or complexes, which are highly correlated with GIA (*g*), they are different from GIA (*g*).

# Internal Structure of the WJ IV

The primary source of validity evidence relevant to the internal structure of educational and psychological tests is the extent to which the relationships among test scores conform to the relationships implied by the underlying theoretical construct (AERA et al., 2014). Two forms of internal structure validity evidence are presented for the WJ IV. First, the pattern of intercorrelations among the WJ IV cluster scores is described. Next, exploratory and confirmatory multivariate statistical methods are used to analyze the relations between the WJ IV tests.

## WJ IV Norming Sample Test and Cluster Intercorrelations

Appendices E and F report intercorrelations among all WJ IV tests and clusters, respectively. Correlation matrices in Appendices E and F are presented for six broad age group samples (3 through 5, 6 through 8, 9 through 13, 14 through 19, 20 through 39, 40 through 90+). As described in Chapter 3, the plausible data generation procedures used as part of the planned incomplete data collection design for the WJ IV norming study resulted in complete data records for all WJ IV tests (sample sizes for tests ranged from 6,637 to 7,416 and varied due to the minimum age appropriate for administration of some tests). Test and cluster intercorrelation matrices were calculated on these large, relatively complete data records using listwise deletion for missing data. The resulting WJ IV test and cluster correlations are all based on the same set of study participants. As reported in Appendix Tables E-2 through E-6, the test correlation matrices for examinee age groups 6 years and older are based on all WJ IV tests, with sample sizes ranging from 825 to 1,685 study participants. For the preschool age group (3 through 5 years) in Appendix Table E-1, correlations were calculated among only the 28 age-appropriate tests. The sample sizes for the preschool age group varied by test[16] and are reported in Appendix Table E-1. The sample sizes for the cluster intercorrelation matrices in Appendix F Tables F-1 through F-6 ranged from 435 to 1,685 examinees.

The direction and magnitude of correlations among test and cluster scores can provide evidence that the scores conform to theoretical expectations about the underlying constructs (AERA et al., 2014; Campbell & Fiske, 1959). The test and cluster intercorrelations in Appendices E and F provide empirical support for several inferences about the relations between WJ IV test scores. First, correlations are generally higher among related CHC domain tests or clusters than among unrelated tests or clusters. For example, in Appendix E Table

[15] It might be useful to conceptualize the achievement domain-specific nature of the WJ IV SAPTs as mini-g measures—$g_{raptA}$, $g_{raptB}$, $g_{maptA}$, $g_{maptB}$, $g_{wlaptA}$, $g_{wlaptB}$.

[16] The sample sizes for most tests reported in Appendix Table E-1 range from 541 to 631; in contrast, only 205 examinee scores were available at ages 3 to 5 for WJ IV COG Test 1: Oral Vocabulary. To account for this, the correlation matrix in Appendix Table E-1 was calculated by using the EM missing data algorithm in the SYSTAT (version 13) software program (SYSTAT, 2009).

E-3 (ages 9 through 13), Oral Vocabulary (*Gc*) correlations with two other *Gc* tests (Oral Comprehension and Picture Vocabulary) range from .62 to .70 but range from only .26 to .32 with the three COG *Gs* tests (Letter-Pattern Matching, Number-Pattern Matching, and Pair Cancellation). In contrast, the correlations among these three COG *Gs* tests range from .57 to .60. A cluster-level example can be found in Appendix F Table F-4 (ages 14 through 19).

Second, the range of broad CHC cognitive cluster intercorrelations (typically .30 to .60) is lower than those reported among the primary achievement clusters, providing evidence that the WJ IV COG clusters measure distinct cognitive abilities. Third, within the achievement clusters, correlations are consistently higher between clusters from the same achievement domain and lower between clusters from different domains. The correlations between the Basic Reading Skills cluster and the two Reading Comprehension clusters are .74 and .78. In contrast, the Basic Reading Skills cluster shows weaker correlations (ranging from .56 to .62) with the four math clusters.

Multivariate statistical procedures (e.g., cluster analysis, multidimensional scaling, exploratory and confirmatory factor analysis) are helpful in uncovering patterns of convergent and divergent associations between the tests in the correlation matrices reported in Appendix E. The results of these statistical procedures are presented later in this chapter.

## Comparison of GIA, *Gf-Gc* Composite, and Scholastic Aptitude Cluster Correlations With Achievement Clusters

WJ IV users can examine the cluster correlation matrices (Appendix F) to answer specific questions regarding the relationships between all WJ IV COG, WJ IV OL, and WJ IV ACH clusters. Given the inclusion of the new *Gf-Gc* Composite and Scholastic Aptitude clusters (SAPTs), one obvious question is: How do these two COG clusters correlate with ACH clusters and, more importantly, how do they compare to the GIA? To highlight these cluster relationships, the correlations between the WJ IV COG GIA, *Gf-Gc* Composite, and SAPTs and the WJ IV ACH reading, math, and writing clusters have been extracted from Appendix F and are summarized in Tables 5-7 through 5-9.

Across all age groups, the median GIA and *Gf-Gc* Composite cluster correlations with the various reading (Table 5-7) and math (Table 5-8) achievement clusters reveal comparable values. The GIA correlations are always slightly higher than the *Gf-Gc* Composite, but only by small and not practically relevant margins (.01 to .03). These findings support the use of the *Gf-Gc* Composite as a predictor of concurrent reading and math achievement. This finding also supports one of the main design objectives for creating the WJ IV *Gf-Gc* Composite—for use as an indicator of intact cognitive abilities within a pattern of relative strengths and weaknesses in specific cognitive processing (*Gv, Ga*), memory (*Glr, Gwm*), or efficiency (*Gs, Gwm*) abilities (i.e., discrepancy-consistency specific learning disability [SLD] identification models) (Flanagan, Alfonso, & Mascolo, 2011; Flanagan, Fiorello, & Ortiz, 2010; Hale, Wycoff, & Fiorello, 2011; McGrew, in press a, 2012; Naglieri, 2011).

***Table 5-7.***
*Correlations Between GIA,* Gf-Gc *Composite, Reading Scholastic Aptitude Clusters, and Reading Achievement Clusters Across Five Age Groups*

| Age Group and Predictor Cluster | Reading Achievement Clusters | | | | | | | Median |
|---|---|---|---|---|---|---|---|---|
| | **Reading** | **Broad Reading** | **Basic Reading Skills** | **Reading Comprehension** | **Reading Comprehension–Extended** | **Reading Fluency** | **Reading Rate** | |
| Ages 6–8 ($n$ = 825) | | | | | | | | |
| GIA | 0.73 | 0.73 | 0.70 | 0.73 | 0.77 | 0.66 | 0.63 | 0.73 |
| *Gf-Gc* Composite | 0.72 | 0.70 | 0.66 | 0.70 | 0.74 | 0.62 | 0.55 | 0.70 |
| Reading Aptitude A | 0.70 | 0.75 | | 0.68 | 0.71 | 0.71 | 0.72 | 0.71 |
| Reading Aptitude B | | | 0.65 | | | | | 0.65 |
| Ages 9–13 ($n$ = 1,572) | | | | | | | | |
| GIA | 0.72 | 0.73 | 0.69 | 0.70 | 0.75 | 0.65 | 0.64 | 0.70 |
| *Gf-Gc* Composite | 0.71 | 0.72 | 0.63 | 0.69 | 0.74 | 0.63 | 0.58 | 0.69 |
| Reading Aptitude A | 0.67 | 0.74 | | 0.65 | 0.68 | 0.68 | 0.72 | 0.68 |
| Reading Aptitude B | | | 0.65 | | | | | 0.65 |
| Ages 14–19 ($n$ = 1,685) | | | | | | | | |
| GIA | 0.76 | 0.75 | 0.70 | 0.73 | 0.78 | 0.66 | 0.63 | 0.73 |
| *Gf-Gc* Composite | 0.75 | 0.74 | 0.66 | 0.72 | 0.78 | 0.65 | 0.58 | 0.72 |
| Reading Aptitude A | 0.72 | 0.76 | | 0.69 | 0.74 | 0.69 | 0.69 | 0.71 |
| Reading Aptitude B | | | 0.66 | | | | | 0.66 |
| Ages 20–39 ($n$ = 1,251) | | | | | | | | |
| GIA | 0.78 | 0.77 | 0.73 | 0.75 | 0.80 | 0.67 | 0.62 | 0.75 |
| *Gf-Gc* Composite | 0.77 | 0.74 | 0.68 | 0.74 | 0.80 | 0.64 | 0.54 | 0.74 |
| Reading Aptitude A | 0.74 | 0.77 | 0.66 | 0.71 | 0.76 | 0.69 | 0.68 | 0.71 |
| Reading Aptitude B | | | 0.69 | | | | | 0.69 |
| Ages 40–90+ ($n$ = 1,146) | | | | | | | | |
| GIA | 0.80 | 0.79 | 0.75 | 0.77 | 0.82 | 0.71 | 0.68 | 0.77 |
| *Gf-Gc* Composite | 0.79 | 0.77 | 0.70 | 0.77 | 0.82 | 0.68 | 0.61 | 0.77 |
| Reading Aptitude A | 0.75 | 0.78 | | 0.73 | 0.78 | 0.72 | 0.73 | 0.74 |
| Reading Aptitude B | | | 0.72 | | | | | 0.72 |

**Table 5-8.**
*Correlations Between GIA,* Gf-Gc *Composite, Math Scholastic Aptitude Clusters, and Math Achievement Clusters Across Five Age Groups*

| Age Group and Predictor Cluster | Math Achievement Clusters | | | | Median |
|---|---|---|---|---|---|
| | Mathematics | Broad Mathematics | Math Calculation Skills | Math Problem Solving | |
| Ages 6–8 ($n$ = 825) | | | | | |
| GIA | 0.75 | 0.76 | 0.73 | 0.74 | 0.74 |
| *Gf-Gc* Composite | 0.72 | 0.69 | 0.62 | 0.76 | 0.71 |
| Math Aptitude A | 0.76 | 0.76 | 0.71 | | 0.76 |
| Math Aptitude B | | | | 0.68 | 0.68 |
| Ages 9–13 ($n$ = 1,572) | | | | | |
| GIA | 0.77 | 0.78 | 0.73 | 0.76 | 0.76 |
| *Gf-Gc* Composite | 0.76 | 0.73 | 0.65 | 0.77 | 0.74 |
| Math Aptitude A | 0.77 | 0.77 | 0.72 | | 0.77 |
| Math Aptitude B | | | | 0.68 | 0.68 |
| Ages 14–19 ($n$ = 1,685) | | | | | |
| GIA | 0.80 | 0.80 | 0.75 | 0.80 | 0.80 |
| *Gf-Gc* Composite | 0.80 | 0.76 | 0.69 | 0.81 | 0.78 |
| Math Aptitude A | 0.80 | 0.79 | 0.75 | | 0.79 |
| Math Aptitude B | | | | 0.73 | 0.73 |
| Ages 20–39 ($n$ = 1,251) | | | | | |
| GIA | 0.79 | 0.79 | 0.74 | 0.81 | 0.79 |
| *Gf-Gc* Composite | 0.79 | 0.76 | 0.68 | 0.82 | 0.77 |
| Math Aptitude A | 0.80 | 0.79 | 0.73 | | 0.79 |
| Math Aptitude B | | | | 0.74 | 0.74 |
| Ages 40–90+ ($n$ = 1,146) | | | | | |
| GIA | 0.80 | 0.81 | 0.76 | 0.82 | 0.81 |
| *Gf-Gc* Composite | 0.82 | 0.79 | 0.72 | 0.83 | 0.80 |
| Math Aptitude A | 0.82 | 0.82 | 0.77 | | 0.82 |
| Math Aptitude B | | | | 0.77 | 0.77 |

In Tables 5-7 through 5-9, there are differences in the correlations between the GIA and *Gf-Gc* Composite clusters and the achievement clusters that include measures of speed or fluency (*Gs*). In Table 5-7, the GIA cluster is stronger than the *Gf-Gc* Composite as a predictor of the Reading Rate ACH cluster. The GIA-Reading Rate correlation is higher because the GIA cluster includes one *Gs* test (Letter-Pattern Matching), and the target Reading Rate cluster includes two *Gs* tests (Sentence Reading Fluency and Word Reading Fluency). In contrast, the *Gf-Gc* Composite does not include any measures of *Gs*. This differential pattern of correlations suggests that when evaluating the use of the GIA and *Gf-Gc* Composite cluster scores, the GIA cluster would provide the best prediction of expected Reading Rate scores. However, if the user wishes to remove the influence of *Gs* when predicting Reading Rate scores, then the *Gf-Gc* Composite would be a better selection, although some prediction accuracy is sacrificed. The GIA and *Gf-Gc* Composite correlations

**_Table 5-9._**
*Correlations Between GIA,* Gf-Gc *Composite, Written Language Scholastic Aptitude Clusters, and Writing Achievement Clusters Across Five Age Groups*

| Age Group and Predictor Cluster | Writing Achievement Clusters | | | | Median |
|---|---|---|---|---|---|
| | Written Language | Broad Written Language | Basic Writing Skills | Written Expression | |
| Ages 6–8 ($n$ = 825) | | | | | |
| GIA | 0.74 | 0.75 | 0.73 | 0.70 | 0.73 |
| *Gf-Gc* Composite | 0.63 | 0.62 | 0.65 | 0.54 | 0.62 |
| Writing Aptitude A | 0.70 | 0.73 | | 0.70 | 0.70 |
| Writing Aptitude B | | | 0.72 | | 0.72 |
| Ages 9–13 ($n$ = 1,572) | | | | | |
| GIA | 0.73 | 0.75 | 0.74 | 0.67 | 0.74 |
| *Gf-Gc* Composite | 0.63 | 0.63 | 0.67 | 0.53 | 0.63 |
| Writing Aptitude A | 0.70 | 0.74 | | 0.69 | 0.70 |
| Writing Aptitude B | | | 0.73 | | 0.73 |
| Ages 14–19 ($n$ = 1,685) | | | | | |
| GIA | 0.76 | 0.77 | 0.76 | 0.70 | 0.76 |
| *Gf-Gc* Composite | 0.68 | 0.68 | 0.69 | 0.58 | 0.68 |
| Writing Aptitude A | 0.74 | 0.76 | | 0.71 | 0.74 |
| Writing Aptitude B | | | 0.76 | | 0.76 |
| Ages 20–39 ($n$ = 1,251) | | | | | |
| GIA | 0.74 | 0.76 | 0.76 | 0.68 | 0.75 |
| *Gf-Gc* Composite | 0.66 | 0.65 | 0.69 | 0.55 | 0.65 |
| Writing Aptitude A | 0.72 | 0.74 | | 0.68 | 0.72 |
| Writing Aptitude B | | | 0.76 | | 0.76 |
| Ages 40–90+ ($n$ = 1,146) | | | | | |
| GIA | 0.79 | 0.80 | 0.79 | 0.74 | 0.79 |
| *Gf-Gc* Composite | 0.71 | 0.70 | 0.72 | 0.63 | 0.71 |
| Writing Aptitude A | 0.76 | 0.78 | | 0.74 | 0.76 |
| Writing Aptitude B | | | 0.79 | | 0.79 |

with Reading Fluency are more alike. This is expected, because the two-test Reading Fluency target cluster includes only one *Gs* test (Sentence Reading Fluency).

In Table 5-8, the GIA correlations generally are higher than the *Gf-Gc* Composite correlations across the math achievement clusters. This most likely reflects the inclusion of a *Gs* test (Letter-Pattern Matching) in the GIA cluster and *Gs* math fluency tests in two of the math clusters. The relative merits of using either the GIA or *Gf-Gc* Composite to predict expected Reading Rate scores, discussed earlier, also applies to the *Gs*-influenced Broad Math and Math Calculations clusters.

The above observations regarding the *Gs* influence in correlations of math achievement clusters that include one *Gs* test hold true for the Broad Written Language and Written Expression clusters in Table 5-9. These two clusters both include the Sentence Writing Speed test (*Gs*). This *Gs* test is half of the Written Expression cluster and one third of the Broad Written Language cluster. However, in contrast to reading and math, the GIA cluster is more highly correlated than the *Gf-Gc* Composite cluster with all WJ IV written language clusters, whether the written language clusters include the Sentence Writing Speed test or not. This is evident from a review of the median correlations in Table 5-9, where the median GIA cluster correlations are generally .08 to .11 higher than the *Gf-Gc* Composite correlations across age groups. This finding suggests that in the domain of written language, the GIA is more strongly associated with written language achievement than the *Gf-Gc* Composite. One possible explanation for this difference is that written language skills may be more dependent on the CHC abilities of *Ga*, *Glr*, or *Gwm* (which are included in the GIA cluster but not in the *Gf-Gc* Composite cluster). Future research is needed to clarify this hypothesis.

A comparison of the median correlations of the GIA and the SAPT clusters with achievement clusters supports the academic domain-specific validity of the WJ IV COG SAPT clusters. Across all age groups reported in Table 5-7, the Reading Aptitude A cluster and GIA cluster correlated with the academic domain-relevant target reading achievement clusters at levels that are not practically different (i.e., median GIA correlations only .02 to .04 higher). For the Reading Aptitude B cluster, which is appropriate for predicting the Basic Reading Skills cluster, correlations range from .05 to .08 lower than the median GIA correlations.

As summarized in Table 5-8, the median Math Aptitude A cluster correlations with the math achievement domain-relevant target clusters are identical or nearly identical to the GIA and math achievement cluster correlations. In contrast, the Math Aptitude B cluster correlations with Math Problem Solving are .06 to .08 lower than the GIA cluster correlations with Math Problem Solving across all ages. This is not unexpected, given that the GIA and Math Problem Solving correlation is spuriously high due to the strong similarity in task requirements and shared quantitative reasoning ability (*Gf*-RQ) measured by the Number Series and Number Matrices tests included in the GIA and Math Problem Solving clusters, respectively. The Math Aptitude B cluster was constructed to eliminate this predictor-criterion overlap by removing the Number Series test and replacing it with Analysis-Synthesis (*Gf*-RG). Therefore, the Math Aptitude B cluster is the recommended predictor of Math Problem Solving.

Finally, the Writing Aptitude A and B clusters both correlate with their academic domain-relevant target written language achievement clusters at levels equal to or only slightly different from the similar GIA correlations (Table 5-9). When considered with the previously cited finding that the *Gf-Gc* Composite is a slightly weaker predictor of written language than is the GIA, this observation suggests that the two Writing Aptitude clusters may serve a particularly important function in predicting and understanding written language achievement.

When the WJ IV SAPT and GIA achievement cluster correlations are compared to the WJ and WJ-R SAPT and Broad Cognitive Ability (BCA) achievement cluster correlations, the WJ IV SAPT correlations do not demonstrate the relatively higher prediction of achievement (than the GIA) observed in the WJ and WJ-R (see McGrew, 1986, 1994 for a review and discussion of this research).[17] This does not mean that the WJ IV SAPT clusters are not as strong as the WJ and WJ-R SAPT clusters. Rather, the relatively equal achievement correlations found for the WJ IV SAPT and GIA clusters instead reflect an improvement in the composition of the WJ IV GIA cluster. As described in the WJ IV test blueprint plan (see Chapter 1) and in other sections of this validity chapter, the collection of the seven WJ IV GIA tests is explicitly designed to include more cognitively complex tests than were included in the prior WJ and WJ-R BCA and WJ III GIA clusters.

Support for this interpretation is seen in Figure 5-2,[18] where tests nearer the center of the MDS plot for ages 9 through 13 are interpreted as more cognitively complex. WJ IV

[17] The WJ III did not include SAPTs. Instead, a differentially weighted "predicted achievement" option based on the seven GIA tests was used to perform a similar prediction of achievement function.

[18] Similar MDS-based cognitively complexity information is reported for the other age groups in Appendix I.

Phonological Processing has replaced Sound Blending from the WJ, WJ-R, and WJ III as the featured *Ga* test in the WJ IV global *g*-based GIA cluster. In Figure 5-2 Phonological Processing is much closer to the center of the MDS plot than Sound Blending is. In the same figure, Verbal Attention (*Gwm*) from the WJ IV GIA cluster is more cognitively complex than is Numbers Reversed that was included in the WJ-R BCA cluster and WJ III GIA cluster. Similarly, Number Series, the *Gf* test in the WJ IV GIA cluster, is more cognitively complex than is Concept Formation, which was the *Gf* test in the WJ III GIA cluster.

In summary, the WJ IV COG SAPT clusters are strong predictors of academic achievement within their domain-relevant target achievement domains. Across the five broad age groups in the WJ IV norming data, the SAPTs demonstrate correlations with achievement clusters that are similar to the correlations between the GIA and achievement clusters. When differences are present, the GIA correlations with achievement are only marginally higher (i.e., to the second decimal place of the correlations). In the case of the Math Problem Solving cluster, the correlations with the GIA cluster are higher due to the overlap in a narrow ability (*Gf*-RQ) in the two clusters. The most important inference from the correlations in Tables 5-7 through 5-9 is that the four-test SAPT clusters are more efficient measures than the seven-test GIA cluster for making predictions about domain-specific expected achievement. The SAPT clusters, which can be administered in less time than the GIA cluster, provide users with the ability to administer more flexible, selective, referral-focused assessments (McGrew, 2012; McGrew & Wendling, 2010). In addition, McGrew (1994) found the use of WJ and WJ-R differential scholastic aptitude clusters to be more clinically valid than broad *g*-based global IQ scores. Finally, the use of the SAPT clusters fits well with contemporary pattern of strengths and weaknesses consistency-discordance discrepancy models of SLD identification (Flanagan et al., 2010; Flanagan et al., 2011; Hale et al., 2011; McGrew, 2012; Naglieri, 2011).

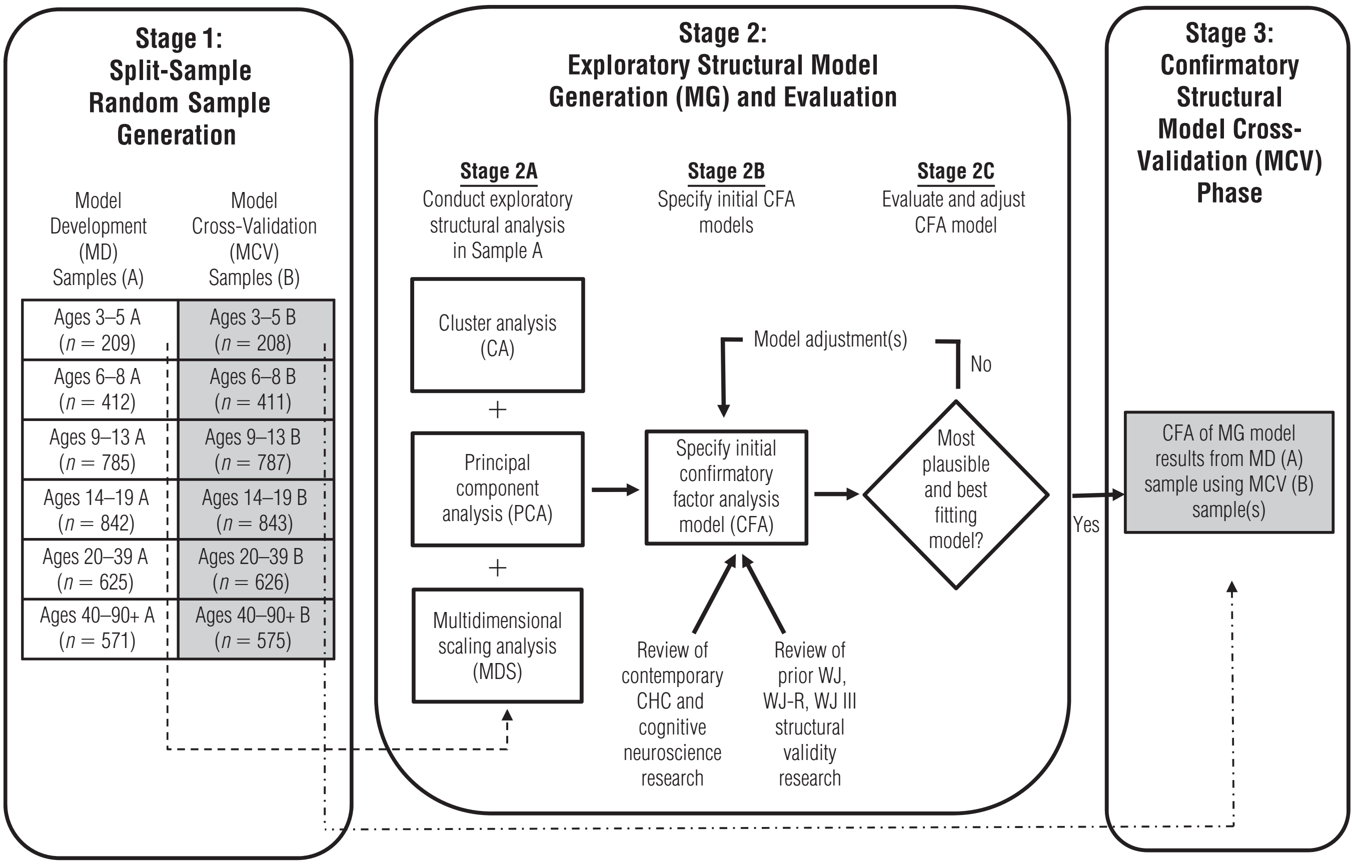
## Internal Structure Evidence: Three-Stage Structural Validity Analysis of the WJ IV

The primary indicator of internal, or structural, validity for educational and psychological tests is the "degree to which the relationships among test items and test components conform to the construct on which the proposed test score interpretations are based" (AERA et al., 2014, p. 16). The WJ IV structural analysis has the advantage of building on the extensive structural analyses of the WJ (Woodcock, 1978), WJ-R (McGrew, Werder, & Woodcock, 1991), and WJ III (McGrew & Woodcock, 2001). Braden and Niebling (2012) judged the quality of the WJ III internal structure validity evidence, upon which the WJ IV builds, as strong by assigning it a global rating of 5 on a *quality of validity evidence* scale that ranged from 0 to 5, with 1 indicating *weak* and 5 indicating *strong* quality. In a review of 20 years of research on the CHC abilities measured by different intelligence test batteries, Keith and Reynolds (2010) concluded that the extant structural research supported the CHC structure of the WJ-R and WJ III.

A series of exploratory cluster, factor, and confirmatory factor analyses were conducted during the early stages of WJ IV data collection. These analyses were completed across all age ranges for the first 1,517 WJ IV standardization study participants. The primary objective of these analyses was to determine how the new or revised tests loaded on the different cognitive, oral language, and achievement factors. This step, which also included logical and psychological content analyses of the tests, informed the modification or elimination of a small number of tests. Similar analyses were completed after data had been collected on 3,815 norming participants. At this point, the relationship between the WJ IV tests and the CHC broad factors, and a preliminary WJ IV organizational structure, was established.

When norming data collection was complete ($N = 7{,}416$), the three-stage process portrayed in Figure 5-9 was used to investigate the internal structural validity of the WJ IV battery.

***Figure 5-9.***
*Three-stage structural validity procedures for the WJ IV.*




## *Stage 1: Split-Sample Random Sample Generation*

As illustrated in Figure 5-9, the WJ IV norming sample was divided into six age-differentiated groups (3 through 5, 6 through 8, 9 through 13, 14 through 19, 20 through 39, and 40 through 90+). Next, each sample was randomly split into separate model development (MD; sample A) and model cross-validation (MCV; sample B) samples of approximately equal size (see Stage 1 in Figure 5-9). The 12 resulting samples ranged in size from 208 to 843 WJ IV norming study participants.

As described in Chapter 1, several WJ III tests were dropped and several new tests were added during the development of the WJ IV. Some of the WJ III tests were redesigned for the WJ IV to make them more cognitively complex (see Chapter 1 for definition). In addition, contemporary CHC theory, augmented by neurocognitive research, informed the development and revision of the WJ IV. The nature and number of test changes in the WJ IV made it likely that a strict confirmatory CHC-based analysis of the WJ IV—similar to that performed on the

WJ III—might fail to identify new structural dimensions and relations. Instead, a systematic exploratory, model generation, and cross-validation structural validity strategy was applied to the WJ IV standardization data.

The WJ IV split-sample, multiple-stage, exploratory-confirmatory approach is the most thorough scientific approach to the examination of the structural validity of any contemporary battery of cognitive, language, and achievement tests. The structural validity evidence for most all cognitive and achievement test batteries in recent years has been gathered primarily through confirmatory factor analysis (CFA) (see Keith & Reynolds, 2012 for an excellent description of the use of CFA methods in intelligence test validity research). The WJ III relied exclusively on CFA methods. The *Differential Ability Scales®–Second Edition* (DAS-II®) (Elliott, 2007), KABC-II (Kaufman & Kaufman, 2004a), *Stanford-Binet Intelligence Scales, Fifth Edition* (SB5) (Roid, 2003a), and *Wechsler Adult Intelligence Scale–Fourth Edition* (WAIS-IV) (Wechsler, 2008) all used CFA methods to demonstrate structural validity. In contrast, the WISC-IV (Wechsler, 2003) used a combination of exploratory factor analysis (EFA) and CFA methods.

### Structural Validity Analysis in All Six Age Groups

The age 9 through 13 model development (MD) sample was deliberately selected as the first age group to be analyzed using the three-stage structural validity process. This age range represents one of the major age groups that the WJ IV battery is typically used with. Completing the three-stage multiple-sample validation process (see Figure 5-9) in the age 9 through 13 sample and using the final results from this age group as an approximate starting model (Stage 2b) for all other age groups made the complex three-stage multiple-sample structural validity processes more efficient. More importantly, this strategy is grounded on the assumption, based on inspection of the exploratory MD sample results across all age groups (Stage 2a in Figure 5-9), that a common structural organization existed in the WJ IV battery across all ages. Any differences between age group results are not in the form of the presence or absence of broad or narrow factors, but instead reflect age differences in specific test loadings on factors and correlated test residuals. The exception to the common approximate starting model is in the preschool age MD group (ages 3 through 5). The age 3 through 5 samples included a smaller collection of tests (28) than were included in other age group samples (51).

Given the role the age 9 through 13 sample analyses played in providing the preliminary starting point for the same procedures for all other samples, all results from this age group are described and interpreted in this chapter. The results of this three-stage structural validity examination are summarized for all age groups in subsequent tables in this chapter as well as in Appendices G through I.

Exploratory factor analysis (EFA) is most appropriate when a battery of tests is first constructed, is substantially revised and reorganized, or when strong theories are not available to guide the test design process. Confirmatory factor analysis (CFA) methods, in contrast, are preferred when the internal structure of a collection of tests has been clearly established over multiple test revisions or when an explicit strong theory of the underlying constructs is available (Brown, 2006; Kline, 2011; Schreiber, Nora, Stage, Barlow, & King, 2006).

With regard to structural equation modeling based CFA, Jöreskog (1993) distinguished between strictly confirmatory (SC), alternative models (AM), and model generating (MG) methods.[19] In SC methods, one model is formulated and evaluated, whereas in AM analysis the investigator evaluates competing or alternative models and selects the best fitting model (or models). According to Jöreskog (1993), "the MG situation is by far the most common" (p. 295). The MG approach is characterized by (a) the specification of an initial model

[19] The MG approach is also referred to as a *model building* approach (Kline, 2011).

based on substantive theory, research based hypotheses, or tentative ideas; (b) estimation of the initial model and evaluation of overall model fit and other statistics (e.g., standardized residuals and modification indices) for hints about possible modifications, or "tweaks," to the model; (c) specification and estimation of the revised model; and (d) iteration of steps (b) and (c) until a model is found that "fits the data of the sample reasonably well and in which all parameters are meaningful and substantively interpretable" (Jöreskog, 1993, p. 313).

The MG approach is particularly suited to applied psychological test development. The MG approach was a major component in the complete multistage WJ IV structural validity procedures described in this chapter. However, the MG approach capitalizes on chance and makes inferential fit statistics inappropriate. If taken to the extreme, Wagenmakers, Wetzels, Borsbom, van der Mass, & Kievit (2012) warn:

> you turn your data set inside and out, looking for interesting patterns, you have used the data to help you formulate a specific hypothesis. Although the data may still serve many purposes after such fishing expeditions, there is one purpose for which the data are no longer appropriate—namely, for testing the hypothesis that they helped to suggest. (p. 633)

To guard against what Wagenmakers et al. (2012) describe as "data dredging or torture," but yet to glean insights from exploratory scientific methods that allow for new discoveries and progress, several authoritative researchers recommend cross-validation of a final MG model in independent samples (Brown, 2006; Jöreskog, 1993; Wagenmakers et al., 2012). The creation of the WJ IV MD and MCV samples allowed for the implementation of the best practice recommendations for combining exploratory MG and CFA methods.

### Stage 2: Exploratory Structural Model Generation (MG) and Evaluation With Model Development (MD) Samples

Each of the six MD samples was analyzed with three different exploratory multivariate methods—cluster analysis (CA), exploratory principal components analysis (PCA), and multidimensional scaling analysis (see Stage 2a in Figure 5-9). The use of three methodological lenses allows for the detailed exploration of the relations among the complete collection of WJ IV tests. This "leave no stone unturned" approach provides a thorough exploration of the structure of the WJ IV battery free from a rigid a priori bias (e.g., strict CHC model).[20] Although the three data analytic lenses are defined and illustrated in this section with analysis of the age 9 through 13 MD sample, similar sets of exploratory analyses for all other broad age group samples are presented in Appendices G (CA), H (PCA), and I (MDS).

In addition to the 47 WJ IV COG, OL, and ACH tests, four research tests were included in the structural validity analyses. All 51 tests are listed in Table 5-10. For ease of presentation, all tests names included in CA, MDS, and CFA figures presented in this chapter are abbreviated. These abbreviations are included in Table 5-10 to assist the user with interpretation. All but one of the four WJ IV research tests is from the WJ III COG or the

[20] This exploratory approach was not completely pure or blind. Contemporary CHC theory, as defined in Chapter 1 and Appendix A, was used as the primary theoretical lens when interpreting the results generated by these exploratory procedures. The important point is that a rigid CHC model was not simply imposed on the WJ IV in a CFA-only strategy.

*Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities* (WJ III COG DS) (Woodcock, McGrew, Mather, & Schrank, 2003).[21]

***Table 5-10.***
*WJ IV and Research Test Names and Abbreviations Reported in the WJ IV Technical Manual*

| Battery/Test Name | Test Name Abbreviation | Battery/Test Name | Test Name Abbreviation |
|---|---|---|---|
| **Tests of Cognitive Abilities** | | **Tests of Achievement** | |
| 1: Oral Vocabulary | ORLVOC | 1: Letter-Word Identification | LWIDNT |
| 2: Number Series | NUMSER | 2: Applied Problems | APPROB |
| 3: Verbal Attention | VRBATN | 3: Spelling | SPELL |
| 4: Letter-Pattern Matching | LETPAT | 4: Passage Comprehension | PSGCMP |
| 5: Phonological Processing | PHNPRO | 5: Calculation | CALC |
| 6: Story Recall | STYREC | 6: Writing Samples | WRTSMP |
| 7: Visualization | VISUAL | 7: Word Attack | WRDATK |
| 8: General Information | GENINF | 8: Oral Reading | ORLRDG |
| 9: Concept Formation | CONFRM | 9: Sentence Reading Fluency | SNRDFL |
| 10: Numbers Reversed | NUMREV | 10: Math Facts Fluency | MTHFLU |
| 11: Number-Pattern Matching | NUMPAT | 11: Sentence Writing Fluency | SNWRFL |
| 12: Nonword Repetition | NWDREP | 12: Reading Recall | RDGREC |
| 13: Visual-Auditory Learning | VAL | 13: Number Matrices | NUMMAT |
| 14: Picture Recognition | PICREC | 14: Editing | EDIT |
| 15: Analysis-Synthesis | ANLSYN | 15: Word Reading Fluency | WRDFLU |
| 16: Object-Number Sequencing | OBJNUM | 16: Spelling of Sounds | SPLSND |
| 17: Pair Cancellation | PAIRCN | 17: Reading Vocabulary | RDGVOC |
| 18: Memory for Words | MEMWRD | 18: Science | SCI |
| | | 19: Social Studies | SOC |
| | | 20: Humanities | HUM |
| **Tests of Oral Language** | | **Non-WJ IV Research Tests** | |
| 1: Picture Vocabulary | PICVOC | Memory for Names[a] | MEMNAM |
| 2: Oral Comprehension | ORLCMP | Verbal Analogies[a] | VRBANL |
| 3: Segmentation | SEGMNT | Visual Closure[a] | VISCLO |
| 4: Rapid Picture Naming | RPCNAM | Number Sense | NUMSEN |
| 5: Sentence Repetition | SENREP | | |
| 6: Understanding Directions | UNDDIR | | |
| 7: Sound Blending | SNDBLN | | |
| 8: Retrieval Fluency | RETFLU | | |
| 9: Sound Awareness | SNDAWR | | |

[a] Tests or subtests in WJ III COG Diagnostic Supplement.

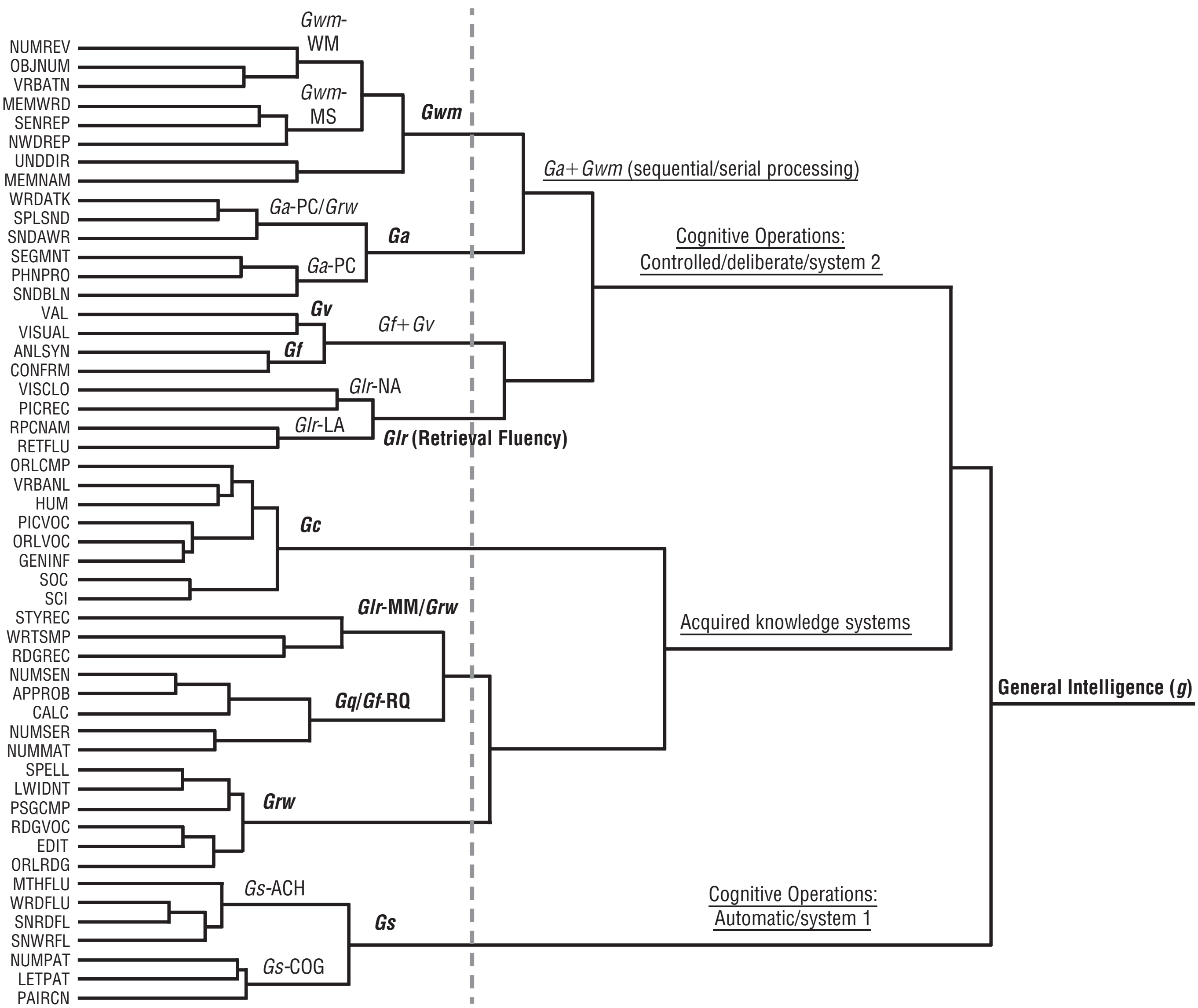
[21] Detailed descriptions, including psychometric characteristics, for these tests can be found in the *Woodcock-Johnson III Technical Manual* (McGrew & Woodcock, 2001) and in the *Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities Manual* (Woodcock et al., 2003). Briefly, Memory for Names is included in the WJ III COG DS as a measure of associative memory (MA). Verbal Analogies is a subtest of the WJ III Verbal Comprehension test and is a mixed measure of lexical knowledge and language development (VL/LD) and deductive reasoning (RG). Visual Closure is a test in the WJ III COG DS and is a measure of closure speed (CS). Finally, Number Sense is a new research test in the WJ IV norming study. Number Sense is a measure of *numerosity* (Berch, 2005), as it measures an individual's understanding of what numbers mean in relationship to other numbers, as well as the vocabulary and concepts required to compare, judge, and estimate size, quantity, position, or volume.

### Stage 2A: Exploratory Cluster Analysis

The cluster analysis (CA) results for ages 9 through 13 are presented in Figure 5-10. The CA results for the other age groups are presented in Appendix H. According to Aldenderfer & Blashfield (1984), cluster analysis is:

> the generic name for a wide variety of procedures that can be used to create a classification. These procedures empirically form "clusters" or groups of highly similar entities. More specifically, a clustering method is a multivariate statistical procedure that starts with a data set containing information about a sample of entities and attempts to reorganize these entities into relatively homogeneous groups. (p. 7)

***Figure 5-10.***
*Ward's cluster analysis of ages 9 through 13 model-development sample A (n = 785).*




*Note.* Bold font = Broad or general CHC abilities. Underlined text = Possible intermediate level stratum dimensions. Groupings to the left of the vertical dashed line indicate they are interpreted as valid CHC abilities. Higher-order groupings to the left of the dashed line are potentially interesting hypothesized intermediate-ability dimensions.

CA involves the "sorting of subjects or variables according to their similarity on one or more dimensions and producing groups that maximize within-group similarity and minimize between-group similarity" (Henry, Tolan, & Gorman-Smith, 2005, p. 121). The CA literature includes a wide variety of different sorting algorithms and approaches (Aldenderfer & Blashfield, 1984; Borgen & Barnett, 1987; Henry et al., 2005). Ward's hierarchical minimum variance CA method, which minimizes the within-cluster sum of squares of each cluster when clusters are joined, is one of the most frequently used and empirically validated CA methods for recovering a known taxonomic structure (Borgen & Barnett, 1987; Henry et al., 2005; Konold, Glutting, McDermott, Kush, & Watkins, 1999). In the current context, the Ward's CA method begins by linking the WJ IV tests that are closest to each other (i.e., most highly correlated) into groupings.[22] Once formed, initial groups join with other groups or individual tests to create larger groups. As illustrated in Figure 5-10, this process continues until all tests are joined together into a single, all-encompassing group. CA interpretation is somewhat subjective, but typically a point is reached in the process where the continued merging of test groupings makes interpretation of the larger groupings difficult, if not impossible. For the CA in Figure 5-10, this point is indicated by the dashed vertical line. The theoretical foundations described in Chapter 1 and Appendix A were used to interpret the CA results to the left of the dashed line.

The information in Figure 5-10 provides support for the broad CHC factor clusters interpreted to represent *Gwm*, *Ga*, *Gv*, *Gf*, *Glr*, *Gq*, *Gc*, *Grw,* and *Gs*. Some groupings reveal potentially important structural insights. The quantitative grouping (*Gq*/*Gf*-RQ) consists of acquired math achievement (*Gq*-A3) and *Gf*-based quantitative reasoning (RQ) tests. The possibility of an intermediate *Glr*-Retrieval Fluency dimension is consistent with Schneider and McGrew's (2012) differentiation between learning efficiency and retrieval fluency in memory abilities (see Appendix A). The explanation of this intermediate memory dimension hinges on the user's acceptance of two interpretations from Figure 5-10. First, the Rapid Picture Naming and Retrieval Fluency tests together appear to be a measure of speed of lexical access (*Glr*-LA; see Chapter 1 and Appendix A).[23] Second, the shared similarity of Visual Closure and Picture Recognition may be partially a function of the data set. Visual Closure and Picture Recognition both require object recognition, but Visual Closure also requires naming while Picture Recognition does not. They are likely grouped in this data set based on the common processing variable of nonspeeded icon recognition.

Subgroups under the broad *Gwm* grouping suggest the narrow abilities of working memory (*Gwm*-WM) and memory span (*Gwm*-MS); while subgroups under the broad *Gs* grouping suggest a possible COG/ACH distinction in *Gs* (*Gs*-ACH; *Gs*-COG). The combined *Gf*+*Gv* grouping is consistent with the frequently reported difficulty in differentiating *Gf* and *Gv* abilities in factor analysis (Carroll, 1993). The unexpected emergence of the test group defined by Reading Recall, Writing Samples, and Story Recall is interpreted as reflecting the narrow ability of meaningful memory (*Glr*-MM).

Although higher-level CA groupings are often too heterogeneous to make substantive sense, in Figure 5-10 four intermediate ability dimensions, consistent with recognized bodies of empirical and theoretical research, are suggested. These include (a) sequential or serial processing as per the Luria-Das framework (Naglieri, Das, & Goldstein, 2012), (b) System 1 or automatic cognitive processes distinct from System 2 or controlled-deliberate cognitive processes under the dual-process model of cognition (Evans, 2008; Kahneman, 2011), and

[22] To avoid confusion with the use of the term *cluster*, as previously defined as "*a combination of* WJ IV *tests*," the clusters formed by cluster analysis are subsequently referred to as *groups* or *groupings* in this chapter.

[23] As discussed later in this chapter, consistent evidence for a *speed of lexical access* (*Glr*-LA) dimension surfaced in almost all WJ IV exploratory and confirmatory analysis and is proposed by the WJ IV authors as a new narrow ability to be added to the CHC model.

(c) acquired knowledge systems. These hypothesized intermediate-level dimensions need more research and exploration than is possible here.

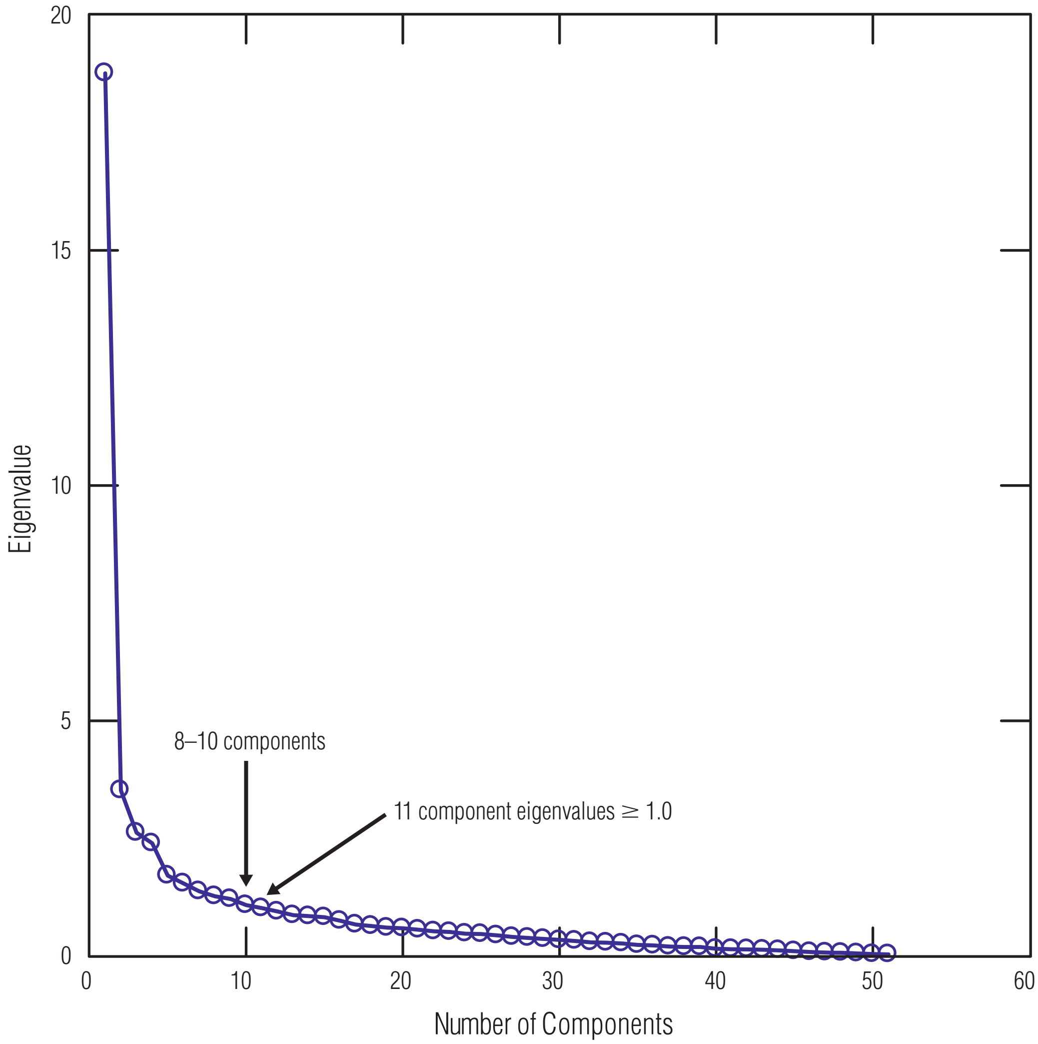
### Stage 2A: Exploratory Principal Components Analysis

The relations among the 51 test variables also were investigated with exploratory principal components analysis (PCA) followed by varimax rotation of the components (orthogonal or uncorrelated components). Although common-factor or principal axis factor analysis followed by oblique (correlated factors) rotation is the typical exploratory factor analysis method for investigating the underlying theoretical structure of a set of correlated test variables and constructs, PCA was used for a number of reasons. First, principal components analysis was applied during the exploratory MD stage and was augmented by two other exploratory methods—cluster analysis and multidimensional scaling—so the exploratory PCA was not the only method used to explore the dimensionality of the WJ IV battery. Second, the combined exploratory results are used primarily to specify the most plausible structure of the WJ IV battery for evaluation via CFA methods. Third, the oblique correlations between latent factors are estimated in the subsequent CFA analysis. Finally, the use of the PCA-varimax procedure was a practical decision. The analysis of 51 tests, many that are highly correlated within (or across) CHC domains, presents unique statistical challenges. For instance, the *Grw* domain includes 13 reading and writing tests with moderate to high intercorrelations. There are 7 *Gc* tests across the WJ IV COG, OL, and ACH batteries, and there are no fewer than 9 tests of speed or fluency (*Gs*). Collectively, this means that it was not unusual for at least one test, and often more than one test, to be perfectly or nearly perfectly predictable from a linear combination of a subset of other highly correlated tests. The presence of this high degree of multicollinearity,[24] which does not reflect poorly on the WJ IV data or tests but is instead a function of the extensive coverage of certain domains in the WJ IV battery, can produce convergence problems when attempting the principal axis factor extraction method followed by oblique factor rotation. The PCA-varimax procedure is computationally simpler and less susceptible to improper solutions (Brown, 2006; Dunteman, 1989). The use of this method eliminated most of the multicollinearity problems and allowed the analysis of the complete set of 51 tests. In contrast, the completion of principal axis oblique solutions would have required the iterative, selective removal of tests, one at a time, until a solution with oblique rotated common factors was properly estimated. This loss of test and factor information via the removal of WJ IV tests from the analysis was deemed unacceptable.

As noted by Brown (2006), strict adherence to a specific factor or component extraction criterion is not straightforward; "substantive and practical considerations should strongly guide the factor analytic process" (p. 30). Given the exploratory nature of the PCA, a simple and flexible set of rules was used to determine the number of components to extract in each of the six MD samples. Figure 5-11 presents a scree plot (Cattell, 1966) of the PCA-based eigenvalues extracted for the collection of 51 tests in the age 9 through 13 MD sample.

[24] The presence of multicollinearity was concluded from variable inflation factor (VIF) analysis methods. Multicollinearity "can occur even when the correlations among variables are not excessive" (Keith, 2005, p. 200).

***Figure 5-11.***
*Scree plot (eigenvalues/ latent roots) of ages 9 through 13 model-development sample A (n = 785).*




Although the point where the component eigenvalues are ≥1.0 (also known as the Kaiser-Guttman rule; Brown, 2006) is designated in Figure 5-11, the "eigenvalue ≥1.0" rule of thumb was not used to determine the number of components to retain. Some readers might argue that the major bend in the scree plot occurs before the designated "8–10" components in Figure 5-11; however, the number of components to extract also was informed by the previously discussed CA results, which suggested up to at least 8 broad CHC dimensions.[25] Given this information, solutions with 8 to 10 components were extracted, as well as two solutions with fewer components. The result was five solutions ranging from 6 to 10 components. All solutions were reviewed; the 8-, 9-, and 10-factor solutions were the most interpretable and were retained.[26] Tables 5-11 through 5-13 present the final 8-, 9-, and 10-component varimax rotated solutions in the age 9 through 13 MD sample.

[25] See Brown (2006) for a succinct discussion of the various rules (Kaiser-Guttman rule, Cattell's scree test, parallel analysis) for determining the number of components or factors to retain.

[26] The retained exploratory component analyses for all age groups, and their respective eigenvalue scree plots, are presented in Appendix H.

**Table 5-11.**

*Eight-Component Varimax Rotated Exploratory Analysis Solution of Ages 9 Through 13 Model-Development Sample A (n = 785)*

| Tests | Eight Varimax Rotated Components | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ***Gc*** | ***Gs*** | ***Gv+Gf+Ga*** | ***Grw*** | ***Glr*-(Ret Flu)** | ***Gq+Gf*** | ***Gwm*** | ***Gv*-MV/MA** |
| PICVOC | 0.82 | | | | | | | |
| GENINF | 0.80 | | | | | | | |
| ORLVOC | 0.75 | | | | | | | |
| SOC | 0.73 | | | | | | | |
| HUM | 0.71 | | | | | | | |
| ORLCMP | 0.68 | | | | | | | |
| RDGVOC | 0.67 | | | 0.47 | | | | |
| SCI | 0.61 | | | | | *0.43* | | |
| VRBANL | 0.59 | | 0.48 | | | | | |
| WRDFLU | | 0.79 | | | | | | |
| LETPAT | | 0.77 | | | | | | |
| SNRDFL | | 0.74 | | | | | | |
| NUMPAT | | 0.72 | | | | | | |
| MTHFLU | | 0.70 | | | | | | |
| SNWRFL | | 0.66 | | *0.44* | | | | |
| PAIRCN | | 0.65 | | | | | | |
| VAL | | | 0.70 | | | | | |
| VISUAL | | | 0.66 | | | | | |
| SNDBLN | | | 0.59 | | | | | |
| SEGMNT | | | 0.51 | | | | | |
| WRDATK | | | | 0.69 | | | | |
| LWIDNT | *0.42* | | | 0.68 | | | | |
| WRTSMP | | | | 0.68 | | | | |
| PSGCMP | *0.44* | | | 0.64 | | | | |
| RDGREC | | | | 0.61 | | | | |
| SPELL | *0.41* | *0.42* | | 0.57 | | | | |
| SPLSND | | | | 0.54 | | | | |
| ORLRDG | *0.44* | | | 0.51 | | | | |
| PICREC | | | | | 0.61 | | | |
| RPCNAM | | | | | 0.52 | | | |
| NUMSER | | | | 0.49 | | 0.63 | | |
| CALC | | *0.44* | | | | 0.58 | | |
| APPROB | 0.45 | | | | | 0.54 | | |
| ANLSYN | | | *0.44* | | | 0.53 | | |
| NUMMAT | | | | | | 0.50 | | |
| MEMWRD | | | | | | | 0.71 | |
| VRBATN | | | | | | | 0.65 | |
| OBJNUM | | | | | | | 0.61 | |
| NWDREP | | | | | | | 0.56 | |
| SENREP | | | | | | | 0.55 | |
| PHNPRO | | | | | | | 0.52 | |
| VISCLO | | | | | | | | 0.68 |
| MEMNAM | | | | | | | | 0.61 |
| UNDDIR | | | | | | | 0.39 | |
| SNDAWR | | | | 0.50 | | | | |
| NUMSEN | 0.45 | | | | | *0.41* | | |
| CONFRM | | | 0.48 | | | | | |
| STYREC | | | | | 0.48 | | | |
| RETFLU | | | | | *0.41* | | | |
| EDIT | 0.49 | | | 0.49 | | | | |
| NUMREV | | 0.34 | | | | | 0.37 | |

*Note.* Regular font = loading of ≥.45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤.40; other loadings of <.40 were removed for readability purposes.

**Table 5-12.**
*Nine-Component Varimax Rotated Exploratory Analysis Solution of Ages 9 Through 13 Model-Development Sample A (n = 785)*

| | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gs*** | ***Gv+Gf*** | ***Grw*** | ***Glr*-MM** | ***Gq+Gf*** | ***Gwm*** | ***Gv*-MV/MA** | ***Ga*** |
| PICVOC | 0.83 | | | | | | | | |
| GENINF | 0.80 | | | | | | | | |
| ORLVOC | 0.76 | | | | | | | | |
| SOC | 0.74 | | | | | | | | |
| HUM | 0.73 | | | | | | | | |
| ORLCMP | 0.70 | | | | | | | | |
| RDGVOC | 0.67 | | | *0.44* | | | | | |
| SCI | 0.62 | | | | | | | | |
| VRBANL | 0.59 | | | | | | | | |
| WRDFLU | | 0.79 | | | | | | | |
| LETPAT | | 0.78 | | | | | | | |
| NUMPAT | | 0.74 | | | | | | | |
| SNRDFL | | 0.71 | | *0.40* | | | | | |
| PAIRCN | | 0.68 | | | | | | *0.43* | |
| MTHFLU | | 0.66 | | | | | | | |
| SNWRFL | | 0.64 | | 0.45 | | | | | |
| PICREC | | | 0.65 | | | | | | |
| VISUAL | | | 0.65 | | | | | | |
| VAL | | | 0.59 | | | | | | |
| WRTSMP | | | | 0.68 | 0.35 | | | | |
| LWIDNT | *0.43* | | | 0.67 | | | | | |
| WRDATK | | | | 0.67 | | | | | |
| RDGREC | | | | 0.65 | | | | | |
| PSGCMP | *0.44* | | | 0.63 | | | | | |
| SPELL | *0.41* | *0.41* | | 0.55 | | | | | |
| NUMSER | | | | 0.51 | | 0.64 | | | |
| RETFLU | | | | | 0.51 | | | | |
| CALC | | *0.40* | | | | 0.60 | | | |
| APPROB | *0.44* | | | | | 0.59 | | | |
| ANLSYN | | | *0.41* | | | 0.55 | | | |
| NUMMAT | | | | | | 0.52 | | | |
| VRBATN | | | | | | | 0.65 | | |
| NWDREP | | | | | | | 0.62 | | |
| OBJNUM | | | | | | | 0.60 | | |
| SENREP | | | | | | | 0.60 | | |
| MEMWRD | | | | | | | 0.60 | | *0.42* |
| UNDDIR | | | | | | | 0.54 | | |
| VISCLO | | | | | | | | 0.75 | |
| SEGMNT | | | | | | | | | 0.72 |
| SNDBLN | | | | | | | | | 0.69 |
| PHNPRO | | | | | | | | | 0.64 |
| SPLSND | | | | 0.47 | | | | | 0.54 |
| SNDAWR | | | | 0.45 | | | | | *0.43* |
| NUMREV | | | | | | 0.38 | 0.33 | | |
| ORLRDG | *0.42* | | | 0.47 | | | | | |
| CONFRM | | | *0.44* | | | *0.44* | | | |
| EDIT | 0.49 | | | 0.47 | | | | | |
| NUMSEN | 0.45 | | | | | *0.44* | | | |
| RPCNAM | | | | | | | *0.41* | | |
| MEMNAM | | | | | | | | 0.47 | |
| STYREC | | | *0.41* | | 0.38 | | | | |

*Note.* Regular font = loading of ≥.45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤.40; other loadings of <.40 were removed for readability purposes.

***Table 5-13.***
*Ten-Component Varimax Rotated Exploratory Analysis Solution of Ages 9 Through 13 Model-Development Sample A* (n = *785)*

| | **Ten Varimax Rotated Components** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gs*** | ***Gv*** | ***Grw*** | ***Gwm*** | ***Gq+Gf*** | **?** | ***Gv*-MV/SS** | ***Ga*** | ***Glr*-LA** |
| PICVOC | 0.83 | | | | | | | | | |
| GENINF | 0.80 | | | | | | | | | |
| ORLVOC | 0.77 | | | | | | | | | |
| SOC | 0.75 | | | | | | | | | |
| HUM | 0.74 | | | | | | | | | |
| ORLCMP | 0.70 | | | | | | | | | |
| RDGVOC | 0.68 | | | | | | | | | |
| SCI | 0.63 | | | | | | | | | |
| VRBANL | 0.60 | | | | | | | | | |
| EDIT | 0.51 | | | 0.45 | | | | | | |
| WRDFLU | | 0.80 | | | | | | | | |
| LETPAT | | 0.77 | | | | | | | | |
| SNRDFL | | 0.75 | | | | | | | | |
| NUMPAT | | 0.73 | | | | | | | | |
| MTHFLU | | 0.69 | | | | | | | | |
| SNWRFL | | 0.67 | | *0.40* | | | | | | |
| PAIRCN | | 0.64 | | | | | | 0.52 | | |
| PICREC | | | 0.73 | | | | | | | |
| VISUAL | | | 0.59 | | | | | | | |
| WRTSMP | | | | 0.74 | | | | | | |
| WRDATK | | | | 0.66 | | | | | | |
| LWIDNT | 0.45 | | | 0.66 | | | | | | |
| RDGREC | | | | 0.59 | | | | | | |
| PSGCMP | 0.45 | | | 0.57 | | | | | | |
| SPELL | *0.43* | 0.45 | | 0.52 | | | | | | |
| NUMSER | | | | 0.50 | | 0.62 | | | | |
| VRBATN | | | | | 0.70 | | | | | |
| MEMWRD | | | | | 0.66 | | | | | |
| OBJNUM | | | | | 0.65 | | | | | |
| SENREP | | | | | 0.55 | | | | | |
| NWDREP | | | | | 0.54 | | | | | |
| NUMMAT | | | | | | 0.59 | | | | |
| ANLSYN | | | | | | 0.58 | | | | |
| CALC | | *0.43* | | | | 0.56 | | | | |
| CONFRM | | | | | | 0.56 | | | | |
| APPROB | 0.47 | | | | | 0.55 | | | | |
| MEMNAM | | | | | | | 0.71 | | | |
| VISCLO | | | | | | | | 0.73 | | |
| SEGMNT | | | | | | | | | 0.76 | |
| SNDBLN | | | | | | | | | 0.69 | |
| PHNPRO | | | | | | | | | 0.64 | |
| RPCNAM | | | | | | | | | | 0.60 |
| RETFLU | | | | | | | | | | 0.51 |
| NUMREV | | | | | 0.50 | | | | | |
| ORLRDG | *0.44* | *0.41* | | | | | | | | |
| SPLSND | | | | 0.46 | | | | | 0.49 | |
| UNDDIR | | | | | *0.41* | | *0.42* | | | |
| STYREC | | | *0.44* | | | | | | | |
| NUMSEN | 0.47 | | | | | | | | | |
| SNDAWR | | | | *0.41* | | | | | 0.45 | |
| VAL | | | 0.45 | | | | | | 0.48 | |

*Note.* Regular font = loading of ≥.45; italic font = loading of .40 to .44; ? = component that was not interpretable; other loadings of <.40 were removed for readability purposes.

Across all three exploratory PCA solutions, five interpretable broad CHC components appear consistently—*Gc*, *Gs*, *Grw*, *Gq+Gf*, and *Gwm*. A separate *Ga* component is not present in the 8-component solution but is present in the 9- and 10-component solutions. Strong similarities are noted between the PCA factors of *Gc, Gs, Grw, Gwm*, and *Ga* in Tables 5-11 through 5-13 and the primary groups that emerged in the CA in Figure 5-10.

Evidence for a *Gq+Gf* component also is present in the 8- and 9-component solutions. In the CA solution, the broad quantitative grouping (labeled *Gq/Gf*-RQ in Figure 5-10) consists of acquired math achievement (*Gq*) and *Gf*-based quantitative reasoning (RQ) tests. In the 9- and 10-component PCA solutions a broader dimension emerges that includes the *Gq/Gf*-RQ tests as well as the *Gf* tests of Analysis-Synthesis and Concept Formation. A *Glr* component is present in all three PCA solutions, but it shifts in breadth as more components are extracted. For example, in the 8-component solution the *Glr* component includes Picture Recognition, Rapid Picture Naming, Story Recall, and Retrieval Fluency. (This differs from the *Glr*-Retrieval Fluency cluster identified in the CA only by the replacement of Visual Closure with Story Recall.) In Table 5-12, a less robust *Glr*-MM component is present in the 9-component solution (Retrieval Fluency, Story Recall, and Writing Samples). In the 10-component solution in Table 5-13, a clear speed of lexical access dimension (*Glr*-LA) emerges that includes only Retrieval Fluency and Rapid Picture Naming and is identical to the *Glr*-LA grouping in Figure 5-10. In the 10-component solution (Table 5-13) a purer *Gv* component emerges, defined primarily by the Picture Recognition and Visualization tests. The moderate *Gv* loading for the Visual-Auditory Learning test also is consistent with the *Gv* interpretation of this component.

### Stage 2A: Exploratory Multidimensional Scaling Analysis

The relations between the 51 tests also were investigated with multidimensional scaling analysis (MDS). A description of MDS and its application to the WJ IV standardization data is presented earlier in this chapter. Figure 5-12 presents the MDS results for the 51 tests for the age 9 through 13 MD sample.[27]

The earlier discussion of the MDS presented in Figure 5-12 focused on the content features of the WJ IV tests. Here, the interpretation is on structural validity. As described previously in the content validity section of this chapter, tests that are in close spatial proximity on the MDS map are interpreted as measuring similar dimensions, and tests that are closer to the center of the plot are more cognitively complex.

A number of test groupings provide validity evidence supporting the broad or narrow dimensions reported previously in the exploratory CA and PCA of the same age 9 through 13 MD sample data. The MDS map in Figure 5-12 provides evidence for the broad WJ IV CHC domains of *Ga*, *Gc*, *Grw*, *Gq/Gf*-RQ, *Gwm*, *Gf*, and *Gv*. Similar to the CA results, the differentiation of some broad CHC domains into narrow ability domains is suggested. These include *Gwm*-MS and *Gwm*-WM, *Gs*-ACH and *Gs*-COG, and *Glr*-LA and *Glr*-MM. One test, Memory for Names, is an apparent outlier, suggesting minimal shared relations with the other 50 tests.[28]

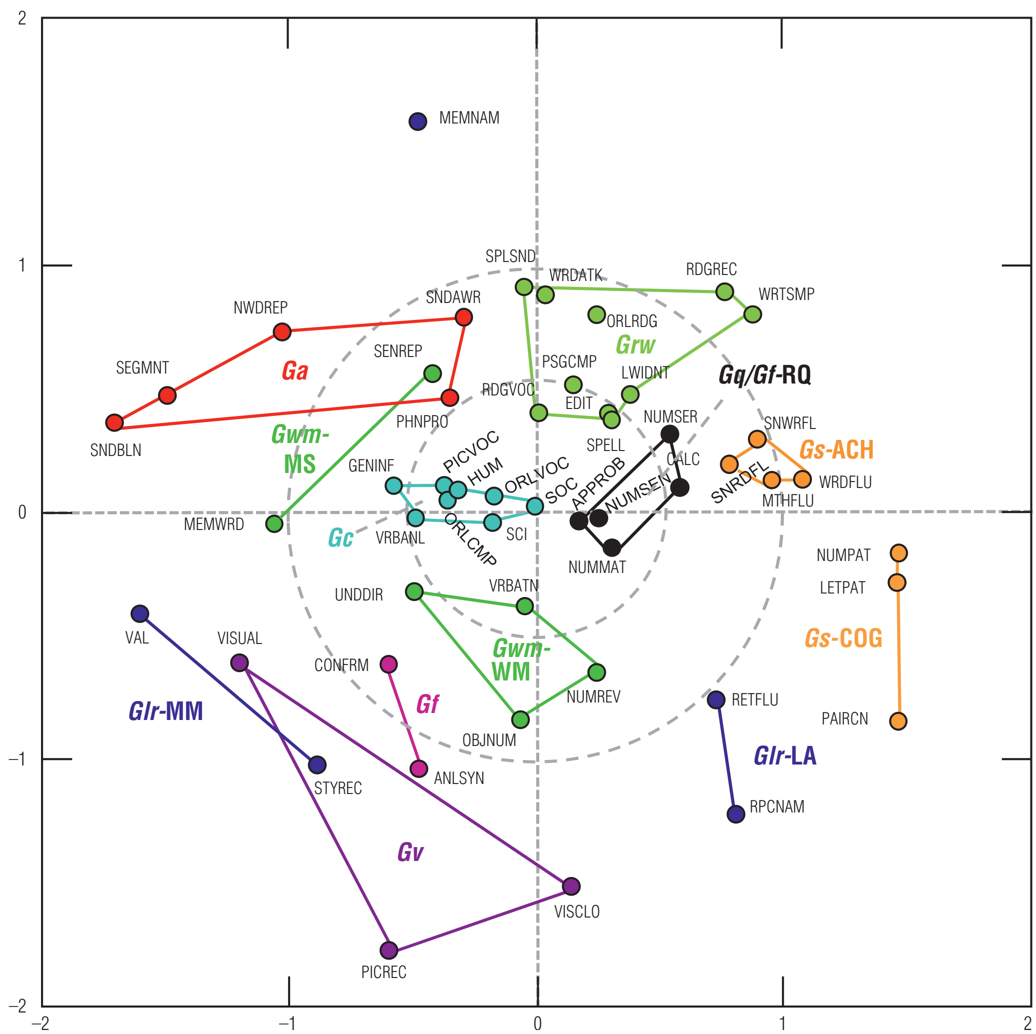
The three sets of speeded or fluency tests depicted in Figure 5-12 are in close proximity. However, there is a distinct difference (represented by spatial distance) between the *Gs*-ACH, *Gs*-COG, and *Glr*-LA test groupings—a finding consistent with the CA results in Figure 5-10. Although the *Gf* Concept Formation and Analysis-Synthesis tests and the quantitative reasoning (*Gf*-RQ) Number Series and Number Matrices tests loaded on a common *Gq+Gf*

[27] Figure 5-12 is identical to the previously reported MDS Figure 5-2 (for content validity evidence section), except that the shaded ovals representing the broad hypothesized stimulus content dimensions have been removed.

[28] However, as noted previously in the content validity section of this chapter, it is likely that three-dimensional (3-D) MDS models may be needed to provide the most accurate MDS representation of the relations between all tests. Some relations may be masked in the current 2-D MDS representation.

factor in the PCA analysis in Tables 5-11 through 5-13, in Figure 5-12, the *Gf*-RQ tests group with the *Gq* tests and are spatially distant from the *Gf* Concept Formation and Analysis-Synthesis tests. This finding is consistent with Wilhelm's (2005) Berlin Intelligence Structure (BIS) analysis of *Gf* tests, where he reported that a CFA model that classified *Gf* tests as per stimulus characteristics (i.e., verbal, quantitative, figural) produced a better fit than a model that specified traditional CHC cognitive operations (i.e., induction, general sequential reasoning, quantitative reasoning).

***Figure 5-12.***
*MDS (Guttman Radex) of WJ IV ages 9 through 13 model-development sample A (n = 785).*




One final illustrative finding from the MDS analysis is the relatively close proximity of the Nonword Repetition test (part of the *Ga* grouping in Figure 5-12) to the *Gwm*-MS grouping, compared to its distance from the *Gwm*-MW grouping. In the PCA analysis shown in Tables 5-11 through 5-13, the Nonword Repetition test loaded on the broad *Gwm* factor. The MDS results suggest that the Nonword Repetition PCA loading on *Gwm* is due to more similarity with other memory span (MS) tests (i.e., Memory for Words, Sentence Repetition) than with working memory (WM) tests (i.e., Understanding Directions, Verbal Attention, Numbers Reversed, Object-Number Sequencing). Both the MDS (Figure 5-12) and CA (Figure 5-10) results for the age 9 through 13 MD sample suggest separate *Gwm*-MS and *Gwm*-WM narrow abilities. The exploratory PCA did not reveal the potential *Gwm*-MS/WM substructure. This finding demonstrates the value of augmenting traditional exploratory factor or principal components methods with CA and MDS methods.

### Stage 2B: Specification of Initial Model Generation CFA Models

The CA, PCA, and MDS findings for the age 9 through 13 MD sample shared many similarities, providing a form of method-invariant structural validity evidence for many of the CHC broad and select narrow abilities. However, the CA and MDS results also suggested potentially different insights into the structure of the WJ IV battery. As illustrated in Figure 5-9, the next step (Stage 2B) was the specification of the initial model-generating (MG) CFA models based on the integration of the CA, PCA, and MDS results. As reflected in Stage 2B in Figure 5-9, a comprehensive review of contemporary CHC and neuroscience research (see Chapter 1) and structural research on all three prior editions of the Woodcock-Johnson tests (WJ, WJ-R, and WJ III) was integrated with the exploratory results from Stage 2A to specify the initial WJ IV MG CFA models.

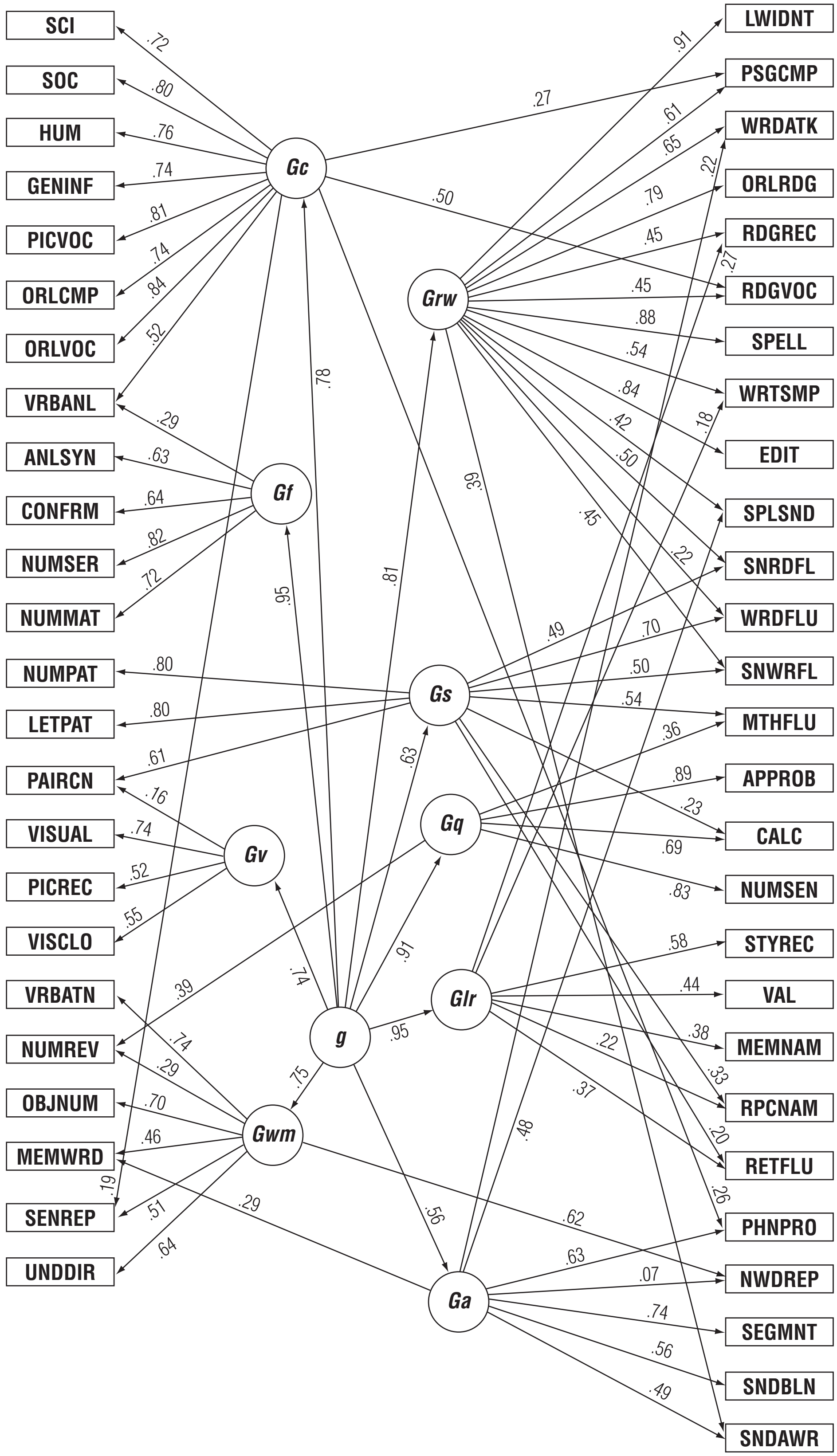
Three distinct models were proposed in Stage 2a. Model 1 was a single *g*-factor baseline model, where all 51 tests loaded on a single latent *g* factor. Models 2 and 3 represented two major types of MG CFA analysis. Model 2, a *broad CHC factor top-down* CFA model, was specified to best represent the broad-strokes outline of contemporary CHC theory as articulated in Chapter 1 and Appendix A. In addition to a higher-order *g* factor, this starting model included nine broad CHC factors—*Gc*, *Grw*, *Gf*, *Gs*, *Gq*, *Gv*, *Glr*, *Gwm*, and *Ga*. Possible significant correlated residuals also were explored. Figure 5-13 presents Model 2 for the 9 through 13 age group.[29] The model visually portrays, in standard path diagram format, the hypothesized correspondence between the WJ IV tests and the broad CHC factors. Models 1 (single *g* factor) and 2 (broad CHC factor top-down) were the only models specified and evaluated at the preschool age level.

Model 3, also a type of MG CFA model, is a broad plus narrow CHC factor bottom-up model. Figure 5-14 illustrates this model, which includes three levels of factors—g, as well as broad and narrow CHC factors. In Model 3, plausible narrow factors were first specified and evaluated, based on the combination of the exploratory structural analyses and prior research and theory. For example, the two narrow *Gc* factors of language development/lexical knowledge (*Gc*-VL/LD) and general information (*Gc*-K0) were specified as being subsumed by the broader *Gc* factor. In this particular example, as well as in others listed below, the model results were deemed inappropriate (e.g., Heywood cases, negative loadings or residuals, patterns of illogical latent factor loadings) and were dropped.

Possible significant correlated residuals also were also explored; that is, correlations between pairs of tests that the exploratory results or CFA modification indices suggested as possibly sharing variance not accounted for by the latent factors. When narrow factors within a broad CHC domain were not supported, a single broad CHC factor was specified for the relevant tests.

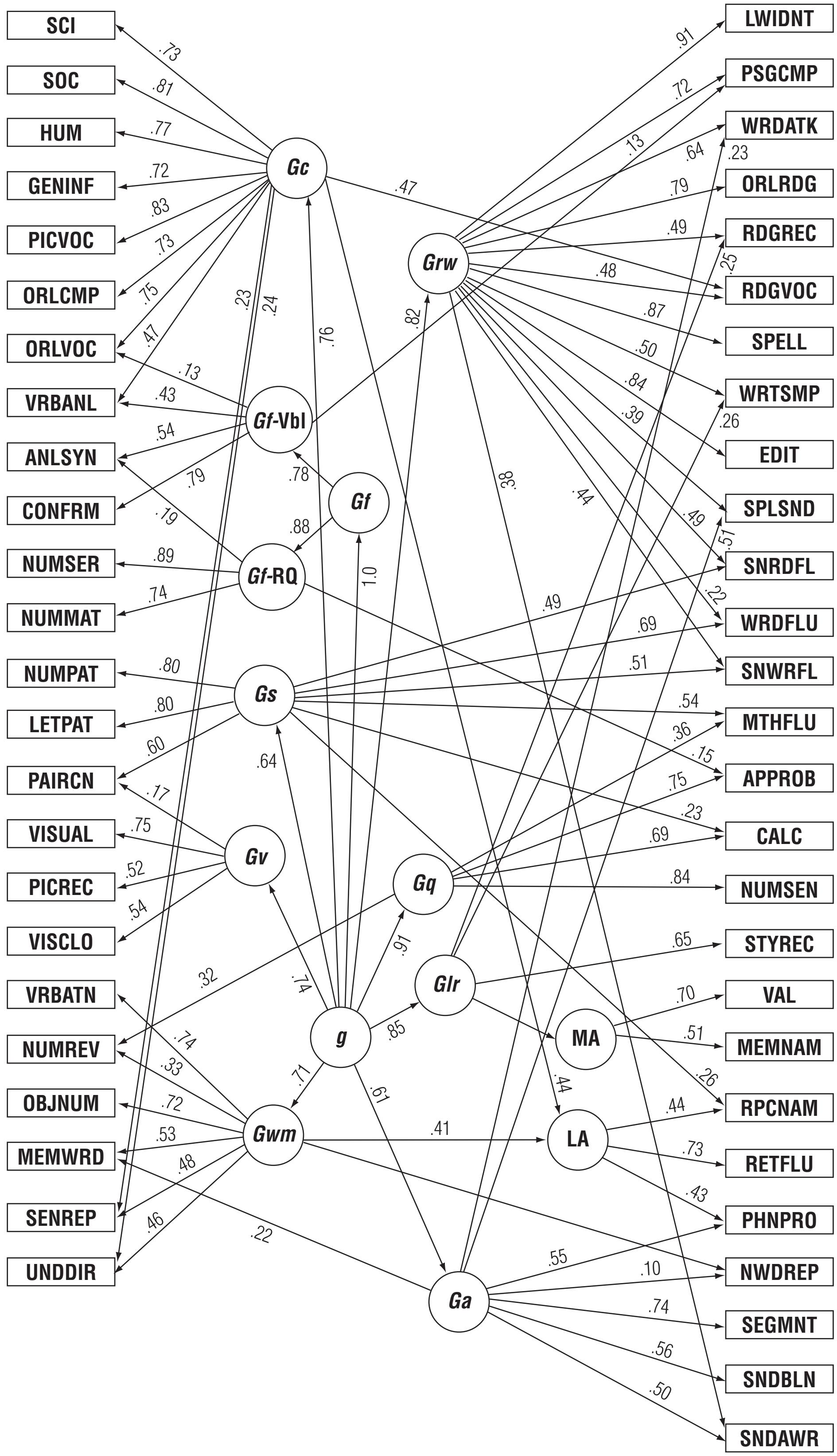
[29] The model in Figure 5-13 is the final MG model for the ages 9 through 13 years MD sample produced at the end of all Stage 2 steps presented in Figure 5-9.

***Figure 5-13.***
*Final cross-validated CHC broad 9-factor model (top-down; Model 2) of ages 9 through 13 model-development sample A (n = 785).*




*Note.* Latent factor, test residual, and correlated test residual terms were omitted for readability purposes.

***Figure 5-14.***
*Final cross-validated CHC broad + narrow 13-factor model (bottom-up; Model 3) of ages 9 through 13 model-development sample A (n = 785).*




*Note.* Latent factor, test residual, and correlated test residual terms were omitted for readability purposes.

Based on the results from all three types of exploratory analysis in Stage 2A, as well as theoretical and substantive considerations, the following narrow abilities were considered as candidate factors during the MG analyses for Model 3.

- *Gc*: Lexical knowledge/language development (VL/LD) and general information (K0)
- *Gf*: Verbal language-based reasoning (Vbl) and quantitative reasoning (RQ)
- *Gs*: *Gs*-Achievement (*Gs*-ACH) and *Gs*-Cognitive (*Gs*-COG)
- *Grw*: Reading decoding (RD) and reading comprehension (RC)
- *Gwm*: Memory span (MS) and working memory (WM)
- *Gq*: Mathematical achievement (A3) and quantitative reasoning (RQ)
- *Glr*: Meaningful memory (MM), associative memory (MA), and speed of lexical access (LA)
- *Gv*: Visualization (Vz) and Visual Memory (MV)

Of the above broad-narrow factor specifications, four possible narrow factors were deemed plausible in the age 9 through 13 MD sample—*Gf*-Vbl, *Gf*-RQ, *Glr*-MA, and *Gwm*/*Gc*-LA. All model parameters for the final MD model for ages 9 through 13 were significant ($p < .05$). The final broad plus narrow CHC factor bottom-up solution for the age 9 through 13 MD sample, which contains 13 factors, is presented in Figure 5-14. The description of the MG process conveys the fact that the broad plus narrow CHC factor bottom-up models were developed according to the philosophy of exploratory model-generating (MG) CFA methods. The use of the MG aspects of CFA methods, informed by prior research, theory, and the comprehensive exploratory structural analyses results from Stage 2A, resulted in the most plausible exploratory-based broad plus narrow CHC structural WJ IV models for all age groups.

## Stage 3: Confirmatory Structural Model Cross-Validation

It was determined at the outset of Stage 3 that Model 1 did not fit the data well. The model fit statistics for Model 1 showed a much poorer fit to the data than the other two models did. Also, the single *g*-factor model was inconsistent with both the exploratory CA, PCA, and MDS analyses and the prior structural research of the previous editions of the test (WJ-R and WJ III). In the remaining Models 2 and 3, all model parameters for the age 9 through 13 model-development sample were positive, significant ($p < .05$), and meaningful. In Stage 3, Models 2 and 3 were taken “as is” and cross-validated with the age 9 through 13 MCV (B) sample. The only model adjustment allowed in the cross-validation stage was the occasional constraint of *Heywood cases* (i.e., factor loadings $\geq 1.0$) to 1.0 in some of the Model 2 solutions.[30] No model parameters were added or deleted in Stage 3.

### Model Fit Evaluation

A variety of CFA model fit indices were used to evaluate and compare the three types of models in five of the six MD age groups (6 through 8 and older groups).[31] The models were evaluated not only for overall CFA model fit, but also for the direction, magnitude, and significance of all model parameters and the possibility of localized areas of strain[32] (Brown, 2006). Only Model 1 and Model 2 were compared in the preschool (ages 3 through 5 years) MD sample. As noted previously, Model 1 (single *g* factor) demonstrated a much weaker fit to

[30] According to Brown (2006), Heywood cases may be admissible in models where significant multicollinearity is present in the sample data. As described in the section entitled “Stage 2A: Exploratory Principal Components Analysis” earlier in this chapter, explainable multicollinearity was present in the WJ IV data, given the large numbers of significantly correlated tests in and across certain CHC domains.

[31] Information regarding the fit statistics used is presented in the next section of this chapter. (“Internal Structure Evidence: Results and Interpretation of Structural Validity Evidence”).

[32] *Localized model strain* occurs when some relations among indicators in the data are not reproduced adequately or some model-implied relations markedly exceed the relations in the observed data. This most frequently occurs in complex models that include a large collection of indicators (Brown, 2006).

the data in all MD samples and was dropped after Stage 2 of the structural validation process. The remaining two models (Model 2—broad CHC factor top-down and Model 3—broad plus narrow CHC factor bottom-up) were retained and evaluated at the end of the model generating (Stage 2) and cross-validation stages (Stages 2 and 3, respectively; see Figure 5-9).

## Internal Structure Evidence: Results and Interpretation of Structural Validity Evidence

The evaluation of CFA models and the assessment of model fit are not purely statistical matters:

> The goal is to find a model within this class of models that not only fits the data well from a statistical point of view, taking all aspects of error into account, but also has the property that every parameter of the model can be given a substantively meaningful interpretation. (Jöreskog, 1993, p. 307)

The WJ IV CFA models were evaluated for overall statistical model fit and for size, statistical significance, and interpretability of all model parameter estimates (Brown, 2006).

### *CFA Model Fit Comparisons*

Table 5-14 presents fit statistics for the final CFA models in the MD and MDV samples across all six age groups.

A wide variety of model fit indices are available (Arbuckle, 2012; Brown, 2006; Kline, 2011), each of which accounts for different aspects of model fit (e.g., the degree to which observed and implied variance-covariance matrices are similar; model parsimony). The fit indices reported in Table 5-14[†] include (a) minimum discrepancy (CMIN)[33] and degrees of freedom (*df*), (b) adjusted goodness-of-fit (AGFI), (c) comparative fit index (CFI), (d) Tucker-Lewis non-normed fit index (TLI), (e) the parsimony adjustment to the normed fit index (PNFI), and (f) the root mean squared error of approximation (RMSEA).[34] (The [†] endnote reference in the prior sentence provides *critical* information that explains the reasons for the differences in the absolute magnitude of the maximum-likelihood [ML] and scale-free least squares [SFLS] estimated fit statistics reported.) In general, the closer the AGFI, CFA, TLI, and PNFI values are to 1.0, the better the model fit. Depending on the specific index, desired values typically range from .90 to .95 and higher. In the case of the RMSEA index, smaller values approaching zero are indicative of good model fit, with values in the range of .05 to .08 and lower typically suggesting good model fit. These general rules of thumb, however, are dependent on a number of different characteristics of the sample, data, and model (see Brown, 2006; Fan, Thompson, & Wang, 1999; Hu & Bentler, 1999; Kline, 2011).

A comparison of the relative magnitude of the CMIN values in both the MD and MCV samples in Table 5-14 reveals that the Model 3 values are slightly smaller in the school-age samples (6 through 8, 9 through 13, and 14 through 19) and are approximately equal in the two adult age groups (20 through 39 and 40 through 90+). However, when the

[33] CMIN is the minimum discrepancy for each model. In the case of maximum-likelihood (ML) estimation, this value is the chi-square statistic (Arbuckle, 2012).

[34] The fit statistics reported here are similar to those reported in other intelligence test manuals (see Kaufman & Kaufman, 2004a; Roid, 2003b; Wechsler, 2008) and represent different indices from categories of *approximate fit indices* (absolute, incremental or comparative, parsimony-adjusted, predictive; Kline, 2011). The AGFI indicates the proportion of the observed variance-covariance matrix explained by the model-based implied variance-covariance matrix, adjusted for degrees of freedom. The CFI uses a baseline model and indicates how well the specified model reproduces the observed variance-covariance matrix compared to the baseline model. The TLI is similar to the CFI but adds an adjustment for degrees of freedom. The PNFI also adjusts for degrees of freedom, but is based on the normed fit index (NFI); the NFI and PNFI "penalize" for model complexity in favor of model parsimony. RMSEA is an estimate of the degree of match between the estimated variance-covariance matrix and the population covariance matrix, adjusted for degrees of freedom. RMSEA is often called a "badness of fit index" (Brown, 2006; Kline, 2011; Mulaik et al., 1989).

degrees of freedom (*df*) are considered, the best conclusion is that Model 2 and Model 3 are equally plausible models at ages 6 and above. This conclusion is reinforced by the negligible differences between the respective AGFI, CFI, TLI, PNFI, and RMSEA fit values for both models across all age groups, as well as across the MD and MCV samples. Based on the SLFS-based AGFI and PNFI fit statistics, Model 2 appears to be a reasonably good fit at the preschool age level (3 through 5).

***Table 5-14.***
*Comparison of CFA Fit Statistics for Final Model Development and Cross-Validation, WJ IV Structural Models Across Six Age Groups*

| WJ IV Structural Models | *df* | CMIN + | | AGFI | | CFI | | TLI | | PNFI | | RMSEA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ML | SFLS | ML | SFLS | ML | SFLS | ML | SFLS | ML | SFLS | ML | SFLS |
| **Best fitting initial models in MD samples** | | | | | | | | | | | | | |
| Ages 3–5 (*n* = 209) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors + *g* (top down) | 481 | 1,856.81 | 692.31 | 0.623 | 0.956 | 0.688 | NA | 0.657 | NA | 0.568 | 0.868 | 0.115 | NA |
| Ages 6–8 (*n* = 412) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors + *g* (top down) | 1,187 | 8,529.77 | 2,884.64 | 0.543 | 0.966 | 0.636 | NA | 0.609 | NA | 0.561 | 0.900 | 0.123 | NA |
| Model 3: CHC 13 broad + narrow factors + *g* (bottom up) | 1,178 | 8,222.59 | 2,652.19 | 0.550 | 0.968 | 0.651 | NA | 0.622 | NA | 0.570 | 0.894 | 0.121 | NA |
| Ages 9–13 (*n* = 785) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors + *g* (top down) | 1,183 | 13,642.57 | 4,748.41 | 0.600 | 0.966 | 0.638 | NA | 0.610 | NA | 0.573 | 0.896 | 0.123 | NA |
| Model 3: CHC 13 broad + narrow factors + *g* (bottom up) | 1,178 | 13,511.37 | 4,631.80 | 0.604 | 0.966 | 0.642 | NA | 0.612 | NA | 0.574 | 0.889 | 0.121 | NA |
| Ages 14–19 (*n* = 842) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors + *g* (top down) | 1,179 | 15,242.61 | 4,386.61 | 0.594 | 0.977 | 0.662 | NA | 0.634 | NA | 0.596 | 0.904 | 0.116 | NA |
| Model 3: CHC 13 broad + narrow factors + *g* (bottom up) | 1,176 | 15,162.48 | 4,411.97 | 0.593 | 0.977 | 0.663 | NA | 0.635 | NA | 0.596 | 0.901 | 0.116 | NA |
| Ages 20–39 (*n* = 625) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors + *g* (top down) | 1,176 | 11,472.65 | 3,251.83 | 0.587 | 0.978 | 0.676 | NA | 0.648 | NA | 0.602 | 0.902 | 0.118 | NA |
| Model 3: CHC 13 broad + narrow factors + *g* (bottom up) | 1,184 | 11,553.79 | 3,389.37 | 0.589 | 0.977 | 0.673 | NA | 0.648 | NA | 0.604 | 0.907 | 0.118 | NA |
| Ages 40–90+ (*n* = 571) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors + *g* (top down) | 1,187 | 10,894.76 | 2,706.56 | 0.571 | 0.984 | 0.699 | NA | 0.676 | NA | 0.628 | 0.916 | 0.120 | NA |
| Model 3: CHC 13 broad + narrow factors + *g* (bottom up) | 1,180 | 10,856.99 | 2,694.38 | 0.569 | 0.984 | 0.700 | NA | 0.675 | NA | 0.625 | 0.911 | 0.120 | NA |

**Table 5-14.** *(cont.)*
*Comparison of CFA Fit Statistics for Final Model Development and Cross-Validation, WJ IV Structural Models Across Six Age Groups*

| WJ IV Structural Models | *df* | CMIN + ML | CMIN + SFLS | AGFI ML | AGFI SFLS | CFI ML | CFI SFLS | TLI ML | TLI SFLS | PNFI ML | PNFI SFLS | RMSEA ML | RMSEA SFLS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cross-validation of final MD models in MCV samples** | | | | | | | | | | | | | |
| Ages 3–5 (*n* = 209) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors+*g* (top down) | 480 | 1,791.15 | 664.85 | 0.623 | 0.961 | 0.713 | NA | 0.684 | NA | 0.589 | 0.873 | 0.115 | NA |
| Ages 6–8 (*n* = 411) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors+*g* (top down) | 1,187 | 8,529.57 | 2,961.19 | 0.550 | 0.965 | 0.634 | NA | 0.607 | NA | 0.559 | 0.899 | 0.123 | NA |
| Model 3: CHC 13 broad+narrow factors+*g* (bottom up) | 1,178 | 8,229.24 | 2,751.08 | 0.560 | 0.967 | 0.649 | NA | 0.620 | NA | 0.568 | 0.894 | 0.121 | NA |
| Ages 9–13 (*n* = 787) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors+*g* (top down) | 1,183 | 14,245.21 | 4,609.40 | 0.585 | 0.971 | 0.647 | NA | 0.619 | NA | 0.582 | 0.902 | 0.119 | NA |
| Model 3: CHC 13 broad+narrow factors+*g* (bottom up) | 1,178 | 14,007.90 | 4,455.41 | 0.593 | 0.972 | 0.603 | NA | 0.625 | NA | 0.586 | 0.898 | 0.118 | NA |
| Ages 14–19 (*n* = 843) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors+*g* (top down) | 1,179 | 15,015.90 | 4,267.93 | 0.597 | 0.977 | 0.662 | NA | 0.634 | NA | 0.595 | 0.905 | 0.118 | NA |
| Model 3: CHC 13 broad+narrow factors+*g* (bottom up) | 1,176 | 14,920.27 | 4,264.47 | 0.597 | 0.977 | 0.657 | NA | 0.636 | NA | 0.596 | 0.902 | 0.118 | NA |
| Ages 20–39 (*n* = 626) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors+*g* (top down) | 1,176 | 11,735.71 | 3,521.53 | 0.572 | 0.976 | 0.670 | NA | 0.642 | NA | 0.597 | 0.900 | 0.120 | NA |
| Model 3: CHC 13 broad+narrow factors+*g* (bottom up) | 1,184 | 11,731.56 | 3,603.41 | 0.577 | 0.976 | 0.671 | NA | 0.645 | NA | 0.601 | 0.906 | 0.119 | NA |
| Ages 40–90+ (*n* = 574) | | | | | | | | | | | | | |
| Model 2: CHC 9 broad factors+*g* (top down) | 1,186 | 11,168.41 | 2,646.37 | 0.566 | 0.984 | 0.692 | NA | 0.669 | NA | 0.622 | 0.916 | 0.121 | NA |
| Model 3: CHC 13 broad+narrow factors+*g* (bottom up) | 1,180 | 11,317.36 | 2,711.91 | 0.560 | 0.984 | 0.687 | NA | 0.662 | NA | 0.615 | 0.910 | 0.122 | NA |

*Note. df* = degrees of freedom, CMIN = minimum discrepancy, AGFI = adjusted goodness of fit, CFI = comparative fit index, TLI = Tucker-Lewis non-normed fit index, PNFI = parsimony adjustment to the normed fit index, RMSEA = root mean squared error of approximation, ML = maximum likelihood, SFLS = scale-free least squares, NA = Not appropriate—not available when SFLS estimation algorithm is used.

Of Models 2 and 3, Model 2 (broad CHC factors top-down; see Figure 5-13) is the preferred model per the *parsimony principle* (also known as Occam's Razor), which states that "given two models with similar fit to the data, the simpler model is preferred" (Kline, 2011, p. 102). Although the broad CHC factor model (Model 2) is more parsimonious, and thus the most solid framework from which to evaluate the structural validity of the WJ IV, the more complex broad plus narrow CHC bottom-up factor model (Model 3) offers potentially important insights regarding the structure of the WJ IV battery, possible clinically relevant interpretation information, and potential new insights into the CHC model of intelligence. The more complex models should not be summarily dismissed based only on the parsimony principle for two reasons. First, Stankov, Boyle, and Cattell (1995) stated, within the context of research on human intelligence, that "while we acknowledge the principle of parsimony and endorse it whenever applicable, the evidence points to relative complexity rather than simplicity. The insistence on parsimony at all costs can lead to bad science" (p. 16). Second, and more important, the exploratory CA, PCA, and MDS results from Stage 2 provide evidence for a more nuanced, complex structure, or clinical interpretation framework, for the WJ IV battery. Recall from previous sections that the collective exploratory evidence from Stage 2 indicated that (a) the WJ IV *Gf* tests might be further differentiated by stimulus content (verbal versus quantitative)—a finding also supported by Wilhelm's (2005) research that suggested the existence of verbal, quantitative, and figural-visual *Gf* content dimensions; (b) memory span and working memory might be differentiated by different sets of WJ IV tests; and (c) speed of lexical access (*Glr*-LA) may represent a new narrow ability measured by the WJ IV that should be considered for admittance in the contemporary CHC model (see Chapter 1 and Appendix A).

The respective fit statistics for Model 2 and 3 in the cross-validation samples (MCV) are approximately equal to those for the same models in the MD samples. For example, as reported in Table 5-14, the SFLS-based AGFI fit indices for Model 2 are .966 and .971 in the age 9 through 13 MD and MCV samples, respectively. The PNFI fit indices for Model 2 in the age 9 through 13 MD and MCV samples are .896 and .902, respectively. For Model 3, the SFLS-based AGFI fit indices are .966 and .972 in the age 9 through 13 MD and MCV samples, respectively. The PNFI fit indices for Model 3 in the age 9 through 13 MD and MCV samples are .889 and .898, respectively. Similar findings are observed for all MD and MCV ML-based fit indices across all age groups. The respective ML- or SLFS-based CMIN values also are very similar for Models 2 and 3 across the MD and MCV samples at all age groups. These findings support the stability and generalizability of the structural validity of the WJ IV as represented by the two models (Model 2 and 3). As will be discussed in the next section, the finding that only a small number of factor loadings or correlated residual parameters were not significant in the MCV samples further supports the generalizability of the two plausible WJ IV structural models.

## *Model 2 CFA Results and Interpretations*

Table 5-15 presents all test and factor loading parameters for Model 2 (broad CHC factor top-down) for the MD and MCV samples across all age groups.

**Table 5-15.**
*WJ IV CHC Broad 9-Factor (Top-Down; Model 2) CFA ML Model Results in Six Age Groups*

| Latent Factors/ Tests | Age Group 3–5 MD (*n* = 209) | 3–5 MCV (*n* = 209) | 6–8 MD (*n* = 412) | 6–8 MCV (*n* = 411) | 9–13 MD (*n* = 785) | 9–13 MCV (*n* = 787) | 14–19 MD (*n* = 842) | 14–19 MCV (*n* = 843) | 20–39 MD (*n* = 625) | 20–39 MCV (*n* = 626) | 40–90+ MD (*n* = 571) | 40–90+ MCV (*n* = 574) | Median |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***g*** | | | | | | | | | | | | | |
| *Glr* | *1.00* | 0.98 | 0.99 | 0.99 | 0.92 | 0.95 | 0.89 | 0.95 | 0.95 | 0.93 | *1.00* | 0.97 | 0.95 |
| *Gf* | 0.87 | 0.80 | 0.94 | 0.94 | 0.91 | 0.95 | 0.94 | 0.93 | 0.93 | 0.94 | 0.94 | 0.93 | 0.94 |
| *Gq* | 0.81 | 0.87 | 0.84 | 0.87 | 0.88 | 0.91 | 0.91 | 0.89 | 0.87 | 0.88 | 0.89 | 0.90 | 0.89 |
| *Gc* | 0.79 | 0.83 | 0.76 | 0.73 | 0.79 | 0.78 | 0.84 | 0.84 | 0.87 | 0.84 | 0.88 | 0.87 | 0.84 |
| *Gv* | 0.85 | 0.81 | 0.81 | 0.81 | 0.72 | 0.74 | 0.81 | 0.86 | 0.84 | 0.83 | 0.87 | 0.85 | 0.82 |
| *Ga* | 0.88 | 0.88 | 0.81 | 0.79 | 0.56 | 0.63 | 0.72 | 0.76 | 0.81 | 0.81 | 0.87 | 0.88 | 0.80 |
| *Grw* | 0.80 | 0.83 | 0.75 | 0.78 | 0.78 | 0.81 | 0.80 | 0.79 | 0.80 | 0.78 | 0.81 | 0.82 | 0.80 |
| *Gwm* | 0.73 | 0.80 | 0.76 | 0.79 | 0.76 | 0.75 | 0.78 | 0.77 | 0.81 | 0.81 | 0.85 | 0.88 | 0.79 |
| *Gs* | 0.75 | 0.83 | 0.54 | 0.63 | 0.52 | 0.63 | 0.62 | 0.56 | 0.42 | 0.58 | 0.59 | 0.60 | 0.59 |
| ***Gc*** | | | | | | | | | | | | | |
| ORLVOC | 0.77 | 0.81 | 0.83 | 0.85 | 0.86 | 0.84 | 0.87 | 0.88 | 0.88 | 0.89 | 0.88 | 0.88 | 0.87 |
| SOC | 0.74 | 0.79 | 0.76 | 0.82 | 0.80 | 0.80 | 0.84 | 0.84 | 0.85 | 0.83 | 0.86 | 0.83 | 0.83 |
| PICVOC | 0.78 | 0.77 | 0.77 | 0.78 | 0.82 | 0.81 | 0.83 | 0.84 | 0.85 | 0.83 | 0.85 | 0.79 | 0.82 |
| HUM | 0.76 | 0.76 | 0.75 | 0.74 | 0.78 | 0.76 | 0.79 | 0.82 | 0.84 | 0.84 | 0.85 | 0.86 | 0.81 |
| ORLCMP | 0.77 | 0.73 | 0.77 | 0.72 | 0.76 | 0.74 | 0.79 | 0.79 | 0.81 | 0.80 | 0.83 | 0.83 | 0.79 |
| GENINF | 0.67 | 0.61 | 0.65 | 0.69 | 0.77 | 0.74 | 0.78 | 0.77 | 0.81 | 0.82 | 0.82 | 0.81 | 0.78 |
| SCI | 0.72 | 0.75 | 0.75 | 0.72 | 0.74 | 0.72 | 0.78 | 0.79 | 0.80 | 0.76 | 0.82 | 0.80 | 0.77 |
| VRBANL | 0.51 | 0.35 | 0.73 | 0.70 | 0.55 | 0.52 | 0.51 | 0.57 | 0.63 | 0.59 | 0.59 | 0.60 | 0.59 |
| RDGVOC | | | 0.49 | 0.51 | 0.51 | 0.50 | 0.56 | 0.52 | 0.52 | 0.56 | 0.56 | 0.53 | 0.52 |
| PSGCMP | | | 0.21 | 0.20 | 0.30 | 0.27 | 0.31 | 0.32 | 0.42 | 0.41 | 0.38 | 0.35 | 0.31 |
| PHNPRO | | | 0.28 | 0.31 | 0.30 | 0.26 | 0.36 | 0.28 | 0.20 | 0.25 | | | 0.27 |
| SENREP | 0.23 | 0.25 | 0.45 | 0.28 | 0.24 | 0.19 | 0.28 | 0.14 | 0.25 | 0.33 | 0.29 | 0.19 | 0.26 |
| STYREC | | | 0.19 | 0.22 | | | | | | | | | |
| UNDDIR | 0.46 | 0.34 | 0.34 | 0.16 | | | | | | | | | |
| ***Gf*** | | | | | | | | | | | | | |
| NUMSER | | | 0.76 | 0.81 | 0.77 | 0.82 | 0.80 | 0.80 | 0.76 | 0.72 | 0.82 | 0.78 | 0.79 |
| NUMMAT | | | 0.66 | 0.72 | 0.73 | 0.72 | 0.75 | 0.75 | 0.77 | 0.77 | 0.78 | 0.80 | 0.75 |
| CONFRM | 0.63 | 0.60 | 0.65 | 0.67 | 0.61 | 0.64 | 0.68 | 0.69 | 0.74 | 0.72 | 0.71 | 0.70 | 0.69 |
| ANLSYN | | | 0.60 | 0.62 | 0.58 | 0.63 | 0.61 | 0.63 | 0.67 | 0.67 | 0.69 | 0.70 | 0.63 |
| VRBANL | 0.32 | 0.44 | | | 0.28 | 0.29 | 0.36 | 0.29 | 0.26 | 0.31 | 0.31 | 0.30 | 0.30 |
| ***Gwm*** | | | | | | | | | | | | | |
| VRBATN | 0.73 | 0.74 | 0.77 | 0.73 | 0.77 | 0.74 | 0.77 | 0.76 | 0.77 | 0.74 | 0.81 | 0.79 | 0.77 |
| OBJNUM | | | 0.77 | 0.74 | 0.68 | 0.70 | 0.74 | 0.74 | 0.79 | 0.78 | 0.81 | 0.77 | 0.75 |
| MEMWRD | 0.67 | 0.68 | 0.69 | 0.63 | 0.54 | 0.46 | 0.59 | 0.58 | 0.70 | 0.74 | 0.72 | 0.73 | 0.66 |
| UNDDIR | 0.29 | 0.37 | 0.41 | 0.56 | 0.64 | 0.64 | 0.66 | 0.65 | 0.69 | 0.65 | 0.68 | 0.69 | 0.65 |
| NWDREP | 0.59 | 0.67 | 0.51 | 0.50 | 0.50 | 0.62 | 0.43 | 0.58 | 0.60 | 0.62 | 0.64 | 0.66 | 0.59 |
| SENREP | 0.44 | 0.42 | 0.27 | 0.44 | 0.51 | 0.51 | 0.45 | 0.58 | 0.47 | 0.43 | 0.51 | 0.58 | 0.49 |
| NUMREV | 0.44 | 0.35 | 0.49 | 0.47 | 0.36 | 0.29 | 0.36 | 0.36 | 0.50 | 0.48 | 0.69 | 0.67 | 0.48 |
| LETPAT | | | | | | | | | 0.20 | 0.12 | 0.23 | 0.13 | |

***Table 5-15.*** *(cont.)*
*WJ IV CHC Broad 9-Factor (Top-Down; Model 2) CFA ML Model Results in Six Age Groups*

| | Age Group | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **3–5** | | **6–8** | | **9–13** | | **14–19** | | **20–39** | | **40–90+** | | |
| **Latent Factors/ Tests** | **MD** (*n* = 209) | **MCV** (*n* = 209) | **MD** (*n* = 412) | **MCV** (*n* = 411) | **MD** (*n* = 785) | **MCV** (*n* = 787) | **MD** (*n* = 842) | **MCV** (*n* = 843) | **MD** (*n* = 625) | **MCV** (*n* = 626) | **MD** (*n* = 571) | **MCV** (*n* = 574) | **Median** |
| ***Gs*** | | | | | | | | | | | | | |
| NUMPAT | 0.70 | 0.65 | 0.83 | 0.85 | 0.78 | 0.80 | 0.79 | 0.73 | 0.71 | 0.79 | 0.81 | 0.78 | 0.79 |
| LETPAT | | | 0.78 | 0.78 | 0.73 | 0.80 | 0.75 | 0.76 | 0.68 | 0.71 | 0.66 | 0.70 | 0.74 |
| WRDFLU | | | 0.69 | 0.68 | 0.69 | 0.70 | 0.72 | 0.64 | 0.72 | 0.74 | 0.71 | 0.74 | 0.70 |
| PAIRCN | | | 0.63 | 0.65 | 0.58 | 0.61 | 0.57 | 0.60 | 0.44 | 0.54 | 0.49 | 0.59 | 0.58 |
| MTHFLU | | | 0.53 | 0.60 | 0.52 | 0.54 | 0.50 | 0.48 | 0.52 | 0.42 | 0.51 | 0.54 | 0.52 |
| SNRDFL | | | 0.45 | 0.44 | 0.54 | 0.49 | 0.51 | 0.50 | 0.51 | 0.55 | 0.48 | 0.46 | 0.50 |
| SNWRFL | | | 0.43 | 0.47 | 0.49 | 0.50 | 0.46 | 0.49 | 0.51 | 0.51 | 0.50 | 0.41 | 0.49 |
| RPCNAM | 0.68 | 0.57 | | | 0.30 | 0.33 | 0.36 | 0.30 | 0.31 | 0.40 | 0.29 | 0.28 | 0.31 |
| RETFLU | 0.42 | 0.69 | | | 0.17 | 0.20 | 0.28 | 0.22 | 0.18 | 0.30 | 0.25 | 0.31 | 0.23 |
| CALC | | | 0.28 | 0.36 | 0.21 | 0.23 | 0.18 | 0.16 | 0.17 | 0.13 | 0.13 | 0.16 | 0.18 |
| ***Ga*** | | | | | | | | | | | | | |
| SEGMNT | 0.68 | 0.68 | 0.75 | 0.80 | 0.73 | 0.74 | 0.74 | 0.73 | 0.78 | 0.74 | 0.73 | 0.79 | 0.74 |
| SNDBLN | 0.62 | 0.68 | 0.63 | 0.54 | 0.62 | 0.56 | 0.65 | 0.66 | 0.69 | 0.70 | 0.70 | 0.73 | 0.65 |
| PHNPRO | 0.79 | 0.81 | 0.58 | 0.62 | 0.60 | 0.63 | 0.56 | 0.58 | 0.68 | 0.64 | 0.88 | 0.88 | 0.62 |
| SNDAWR | 0.77 | 0.85 | 0.60 | 0.50 | 0.51 | 0.49 | 0.53 | 0.56 | 0.65 | 0.62 | 0.66 | 0.74 | 0.58 |
| SPLSND | | | 0.47 | 0.47 | 0.48 | 0.48 | 0.56 | 0.56 | 0.53 | 0.48 | 0.54 | 0.60 | 0.51 |
| WRDATK | | | 0.24 | 0.27 | 0.23 | 0.22 | 0.27 | 0.29 | 0.25 | 0.22 | 0.24 | 0.23 | 0.24 |
| NWDREP | | | 0.18 | 0.20 | 0.19 | 0.07 | 0.22 | 0.11 | | | | | 0.18 |
| MEMWRD | | | | | 0.25 | 0.29 | 0.14 | 0.16 | | | | | |
| ***Glr*** | | | | | | | | | | | | | |
| STYREC | 0.50 | 0.60 | 0.45 | 0.35 | 0.51 | 0.58 | 0.57 | 0.62 | 0.56 | 0.55 | 0.61 | 0.62 | 0.57 |
| VAL | 0.58 | 0.54 | 0.51 | 0.47 | 0.42 | 0.44 | 0.51 | 0.48 | 0.59 | 0.60 | 0.54 | 0.61 | 0.51 |
| MEMNAM | 0.33 | 0.27 | 0.38 | 0.29 | 0.41 | 0.38 | 0.38 | 0.42 | 0.47 | 0.46 | 0.48 | 0.53 | 0.41 |
| RETFLU | | | 0.48 | 0.50 | 0.44 | 0.37 | 0.35 | 0.40 | 0.44 | 0.33 | 0.42 | 0.37 | 0.41 |
| RPCNAM | | | 0.45 | 0.40 | 0.27 | 0.22 | 0.16 | 0.20 | 0.25 | 0.16 | 0.30 | 0.27 | 0.26 |
| WRTSMP | | | 0.16 | 0.22 | 0.23 | 0.18 | 0.28 | 0.31 | 0.23 | 0.13 | 0.23 | 0.18 | 0.22 |
| RDGREC | | | 0.19 | 0.24 | 0.23 | 0.27 | 0.17 | 0.16 | | | | | 0.21 |
| ***Gv*** | | | | | | | | | | | | | |
| VISUAL | 0.58 | 0.54 | 0.77 | 0.70 | 0.63 | 0.74 | 0.65 | 0.70 | 0.75 | 0.75 | 0.74 | 0.73 | 0.74 |
| VISCLO | 0.58 | 0.69 | 0.55 | 0.48 | 0.59 | 0.55 | 0.61 | 0.59 | 0.62 | 0.61 | 0.65 | 0.60 | 0.60 |
| PICREC | 0.65 | 0.62 | 0.64 | 0.57 | 0.49 | 0.52 | 0.34 | 0.40 | 0.47 | 0.45 | 0.50 | 0.49 | 0.49 |
| PAIRCN | | | | | 0.20 | 0.16 | 0.24 | 0.18 | 0.35 | 0.31 | 0.28 | 0.14 | 0.22 |
| ***Grw*** | | | | | | | | | | | | | |
| LWIDNT | 0.88 | 0.90 | 0.93 | 0.93 | 0.88 | 0.91 | 0.90 | 0.90 | 0.92 | 0.92 | 0.92 | 0.93 | 0.92 |
| SPELL | 0.80 | 0.85 | 0.87 | 0.86 | 0.87 | 0.88 | 0.88 | 0.87 | 0.86 | 0.86 | 0.89 | 0.90 | 0.87 |
| EDIT | | | 0.79 | 0.81 | 0.81 | 0.84 | 0.81 | 0.83 | 0.81 | 0.82 | 0.85 | 0.85 | 0.81 |
| ORLRDG | | | 0.82 | 0.85 | 0.76 | 0.79 | 0.79 | 0.78 | 0.80 | 0.84 | 0.85 | 0.85 | 0.81 |
| WRDATK | | | 0.64 | 0.62 | 0.61 | 0.65 | 0.59 | 0.57 | 0.60 | 0.62 | 0.62 | 0.64 | 0.62 |
| PSGCMP | 0.75 | 0.77 | 0.70 | 0.69 | 0.54 | 0.61 | 0.59 | 0.56 | 0.47 | 0.50 | 0.54 | 0.56 | 0.56 |
| RDGREC | | | 0.60 | 0.51 | 0.42 | 0.45 | 0.45 | 0.48 | 0.60 | 0.58 | 0.69 | 0.67 | 0.55 |
| SNRDFL | | | 0.57 | 0.51 | 0.46 | 0.50 | 0.46 | 0.47 | 0.52 | 0.45 | 0.53 | 0.53 | 0.50 |
| WRTSMP | | | 0.59 | 0.54 | 0.41 | 0.54 | 0.45 | 0.42 | 0.45 | 0.56 | 0.51 | 0.60 | 0.53 |
| SNWRFL | | | 0.55 | 0.48 | 0.45 | 0.45 | 0.45 | 0.42 | 0.47 | 0.42 | 0.45 | 0.52 | 0.45 |
| RDGVOC | | | 0.47 | 0.47 | 0.43 | 0.45 | 0.40 | 0.45 | 0.42 | 0.38 | 0.41 | 0.45 | 0.44 |
| SPLSND | | | 0.45 | 0.44 | 0.42 | 0.42 | 0.35 | 0.33 | 0.33 | 0.39 | 0.36 | 0.31 | 0.37 |
| SNDAWR | | | 0.28 | 0.37 | 0.33 | 0.39 | 0.30 | 0.25 | 0.16 | 0.24 | 0.22 | 0.12 | 0.27 |
| WRDFLU | | | 0.29 | 0.21 | 0.27 | 0.22 | 0.17 | 0.24 | 0.28 | 0.20 | 0.26 | 0.21 | 0.23 |

**Table 5-15.** *(cont.)*
*WJ IV CHC Broad 9-Factor (Top-Down; Model 2) CFA ML Model Results in Six Age Groups*

| Latent Factors/ Tests | 3–5 MD (*n* = 209) | 3–5 MCV (*n* = 209) | 6–8 MD (*n* = 412) | 6–8 MCV (*n* = 411) | 9–13 MD (*n* = 785) | 9–13 MCV (*n* = 787) | 14–19 MD (*n* = 842) | 14–19 MCV (*n* = 843) | 20–39 MD (*n* = 625) | 20–39 MCV (*n* = 626) | 40–90+ MD (*n* = 571) | 40–90+ MCV (*n* = 574) | Median |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Gq*** | | | | | | | | | | | | | |
| APPROB | 0.84 | 0.84 | 0.90 | 0.88 | 0.90 | 0.89 | 0.92 | 0.92 | 0.94 | 0.92 | 0.93 | 0.92 | 0.92 |
| NUMSEN | 0.92 | 0.92 | 0.85 | 0.85 | 0.82 | 0.83 | 0.89 | 0.88 | 0.89 | 0.89 | 0.90 | 0.88 | 0.88 |
| CALC | | | 0.68 | 0.60 | 0.70 | 0.69 | 0.77 | 0.76 | 0.78 | 0.76 | 0.80 | 0.79 | 0.76 |
| MTHFLU | | | 0.41 | 0.30 | 0.40 | 0.36 | 0.38 | 0.39 | 0.42 | 0.44 | 0.40 | 0.37 | 0.39 |
| NUMREV | 0.34 | 0.31 | 0.19 | 0.21 | 0.26 | 0.39 | 0.32 | 0.33 | 0.22 | 0.24 | | | 0.25 |

*Note.* MD = model development sample; MCV = model cross-validation sample. Factor parameter estimates are maximum-likelihood (ML) estimates. Underlined font parameter estimates were not significant in the MCV sample ($p < .05$). Latent factor loadings on *g* and test loadings on broad CHC factors were sorted by median factor parameter loadings for ages 6 through 90+ samples. Median values only reported for tests that had significant loadings in the majority of samples. Italic font = Heywood cases constrained/fixed to 1.0. Blanks for tests under factors indicate that a test/factor loading was not specified in that sample.

The CFA factor pattern loadings results for Model 2 reveal the following general findings and conclusions:

- The large number of significant model parameters in the MD and MCV samples supports the generalizability and stability of the structural validity of Model 2 for the WJ IV. All but four of the model parameters were significant in the MCV samples. The *Ga* loading (.07) for Nonword Repetition at ages 9 through 13 was not significant in the MCV sample. The other three nonsignificant parameters were test residuals (see Table 5-20).
- The high loadings of the broad CHC ability factors (median loadings from .79 to .95, except .59 on *Gs*) on the general intelligence factor (*g*) indicate that the respective WJ IV clusters represent broad abilities that are influenced to a significant degree by general intelligence (*g*).
- The pattern of CHC *g*-factor loadings is generally consistent with the extant research (Carroll, 1993). The high median *g* loadings of .94 and .84 for *Gf* and *Gc*, and the lowest median loading for *Gs* (.59), are consistent with Carroll (1993). The high median *Gq* loading (.89) is consistent with the finding of Keith, Low, and colleagues (Keith, Low, Reynolds, Patel, & Ridley, 2010; Keith & Reynolds, 2010, 2012), where individual *Gq*-RQ or *Gq* tests from the DAS, DAS-II, and Wechsler batteries (e.g., DAS Sequential and Quantitative Reasoning, Wechsler Arithmetic) show the highest loadings on a *g* factor.
- The highest median *g* loading for the *Glr* factor (.95) is noteworthy. *Glr* measures are underrepresented in most intelligence batteries and, thus, the high *Glr g* loading is not a commonly reported finding. However, in a recent cross-battery, reference variable CHC-based CFA analysis of the WISC-III, WISC-IV, KABC-II, and WJ III (Reynolds, Keith, Flanagan, & Alfonso, 2013), an associative memory factor (*Glr*-MA) defined by the KABC-II and WJ III associative memory tests was the second-highest-loading factor on *g*. As noted by Reynolds et al. (2013), "it has been hypothesized that if scores from several new learning tasks were factor analyzed, the general factor obtained from that analysis would be highly correlated with a g factor extracted from an intelligence battery (Jensen, 1989)." (p. 552)

The magnitude of the factor loadings reported for the various tests in Table 5-15 provides structural validity evidence supporting the primary WJ IV COG test and cluster structure. The loadings for the primary tests for the featured WJ IV COG, OL, and ACH clusters are all positive, high, and significant. Table 5-16, which is a modified version of the WJ IV COG selective testing table from Chapter 1 (Table 1-1), demonstrates this point for the primary WJ IV COG interpretive clusters by summarizing the median factor loadings across all age groups from Tables 5-6 and 5-15 for the COG tests.[35]

***Table 5-16.***
*Median Broad CHC Factor Loadings (Model 2) for Primary WJ IV COG Clusters (Organized per Modified WJ IV COG Selective Testing Table)*

| | | | Cognitive Composite Clusters[a] | | | CHC Factors & Clusters[b] | | | | | | | Other CHC Factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Battery & Test Number | Test Name | General Intellectual Ability (*GIA*) | Brief Intellectual Ability (*BIA*) | *Gf-Gc* Composite | Comprehension-Knowledge (*Gc*) | Fluid Reasoning (*Gf*) | Short-Term Working Memory (*Gwm*) | Cognitive Processing Speed (*Gs*) | Auditory Processing (*Ga*) | Long-Term Retrieval (*Glr*) | Visual Processing (*Gv*) | Quantitative Knowledge (*Gq*) |
| Cognitive Standard Battery | COG 1 | Oral Vocabulary | **0.72** | **0.72** | **0.72** | **0.87** | | | | | | | |
| | COG 2 | Number Series | **0.62** | **0.62** | **0.62** | | **0.79** | | | | | | |
| | COG 3 | Verbal Attention | **0.64** | **0.64** | | | | **0.77** | | | | | |
| | COG 4 | Letter-Pattern Matching | **0.57** | | | | | | **0.74** | | | | |
| | COG 5 | Phonological Processing | **0.71** | | | 0.27 | | | | **0.62** | | | |
| | COG 6 | Story Recall | **0.58** | | | | | | | | **0.57** | | |
| | COG 7 | Visualization | **0.61** | | | | | | | | | **0.74** | |
| | COG 8 | General Information | | | **0.59** | **0.78** | | | | | | | |
| | COG 9 | Concept Formation | | | **0.66** | | **0.69** | | | | | | |
| | COG 10 | Numbers Reversed | | | | | | **0.48** | | | | | 0.25 |
| Cognitive Extended Battery | COG 11 | Number-Pattern Matching | | | | | | | | | | | |
| | COG 12 | Nonword Repetition | | | | | | 0.59 | | **0.18** | | | |
| | COG 13 | Visual-Auditory Learning | | | | | | | | | **0.51** | | |
| | COG 14 | Picture Recognition | | | | | | | | | | **0.49** | |
| | COG 15 | Analysis-Synthesis | | | | | *0.63* | | | | | | |
| | COG 16 | Object-Number Sequencing | | | | | | *0.75* | | | | | |
| | COG 17 | Pair Cancellation | | | | | | | **0.58** | | | 0.22 | |
| | COG 18 | Memory for Words | | | | | | | | | | | |
| Other Tests | OL 1 | Picture Vocabulary | | | | *0.82* | | | | | | | |
| | OL 5 | Sentence Repetition | | | | | | | | | | | |

*Note*. Gray shading designates loadings on other CHC factors not listed in CHC Factors and Clusters section. Bold font = tests required to create the primary cluster listed. Italic font = tests required to create the extended cluster listed. Regular font = loading on other nontarget CHC factors.

[a] Indicates median *g* loadings from Table 5-6.

[b] Indicates median CHC factor loadings from Table 5-15.

[35] Tables 5-16, 5-17, and 5-18 were constructed to facilitate the interpretation of the large number of test factor loadings across all ages and two types of analyses. Tables 5-6 and 5-15 should be inspected for age-specific findings and developmental trends.

- The tests that compose the three COG clusters used for estimating general intellectual ability (GIA, BIA, and *Gf-Gc* Composite clusters) all display high, positive, and significant median loadings (.57 to .72) on the first general factor extracted via the common-factor or principal axis factor analysis method (see Table 5-6). These results support the validity of the COG GIA, BIA, and *Gf-Gc* Composite clusters as valid proxies for general intelligence (*g*).
- Table 5-16 also provides support for the structural validity of the seven WJ IV CHC factors; six of the CHC clusters (*Gc*–Comprehension-Knowledge, *Gf*–Fluid Reasoning, *Gwm*–Short-Term Working Memory, *Gs*–Cognitive Processing Speed, *Ga*–Auditory Processing, and *Gv*–Visual Processing) have at least one test that has a median loading .62 or higher on its respective factor.[36]
- The high loadings on the Comprehension-Knowledge (*Gc*) and Fluid Reasoning (*Gf*) clusters provide particularly strong support for the structure of these clusters. The two primary *Gc* cluster tests of Oral Vocabulary and General Information have median loadings of .87 and .78, respectively. The *Gc*–Extended cluster also includes Picture Vocabulary, with a median loading of .82. The three *Gf* tests have median *Gf* loadings of .79 (Number Series), .69 (Concept Formation), and .63 (Analysis-Synthesis).
- The evidence also supports the structural validity of the Short-Term Working Memory (*Gwm*), Cognitive Processing Speed (*Gs*), Long-Term Retrieval (*Glr*), and Visual Processing (*Gv*) clusters. Each of these primary clusters is composed of two tests with median loadings in the .48 to .77 range. The dual factor loading for Numbers Reversed warrants comment. This test had a median loading of .48 on *Gwm* and a secondary median loading of .25 on the *Gq* factor. Task analysis of Numbers Reversed (see Chapter 2 in the WJ IV COG Examiner's Manual (Mather & Wendling, 2014b); see also Table 5-2 and the earlier discussion of validity evidence related to test content in the current chapter) indicates that math achievement skills are not involved in the backward repetition of digits. The secondary *Gq* loading most likely represents the stimulus characteristics (i.e., numerals) of Numbers Reversed—it is a *Gwm* test that taps domain-specific processing of numbers in working memory.
- Interpretation of the structural validity evidence for the Auditory Processing cluster (*Ga*) requires the context of the "beyond CHC theory" material presented in Chapter 1 and Appendix A. The moderate median *Ga* factor loading (.62) supports the inclusion of Phonological Processing in the *Ga* cluster. The median *Ga* loading for Nonword Repetition is only .18; in contrast, Nonword Repetition displays a median *Gwm* loading of .59. This finding informed the proposed revision of the narrow memory for sound patterns (*Ga*-UM) factor definition in CHC theory (see Chapter 1 and Appendix A). Nonword Repetition is believed to measure *Ga*-UM; the proposed expanded definition of *Ga*-UM includes *both* nonspeech and speech sounds as well as phonological processing and storage.

Given that most of the WJ IV OL and ACH clusters were not designed to represent pure CHC factors, but instead are combinations of tests reflecting practical (school curriculum content distinctions), functional, or legal (e.g., federal SLD guidelines) composites, they are

[36] Structural validity evidence for the WJ IV COG clusters does not necessarily require that two combined tests demonstrate high (>.70) factor loadings. In fact, high test factor loadings may be an indicator of limited factor breadth. When indicators of different aspects of a given construct domain are adequately sampled, a factor with all moderate factor loadings may, in fact, be generalized to more external criteria. In the test reliability literature this phenomenon is referred to as the "attenuation paradox" (Boyle, 1991; Clark & Watson, 1995; Loevinger, 1957). This paradox states that if a test's inter-item correlations are too high, it may be homogeneous and reliable, but it also may have become so narrow in content coverage that its validity has been compromised. The same principle holds for the correlation of test factor indicators, where maximizing the absolute magnitude of indices of factor homogeneity (e.g., factor loadings) may occur at the expense of factor breadth and validity. In other words, one may end up with a narrow factor with test indicators that tap similar abilities, rather than a factor that more adequately samples different aspects of the construct domain. Thus, the moderate to high (approximately .50 to .70 range) factor loadings for the tests on the WJ IV COG clusters provides support for the structural validity of the WJ IV COG.

often mixed measures of different CHC abilities. Evidence for the structural validity of the primary WJ IV OL and ACH clusters is summarized in Tables 5-17 and 5-18, respectively.

***Table 5-17.***
*Median Broad CHC Factor Loadings (Model 2) for Primary WJ IV OL Clusters (Organized per Modified WJ IV OL Selective Testing Table)*

| | | | Oral Language Clusters[a] | | | | | | Other CHC Factors | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Battery & Test Number | Test Name | Oral Language (*Gc*) | Broad Oral Language (*Gc*) | Oral Expression (*Gc*) | Listening Comprehension (*Gc*) | Phonetic Coding (*Ga*) | Speed of Lexical Access (*Glr*) | Short-Term Working Memory (*Gwm*) | Processing Speed (*Gs*) |
| Oral Language Battery | OL 1 | Picture Vocabulary | 0.82 | 0.82 | 0.82 | | | | | |
| | OL 2 | Oral Comprehension | 0.79 | 0.79 | | 0.79 | | | | |
| | OL 3 | Segmentation | | | | | 0.74 | | | |
| | OL 4 | Rapid Picture Naming | | | | | | 0.26 | | 0.31 |
| | OL 5 | Sentence Repetition | | | 0.26 | | | | 0.49 | |
| | OL 6 | Understanding Directions | | 0.00 | | 0.00 | | | 0.65 | |
| | OL 7 | Sound Blending | | | | | 0.65 | | | |
| | OL 8 | Retrieval Fluency | | | | | | 0.41 | | 0.23 |
| | OL 9 | Sound Awareness | | | | | | | | |

*Note*. Gray shading designates loadings on other CHC factors not listed in Oral Language Clusters section.
[a] Indicates median CHC factor loadings from Table 5-15.

- With the exception of the Speed of Lexical Access cluster, each of the WJ IV OL clusters presented in Table 5-17 consists of at least one test with a strong, positive, significant factor loading (median factor loadings of .70 or higher across age groups) on the domain-relevant *Gc* and *Ga* factors. The Oral Language and Broad Oral Language clusters include two tests with median loadings of .79 or higher. The Listening Comprehension cluster includes one test (Oral Comprehension) with a *Gc* loading of .79 and a *Gwm* loading of .65 for Understanding Directions, a measure of verbal working memory.
- As described in Chapter 1 and Appendix A, the Speed of Lexical Access cluster is a cognitively complex measure of the efficiency and quickness with which individuals are able to retrieve words (comprehension-knowledge–*Gc*) from long-term storage (*Glr*). The median dual factor loadings for Rapid Picture Naming (*Glr* = .26, *Gs* = .31) and Retrieval Fluency (*Glr* = .41, *Gs* = .23) support the interpretation of the Speed of Lexical Access cluster as a measure of rapid and fluent retrieval of information from an individual's lexicon.
- As summarized in Table 5-18, all nonspeeded reading and writing tests included in the primary WJ IV ACH clusters demonstrate moderate to high median *Grw* factor loadings (.50 to .90 range). This supports the structural validity of the reading and writing clusters. The moderate to strong math test loadings for the four math ACH clusters also provide structural validity evidence. The median *Gq* test factor loading (for nonspeeded tests) for each math cluster ranges from .75 (Math Problem Solving cluster, Number Matrices test, *Gf*-RQ loading) to .92 (Applied Problems). As expected, the various fluency tests included in the Broad Reading, Reading Fluency, Reading Rate, Broad

***Table 5-18.***
*Median Broad CHC Factor Loadings (Model 2) for Primary WJ IV ACH Clusters (Organized per Modified WJ IV ACH Selective Testing Table)*

| | | | Reading (*Grw*)[a] | | | | | | Math (*Gq*)[a] | | | | Writing (*Grw*)[a] | | | | Other CHC Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Battery & Test Number | Test Name | Reading | Broad Reading | Basic Reading Skills | Reading Comprehension | Reading Fluency | Reading Rate | Mathematics | Broad Mathematics | Math Calculation Skills | Math Problem Solving | Written Language | Broad Written Language | Basic Writing Skills | Written Expression | Auditory Processing (*Ga*) | Processing Speed (*Gs*) | Fluid Reasoning (*Gf*-RQ) | Long-Term Retrieval (*Glr*) | Comprehension-Knowledge (*Gc*) |
| Achievement Standard Battery | ACH 1 | Letter-Word Identification | **0.92** | **0.92** | **0.92** | | | | | | | | | | | | | | | | |
| | ACH 2 | Applied Problems | | | | | | | **0.92** | **0.92** | | **0.92** | | | | | | | | | |
| | ACH 3 | Spelling | | | | | | | | | | | **0.87** | **0.87** | **0.87** | | | | | | |
| | ACH 4 | Passage Comprehension | **0.56** | **0.56** | | **0.56** | | | | | | | | | | | | | | | **0.31** |
| | ACH 5 | Calculation | | | | | | | **0.76** | **0.76** | **0.76** | | | | | | | | | | |
| | ACH 6 | Writing Samples | | | | | | | | | | | **0.53** | **0.53** | | **0.53** | | | | **0.22** | |
| | ACH 7 | Word Attack | | | **0.62** | | | | | | | | | | | | **0.24** | | | | |
| | ACH 8 | Oral Reading | | | | | **0.81** | | | | | | | | | | | | | | |
| | ACH 9 | Sentence Reading Fluency | | **0.50** | | | **0.50** | **0.50** | | | | | | | | | | **0.50** | | | |
| | ACH 10 | Math Facts Fluency | | | | | | | | **0.39** | **0.39** | | | | | | | **0.52** | | | |
| | ACH 11 | Sentence Writing Fluency | | | | | | | | | | | | **0.45** | | **0.45** | | **0.49** | | | |
| Achievement Extended Battery | ACH 12 | Reading Recall | | | | **0.55** | | | | | | | | | | | | | | 0.21 | |
| | ACH 13 | Number Matrices | | | | | | | | | | **0.00** | | | | | | | **0.75** | | |
| | ACH 14 | Editing | | | | | | | | | | | | | **0.81** | | | | | | |
| | ACH 15 | Word Reading Fluency | | | | | | **0.23** | | | | | | | | | | 0.70 | | | |
| | ACH 16 | Spelling of Sounds | | | | | | | | | | | | | | | 0.51 | | | | |
| | ACH 17 | Reading Vocabulary | | | | *0.44* | | | | | | | | | | | | | | | 0.52 |
| | ACH 18 | Science | | | | | | | | | | | | | | | | | | | **0.77** |
| | ACH 19 | Social Studies | | | | | | | | | | | | | | | | | | | **0.83** |
| | ACH 20 | Humanities | | | | | | | | | | | | | | | | | | | **0.81** |

*Note*. Gray shading designates loadings on other CHC factors not listed in curricular section. Bold font = tests required to create the primary cluster listed. Italic font = tests required to create the extended cluster listed. Regular font = loading on other nontarget CHC factor. Rectangle in lower right corner reflects *Gc* loadings for Science, Social Studies, and Humanities, which compose the Academic Knowledge cluster.

[a] Indicates median CHC factor loadings from Table 5-15.

Mathematics, Math Calculation Skills, Broad Written Language, and Written Expression clusters demonstrate dual loadings on their respective CHC achievement factors (*Grw* or *Gq*) and the processing speed (*Gs*) factor. This indicates that the academic fluency tests measure both the *level* and *rate* (Carroll, 1993) characteristics of achievement. The expected CHC factorial complexity of several achievement tests included in the ACH clusters is reflected by significant median loadings for *Gc* (Passage Comprehension, .31; Reading Vocabulary, .52), *Glr* (Writing Samples, .22; Reading Recall, .21), and *Ga* (Word Attack, .24; Spelling of Sounds, .51). The secondary CHC cognitive factor loadings for some of the achievement tests may reflect causal influences.

Inspection of the results by age groups in Table 5-15 provides important information regarding the validity of test and associated cluster score interpretations across the life span. The CHC interpretation of most of the WJ IV tests remains relatively invariant across the entire age range. For example, Oral Vocabulary loads at consistently high levels on the *Gc* factor (.77 to .89 across all samples). Most factorially complex tests also are consistent across age groups and samples. For example, Reading Vocabulary loads consistently on both the *Grw* (.38 to .47) and *Gc* (.49 to .56) factors. However, a study of Table 5-15 also reveals a number of age-related trends. The most consistent and salient developmental findings are noted for the following tests:

- *Understanding Directions.* This test is a mixed measure of *Gc*-LS (listening ability) and *Gwm* at the preschool (ages 3 through 5) and early school years (ages 6 through 8). At ages 9 and above Understanding Directions is primarily a measure of *Gwm*-WM (working memory).
- *Letter-Pattern Matching.* This test is consistently a strong indicator of *Gs* (median loading = .74) at all ages. It displays small (.13 to .23), yet significant, *Gwm* factor loadings in the adult samples (ages 20 years and above). Because adult examinees typically reach the more difficult items on the test (consisting of items containing 3- to 5-letter combinations), it may be that the increased complexity of the processing demands taps working memory abilities at these ages.
- *Nonword Repetition.* An interpretation of the dual factor loadings for this *Ga* test was presented previously in this section. The test appears consistent in *Gwm* demands across ages (median loading = .59). Its *Ga* loading is low (.07 to .22) from ages 6 through 19. As discussed previously, these findings suggest that Nonword Repetition is a measure of memory for sound patterns (*Ga*-UM), a narrow ability that is an amalgam of *Ga* and *Gwm* abilities (phonological processing and phonological storage).
- *Pair Cancellation.* This test displays moderate *Gs* loadings (mid-.50s to mid-.60s) in the school-age ranges, followed by a slight decrease in *Gs* loadings (mid-.40s to high-.50s) in adulthood. For ages 9 and older, this test appears to require some visual processing (*Gv*) abilities, albeit at lower levels (loadings range from .14 to .35). Pair Cancellation requires examinees to scan a complex array of visual stimuli and find a pattern (SS-spatial scanning), which might explain the *Gv* influence for this test.
- *Reading Recall.* This test demonstrates consistent *Grw* loadings (median loading = .55). The involvement of meaningful memory (*Glr*-MM) is suggested at a low, but significant, level (.16 to .27) during the school-age years.
- *Phonological Processing.* This test demonstrates significant *Ga* loadings at all ages (median loading = .62) as well as significant but smaller loadings on *Gc* (ranging from .20 to .36) from ages 6 through 39. However, for the youngest (ages 3 through 5) and oldest (ages 40 through 90+) age groups, the Phonological Processing test is a purer measure of *Ga*, with loadings ranging from .79 to .88.
- *Rapid Picture Naming and Retrieval Fluency*. These two tests display similar developmental trends. Both tests load at moderate to high levels (ranging from .42 to

.69) on the *Gs* factor in the preschool age group (ages 3 through 5). Neither of these tests loaded on the *Glr* factor at the preschool age level. After the preschool years, the *Gs* loadings are either nonsignificant or noticeably lower (.20 to .30 range). Processing speed appears more important for performance of the tasks in these two tests during the preschool years. From ages 6 through adulthood, both of these tests demonstrate significant loadings on the *Glr* factor. The Retrieval Fluency test demonstrates higher *Glr* loadings from ages 6 through adult (median = .41) when compared to the Rapid Picture Naming test (median = .26). Potentially important insights into the abilities measured by these two tests, which form the narrow Speed of Lexical Access (*Glr*-LA) factor cluster, are reported in the discussion of the Model 3 (broad plus narrow CHC bottom-up) results.

Table 5-19 presents all test and factor loading parameters for Model 3 (broad plus narrow CHC factor bottom-up) for the MD and MCV samples across all age groups. As noted previously, Model 2 is the most parsimonious and plausible structural model for the WJ IV battery; however, the more complex Model 3 (see Figure 5-14) offers potential insights that warrant future research. Only the findings across age groups are discussed here. Developmental differences for tests or clusters can be ascertained by studying the complete set of results in Table 5-19.

***Table 5-19.***
*WJ IV CHC Broad+Narrow 13-Factor (Bottom Up; Model 3) CFA ML Model Results in Five Age Groups*

| | Age Group | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6–8 | | 9–13 | | 14–19 | | 20–39 | | 40–90+ | | |
| **Latent Factors/ Tests** | **MD** (*n* = 412) | **MCV** (*n* = 411) | **MD** (*n* = 785) | **MCV** (*n* = 787) | **MD** (*n* = 842) | **MCV** (*n* = 843) | **MD** (*n* = 625) | **MCV** (*n* = 626) | **MD** (*n* = 571) | **MCV** (*n* = 574) | **Median** |
| ***g*** | | | | | | | | | | | |
| *Gf* | *1.00* | *1.00* | 0.96 | *1.00* | 0.98 | 0.99 | *1.00* | *1.00* | *1.00* | *1.00* | *1.00* |
| *Gq* | 0.86 | 0.89 | 0.84 | 0.91 | 0.91 | 0.88 | 0.86 | 0.87 | 0.90 | 0.90 | 0.89 |
| *Glr* | 0.82 | 0.83 | 0.96 | 0.85 | 0.79 | 0.86 | 0.83 | 0.85 | 0.93 | 0.94 | 0.85 |
| *Gc* | 0.71 | 0.66 | 0.77 | 0.76 | 0.82 | 0.83 | 0.86 | 0.83 | 0.88 | 0.86 | 0.83 |
| *Gv* | 0.78 | 0.74 | 0.69 | 0.74 | 0.81 | 0.86 | 0.83 | 0.83 | 0.84 | 0.85 | 0.82 |
| *Grw* | 0.77 | 0.79 | 0.80 | 0.82 | 0.80 | 0.79 | 0.81 | 0.78 | 0.82 | 0.82 | 0.80 |
| *Ga* | 0.80 | 0.76 | 0.57 | 0.61 | 0.73 | 0.77 | 0.80 | 0.79 | 0.81 | 0.85 | 0.78 |
| *Gwm* | 0.71 | 0.75 | 0.74 | 0.71 | 0.74 | 0.76 | 0.76 | 0.78 | 0.78 | 0.83 | 0.76 |
| *Gs* | 0.52 | 0.62 | 0.49 | 0.64 | 0.61 | 0.56 | 0.41 | 0.57 | 0.58 | 0.59 | 0.57 |
| ***Gc*** | | | | | | | | | | | |
| SOC | 0.78 | 0.83 | 0.81 | 0.81 | 0.85 | 0.84 | 0.86 | 0.84 | 0.87 | 0.84 | 0.84 |
| PICVOC | 0.79 | 0.80 | 0.79 | 0.83 | 0.84 | 0.84 | 0.86 | 0.83 | 0.85 | 0.80 | 0.83 |
| HUM | 0.75 | 0.76 | 0.80 | 0.77 | 0.80 | 0.83 | 0.85 | 0.85 | 0.86 | 0.86 | 0.82 |
| ORLCMP | 0.76 | 0.71 | 0.79 | 0.73 | 0.78 | 0.79 | 0.81 | 0.79 | 0.83 | 0.83 | 0.79 |
| SCI | 0.76 | 0.73 | 0.78 | 0.73 | 0.79 | 0.80 | 0.81 | 0.77 | 0.83 | 0.81 | 0.79 |
| GENINF | 0.65 | 0.69 | 0.73 | 0.72 | 0.77 | 0.77 | 0.80 | 0.81 | 0.81 | 0.80 | 0.77 |
| ORLVOC | 0.72 | 0.69 | 0.75 | 0.75 | 0.68 | 0.78 | 0.67 | 0.76 | 0.76 | 0.80 | 0.75 |
| RDGVOC | 0.46 | 0.49 | 0.48 | 0.47 | 0.53 | 0.50 | 0.49 | 0.54 | 0.54 | 0.51 | 0.50 |
| VRBANL | 0.44 | 0.40 | 0.49 | 0.47 | 0.43 | 0.50 | 0.47 | 0.48 | 0.48 | 0.54 | 0.48 |
| SENREP | 0.44 | 0.29 | 0.25 | 0.23 | 0.30 | 0.16 | 0.31 | 0.36 | 0.36 | 0.23 | 0.30 |
| UNDDIR | 0.34 | 0.16 | 0.20 | 0.24 | 0.16 | 0.09 | 0.21 | 0.14 | 0.34 | <u>0.09</u> | 0.18 |
| STYREC | 0.25 | 0.25 | | | | | | | | | |
| **<u>LA</u>** | 0.47 | 0.47 | 0.43 | 0.44 | 0.43 | 0.49 | 0.39 | 0.33 | 0.20 | 0.26 | 0.43 |
| RETFLU | 0.70 | 0.64 | 0.73 | 0.73 | 0.70 | 0.68 | 0.74 | 0.69 | 0.74 | 0.75 | 0.71 |
| RPCNAM | 0.45 | 0.36 | 0.42 | 0.44 | 0.37 | 0.36 | 0.40 | 0.34 | 0.47 | 0.43 | 0.41 |
| PHNPRO | 0.41 | 0.50 | 0.39 | 0.43 | 0.46 | 0.37 | 0.26 | 0.45 | 0.36 | 0.29 | 0.40 |

**Table 5-19.** *(cont.)*
*WJ IV CHC Broad+Narrow 13-Factor (Bottom Up; Model 3) CFA ML Model Results in Five Age Groups*

| Latent Factors/ Tests | Age Group | | | | | | | | | | Median |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6–8 | | 9–13 | | 14–19 | | 20–39 | | 40–90+ | | |
| | MD (*n* = 412) | MCV (*n* = 411) | MD (*n* = 785) | MCV (*n* = 787) | MD (*n* = 842) | MCV (*n* = 843) | MD (*n* = 625) | MCV (*n* = 626) | MD (*n* = 571) | MCV (*n* = 574) | |
| ***Gf*** | | | | | | | | | | | |
| ***Gf*-Verbal** | 0.89 | 0.84 | 0.75 | 0.78 | 0.88 | 0.88 | 0.89 | 0.92 | 0.88 | 0.87 | 0.88 |
| CONFRM | 0.71 | 0.77 | 0.77 | 0.79 | 0.75 | 0.76 | 0.78 | 0.75 | 0.77 | 0.77 | 0.77 |
| ANLSYN | 0.63 | 0.67 | 0.47 | 0.54 | 0.37 | 0.51 | 0.45 | 0.61 | 0.50 | 0.45 | 0.50 |
| VRBANL | 0.41 | 0.47 | 0.43 | 0.43 | 0.48 | 0.41 | 0.45 | 0.44 | 0.45 | 0.40 | 0.43 |
| PSGCMP | 0.18 | 0.24 | 0.15 | 0.13 | 0.27 | 0.29 | 0.35 | 0.34 | 0.26 | 0.27 | 0.27 |
| ORLVOC | 0.15 | 0.23 | 0.18 | 0.13 | 0.23 | 0.12 | 0.24 | 0.16 | 0.14 | 0.10 | 0.15 |
| ***Gf*-Quantitative** | 0.87 | 0.93 | 0.86 | 0.88 | 0.88 | 0.85 | 0.86 | 0.82 | 0.86 | 0.88 | 0.87 |
| NUMSER | 0.86 | 0.86 | 0.85 | 0.89 | 0.86 | 0.87 | 0.81 | 0.81 | 0.88 | 0.82 | 0.86 |
| NUMMAT | 0.69 | 0.71 | 0.77 | 0.74 | 0.79 | 0.80 | 0.82 | 0.85 | 0.83 | 0.85 | 0.80 |
| ANLSYN | | | 0.19 | 0.19 | 0.26 | 0.16 | 0.26 | 0.09 | 0.22 | 0.29 | 0.20 |
| APPROB | | | 0.30 | 0.15 | 0.17 | 0.17 | 0.20 | 0.16 | 0.20 | 0.08 | 0.17 |
| ***Gwm*** | | | | | | | | | | | |
| OBJNUM | 0.78 | 0.75 | 0.70 | 0.72 | 0.76 | 0.75 | 0.81 | 0.80 | 0.84 | 0.79 | 0.77 |
| VRBATN | 0.77 | 0.72 | 0.79 | 0.74 | 0.75 | 0.76 | 0.77 | 0.74 | 0.81 | 0.78 | 0.76 |
| MEMWRD | 0.69 | 0.64 | 0.49 | 0.53 | 0.72 | 0.70 | 0.72 | 0.75 | 0.74 | 0.74 | 0.71 |
| UNDDIR | 0.42 | 0.55 | 0.55 | 0.46 | 0.52 | 0.57 | 0.52 | 0.52 | 0.40 | 0.62 | 0.52 |
| NWDREP | 0.49 | 0.48 | 0.44 | 0.59 | 0.43 | 0.58 | 0.49 | 0.49 | 0.63 | 0.66 | 0.49 |
| NUMREV | 0.47 | 0.47 | 0.31 | 0.33 | 0.42 | 0.40 | 0.51 | 0.50 | 0.56 | 0.42 | 0.44 |
| SENREP | 0.28 | 0.44 | 0.52 | 0.48 | 0.44 | 0.57 | 0.41 | 0.40 | 0.44 | 0.56 | 0.44 |
| LETPAT | | | | | | | 0.23 | 0.15 | 0.26 | 0.17 | |
| **LA**[a] | 0.48 | 0.52 | 0.42 | 0.41 | 0.47 | 0.40 | 0.43 | 0.53 | 0.70 | 0.56 | 0.48 |
| ***Gs*** | | | | | | | | | | | |
| NUMPAT | 0.83 | 0.85 | 0.85 | 0.80 | 0.79 | 0.73 | 0.70 | 0.79 | 0.80 | 0.77 | 0.80 |
| LETPAT | 0.78 | 0.79 | 0.80 | 0.80 | 0.76 | 0.76 | 0.66 | 0.71 | 0.65 | 0.68 | 0.76 |
| WRDSPD | 0.67 | 0.66 | 0.63 | 0.69 | 0.71 | 0.64 | 0.71 | 0.73 | 0.72 | 0.73 | 0.70 |
| PAIRCN | 0.66 | 0.67 | 0.58 | 0.60 | 0.58 | 0.59 | 0.44 | 0.54 | 0.41 | 0.51 | 0.58 |
| MTHSPD | 0.53 | 0.60 | 0.56 | 0.54 | 0.50 | 0.49 | 0.53 | 0.43 | 0.51 | 0.53 | 0.53 |
| SNRDSP | 0.45 | 0.43 | 0.53 | 0.49 | 0.51 | 0.51 | 0.53 | 0.55 | 0.50 | 0.49 | 0.51 |
| SNWRSP | 0.41 | 0.45 | 0.49 | 0.51 | 0.47 | 0.51 | 0.53 | 0.52 | 0.53 | 0.46 | 0.50 |
| RPCNAM | 0.25 | 0.25 | 0.23 | 0.26 | 0.25 | 0.23 | 0.28 | 0.30 | 0.23 | 0.22 | 0.25 |
| CALC | 0.28 | 0.36 | 0.29 | 0.23 | 0.18 | 0.16 | 0.19 | 0.12 | 0.14 | 0.16 | 0.18 |
| ***Ga*** | | | | | | | | | | | |
| SEGMNT | 0.75 | 0.81 | 0.71 | 0.74 | 0.74 | 0.73 | 0.78 | 0.76 | 0.74 | 0.80 | 0.75 |
| SNDBLN | 0.63 | 0.55 | 0.65 | 0.56 | 0.66 | 0.66 | 0.69 | 0.71 | 0.72 | 0.74 | 0.66 |
| SNDAWR | 0.61 | 0.49 | 0.51 | 0.50 | 0.54 | 0.57 | 0.66 | 0.60 | 0.63 | 0.73 | 0.58 |
| PHNPRO | 0.52 | 0.49 | 0.62 | 0.55 | 0.51 | 0.54 | 0.67 | 0.53 | 0.62 | 0.69 | 0.54 |
| SPLSND | 0.51 | 0.49 | 0.48 | 0.51 | 0.59 | 0.58 | 0.54 | 0.50 | 0.55 | 0.61 | 0.53 |
| WRDATK | 0.26 | 0.29 | 0.24 | 0.23 | 0.27 | 0.29 | 0.25 | 0.23 | 0.24 | 0.23 | 0.24 |
| NWDREP | 0.20 | 0.23 | 0.24 | 0.10 | 0.22 | 0.11 | 0.14 | 0.16 | | | 0.18 |
| MEMWRD | | | 0.26 | 0.22 | | | | | | | |

**Table 5-19.** *(cont.)*
*WJ IV CHC Broad+Narrow 13-Factor (Bottom Up; Model 3) CFA ML Model Results in Five Age Groups*

| | Age Group | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6–8 | | 9–13 | | 14–19 | | 20–39 | | 40–90+ | | |
| **Latent Factors/ Tests** | **MD** (*n* = 412) | **MCV** (*n* = 411) | **MD** (*n* = 785) | **MCV** (*n* = 787) | **MD** (*n* = 842) | **MCV** (*n* = 843) | **MD** (*n* = 625) | **MCV** (*n* = 626) | **MD** (*n* = 571) | **MCV** (*n* = 574) | **Median** |
| ***Glr*** | | | | | | | | | | | |
| STYREC | 0.49 | 0.43 | 0.49 | 0.65 | 0.64 | 0.69 | 0.66 | 0.60 | 0.66 | 0.64 | 0.64 |
| WRTSMP | 0.30 | 0.34 | 0.11 | 0.26 | 0.37 | 0.39 | 0.35 | 0.19 | 0.27 | 0.20 | 0.28 |
| RDGREC | 0.20 | 0.32 | 0.07 | 0.25 | 0.19 | 0.20 | 0.20 | 0.09 | | | 0.20 |
| **MA** | 0.79 | 0.68 | 0.73 | 0.69 | 0.68 | 0.70 | 0.79 | 0.83 | 0.79 | 0.83 | 0.76 |
| VAL | 0.71 | 0.71 | 0.58 | 0.70 | 0.80 | 0.73 | 0.81 | 0.79 | 0.74 | 0.74 | 0.74 |
| MEMNAM | 0.49 | 0.51 | 0.61 | 0.51 | 0.50 | 0.54 | 0.54 | 0.54 | 0.60 | 0.63 | 0.54 |
| VISCLO | 0.43 | 0.32 | | | | | | | | | |
| ***Gv*** | | | | | | | | | | | |
| VISUAL | 0.80 | 0.75 | 0.67 | 0.75 | 0.65 | 0.71 | 0.75 | 0.76 | 0.72 | 0.71 | 0.74 |
| VISCLO | 0.25 | 0.28 | 0.61 | 0.54 | 0.61 | 0.58 | 0.62 | 0.60 | 0.71 | 0.65 | 0.60 |
| PICREC | 0.63 | 0.59 | 0.50 | 0.52 | 0.35 | 0.41 | 0.47 | 0.45 | 0.47 | 0.47 | 0.47 |
| PAIRCN | 0.00 | 0.00 | 0.14 | 0.17 | 0.24 | 0.17 | 0.34 | 0.31 | 0.42 | 0.28 | 0.21 |
| ***Grw*** | | | | | | | | | | | |
| LWIDNT | 0.93 | 0.93 | 0.88 | 0.91 | 0.90 | 0.91 | 0.92 | 0.92 | 0.92 | 0.93 | 0.92 |
| SPELL | 0.87 | 0.86 | 0.90 | 0.87 | 0.87 | 0.87 | 0.86 | 0.86 | 0.89 | 0.90 | 0.87 |
| EDIT | 0.79 | 0.81 | 0.87 | 0.84 | 0.81 | 0.83 | 0.81 | 0.82 | 0.85 | 0.85 | 0.83 |
| ORLRDG | 0.82 | 0.85 | 0.77 | 0.79 | 0.79 | 0.78 | 0.80 | 0.84 | 0.85 | 0.85 | 0.81 |
| PSGCMP | 0.71 | 0.66 | 0.70 | 0.72 | 0.62 | 0.60 | 0.54 | 0.55 | 0.65 | 0.63 | 0.64 |
| WRDATK | 0.62 | 0.61 | 0.56 | 0.64 | 0.57 | 0.56 | 0.59 | 0.61 | 0.63 | 0.65 | 0.61 |
| RDGREC | 0.62 | 0.49 | 0.55 | 0.49 | 0.46 | 0.46 | 0.46 | 0.52 | 0.68 | 0.66 | 0.51 |
| SNRDSP | 0.58 | 0.52 | 0.45 | 0.49 | 0.46 | 0.46 | 0.51 | 0.45 | 0.53 | 0.51 | 0.50 |
| WRTSMP | 0.52 | 0.49 | 0.51 | 0.50 | 0.42 | 0.38 | 0.40 | 0.53 | 0.49 | 0.58 | 0.50 |
| RDGVOC | 0.51 | 0.51 | 0.44 | 0.48 | 0.42 | 0.47 | 0.45 | 0.40 | 0.43 | 0.47 | 0.46 |
| SNWRSP | 0.56 | 0.51 | 0.42 | 0.44 | 0.44 | 0.41 | 0.45 | 0.41 | 0.44 | 0.49 | 0.44 |
| SPLSND | 0.41 | 0.43 | 0.37 | 0.39 | 0.32 | 0.31 | 0.32 | 0.38 | 0.37 | 0.31 | 0.37 |
| SNDAWR | 0.27 | 0.38 | 0.34 | 0.38 | 0.28 | 0.23 | 0.15 | 0.26 | 0.27 | 0.15 | 0.27 |
| WRDSPD | 0.31 | 0.24 | 0.29 | 0.22 | 0.18 | 0.24 | 0.28 | 0.21 | 0.26 | 0.22 | 0.24 |
| ***Gq*** | | | | | | | | | | | |
| NUMSEN | 0.85 | 0.85 | 0.89 | 0.84 | 0.89 | 0.89 | 0.89 | 0.89 | 0.90 | 0.88 | 0.89 |
| APPROB | 0.90 | 0.88 | 0.62 | 0.75 | 0.78 | 0.78 | 0.78 | 0.80 | 0.77 | 0.86 | 0.78 |
| CALC | 0.68 | 0.60 | 0.65 | 0.69 | 0.77 | 0.76 | 0.78 | 0.77 | 0.80 | 0.80 | 0.77 |
| MTHSPD | 0.41 | 0.31 | 0.39 | 0.36 | 0.38 | 0.39 | 0.42 | 0.45 | 0.41 | 0.38 | 0.39 |
| NUMREV | 0.21 | 0.22 | 0.34 | 0.32 | 0.29 | 0.31 | 0.22 | 0.24 | 0.18 | 0.32 | 0.27 |

*Note.* MD = model development sample; MCV = model cross-validation sample. Underlined factor codes (e.g., LA) are first-order factors. Italic font parameters = Heywood cases constrained/fixed to 1.0. Factor parameter estimates are maximum-likelihood (ML) estimates. Underlined font parameter estimates were not significant in MCV sample ($p < .05$). Median values were only reported for tests that had significant loadings in the majority of samples. Blanks for tests under factors indicates that a test/factor loading was not specified in that sample. Latent factor *g* loadings and broad CHC factor test loadings were sorted by median factor parameter loadings for ages 6 through 90+ samples.

[a] Compare these *Gwm*-LA loadings with the *Gc*-LA loadings. Note the similar low to mid loadings.

The CFA factor pattern loadings for Model 3 (see Table 5-19) reveal the following general findings and conclusions:

- Although the *Gc*, *Gf*, and *Glr* broad CHC factors in Model 3 subsume four narrow or first-order factors not present in Model 2 (see Figure 5-13), the pattern, size, and significance of the test indicators that load directly on the 9 broad CHC factors are similar to those reported for Model 2. Therefore, these findings will not be discussed again here.

- The CHC broad factor loadings on the general intelligence (*g*) factor differ slightly from those reported for Model 2. The *Gf* factor, which includes a broad array of test indicators that load on two separate, lower-order *Gf* factors (*Gf*-Verbal and *Gf*-Quantitative), has *g* loadings at or near unity (1.0). In Model 2, the *Glr* factor demonstrated the highest loading on g. The other broad CHC factors load at similar levels in both models. The *Gf* = *g* finding is consistent with a number of research studies that have suggested that *Gf*, when properly measured, may be identical to *g* (Gustafsson, 1984; Keith, 2005; Kvist & Gustafsson, 2008; Reynolds & Keith, 2007; Schneider & McGrew, 2012).
- The presence of four possible narrow factors, as suggested by the exploratory CA, PCA, and MDS analyses, provides tentative validity evidence for the following four first-order factors included in Model 3:
    - *Speed of Lexical Access (Glr-*LA*).* This factor is interpreted as a cognitively complex measure of efficiency and quickness by which individuals are able to retrieve words (comprehension-knowledge–*Gc*) from long-term storage (*Glr*). This factor is defined by consistently high factor loadings for Retrieval Fluency (median loading = .71) and moderate loadings for Rapid Picture Naming and Phonological Processing (median loadings = .41 and .40, respectively). Support for this factor also emerged in the exploratory analyses. A similar *Glr*-LA dimension emerged in the CA (see Figure 5-10), MDS (see Figure 5-2), and PCA (see Table 5-13).

      In Model 2, two of the LA tests (Retrieval Fluency and Rapid Picture Naming) loaded on the broad *Glr* and *Gs* factors. In Model 3, these two tests define the LA factor, which, in turn, loads on the broad factors of *Gc* (median loading = .43) and *Gwm* (median loading = .48). Additional research is needed to clarify the specific mixture of CHC abilities that contributes to the hypothesized Speed of Lexical Access (LA) factor.
    - *Verbal and Quantitative* Gf *Factors.* The two narrow *Gf* factors are differentiated by the nature of the test stimuli and are consistent with Wilhelm's (2005) CFA-based evidence for three different content-based *Gf* factors (verbal, quantitative, and figural-visual). The *Gf*-Verbal factor is defined primarily by the verbal or language-based tests Concept Formation (median loading = .77) and Analysis-Synthesis (median loading = .50), the research test Verbal Analogies (median loading = .43), and, to a lesser extent, Passage Comprehension (median loading =. 27) and Oral Vocabulary (median loading = .15). The *Gf*-Quantitative factor is defined consistently by median factor loadings for Numbers Series (.86) and Number Matrices (.80) , followed by low but significant loadings for Analysis-Synthesis (median loading = .20) and Applied Problems (median loading = .17). These two sub-*Gf* factors consistently load similarly (medians = .88 and .87) on the second-order broad *Gf* factor. Further support for this *Gf* dichotomy is present in the exploratory analyses (e.g., see Figures 5-2 and 5-10).
    - *Associative Memory (Glr-*MA*).* This narrow *Glr* factor is defined by consistent median loadings of .74 and .54 for WJ IV COG Visual-Auditory Learning and the research test Memory for Names. These two tests formed a similar *Glr*-MA factor in the WJ-R and WJ III batteries (McGrew et al., 1991; McGrew & Woodcock, 2001), providing structural validity evidence across three editions of the Woodcock-Johnson battery. The narrow MA factor loads consistently high on the broad *Glr* factor (median loading = .76).

Finally, the significant residual test correlations for Models 2 and 3 are summarized in Tables 5-20 and 5-21. Correlated test residuals represent sources of shared test variance not accounted for by the broad CHC factors. Hypothesized interpretations of the most frequent pairs of significant test residuals in the MCV samples in Model 2 and 3 are summarized in Table 5-22. In some cases, the correlated residuals reflect shared *content* variance (e.g., Number Series and Calculation, which have shared numerical stimulus content), *common method* variance (e.g. Concept Formation and Visual-Auditory Learning, which are both controlled learning tasks), or *narrow ability* variance (e.g., Retrieval Fluency and Rapid Picture Naming, which both measure aspects of speed of lexical access—*Glr*-LA).

***Table 5-20.***
*WJ IV CHC Broad 9-Factor (Top-Down; Model 2) CFA ML Model Correlated Test Residuals in Six Samples*

| Ages 3–5 | | MD | MCV | Ages 6–8 | | MD | MCV |
|---|---|---|---|---|---|---|---|
| SCI | SOC | 0.50 | 0.42 | WRDFLU | SNRFLU | 0.31 | 0.40 |
| RPCNAM | RETFLU | 0.32 | 0.13 | VAL | MEMNAM | 0.22 | 0.30 |
| | | | | RPCNAM | RETFLU | 0.27 | 0.28 |
| | | | | CONFRM | VAL | 0.16 | 0.26 |
| | | | | RDGREC | PSGCMP | 0.24 | 0.26 |
| | | | | PICVOC | RPCNAM | 0.18 | 0.25 |
| | | | | ANLSYN | VISUAL | 0.16 | 0.20 |
| | | | | RDGREC | ORLRDG | 0.12 | 0.13 |
| | | | | RPCNAM | PICREC | 0.14 | 0.13 |
| | | | | ORLCMP | STYREC | 0.24 | 0.01 |
| **Ages 9–13** | | **MD** | **MCV** | **Ages 14–19** | | **MD** | **MCV** |
| RDGREC | PSGCMP | 0.23 | 0.29 | NUMSER | CALC | 0.32 | 0.30 |
| CONFRM | VAL | 0.29 | 0.26 | CONFRM | VAL | 0.23 | 0.28 |
| WRDFLU | SNRDFL | 0.19 | 0.26 | ANLSYN | VISUAL | 0.30 | 0.26 |
| RPCNAM | RETFLU | 0.25 | 0.24 | VAL | MEMNAM | 0.26 | 0.25 |
| VAL | MEMNAM | 0.25 | 0.24 | RDGREC | PSGCMP | 0.22 | 0.24 |
| ANLSYN | VISUAL | 0.28 | 0.23 | WRDFLU | SNRDFL | 0.26 | 0.22 |
| PICVOC | RPCNAM | 0.24 | 0.23 | RPCNAM | PICREC | 0.25 | 0.20 |
| ORLCMP | STYREC | 0.14 | 0.21 | RPCNAM | RETFLU | 0.26 | 0.19 |
| RPCNAM | PICREC | 0.22 | 0.19 | NUMSER | NUMPAT | 0.13 | 0.19 |
| LETPAT | NUMREV | 0.30 | 0.18 | ORLCMP | STYREC | 0.10 | 0.18 |
| RDGREC | ORLRDG | 0.18 | 0.10 | LETPAT | NUMREV | 0.28 | 0.18 |
| | | | | PICVOC | RPCNAM | 0.19 | 0.16 |
| | | | | RDGREC | ORLRDG | 0.12 | 0.12 |
| | | | | VAL | VISUAL | 0.10 | 0.11 |
| | | | | VAL | SNDBLN | 0.17 | 0.11 |
| **Ages 20–39** | | **MD** | **MCV** | **Ages 40–90+** | | **MD** | **MCV** |
| NUMSER | CALC | 0.31 | 0.36 | PAIRCN | VISCLO | 0.50 | 0.53 |
| CONFRM | VAL | 0.18 | 0.29 | NUMSER | CALC | 0.40 | 0.44 |
| PICVOC | RPCNAM | 0.19 | 0.27 | WRDFLU | SNRDFL | 0.20 | 0.30 |
| WRDFLU | SNRDFL | 0.26 | 0.25 | LETPAT | NUMREV | 0.19 | 0.29 |
| VAL | MEMNAM | 0.22 | 0.22 | ANLSYN | VISUAL | 0.30 | 0.29 |
| LETPAT | NUMREV | 0.28 | 0.21 | CONFRM | VAL | 0.26 | 0.26 |
| NUMSER | NUMPAT | 0.13 | 0.21 | VAL | SNDBLN | 0.13 | 0.26 |
| RPCNAM | RETFLU | 0.20 | 0.21 | RPCNAM | PICREC | 0.21 | 0.23 |
| RDGREC | PSGCMP | 0.28 | 0.21 | VAL | MEMNAM | 0.25 | 0.23 |
| ANLSYN | VISUAL | 0.21 | 0.20 | PICVOC | RPCNAM | 0.25 | 0.22 |
| VAL | VISUAL | 0.17 | 0.16 | RPCNAM | RETFLU | 0.22 | 0.20 |
| RPCNAM | PICREC | 0.20 | 0.16 | VAL | VISUAL | 0.18 | 0.12 |
| VAL | SNDBLN | 0.12 | 0.16 | | | | |
| ORLCMP | STYREC | 0.17 | 0.11 | | | | |
| RDGREC | STYREC | 0.20 | 0.10 | | | | |
| RDGREC | ORLRDG | 0.15 | 0.07 | | | | |

*Note.* MD = model development sample; MCV = model cross-validation sample. Correlation parameter estimates are maximum-likelihood (ML) estimates. All parameters in model development samples are significant ($p < .05$). Underlined text = parameter estimates that were nonsignificant ($p < .05$) in the model cross-validation sample. Correlated residuals are sorted (within age groups) by model cross-validation sample loadings.

***Table 5-21.***

*WJ IV CHC Broad+Narrow 13-Factor (Bottom Up; Model 3) CFA ML Model Correlated Test Residuals in Five Samples*

| Ages 6–8 | | MD | MCV |
|---|---|---|---|
| PAIRCN | VISCLO | 0.48 | 0.44 |
| WRDFLU | SNRDFL | 0.30 | 0.40 |
| VAL | VISUAL | 0.31 | 0.37 |
| STYREC | ANLSYN | 0.19 | 0.29 |
| PICVOC | RPCNAM | 0.20 | 0.29 |
| RDGREC | PSGCMP | 0.18 | 0.21 |
| RPCNAM | PICREC | 0.21 | 0.20 |
| RDGREC | ORLRDG | 0.11 | 0.14 |
| PSGCMP | ORLCMP | 0.13 | 0.09 |
| SPLSND | SPELL | 0.18 | 0.09 |
| STYREC | ORLCMP | 0.24 | 0.04 |

| Ages 9–13 | | MD | MCV |
|---|---|---|---|
| VAL | VISUAL | 0.32 | 0.28 |
| WRDFLU | SNRDFL | 0.19 | 0.26 |
| RPCNAM | PICREC | 0.27 | 0.23 |
| PICVOC | RPCNAM | 0.24 | 0.22 |
| STYREC | ORLCMP | 0.14 | 0.22 |
| RDGREC | PSGCMP | 0.17 | 0.21 |
| PSGCMP | ORLCMP | 0.23 | 0.14 |
| SPLSND | SPELL | 0.14 | 0.11 |
| RDGREC | ORLRDG | 0.15 | 0.08 |

| Ages 14–19 | | MD | MCV |
|---|---|---|---|
| CONFRM | VAL | 0.27 | 0.28 |
| NUMPAT | NUMSER | 0.20 | 0.27 |
| RPCNAM | PICREC | 0.31 | 0.24 |
| ANLSYN | VISUAL | 0.29 | 0.24 |
| WRDFLU | SNRDFL | 0.26 | 0.22 |
| STYREC | ORLCMP | 0.11 | 0.21 |
| VAL | VISUAL | 0.14 | 0.15 |
| PICVOC | RPCNAM | 0.20 | 0.15 |
| RDGREC | PSGCMP | 0.15 | 0.14 |
| PSGCMP | ORLCMP | 0.25 | 0.12 |
| RDGREC | ORLRDG | 0.10 | 0.12 |

| Ages 20–39 | | MD | MCV |
|---|---|---|---|
| NUMPAT | NUMSER | 0.21 | 0.31 |
| CONFRM | VAL | 0.16 | 0.30 |
| PICVOC | RPCNAM | 0.18 | 0.27 |
| WRDFLU | SNRDFL | 0.25 | 0.25 |
| VAL | VISUAL | 0.23 | 0.24 |
| PSGCMP | ORLCMP | 0.18 | 0.21 |
| RPCNAM | PICREC | 0.22 | 0.19 |
| ANLSYN | VISUAL | 0.20 | 0.17 |
| STYREC | ORLCMP | 0.18 | 0.10 |
| RDGREC | PSGCMP | 0.17 | 0.09 |
| RDGREC | ORLRDG | 0.16 | 0.06 |

| Ages 40–90+ | | MD | MCV |
|---|---|---|---|
| CONFRM | VAL | 0.28 | 0.28 |
| RPCNAM | PICREC | 0.22 | 0.26 |
| WRDFLU | SNRDFL | 0.16 | 0.26 |
| ANLSYN | VISUAL | 0.26 | 0.24 |
| PICVOC | RPCNAM | 0.26 | 0.23 |
| NUMPAT | NUMSER | 0.22 | 0.21 |
| VAL | VISUAL | 0.26 | 0.19 |
| RDGREC | PSGCMP | 0.11 | 0.16 |
| PSGCMP | ORLCMP | 0.11 | 0.12 |

*Note.* MD = model development sample; MCV = model cross-validation sample. Correlation parameter estimates are maximum-likelihood (ML) estimates. All parameters in MD samples are significant ($p < .05$). Underlined font = parameter estimates that were nonsignificant ($p < .05$) in the cross-validation sample.

**Table 5-22.**
*Interpretation of Consistent and Significant Correlated Test Residuals in Model 2 and Model 3*

| Pairs of Significant Correlated Test Residuals | | Number of MCV Samples Where Significant | Possible Hypothesized Reasons for Shared Variance[a] |
|---|---|---|---|
| RPCNAM | RETFLU | 6 | Speed of lexical access (*Glr*-LA) |
| WRDFL | SNRFL | 5 | Reading speed (*Grw*-RS) |
| VAL | MEMNAM | 5 | Associative memory (*Glr*-MA) |
| CONFRM | VAL | 5 | Shared figural-visual stimulus and language content |
| PICVOC | RPCNAM | 5 | Lexical knowledge (*Gc*-VL) or common visual-pictorial stimulus content |
| RPCNAM | PICREC | 5 | Lexical knowledge (*Gc*-VL), visual memory (*Gv*-MV), or common visual-pictorial stimulus content |
| ANLSYN | VISUAL | 5 | Some form of visual working memory or shared visual-figural stimulus content |
| RDGREC | ORLRDG | 4 | Verbal (printed) language comprehension (*Grw*-V) |
| ORLCMP | STYREC | 4 | Listening ability (*Gc*-LS) or meaningful memory (*Glr*-MM) |
| LETPAT | NUMREV | 4 (ages 9–13 and above) | Shared figural-visual stimuli |
| NUMSER | CALC | 3 (ages 14–19 and above) | Number facility (*Gs*-N) or shared numerical stimulus content |
| VAL | VISUAL | 3 (ages 14–19 and above) | Visualization or visual memory (*Gv*-VZ, MV) or shared figural-visual stimulus content |

[a] Possible reasons for shared test residual variance are: (a) common narrow ability variance, (b) common stimulus content variance, or (c) common method variance.

# Relationship of WJ IV Scores to Other Measures of Cognitive Abilities, Oral Language, and Achievement

The necessary and sufficient conditions for construct validity are met when structurally valid measures demonstrate expected convergent and divergent relations with measures of constructs external to the focal measures (Benson, 1998; Benson & Hagtvet, 1996; Cronbach & Meehl, 1955). This section reports results from a variety of studies that examine the relations between WJ IV scores and a number of external criterion variables. The types of external validity evidence reported include concurrent validity of (a) the WJ IV COG with other intelligence test batteries, (b) the WJ IV OL with other oral language batteries, and (c) the WJ IV ACH with other measures of school achievement.

In an independent review, Braden and Niebling (2012) judged the quality of the WJ III concurrent validity evidence, upon which the WJ IV continues to build, as near the strong end of their rating scale. They assigned the WJ III a global rating of 4 on a "quality of validity evidence" scale that ranged from 0 to 5, with 1 indicating weak and 5 indicating strong quality. In the following sections, concurrent validity correlations between the WJ IV and external criterion measures are presented for 15 studies.

The concurrent validity study participants were randomly selected in an attempt to produce samples representative of the typical range of abilities in the U.S. population. The samples were not selected to match U.S. census stratification variables as was the WJ IV norming sample (see Chapter 3). Unless otherwise specified, the primary unit of analysis is at the cluster or composite score level for all studies. Table 5-23 presents sample size and demographic information for all 15 studies, including age characteristics (mean, *SD*, and range, in years) and percentages for sex, race, ethnicity, mother's level of education, and father's level of education.

***Table 5-23.***
*Demographic Characteristics of the External Concurrent Validity Studies*

| | External Cognitive Measures | | | | | | External Oral Language Measures | | | | External Achievement Measures | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **WISC-IV** | **WAIS-IV** | **WPPSI-III** | **KABC-II** | **SB5** | **DAS-II** | **CELF-4 + PPVT-4** | **CELF-4 + PPVT-4** | **CASL + OWLS** | **CASL + OWLS** | **KTEA-II** | **KTEA-II** | **WIAT-III (Grade 1–8)** | **WIAT-III (Grade 9–12)** | **OWLS WE** |
| Chapter 5 Table # | 5-24 | 5-25 | 5-26 | 5-27 | 5-28 | 5-29 | 5-30 | 5-31 | 5-32 | 5-33 | 5-34 | 5-35 | 5-36 | 5-37 | 5-38 |
| **Demographic Characteristics** | | | | | | | | | | | | | | | |
| ***N*** | 174 | 177 | 99 | 50 | 50 | 50 | 50 | 56 | 50 | 50 | 49 | 50 | 51 | 49 | 51 |
| **Age (years)** | | | | | | | | | | | | | | | |
| Range | 6–16 | 16–82 | 4–7 | 7–18 | 6–16 | 3–6 | 5–8 | 10–18 | 3–6 | 7–17 | 8–12 | 13–18 | 6–14 | 13–18 | 7–17 |
| Mean | 10.2 | 37.1 | 5.4 | 11.4 | 11.1 | 5.2 | 6.8 | 13.6 | 5.1 | 13.6 | 9.8 | 16.3 | 11.0 | 16.1 | 10.6 |
| *SD* | 2.6 | 14.3 | 0.8 | 3.3 | 3.0 | 0.9 | 1.3 | 2.2 | 1.1 | 3.0 | 1.2 | 1.8 | 2.2 | 1.4 | 2.5 |
| **Sex** | | | | | | | | | | | | | | | |
| Male | 43.7 | 28.2 | 39.4 | 46.0 | 50.0 | 56.0 | 54.0 | 33.9 | 50.0 | 30.0 | 34.7 | 46.0 | 35.3 | 40.8 | 21.6 |
| Female | 56.3 | 71.8 | 60.6 | 54.0 | 50.0 | 44.0 | 46.0 | 66.1 | 50.0 | 70.0 | 65.3 | 54.0 | 64.7 | 59.2 | 78.4 |
| **Race** | | | | | | | | | | | | | | | |
| White | 68.4 | 86.4 | 66.7 | 74.0 | 90.0 | 92.0 | 90.0 | 87.5 | 84.0 | 98.0 | 44.9 | 92.0 | 82.4 | 85.7 | 82.4 |
| Black | 19.5 | 7.9 | 24.2 | 20.0 | 2.0 | 4.0 | 2.0 | 1.8 | 10.0 | — | 40.8 | 2.0 | 7.8 | 2.0 | 7.8 |
| Indian | 0.6 | — | — | 2.0 | — | — | 2.0 | — | — | — | 2.0 | — | — | — | — |
| Asian/Pacific Islander | 8.0 | 4.5 | 5.1 | — | 8.0 | 4.0 | 4.0 | 8.9 | 4.0 | 2.0 | 10.2 | 6.0 | 7.8 | 8.2 | 7.8 |
| Other/Mixed | 3.4 | 1.1 | 4.0 | 4.0 | — | — | 2.0 | 1.8 | 2.0 | 0.0 | 2.0 | — | 2.0 | 4.1 | 2.0 |
| **Ethnicity** | | | | | | | | | | | | | | | |
| Not Hispanic | 90.2 | 92.1 | 86.9 | 90.0 | 86.0 | 80.0 | 88.0 | 89.3 | 82.0 | 76.0 | 87.8 | 86.0 | 98.0 | 93.9 | 94.1 |
| Hispanic | 9.8 | 7.9 | 13.1 | 10.0 | 14.0 | 20.0 | 12.0 | 10.7 | 18.0 | 24.0 | 12.2 | 14.0 | 2.0 | 6.1 | 5.9 |
| **Mother's Education** | | | | | | | | | | | | | | | |
| No Information Provided | 1.1 | 92.7 | 1.0 | 2.0 | 2.0 | — | — | 3.6 | — | — | — | 12.0 | — | — | — |
| <HS Graduate | 6.3 | 0.6 | 5.1 | 4.0 | 12.0 | — | — | 1.8 | 6.0 | 16.0 | 10.2 | 4.0 | — | 2.0 | 5.9 |
| HS Graduate | 19.5 | 1.1 | 21.2 | 6.0 | 10.0 | 4.0 | 18.0 | 10.7 | 22.0 | 14.0 | 28.6 | 10.0 | 15.7 | 14.3 | 15.7 |
| >HS | 73.0 | 5.6 | 72.7 | 88.0 | 76.0 | 96.0 | 82.0 | 83.9 | 72.0 | 70.0 | 61.2 | 74.0 | 84.3 | 83.7 | 78.4 |
| **Father's Education** | | | | | | | | | | | | | | | |
| No Information Provided | 2.3 | 92.7 | 3.0 | 4.0 | 6.0 | 4.0 | 4.0 | 7.1 | — | 4.0 | 8.2 | 18.0 | — | 6.1 | 7.8 |
| <HS Graduate | 5.2 | 0.6 | 6.1 | 12.0 | 6.0 | 4.0 | 4.0 | 3.6 | 2.0 | 12.0 | 10.2 | 4.0 | 2.0 | 4.1 | 2.0 |
| HS Graduate | 21.3 | 1.7 | 26.3 | 12.0 | 18.0 | 30.0 | 20.0 | 23.2 | 38.0 | 22.0 | 26.5 | 18.0 | 23.5 | 18.4 | 27.5 |
| >HS | 71.3 | 5.1 | 64.6 | 72.0 | 70.0 | 62.0 | 72.0 | 66.1 | 60.0 | 62.0 | 55.1 | 60.0 | 74.5 | 71.4 | 62.7 |

An inspection of the mean scores for the WJ IV and external measure scores reveals, across all studies, samples with average to slightly above average ability on the measured traits; the samples with above average mean scores are noted in the individual study discussions. The standard deviations across the various WJ IV and external measures suggest that most samples had typical ranges of ability. When less-than-normal sample variability is present, it is mentioned in the discussion of the specific study. The raw uncorrected (i.e., not corrected for possible range restriction) correlations are reported in all tables. The WJ IV and external measures in each study were administered in a counterbalanced order within a period of time ranging from the same day to no longer than 21 days apart.

## Correlations for the WJ IV COG With Other Measures of Intelligence

The WJ IV COG scores were examined in five studies that included the following external measures: the *Wechsler Intelligence Scale for Children–Fourth Edition* (WISC-IV) (Wechsler, 2003), the *Wechsler Adult Intelligence Scale–Fourth Edition* (WAIS-IV) (Wechsler, 2008), the *Wechsler Preschool and Primary Scale of Intelligence™–Third Edition* (WPPSI™-III) (Wechsler, 2002), the *Kaufman Assessment Battery for Children–Second Edition* (KABC-II) (Kaufman & Kaufman 2004a), the *Stanford-Binet Intelligence Scales, Fifth Edition* (SB5) (Roid, 2003a), and the *Differential Abilities Scales–Second Edition* (DAS-II) (Elliott, 2007). Each of these external measures is an individually administered assessment of intelligence and cognitive abilities.[37]

When possible, research-based CHC interpretations of the composite scores from the external intelligence batteries are presented in the discussion of results. CHC factor codes also are included in the concurrent validity study tables with intelligence batteries; logical and empirical CHC analyses of intelligence batteries is well documented (see Flanagan, Alfonso, & Reynolds, 2013). The two primary sources for information about the external cognitive batteries are Keith and Reynolds (2010) and Flanagan, Ortiz, and Alfonso (2013). For the WISC-IV and WAIS-IV, the sources also include Claeys (2013); Flanagan, Alfonso, and Reynolds (2013); Grégoire (2013); and Weiss, Keith, Zhu, and Chen (2013a, 2013b).

### *Correlations With the WISC-IV*

Table 5-24 presents the means, standard deviations, and correlations for the WJ IV COG and select WJ IV OL and the WISC-IV composite scores for 174 school-age examinees from ages 6 through 16 ($M$ = 10.2 years, $SD$ = 2.6 years). The mean WJ IV GIA (107.2) and WISC-IV Full Scale IQ scores (106.7) differ by 0.5 standard score points.[38] These mean scores suggest a sample with slightly above average general intelligence. The correlations between the three WJ IV clusters used to represent general intelligence (GIA, BIA, and *Gf-Gc* Composite) are at high levels (.83 to .86) with the WISC-IV Full Scale IQ, providing support for the general intelligence (*g*) interpretation of all three WJ IV COG clusters. Strong concurrent validity evidence is present for three WJ IV COG CHC factor clusters in the form of high correlations between the corresponding three CHC-interpreted WISC-IV index scores. The WJ IV Comprehension-Knowledge (*Gc*) cluster correlates the highest (.79) with the WISC-IV Verbal Comprehension (*Gc*) Index, the WJ IV Fluid Reasoning (*Gf*) cluster correlates the highest (.70) with the WISC-IV Perceptual Reasoning (*Gf/Gv*) Index,[39] and the WJ IV Short-Term Working Memory (*Gwm*) cluster correlates the highest (.72) with the WISC-IV Working Memory (*Gwm*) Index.

[37] Descriptions and overviews of the major intelligence batteries can be found in Flanagan and Harrison (2012).

[38] It is important to note that the WISC-IV and other cognitive battery total IQ scores reported in this section are likely inflated estimates due to varying degrees of norm obsolescence (also known as the "Flynn Effect"; see McGrew, in press a, in press b; Watson, in press). Users who wish to compare the WJ IV GIA and other battery global IQ scores also must take into account content ability differences. For example, the WJ IV GIA includes indicators of seven CHC cognitive factors (*Gf*, *Gc*, *Glr*, *Gsm*, *Gv*, *Ga*, *Gs*), while the WISC-IV and WAIS-IV Full Scale IQ composites do not include measures of *Glr* or *Ga*.

[39] The consensus interpretation of the WISC-IV Perceptual Reasoning Index is that it includes two tests of *Gf* (Matrix Reasoning and Picture Concepts) and one of *Gv* (Block Design) (see Claeys [2013], Flanagan, Alfonso, & Reynolds [2013], Grégoire [2013], and Weiss et al., [2013a, 2013b]).

**Table 5-24.**
*Summary Statistics and Correlations for WJ IV COG and Select WJ IV OL and WISC-IV Scales*

| WJ IV Measures | Mean | *SD* | WISC-IV Measures: Full Scale IQ (*g*) | General Ability Index | Verbal Comprehension (*Gc*) Index | Perceptual Reasoning (*Gf/Gv*) Index | Working Memory (*Gwm*) Index | Processing Speed (*Gs*) Index |
|---|---|---|---|---|---|---|---|---|
| **Cognitive Composite Clusters** | | | | | | | | |
| General Intellectual Ability (*g*) | 107.2 | 14.2 | 0.86 | 0.81 | 0.74 | 0.74 | 0.69 | 0.57 |
| Brief Intellectual Ability (*g*) | 105.2 | 14.9 | 0.83 | 0.80 | 0.75 | 0.71 | 0.70 | 0.46 |
| *Gf-Gc* Composite | 104.8 | 15.4 | 0.83 | 0.83 | 0.79 | 0.73 | 0.66 | 0.44 |
| **CHC Factor Clusters** | | | | | | | | |
| Comprehension-Knowledge (*Gc*) | 100.3 | 13.3 | 0.71 | 0.75 | 0.79 | 0.59 | 0.54 | 0.33 |
| Fluid Reasoning (*Gf*) | 106.7 | 16.0 | 0.77 | 0.75 | 0.66 | 0.70 | 0.64 | 0.43 |
| Short-Term Working Memory (*Gwm*) | 105.4 | 16.6 | 0.72 | 0.65 | 0.58 | 0.61 | 0.72 | 0.42 |
| Processing Speed (*Gs*) | 103.8 | 13.2 | 0.51 | 0.42 | 0.35 | 0.41 | 0.35 | 0.55 |
| Auditory Processing (*Ga*) | 106.6 | 16.6 | 0.71 | 0.67 | 0.68 | 0.55 | 0.61 | 0.43 |
| Long-Term Retrieval (*Glr*) | 102.5 | 14.2 | 0.60 | 0.60 | 0.59 | 0.51 | 0.50 | 0.30 |
| Visual Processing (*Gv*) | 105.6 | 12.2 | 0.57 | 0.50 | 0.37 | 0.55 | 0.44 | 0.48 |
| **Narrow Ability & Clinical Clusters** | | | | | | | | |
| Quantitative Reasoning (RQ) | 107.5 | 15.6 | 0.70 | 0.66 | 0.56 | 0.65 | 0.55 | 0.44 |
| Auditory Memory Span (MS) | 103.6 | 15.8 | 0.65 | 0.61 | 0.60 | 0.53 | 0.52 | 0.42 |
| Number Facility (N) | 105.8 | 14.8 | 0.69 | 0.57 | 0.45 | 0.59 | 0.64 | 0.57 |
| Perceptual Speed (P) | 105.4 | 12.5 | 0.53 | 0.41 | 0.31 | 0.44 | 0.41 | 0.56 |
| Cognitive Efficiency (*Gsm+Gs*) | 106.9 | 14.8 | 0.62 | 0.52 | 0.42 | 0.53 | 0.55 | 0.51 |
| Cognitive Efficiency–Extended (*Gsm+Gs*) | 106.5 | 14.2 | 0.71 | 0.60 | 0.50 | 0.59 | 0.64 | 0.57 |
| **Select Oral Language Clusters** | | | | | | | | |
| Phonetic Coding (PC) | 103.8 | 15.9 | 0.67 | 0.62 | 0.59 | 0.56 | 0.58 | 0.39 |
| Speed of Lexical Access (LA) | 102.7 | 14.1 | 0.50 | 0.47 | 0.47 | 0.37 | 0.32 | 0.43 |
| **Mean** | | | 106.7 | 108.3 | 106.2 | 107.6 | 101.5 | 102.8 |
| **Standard Deviation** | | | 15.2 | 14.5 | 13.5 | 14.8 | 15.4 | 15.1 |

*Note.* $N = 174$ for all measures. Age range (years) = 6–16, $M = 10.2$, $SD = 2.6$

Validity evidence also is present for the WJ IV Processing Speed (*Gs*) cluster through a moderate (.55) correlation with the WISC-IV Processing Speed (*Gs*) Index. This moderate correlation suggests that although both clusters measure *Gs*, the WJ IV and WISC-IV processing speed composites each also measure unique abilities not measured by the other battery's composite score. Because the WISC-IV Perceptual Reasoning Index is composed of two *Gf* tests and one *Gv* test, it is not surprising that the WJ IV Visual Processing (*Gv*) cluster correlates at a moderate level (.55) with this partially *Gv*-influenced index. Because there are no CHC-construct-comparable WISC-IV indices for the *Ga* and *Glr* abilities measured by the WJ IV Auditory Processing and Long-Term Retrieval clusters, the finding of moderately high correlations with multiple WISC-IV index scores is not surprising. The WJ IV Auditory Processing (*Ga*) cluster correlates the highest (.68 and .61) with the WISC-IV Verbal Comprehension (*Gc*) and Working Memory (*Gwm*) Indices, respectively. These findings are consistent with the previously presented MDS and structural validity analysis of the WJ IV (see Figure 5-2 and Table 5-19). *Ga* and *Gc* tasks are interpreted as reflecting a broad auditory-linguistic or language dimension in the MDS analysis; Nonword Repetition is interpreted as a *Ga* test requiring working memory (UM-memory for sound patterns) in the structural validity analysis. The WJ IV Long-Term Retrieval (*Glr*) cluster shows moderate correlations with the WISC-IV Verbal Comprehension (.59), Perceptual Reasoning (.51), and Working Memory (.50) Indices.

The highest correlations between the WJ IV narrow ability, clinical, and two OL clusters are consistent with CHC-based interpretations of the WJ IV and WISC-IV measures. The Quantitative Reasoning cluster is a measure of RQ; thus, its highest correlation (.65) with the WISC-IV Perceptual Reasoning (*Gf/Gv*) Index supports the CHC interpretation of this cluster. The highest correlation between the WJ IV Number Facility (N) cluster (.64) and the WISC-IV Working Memory Index likely is due to both composites including common digit-reversal tasks (WJ IV Numbers Reversed, WISC-IV Digit Span). Support for the interpretation of the WJ IV Perceptual Speed (P) cluster is present in the form of its highest correlation (.56) with the WISC-IV Processing Speed (*Gs*) Index. Both of the WJ-IV Cognitive Efficiency (*Gsm+Gs*) clusters correlate at moderate levels (.51 to .64) with the WISC-IV Perceptual Reasoning (*Gf/Gv*), Working Memory (*Gwm*), and Processing Speed (*Gs*) Indices. The four-test WJ IV Cognitive Efficiency–Extended cluster is more highly related (.64) to the WISC-IV Working Memory (*Gwm*) Index than the two-test Cognitive Efficiency cluster (.55). Not unexpectedly, the WJ IV OL Phonetic Coding (PC) cluster demonstrates the same pattern of moderate correlations (.56 to .59) with the WISC-IV Verbal Comprehension and Perceptual Reasoning Indices as reported for the WJ IV Auditory Processing cluster (.55 to .68).

Potentially, the most interesting findings for the narrow cognitive and oral language clusters are for Auditory Memory Span (MS) and Speed of Lexical Access (LA). As noted previously, the WJ IV Short-Term Working Memory (*Gwm*) cluster correlates highly (.72) with the WISC-IV *Gwm* measure (Working Memory Index). In contrast, the WJ IV Auditory Memory Span (MS) cluster correlates lower with the WISC-IV Working Memory Index (.52) and higher with the Verbal Comprehension Index (.60). This finding is consistent with the previous discussion (see the structural validity section of this chapter) regarding the apparent differentiation of memory span (MS) and working memory (WM) abilities. Finally, WJ IV Speed of Lexical Access cluster shows the lowest correlations (.32 to .50) with all WISC-IV measures (the highest correlation of .50 is with the WISC-IV Full Scale IQ score). These findings suggest that the WJ IV Speed of Lexical Access cluster is measuring an aspect of cognition not represented well in the WISC-IV.

### *Correlations With the WAIS-IV*

Table 5-25 presents the means, standard deviations, and correlations for the WJ IV COG and select WJ IV OL and WAIS-IV composite scores for 177 adolescent and adult examinees ranging from 16 to 82 years of age ($M$ = 37.1 years, $SD$ = 14.3 years). With the exception of the WJ IV Cognitive Efficiency–Extended cluster, the same WJ IV and WAIS-IV measures administered in the WISC-IV study (Table 5-24) were administered in the WAIS-IV study. The mean WJ IV GIA (104.3) and WAIS-IV Full Scale scores (107.1) differ by –2.8 standard score points. The correlations between the three WJ IV COG clusters representing general intelligence (GIA, BIA, and *Gf-Gc* Composite) are at high levels (.74 to .84) with the WAIS-IV Full Scale IQ, providing support for the general intelligence (*g*) interpretation of all three COG clusters. In general, the patterns of correlations between the WJ IV COG clusters and the WAIS-IV scores are the same as those reported for the WJ IV COG/WISC-IV study. However, despite similar index names, the WISC-IV and WAIS-IV Perceptual Reasoning and Working Memory Index scores are composed of different mixtures of CHC abilities; these differences are reflected in different magnitudes and patterns of correlations for certain WJ IV and WAIS-IV measures presented in Table 5-25.

**Table 5-25.**
*Summary Statistics and Correlations for WJ IV COG and Select WJ IV OL Measures and WAIS-IV Scales*

| WJ IV Measures | Mean | *SD* | WAIS-IV Measures: Full Scale IQ (*g*) | General Ability Index | Verbal Comprehension (*Gc*) Index | Perceptual Reasoning (*Gf/Gv*) Index | Working Memory (*Gwm/Gq*) Index | Processing Speed (*Gs*) Index |
|---|---|---|---|---|---|---|---|---|
| **Cognitive Composite Clusters** | | | | | | | | |
| General Intellectual Ability (*g*) | 104.3 | 12.6 | 0.84 | 0.78 | 0.68 | 0.69 | 0.70 | 0.52 |
| Brief Intellectual Ability (*g*) | 104.6 | 13.5 | 0.74 | 0.68 | 0.65 | 0.55 | 0.66 | 0.39 |
| *Gf-Gc* Composite | 105.0 | 13.8 | 0.78 | 0.75 | 0.69 | 0.63 | 0.61 | 0.41 |
| **CHC Factor Clusters** | | | | | | | | |
| Comprehension-Knowledge (*Gc*) | 104.3 | 15.0 | 0.70 | 0.72 | 0.74 | 0.52 | 0.46 | 0.38 |
| Fluid Reasoning (*Gf*) | 104.3 | 13.8 | 0.64 | 0.59 | 0.46 | 0.57 | 0.60 | 0.32 |
| Short-Term Working Memory (*Gwm*) | 104.5 | 15.0 | 0.60 | 0.50 | 0.45 | 0.43 | 0.67 | 0.31 |
| Processing Speed (*Gs*) | 101.8 | 14.5 | 0.54 | 0.49 | 0.41 | 0.46 | 0.34 | 0.44 |
| Auditory Processing (*Ga*) | 102.7 | 14.5 | 0.58 | 0.53 | 0.54 | 0.41 | 0.51 | 0.33 |
| Long-Term Retrieval (*Glr*) | 101.9 | 15.9 | 0.64 | 0.56 | 0.50 | 0.49 | 0.57 | 0.42 |
| Visual Processing (*Gv*) | 100.1 | 15.2 | 0.55 | 0.53 | 0.36 | 0.57 | 0.36 | 0.37 |
| **Narrow Ability & Clinical Clusters** | | | | | | | | |
| Quantitative Reasoning (RQ) | 102.7 | 14.1 | 0.60 | 0.54 | 0.40 | 0.54 | 0.53 | 0.39 |
| Auditory Memory Span (MS) | 101.0 | 14.3 | 0.53 | 0.48 | 0.43 | 0.40 | 0.49 | 0.31 |
| Number Facility (N) | 104.8 | 12.1 | 0.64 | 0.47 | 0.37 | 0.46 | 0.65 | 0.52 |
| Perceptual Speed (P) | 103.2 | 11.4 | 0.57 | 0.45 | 0.34 | 0.45 | 0.38 | 0.61 |
| Cognitive Efficiency (*Gsm+Gs*) | 104.2 | 13.6 | 0.65 | 0.55 | 0.45 | 0.51 | 0.60 | 0.47 |
| **Select Oral Language Clusters** | | | | | | | | |
| Phonetic Coding (PC) | 105.3 | 14.9 | 0.62 | 0.57 | 0.48 | 0.52 | 0.47 | 0.43 |
| Speed of Lexical Access (LA) | 105.3 | 14.5 | 0.51 | 0.45 | 0.38 | 0.41 | 0.40 | 0.40 |
| **Mean** | | | 107.1 | 106.7 | 105.8 | 106.0 | 103.2 | 107.6 |
| **Standard Deviation** | | | 14.1 | 14.5 | 14.1 | 14.5 | 15.1 | 15.0 |

*Note.* $N = 177$ for all measures. Age range (years) = 16–82, $M = 37.1$, $SD = 14.3$

Strong concurrent validity evidence is present for the WJ IV COG Comprehension-Knowledge (*Gc*) cluster, which has a .74 correlation with the WAIS-IV Verbal Comprehension (*Gc*) Index. In contrast to the high .70 WJ IV Fluid Reasoning (*Gf*)/WISC-IV Perceptual Reasoning (*Gf/Gv*) Index correlation (see Table 5-24), the WJ IV Fluid Reasoning (*Gf*) cluster correlates at moderate levels with both the WAIS-IV Perceptual Reasoning (.57) and Working Memory (.60) Indices. This pattern is consistent with research that indicates the WAIS-IV Perceptual Reasoning Index is not as strong a measure of *Gf* as the corresponding WISC-IV index; the WAIS-IV Perceptual Reasoning Index is more a measure of *Gv*—composed of two *Gv* tests (Block Design and Visual Puzzles) and one *Gf* test (Matrix Reasoning).[40] The observation that the highest correlation for the WJ IV Visual Processing cluster (.57) is with WAIS-IV Perceptual Reasoning Index is consistent with the mixed *Gv/Gf* nature of the WAIS-IV Perceptual Reasoning Index. The WJ IV Fluid Reasoning (*Gf*) correlation with the WAIS-IV Working Memory Index (.60) most likely reflects the inclusion of the Arithmetic test in the WAIS-IV Working Memory Index, making the WAIS-IV Working Memory Index a confounded measure of *Gwm* (Digit Span) and *Gf*-RQ (Arithmetic). The WJ IV Short-Term

[40] See Claeys (2013), Flanagan, Alfonso, and Reynolds (2013), Grégoire (2013), and Weiss et al., (2013a, 2013b) for support for the *Gv/Gf* and *Gwm/Gq* interpretations of the WAIS-IV Perceptual Reasoning and Working Memory Indices.

Working Memory cluster (*Gwm*) correlates the highest (.67) with the WAIS-IV Working Memory (*Gwm*) Index.

Similar to the WJ IV/WISC-IV study findings (see Table 5-24), the moderate (.44) correlation between the broad *Gs* measures in the two batteries—the WJ IV Processing Speed cluster and the WAIS-IV Processing Speed Index—indicates that although these measures of processing speed are significantly related, each appears to measure unique abilities not shared by the other. A possible hint for these differences is the relatively high correlation (.61) between the WJ IV narrow Perceptual Speed (P) cluster and the WAIS-IV Processing Speed Index. However, this finding is not consistent with the same measures in the WJ IV/WISC-IV study and thus needs further exploration.

As was the case in the WJ IV/WISC-IV study, there are no CHC-construct-comparable WAIS-IV indices for the *Ga* and *Glr* abilities measured by the WJ IV Auditory Processing and Long-Term Retrieval clusters. The finding of moderately high correlations for these two WJ IV clusters with multiple WAIS-IV index scores, as also reported in the WJ IV/WISC-IV study (see Table 5-24), is not surprising. The WJ IV Auditory Processing (*Ga*) cluster correlates .54 and .51 with the WAIS-IV Verbal Comprehension (*Gc*) and Working Memory (*Gwm*) Indices; the WJ IV Long-Term Retrieval (*Glr*) cluster correlates .50, .49, and .57 with the WAIS-IV Verbal Comprehension, Perceptual Reasoning, and Working Memory Indices, respectively.

The magnitude and pattern of correlations between the WJ IV narrow ability, clinical, and two OL clusters and the WAIS-IV indices are generally consistent with those reported in the WJ IV/WISC-IV study (see Table 5-24), although there is one notable difference. In Table 5-25 the Quantitative Reasoning (RQ) cluster correlates .54 and .53 with the WAIS-IV Perceptual Reasoning and Working Memory Indices, most likely due to the mixed *Gv/Gf* and *Gwm/Gq* nature of these measures in the WAIS-IV. The highest correlation of the WJ IV Number Facility (N) cluster (.65) with the WAIS-IV Working Memory Index is likely due to both composites including common digit-reversal tasks (WJ IV Numbers Reversed and WAIS-IV Digit Span) and possibly to the numerical nature of the WAIS-IV Arithmetic test. Next to the correlation with the WAIS-IV Full Scale IQ score (.65), the WJ IV Cognitive Efficiency (*Gsm*+*Gs*) cluster correlates second highest (.60) with the WAIS-IV Working Memory Index. The WJ IV OL Phonetic Coding cluster also correlates highest with the WAIS-IV Full Scale IQ score (.62). Given the absence of auditory processing measures in the WAIS-IV, the .43 to .52 correlations for the WJ IV OL Phonetic Coding (PC) cluster with the four WAIS-IV composite index scores are not unexpected.

The discussion regarding the WJ IV Auditory Memory (MS) and Speed of Lexical Access (LA) cluster correlations with WISC-IV indices appears relevant to the interpretation of the same WJ IV/WAIS-IV correlations (see Table 5-25). Briefly, there appears to be a differentiation of memory span (MS) and working memory (WM) narrow abilities; thus, comparing performance on the WJ IV Short-Term Working Memory (*Gwm)* and Auditory Memory Span clusters may provide insights into differences in these two *Gwm* abilities. Also, the WJ IV Speed of Lexical Access cluster is measuring an aspect of cognition not represented well in the WAIS-IV.

### Correlations With the WPPSI-III

This study compares select age-appropriate WJ IV OL, COG, and research measures with the composite scores from the WPPSI-III. Table 5-26 presents the means, standard deviations, and correlations for five measures from the WJ IV OL battery (including four tests and the Oral Expression cluster), one COG test (Verbal Attention), and four research tests (see Table 5-10) for 99 examinees from ages 4 through 7 ($M$ = 5.9 years, $SD$ = 0.8 years).

The WPPSI-III Full Scale IQ for the sample is 107.7. No comparable WJ IV measure of general intelligence was obtained in this study. The mean scores for the 10 WJ IV and research measures range from 100.1 to 109.1, suggesting that this sample has slightly above average general intelligence.

***Table 5-26.***
*Summary Statistics and Correlations for WJ IV COG and Select WJ IV OL Measures and WPPSI-III Scales*

| Select WJ IV Measures | Mean | *SD* | WPPSI-III Measures: Full Scale IQ (*g*) | Verbal IQ (*Gc*) | Perceptual IQ (*Gf/Gv*) | Processing Speed Quotient (*Gs*) | General Learning Quotient (*Gc-LD/VL*) |
|---|---|---|---|---|---|---|---|
| **Cognitive and Oral Language** | | | | | | | |
| Oral Expression (*Gc*-VL/LD, *Gwm-MS*) | 106.0 | 15.2 | 0.72 | 0.81 | 0.50 | 0.40 | 0.81 |
| Verbal Attention (*Gwm*-WM/AC) | 104.0 | 15.8 | 0.50 | 0.50 | 0.40 | 0.37 | 0.39 |
| Picture Vocabulary (*Gc*-VL/LD) | 102.2 | 14.4 | 0.67 | 0.76 | 0.46 | 0.24 | 0.78 |
| Rapid Picture Naming (*Glr*-NA/LA) | 109.1 | 11.8 | 0.41 | 0.46 | 0.27 | 0.23 | 0.42 |
| Sentence Repetition (*Gwm*-MS) | 106.7 | 14.2 | 0.62 | 0.70 | 0.43 | 0.43 | 0.69 |
| Sound Blending (*Ga*-PC) | 104.0 | 11.2 | 0.41 | 0.51 | 0.30 | 0.13 | 0.47 |
| **Research Tests** | | | | | | | |
| Memory for Names (*Glr*-MA) | 100.1 | 11.2 | 0.45 | 0.51 | 0.32 | 0.31 | 0.57 |
| Verbal Analogies (*Gf*-RG, *Gc*-LD) | 103.4 | 14.9 | 0.56 | 0.57 | 0.49 | 0.26 | 0.47 |
| Visual Closure (*Gv*-CS) | 104.7 | 15.1 | 0.33 | 0.34 | 0.26 | 0.29 | 0.33 |
| Number Sense (*Gf*-RQ) | 104.4 | 15.1 | 0.68 | 0.65 | 0.60 | 0.36 | 0.55 |
| **Mean** | | | 107.7 | 105.2 | 107.8 | 107.1 | 106.9 |
| **Standard Deviation** | | | 14.0 | 15.1 | 14.7 | 11.5 | 14.6 |

*Note.* *N* = 99 for all measures. Age range (years) = 4–7, *M* = 5.9, *SD* = 0.8

The highest correlations in Table 5-26 provide validity evidence for the WJ IV *Gc*-based OL measures reported. The WJ IV OL Oral Expression cluster correlates highly with the WPPSI-III Full Scale IQ (.72), Verbal IQ (.81), and General Learning Quotient (.81).[41] The WJ IV OL Oral Expression cluster appears to be a good indicator of general intelligence and language abilities (*Gc*). Correlations of .76 and .78 for WJ IV OL Picture Vocabulary with the WPPSI-III Verbal IQ and General Learning Quotient support the validity of this test as a measure of *Gc*-based language abilities (VL/LD). WJ IV OL Sentence Repetition also appears to be a strong measure of memory aspects of *Gc* or language (LS/MS) as evidenced by correlations of .70 and .69 with the WPPSI-III Verbal IQ and General Learning Quotient.

The remaining WJ IV tests' (Verbal Attention, Rapid Picture Naming, and Sound Blending) correlations with WPPSI-III measures are all low to moderate (.13 to .51). These correlations suggest that the abilities measured by these three WJ IV tests are not represented strongly in the WPPSI-III, and that they provide unique information that would complement an assessment with the WPPSI-III. The correlations between the four WJ IV research tests and the WPPSI-III composites are presented for information purposes only. The most interesting correlations are for Number Sense (see prior discussion related to Table 5-10), a measure of numerosity, which is defined as an individual's ability to understand what numbers mean in relationship to other numbers, as well as the vocabulary and concepts required to compare, judge, and estimate size, quantity, position, or volume. Number Sense correlates at .68, .65, and .60 with the WPPSI-III Full Scale, Verbal IQ, and Performance IQ scores, respectively. These correlations suggest that early quantitative reasoning abilities are significantly related to general intelligence (*g*). This is consistent with research that has found measures of

[41] The WPPSI-III General Learning Quotient is composed of two *Gc* or language-based tests—Receptive Vocabulary and Picture Naming.

quantitative reasoning in other IQ tests to be among the highest-correlated measures with general intelligence (*g*) (see Keith et al., 2010; Keith & Reynolds, 2010, 2012).

## *Correlations With the KABC-II*

Table 5-27 presents the means, standard deviations, and correlations for the WJ IV COG and KABC-II composite scores for 50 school-age examinees from ages 7 through 18 ($M$ = 11.4 years, $SD$ = 3.3 years). The mean WJ IV GIA (99.5) and KABC-II Fluid-Crystallized Index[42] scores (100.3) differ by –0.8 standard score points. The correlations between the three WJ IV COG clusters representing general intelligence (GIA, BIA, and *Gf-Gc* Composite) are at high levels (.71 to .77) with the KABC-II Fluid-Crystallized Index, providing support for the general intelligence (*g*) interpretation of all three COG clusters.

***Table 5-27.***
*Summary Statistics and Correlations for WJ IV COG Clusters and KABC-II Scales*

| | | | KABC-II Measures | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **WJ IV Measures** | **Mean** | ***SD*** | **Mental Processing Index** | **Fluid-Crystallized Index (*g*)** | **Sequential/ *Gsm* Index** | **Simultaneous/ *Gv* Index** | **Learning/ *Glr* Index** | **Planning/ *Gf* Index** | **Knowledge/ *Gc* Index** |
| **Cognitive Composite Clusters** | | | | | | | | | |
| General Intellectual Ability (*g*) | 99.5 | 14.4 | 0.72 | 0.77 | 0.41 | 0.44 | 0.60 | 0.51 | 0.58 |
| Brief Intellectual Ability (*g*) | 98.1 | 15.7 | 0.67 | 0.76 | 0.34 | 0.36 | 0.58 | 0.54 | 0.68 |
| *Gf-Gc* Composite | 97.2 | 14.8 | 0.57 | 0.71 | 0.33 | 0.33 | 0.50 | 0.41 | 0.78 |
| **CHC Factor Clusters** | | | | | | | | | |
| Comprehension-Knowledge (*Gc*) | 97.0 | 15.1 | 0.42 | 0.60 | 0.31 | 0.21 | 0.37 | 0.27 | 0.82 |
| Fluid Reasoning (*Gf*) | 97.4 | 13.8 | 0.59 | 0.67 | 0.28 | 0.37 | 0.50 | 0.46 | 0.59 |
| **CHC Factor Clusters** | | | | | | | | | |
| Short-Term Working Memory (*Gwm*) | 98.2 | 18.9 | 0.69 | 0.74 | 0.42 | 0.38 | 0.56 | 0.52 | 0.54 |
| Processing Speed (*Gs*) | 100.2 | 12.8 | 0.43 | 0.38 | 0.23 | 0.18 | 0.43 | 0.33 | 0.09 |
| Auditory Processing (*Ga*) | 94.8 | 18.3 | 0.51 | 0.58 | 0.43 | 0.27 | 0.36 | 0.35 | 0.50 |
| Long-Term Retrieval (*Glr*) | 100.6 | 14.2 | 0.60 | 0.67 | 0.29 | 0.34 | 0.64 | 0.39 | 0.53 |
| Visual Processing (*Gv*) | 103.1 | 12.8 | 0.38 | 0.40 | 0.21 | 0.37 | 0.29 | 0.20 | 0.31 |
| **Narrow Ability & Clinical Clusters** | | | | | | | | | |
| Quantitative Reasoning (RQ) | 97.2 | 14.1 | 0.52 | 0.56 | 0.17 | 0.26 | 0.54 | 0.40 | 0.48 |
| Number Facility (N) | 98.2 | 17.5 | 0.59 | 0.65 | 0.34 | 0.37 | 0.48 | 0.45 | 0.50 |
| Perceptual Speed (P) | 99.6 | 13.1 | 0.50 | 0.49 | 0.26 | 0.35 | 0.42 | 0.37 | 0.23 |
| Cognitive Efficiency (*Gsm*+*Gs*) | 99.3 | 13.6 | 0.65 | 0.66 | 0.46 | 0.45 | 0.49 | 0.37 | 0.41 |
| Cognitive Efficiency–Extended (*Gsm*+*Gs*) | 99.2 | 15.6 | 0.67 | 0.70 | 0.38 | 0.41 | 0.55 | 0.50 | 0.43 |
| **Mean** | | | 99.7 | 100.3 | 100.1 | 98.0 | 99.7 | 102.8 | 101.6 |
| **Standard Deviation** | | | 13.6 | 12.7 | 14.4 | 14.9 | 14.6 | 15.3 | 13.0 |

*Note.* $N$ = 50 for all measures. Age range (years) = 7–18, $M$ = 11.4, $SD$ = 3.3

[42] The KABC-II provides two different global composite scores. The Mental Processing Index is based on the Luria Neuropsychological model. The Fluid-Crystallized Index, which is a combination of the KABC-II *Gf*, *Gc*, *Glr*, *Gv*, and *Gsm* tests, is based on CHC theory and is the most appropriate score to compare to the WJ IV COG GIA. The KABC-II domain scores include labels based on the Luria or CHC models. The CHC composite labels are used here.

Strong concurrent validity evidence is present for the WJ IV COG Comprehension-Knowledge (*Gc*) cluster; it correlates .82 with the KABC-II Knowledge (*Gc*) Index. Concurrent validity evidence also is observed for the WJ IV Long-Term Retrieval (*Glr*) cluster; it has a correlation of .64 with the KABC-II Learning (*Glr*) Index. The three other corresponding WJ IV and KABC-II CHC measures display more moderate correlations: the WJ IV Short-Term Working Memory (*Gwm*) and KABC-II Sequential (*Gsm*) clusters correlate at .42, the WJ IV Visual Processing, and KABC-II Simultaneous (*Gv*) clusters correlate at .37, and the WJ IV Fluid Reasoning (*Gf*) and KABC-II Planning (*Gf*) clusters correlate at .46. The low to moderate correlations between the respective WJ IV and KABC-II *Gwm*, *Gv*, and *Gf* measures suggest that although statistically related, these respective CHC domain measures are not interchangeable—they contain more unique variance than shared variance.

Future investigations via joint cross-battery factor analysis of the individual tests from the WJ IV and KABC-II are needed to further investigate the nature of the lower *Gwm*, *Gv*, and *Gf* correlations.[43] It is possible that although the CHC composite or cluster scores for *Gwm*, *Gv*, and *Gf* share a common CHC label, the specific narrow abilities measured by the tests composing the three respective CHC domain scores differ. For example, although the respective WJ IV and KABC-II composites both include tests classified as measures of visualization (Vz, as measured by the WJ IV Visualization test and the KABC-II Triangles and Block Counting test), the WJ IV *Gv* cluster also includes a measure of the narrow ability of visual memory (MV; Picture Recognition), while the KABC-II *Gv* index includes a test classified as measuring spatial scanning (SS; as measured by the Rover test) (Flanagan, Ortiz, & Alfonso, 2013). Additionally, a CHC CFA study of the KABC-II norming sample reported by Reynolds and Keith (2007) suggests that some of the tests in certain KABC-II composites, such as the Rover test in the *Gv* index and the Pattern Reasoning test in the *Gf* index, are mixed measures of CHC abilities.

### Correlations With the SB5

Table 5-28 presents the means, standard deviations, and correlations for the WJ IV COG and SB5 composite scores for 50 school-age examinees from ages 6 through 16 ($M$ = 11.1 years, $SD$ =3.0 years). The mean WJ IV GIA (97.8) and SB5 Full-Scale IQ (100.0) scores differ by −2.2 standard score points. The correlations between the three WJ IV COG clusters representing general intelligence (GIA, BIA, and *Gf-Gc* Composite) are at high levels (.79 to .82) with the SB5 Full Scale IQ, providing support for the general intelligence (*g*) interpretation of all three COG clusters.

With the exception of the WJ IV Visual Processing (*Gv*) cluster, the WJ IV CHC factor clusters correlate between low to moderate (WJ IV Short-Term Working Memory/SB5 Quantitative Reasoning correlation = .41) and high levels (WJ IV Auditory Processing/SB5 Verbal IQ correlation = .81) with the SB5 Verbal and Nonverbal IQ scores and the SB5 CHC-based index scores. However, the patterns of correlations between corresponding CHC factor scores from the two batteries are not consistent with expectations. For example, the WJ IV Comprehension Knowledge (*Gc*) cluster shows high correlations with the SB5 *Gc* Verbal IQ (.79) and Knowledge (.68) scales. However, it also shows high correlations with the SB5 Fluid Reasoning (*Gf*, .75), Visual-Spatial Processing (*Gv*, .72), and Working Memory (*Gwm*, .72) Indices. Another example is the high correlation of the WJ IV Fluid Reasoning (*Gf*) cluster (.67) with the SB5 Fluid Reasoning (*Gf*) scale and also high and higher correlations with the SB5 Verbal IQ (*Gc*, .76), Visual-Spatial (*Gv*, .66), and Working Memory (*Gwm*, .66) Indices.

[43] Future joint cross-battery CFA studies with the WJ IV, WISC-IV, and WAIS-IV study samples, which are large enough for CFA analysis, also will shed light on the concurrent correlations reported for those two studies (see Tables 5-24 and 5-25).

***Table 5-28.***
*Summary Statistics and Correlations for WJ IV COG and Select WJ IV OL Measures and SB5 Scales*

| | | | SB5 Measures | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **WJ IV Measures** | **Mean** | ***SD*** | **Full Scale IQ (*g*)** | **Nonverbal IQ** | **Verbal IQ** | **Fluid Reasoning (*Gf*)** | **Knowledge (*Gc*)** | **Quantitative Reasoning (*Gf*-RQ)** | **Visual-Spatial Processing (*Gv*)** | **Working Memory (*Gwm*)** |
| **Cognitive Composite Clusters** | | | | | | | | | | |
| General Intellectual Ability (*g*) | 97.8 | 17.2 | 0.80 | 0.67 | 0.84 | 0.72 | 0.72 | 0.57 | 0.77 | 0.75 |
| Brief Intellectual Ability (*g*) | 95.8 | 17.1 | 0.79 | 0.66 | 0.82 | 0.72 | 0.66 | 0.57 | 0.73 | 0.77 |
| *Gf-Gc* Composite | 95.2 | 15.4 | 0.82 | 0.68 | 0.85 | 0.78 | 0.70 | 0.60 | 0.76 | 0.75 |
| **CHC Factor Clusters** | | | | | | | | | | |
| Comprehension-Knowledge (*Gc*) | 95.9 | 14.2 | 0.77 | 0.65 | 0.79 | 0.75 | 0.68 | 0.51 | 0.72 | 0.72 |
| Fluid Reasoning (*Gf*) | 95.5 | 15.3 | 0.72 | 0.59 | 0.76 | 0.67 | 0.60 | 0.56 | 0.66 | 0.66 |
| Short-Term Working Memory (*Gwm*) | 98.8 | 18.3 | 0.64 | 0.50 | 0.71 | 0.55 | 0.52 | 0.41 | 0.62 | 0.69 |
| Processing Speed (*Gs*) | 100.8 | 15.9 | 0.58 | 0.50 | 0.58 | 0.51 | 0.57 | 0.44 | 0.57 | 0.48 |
| Auditory Processing (*Ga*) | 95.5 | 18.4 | 0.77 | 0.63 | 0.81 | 0.68 | 0.68 | 0.55 | 0.73 | 0.72 |
| Long-Term Retrieval (*Glr*) | | | | | | | | | | |
| Visual Processing (*Gv*) | 98.6 | 12.4 | 0.36 | 0.30 | 0.37 | 0.31 | 0.25 | 0.24 | 0.40 | 0.37 |
| **Narrow Ability & Clinical Clusters** | | | | | | | | | | |
| Quantitative Reasoning (RQ) | 97.0 | 16.0 | 0.72 | 0.63 | 0.72 | 0.66 | 0.61 | 0.57 | 0.67 | 0.65 |
| Number Facility (N) | 94.8 | 20.9 | 0.61 | 0.49 | 0.65 | 0.57 | 0.51 | 0.49 | 0.56 | 0.56 |
| Perceptual Speed (P) | 97.1 | 18.3 | 0.61 | 0.51 | 0.63 | 0.56 | 0.57 | 0.48 | 0.57 | 0.52 |
| Cognitive Efficiency (*Gsm*+*Gs*) | 100.2 | 18.5 | 0.62 | 0.50 | 0.67 | 0.54 | 0.55 | 0.40 | 0.62 | 0.61 |
| Cognitive Efficiency–Extended (*Gsm*+*Gs*) | 97.8 | 19.7 | 0.66 | 0.54 | 0.70 | 0.59 | 0.59 | 0.48 | 0.63 | 0.62 |
| **Mean** | | | 100.0 | 100.4 | 99.9 | 103.3 | 98.4 | 97.8 | 99.2 | 102.8 |
| **Standard Deviation** | | | 15.4 | 16.5 | 14.9 | 16.7 | 13.8 | 13.3 | 13.0 | 18.1 |

*Note.* $N = 50$ for all measures. Age range (years) = 6–16, $M = 11.1$, $SD = 3.0$

The lack of clear and consistent CHC cross-battery correlations is most likely a function of the lack of strong CHC structural evidence for the SB5 CHC factor scores. Independent factor analysis of the SB5 has not supported the five-factor CHC structure of the battery (Canivez, 2008; DiStefano & Dombrowski, 2006). Keith and Reynolds (2010) concluded that “no one has so far estimated the true theoretical structure of the SB5, a structure that includes both CHC factors and method-like modality factors representing verbal and nonverbal presentation” (p. 640). These conclusions reflect the fact that both SB5 verbal and nonverbal tests are combined together to form the CHC factor index scores, a process that introduces verbal/nonverbal method variance into the scores; the scales “are meshed together to measure a particular dimension of intelligence” (DiStefano & Dombrowski, 2006, p. 124). As reported in the SB5 Technical Manual (Roid, 2003b), the SB5 CHC factor score intercorrelations across the entire norming sample are quite high (.65 to .75). This also may contribute to the lack of convergent and divergent validity evidence for the WJ IV based on the SB5 factor scores. Given the lack of clear structural validity evidence for the SB5 CHC factor indices, the most important validity evidence in Table 5-28 is the relationship between the WJ IV and SB5 global g-based measures. These high correlations support the use and interpretation of the WJ IV cognitive composite clusters as measures of general intelligence.

## Correlations With the DAS-II

Table 5-29 presents the means, standard deviations, and correlations for the WJ IV and DAS-II scores for 50 preschool examinees from ages 3 through 6 ($M$ = 5.2 years, $SD$ = 0.9 years). Given that the WJ IV does not provide a GIA score for preschool-age examinees, this study compared select age-appropriate WJ IV OL, COG, ACH, and research measures with the primary cluster scores from the DAS-II. Table 5-29 presents the descriptive statistics and correlations for the DAS-II measures and six measures from the WJ IV OL (five OL tests and the Oral Expression cluster), one WJ IV COG test (Phonological Processing), two WJ IV ACH tests (Letter-Word Identification and Spelling), and four research tests (see Table 5-10). The mean DAS-II General Conceptual Ability score for the sample is 113.8. No comparable WJ IV GIA score was obtained in this study. Mean scores for the 13 WJ IV and research measures presented in Table 5-29 range from 94.0 to 110.3. The WJ IV and DAS-II mean scores suggest that this sample has above average general intelligence.

***Table 5-29.***
*Summary Statistics and Correlations for Select WJ IV COG, WJ IV ACH, and WJ IV OL Measures and DAS-II Scales*

| | | | | DAS-II Measures | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Select WJ IV Measures** | ***n*** | **Mean** | ***SD*** | **General Conceptual Ability (*g*)** | **Verbal Ability (*Gc*)** | **Nonverbal Reasoning Ability (*Gf*)** | **Spatial Ability (*Gv*)** | **School Readiness (*Gq*/*Gv*/*Ga*)** | **Working Memory (*Gwm*)** | **Processing Speed (*Gs*)** |
| **Cognitive, Achievement, and Oral Language** | | | | | | | | | | |
| Oral Expression (*Gc*-VL/LD, *Gwm*-MS) | 50 | 104.6 | 13.8 | 0.68 | 0.70 | 0.53 | 0.40 | 0.68 | 0.69 | 0.55 |
| Phonological Processing (*Ga*-PC, *Glr*-LA/FW) | 33 | 110.3 | 8.1 | 0.36 | 0.51 | 0.26 | –0.11 | 0.51 | 0.27 | 0.21 |
| Picture Vocabulary *(Gc*-VL/LD*)* | 50 | 102.0 | 14.9 | 0.65 | 0.78 | 0.47 | 0.31 | 0.62 | 0.60 | 0.54 |
| Rapid Picture Naming (*Glr*-NA/LA) | 50 | 106.5 | 9.9 | 0.49 | 0.42 | 0.24 | 0.51 | 0.47 | 0.36 | 0.55 |
| Sentence Repetition (*Gwm*-MS) | 50 | 104.9 | 12.0 | 0.56 | 0.49 | 0.47 | 0.39 | 0.59 | 0.62 | 0.45 |
| Sound Blending (*Ga*-PC) | 50 | 102.8 | 11.9 | 0.66 | 0.51 | 0.52 | 0.55 | 0.56 | 0.60 | 0.45 |
| Sound Awareness (*Ga*-PC) | 44 | 104.3 | 13.0 | 0.63 | 0.52 | 0.41 | 0.47 | 0.62 | 0.51 | 0.34 |
| Letter-Word Identification (*Grw*-RD) | 50 | 99.3 | 12.1 | 0.79 | 0.71 | 0.55 | 0.64 | 0.84 | 0.62 | 0.44 |
| Spelling (*Grw*-SG) | 50 | 101.0 | 9.0 | 0.70 | 0.48 | 0.52 | 0.70 | 0.69 | 0.68 | 0.51 |
| **Research Tests** | | | | | | | | | | |
| Memory for Names (*Glr*-MA) | 50 | 94.0 | 10.5 | 0.38 | 0.29 | 0.30 | 0.31 | 0.40 | 0.31 | 0.11 |
| Verbal Analogies (*Gf*-RG, *Gc*-LD) | 50 | 101.4 | 16.3 | 0.60 | 0.68 | 0.47 | 0.30 | 0.63 | 0.68 | 0.51 |
| Visual Closure (*Gv*-CS) | 50 | 101.6 | 11.4 | 0.61 | 0.30 | 0.55 | 0.62 | 0.31 | 0.29 | 0.24 |
| Number Sense (*Gf*-RQ) | 50 | 109.3 | 13.6 | 0.71 | 0.64 | 0.59 | 0.45 | 0.72 | 0.82 | 0.58 |
| ***n*** | | | | 49 | 50 | 50 | 49 | 31 | 31 | 31 |
| **Mean** | | | | 113.8 | 107.5 | 112.7 | 112.8 | 110.9 | 103.8 | 108.6 |
| **Standard Deviation** | | | | 13.8 | 13.9 | 12.1 | 14.4 | 14.6 | 16.1 | 12.2 |

*Note.* Sample sizes for correlations based on the smaller *n* for each respective pair of correlated measures. Age range (years) = 3–6, $M$ = 5.2, $SD$ = 0.9

An important finding, not reported in Table 5-29, is that the DAS-II General Conceptual Ability and School Readiness clusters correlate at a high level with each other (.82) in this sample—suggesting that the DAS II School Readiness cluster can be interpreted as a reasonable measure of general intelligence. The School Readiness cluster is composed of three tests that measure aspects of *Gq* (Early Number Concepts), *Gv* (Matching Letter-Like Forms), and *Ga* (Phonological Processing). Thus, the School Readiness cluster, in many respects, can be interpreted as another proxy for general intelligence (*g*) in the DAS-II. The WJ IV OL Oral Expression cluster and Picture Vocabulary test correlate at consistently high levels with the DAS-II General Conceptual Ability and School Readiness clusters (.62 to .68) as well as with the DAS-II Verbal Ability cluster (.70 and .78). These WJ IV *Gc* measures appear to be good indicators of general intelligence and language abilities (*Gc*) in this age group.

The .84 correlation between the WJ IV Letter-Word Identification and DAS-II School Readiness cluster provides evidence that this WJ IV test is a strong indicator of general school readiness. Other correlations providing moderate concurrent validity evidence for individual WJ IV tests are: (a) the WJ IV Phonological Processing (*Ga/Glr*) and Sound Awareness (*Ga*) correlations of .51 and .62 with the DAS-II School Readiness (*Gq*, *Gv*, *Ga)* cluster (common *Ga* abilities), (b) the WJ IV Sentence Repetition and DAS-II Working Memory correlation of .62 (shared *Gwm*), and (c) the WJ IV Spelling and DAS-II School Readiness cluster correlation of .69 (shared *Grw*). WJ IV Letter-Word Identification and Spelling demonstrate moderate to high correlations across all DAS-II measures.

The WJ IV research tests and DAS-II cluster correlations are presented for informational purposes. Of particular interest, and consistent with the WJ IV/WPPSI-III study (see Table 5-26 and related discussion) are the high correlations for the WJ IV Number Sense test, a measure of numerosity. Number Sense correlates at .71, .72, and .82 with the DAS-II General Conceptual Ability, School Readiness, and Working Memory clusters, respectively. These findings suggest that early quantitative reasoning abilities are significantly related to general intelligence (*g*) and other important cognitive abilities (working memory).

## Correlations for the WJ IV OL With Other Measures of Oral Language

The WJ IV OL scores were examined in four studies that included the following external measures: the *Clinical Evaluation of Language Fundamentals®–Fourth Edition* (CELF®-4) (Semel, Wiig, & Secord, 2003), the *Peabody Picture Vocabulary Test–Fourth Edition* (PPVT™-4) (Dunn & Dunn, 2007), the *Comprehensive Assessment of Spoken Language* (CASL™) (Carrow-Woolfolk, 1999), and the *Oral and Written Language Scales: Listening Comprehension/Oral Expression* (OWLS) (Carrow-Woolfolk, 1995). The CELF-4, CASL, and OWLS are individually administered multidimensional batteries of different aspects of oral language ability.[44] The PPVT-4 is an individually administered measure of expressive vocabulary and word retrieval.

### *Correlations With the CELF-4 and PPVT-4*

Tables 5-30 and 5-31 present the means, standard deviations, and correlations for five WJ IV OL clusters and one WJ IV COG cluster (Auditory Processing), the six CELF-4 Composite scores, and the single PPVT-4 score for two age-differentiated samples. Table 5-30 summarizes the results for 50 examinees from ages 5 through 8 ($M$ = 6.8 years, $SD$ = 1.3 years). Table 5-31 summarizes the results for 56 examinees from ages 10 through 18 ($M$ = 13.6 years, $SD$ = 2.2 years).

[44] Descriptions and CHC analysis of these batteries can be found in Flanagan et al. (2006).

**Table 5-30.**
*Summary Statistics and Correlations for WJ IV OL and WJ IV COG Clusters and CELF-4 and PPVT-4 Scales, Ages 5 Through 8 Sample*

| WJ IV Measures | Mean | *SD* | CELF-4 Measures: Core Language | Receptive Language | Expressive Language | Language Content | Language Structure | Working Memory | PPVT-4 |
|---|---|---|---|---|---|---|---|---|---|
| **Cognitive Cluster** | | | | | | | | | |
| Auditory Processing (*Ga*) | 102.2 | 12.8 | 0.51 | 0.44 | 0.55 | 0.49 | 0.55 | 0.58 | 0.62 |
| **Oral Language Clusters** | | | | | | | | | |
| Oral Language | 102.4 | 12.8 | 0.63 | 0.59 | 0.64 | 0.67 | 0.67 | 0.50 | 0.74 |
| Oral Expression | 106.0 | 11.4 | 0.74 | 0.64 | 0.72 | 0.67 | 0.73 | 0.58 | 0.70 |
| Listening Comprehension | 102.3 | 11.6 | 0.64 | 0.62 | 0.63 | 0.63 | 0.68 | 0.59 | 0.69 |
| Speed of Lexical Access | 103.2 | 14.9 | 0.31 | 0.37 | 0.32 | 0.35 | 0.38 | 0.57 | 0.43 |
| **Mean** | | | 102.9 | 104.6 | 102.4 | 106.3 | 103.0 | 101.7 | 105.8 |
| **Standard Deviation** | | | 13.6 | 12.7 | 13.5 | 12.2 | 13.1 | 12.7 | 10.5 |

*Note.* *N* = 50 for all measures except CELF-4 Working Memory (*n* = 49). Age range (years) = 5–8, *M* = 6.8, *SD* = 1.3

**Table 5-31.**
*Summary Statistics and Correlations for WJ IV OL and WJ IV COG Clusters and CELF-4 and PPVT-4 Scales, Ages 10 Through 18 Sample*

| WJ IV Measures | Mean | *SD* | CELF-4 Measures: Core Language | Receptive Language | Expressive Language | Language Content | Language Structure | Working Memory | PPVT-4 |
|---|---|---|---|---|---|---|---|---|---|
| **Cognitive Cluster** | | | | | | | | | |
| Auditory Processing (*Ga*) | 100.5 | 14.5 | 0.62 | 0.52 | 0.60 | 0.51 | 0.60 | 0.35 | 0.52 |
| **Oral Language Clusters** | | | | | | | | | |
| Oral Language | 99.5 | 12.1 | 0.75 | 0.46 | 0.69 | 0.49 | 0.65 | 0.17 | 0.76 |
| Oral Expression | 99.0 | 14.3 | 0.83 | 0.56 | 0.79 | 0.49 | 0.74 | 0.33 | 0.62 |
| Listening Comprehension | 104.2 | 13.9 | 0.76 | 0.50 | 0.68 | 0.42 | 0.69 | 0.30 | 0.55 |
| Speed of Lexical Access | 99.7 | 9.5 | 0.42 | 0.19 | 0.36 | 0.18 | 0.39 | 0.23 | 0.14 |
| **Mean** | | | 104.7 | 97.8 | 103.7 | 100.6 | 103.6 | 98.1 | 108.1 |
| **Standard Deviation** | | | 12.3 | 13.9 | 12.4 | 13.9 | 14.4 | 12.5 | 11.6 |

*Note.* *N* = 56 for all measures. Age range (years) = 10–18, *M* = 13.6, *SD* = 2.2

In the ages 5 through 8 sample, the mean CELF-4 and PPVT-4 scores range from 101.7 to 106.3; the six WJ IV clusters range from 102.2 to 106.0. A review of the correlations in Table 5-30 finds that the *primary*[45] WJ IV OL clusters (Oral Language, Oral Expression, and Listening Comprehension) all show consistently high correlations (most in the .60 to low .70 range) with all CELF-4 composites (except Working Memory) and with the total PPVT-4 score (.69 to .74). For example, the WJ IV OL Oral Language cluster correlates at .63, .64, .67, and .67 with CELF-4 Core Language, Expressive Language, Language Content, and Language Structure composites, respectively. The WJ IV OL clusters and the CELF-4 Core Language, Receptive Language, Expressive Language, Language Content, and Language Structure composite measures share common tests within their respective batteries; although not reported in Table 5-30, correlations between the respective oral language clusters within both the CELF-4 (.64 to .92) and the WJ IV OL (.65 to .95) reflect this shared test content overlap. Given these high within-battery CELF-4 cluster correlations, these measures would not be expected to demonstrate strong patterns of divergent and convergent validity. The primary WJ IV OL clusters correlate at high levels (.69 to .74) with the PPVT-4. In general,

[45] When discussing the WJ IV OL clusters in this section of this chapter, the Oral Language, Oral Expression, and Listening Comprehension clusters are referred to as the *primary* WJ IV OL clusters.

the high correlations of the four primary WJ IV OL clusters with the PPVT-4 and primary CELF-4 composites provide concurrent validity evidence that the WJ IV OL clusters measure general oral language abilities. The low WJ IV Speed of Lexical Access correlations (.31 to .57) and moderate WJ IV COG Auditory Processing (*Ga*) correlations (.44 to .62) with all CELF-4 composites and the PPVT-4 suggest that the WJ IV Auditory Processing and Speed of Lexical Access clusters are providing unique information not available in the CELF-4 or PPVT-4. Also, the moderate correlations (.50 to .59) between all five WJ IV clusters and the CELF-4 Working Memory composite suggest that the CELF-4 Working Memory composite is providing unique information not provided by the five WJ IV clusters.

In the ages 10 through 18 sample (Table 5-31), the mean CELF-4 and PPVT-4 scores range from 97.8 to 108.1; the five WJ IV clusters range from 99.0 to 104.2. The pattern of correlations for the same WJ IV, CELF-4, and PPVT-4 measures reported in the ages 10 through 18 sample are generally similar to those discussed for the ages 5 through 8 sample. The primary difference between results for this sample and the ages 5 through 8 sample are that this sample shows even lower correlations between the CELF-4 Working Memory composite and the five WJ IV clusters; this provides additional support for the idea that the CELF-4 Working Memory composite provides additional information beyond what the five WJ IV clusters provide.

## Correlations With the CASL and OWLS

Tables 5-32 and 5-33 present the means, standard deviations, and correlations between four WJ IV OL clusters (Oral Language, Oral Expression, Listening Comprehension, and Speed of Lexical Access) and measures from the CASL and OWLS. Table 5-32 summarizes the results for 50 examinees from ages 3 through 6 ($M$ = 5.1 years, $SD$ = 1.1 years). Table 5-33 summarizes the results for 50 examinees from ages 7 through 17 ($M$ = 13.6 years, $SD$ = 3.0 years). In the ages 3 through 6 sample, the mean CASL Core Composite score is 106.8, and the OWLS measures range from 99.8 to 102.1. The four WJ IV OL clusters range from 109.5 to 113.7. The sample appears to have above average general language abilities. In Table 5-32, the CASL correlation of primary interest is the Core Composite measure; correlations with the five individual CASL tests are reported for informational purposes but are not discussed here. Correlations between the CASL Core Composite and the four WJ IV OL clusters is also of primary interest in Table 5-33; the correlations with the 14 individual CASL tests are presented only for information purposes. Across both Tables 5-32 and 5-33, the four WJ IV OL clusters also correlate significantly with the OWLS Oral Composite, Listening Comprehension, and Oral Expression scales.

**Table 5-32.**
*Summary Statistics and Correlations for WJ IV OL Clusters and CASL and OWLS Scales, Ages 3 Through 6 Sample*

| | | | CASL Measures | | | | | | OWLS Measures | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **WJ IV Measures** | **Mean** | ***SD*** | **Core Composite** | **Basic Concepts** | **Sentence Completion** | **Syntax Construction** | **Paragraph Comprehension** | **Pragmatic Judgment** | **Oral Composite** | **Listening Comprehension** | **Oral Expression** |
| **Oral Language Clusters** | | | | | | | | | | | |
| Oral Language | 109.5 | 12.8 | 0.60 | 0.56 | 0.57 | 0.47 | 0.41 | 0.49 | 0.60 | 0.42 | 0.61 |
| Oral Expression | 109.8 | 13.5 | 0.48 | 0.43 | 0.51 | 0.42 | 0.41 | 0.31 | 0.46 | 0.31 | 0.49 |
| Listening Comprehension | 111.2 | 10.6 | 0.58 | 0.60 | 0.53 | 0.49 | 0.44 | 0.46 | 0.57 | 0.44 | 0.55 |
| Speed of Lexical Access | 113.7 | 12.3 | 0.48 | 0.41 | 0.36 | 0.43 | 0.36 | 0.40 | 0.24 | 0.07 | 0.33 |
| **Mean** | | | 106.8 | 112.9 | 104.8 | 103.1 | 105.6 | 106.4 | 100.7 | 102.1 | 99.8 |
| **Standard Deviation** | | | 13.4 | 14.1 | 12.4 | 12.6 | 13.8 | 12.2 | 10.4 | 10.5 | 11.5 |

*Note.* $N$ = 50 for all measures except WJ IV Phonological Processing ($n$ = 48). All correlations with WJ IV Phonological Processing have $n$ = 48 sample size. Age range (years) = 3–6, $M$ = 5.1, $SD$ = 1.1

**Table 5-33.**
*Summary Statistics and Correlations for WJ IV OL Clusters and CASL and OWLS Scales, Ages 7 Through 17 Sample*

| CASL/OWLS Measures | *n* | Mean | *SD* | WJ IV Oral Language Clusters: Oral Language | Oral Expression | Listening Comprehension | Speed of Lexical Access |
|---|---|---|---|---|---|---|---|
| **CASL Measures** | | | | | | | |
| Core Composite | 50 | 103.6 | 14.8 | 0.85 | 0.72 | 0.76 | 0.57 |
| Antonyms | 50 | 106.7 | 16.0 | 0.82 | 0.64 | 0.75 | 0.39 |
| Synonyms | 50 | 107.3 | 14.9 | 0.71 | 0.55 | 0.70 | 0.32 |
| Sentence Completion | 50 | 104.2 | 12.9 | 0.76 | 0.66 | 0.68 | 0.51 |
| Idiomatic Language | 39 | 100.5 | 12.8 | 0.82 | 0.75 | 0.72 | 0.42 |
| Syntax Construction | 50 | 101.1 | 17.1 | 0.71 | 0.57 | 0.64 | 0.47 |
| Paragraph Comprehension | 24 | 104.8 | 13.5 | 0.66 | 0.54 | 0.75 | 0.56 |
| Grammatical Morphemes | 50 | 104.1 | 12.4 | 0.63 | 0.53 | 0.56 | 0.47 |
| Sentence Comprehension | 39 | 102.3 | 13.1 | 0.59 | 0.58 | 0.57 | 0.47 |
| Grammaticality Judgment | 50 | 107.2 | 14.5 | 0.67 | 0.70 | 0.58 | 0.57 |
| Nonliteral Language | 50 | 104.8 | 12.3 | 0.67 | 0.64 | 0.54 | 0.40 |
| Meaning from Context | 39 | 98.3 | 13.4 | 0.77 | 0.63 | 0.67 | 0.56 |
| Inference | 50 | 97.9 | 12.6 | 0.70 | 0.62 | 0.67 | 0.42 |
| Ambiguous Sentences | 39 | 101.3 | 14.3 | 0.72 | 0.58 | 0.70 | 0.45 |
| Pragmatic Judgment | 50 | 99.0 | 16.3 | 0.52 | 0.34 | 0.42 | 0.48 |
| **OWLS Measures** | | | | | | | |
| Oral Composite | 50 | 108.8 | 14.8 | 0.68 | 0.62 | 0.64 | 0.41 |
| Listening Comprehension | 50 | 106.8 | 12.0 | 0.53 | 0.50 | 0.56 | 0.25 |
| Oral Expression | 50 | 109.3 | 17.3 | 0.67 | 0.60 | 0.59 | 0.45 |
| **Mean** | | | | 105.5 | 104.7 | 105.9 | 102.5 |
| **Standard Deviation** | | | | 13.8 | 16.1 | 15.7 | 13.8 |

*Note.* $N$ = 50 for all WJ IV measures. Sample sizes for correlations are based on the smaller $n$ for each respective pair of correlated measures. Age range (years) = 7–17, $M$ = 13.6, $SD$ = 3.0

In Table 5-32 the moderate correlations (.57 to .60) between the WJ IV Oral Language and Listening Comprehension clusters and the CASL Core Composite and OWLS Oral Composite measures provide concurrent validity evidence for these three WJ IV clusters as measures of general oral language abilities. The correlations between the WJ IV Oral Expression cluster and the CASL Core Composite (.48) and OWLS Oral Composite (.46) are lower than those for the three WJ IV OL clusters mentioned previously in the CELF-4/PPVT-4 study. The WJ IV Oral Expression cluster correlates higher (.49) with the OWLS Oral Expression scale than it does with the OWLS Listening Comprehension scale (.31). The WJ IV Listening Comprehension also correlates higher with the OWLS Oral Expression scale (.55) than with the OWLS Listening Comprehension scale (.44). These oral expression and listening comprehension cluster correlations suggest that, although the WJ IV OL and OWLS may have composite measures with identical names that are statistically significantly related, the respective scales provide measures of some similar, but also some different, aspects of the domains of oral expression and listening comprehension. Finally, the WJ IV Speed of Lexical Access cluster correlates at low levels (.24 to .48) with the primary CASL and OWLS composite measures, indicating that this WJ IV cluster measures unique abilities not measured by the CASL or OWLS.

In Table 5-33, the primary WJ IV OL clusters correlate at high levels (.72 to .85) with the CASL Core Composite, supporting the validity of the WJ IV Oral Language, Oral Expression, and Listening Comprehension clusters as measures of general oral language abilities at ages 7 through 17. These three primary WJ IV OL clusters also correlate the highest with the OWLS Oral Composite (.62 to .68) and with the OWLS Oral Expression measure (.59 to .67). The WJ IV OL Oral Expression cluster correlates higher with the OWLS Oral Expression scale (.60) than with the OWLS Listening Comprehension scale (.50). There is no meaningful difference between the correlations for the WJ IV Listening Comprehension cluster and the OWLS Listening Comprehension (.56) and Oral Expression (.59) scales. Similar to the results for the younger sample (ages 3 through 6; see Table 5-32), the WJ IV Speed of Lexical Access cluster correlates at moderate levels (.25 to .57) with the CASL Core Composite and three OWLS measures, indicating that this WJ IV cluster measures different aspects of oral language not represented in the CASL and OWLS.

## Correlations for the WJ IV ACH With Other Measures of Achievement

Five studies examined the relationships between WJ IV ACH scores and scores from the following external achievement measures: the *Kaufman Test of Educational Achievement–Second Edition* (KTEA™-II) (Kaufman & Kaufman, 2004b), the *Wechsler Individual Achievement Test–Third Edition*® (WIAT®–III) (Wechsler, 2009), and the *Oral and Written Language Scales–Written Expression* (OWLS-WE) (Carrow-Woolfolk, 1996). The KTEA-II and WIAT-III are individually administered multidimensional batteries of oral language and reading, math, and writing achievement. The OWLS-WE is an individually administered measure of written expression.

### *Correlations With the KTEA-II*

Tables 5-34 and 5-35 present the means, standard deviations, and correlations for the WJ IV OL and WJ IV ACH clusters and KTEA-II composites (the reading-related subtests are presented primarily for informational purposes) in two age-differentiated samples. Table 5-34 summarizes the results for 49 examinees from ages 8 through 12 ($M$ = 9.8 years; $SD$ = 1.2 years). Table 5-35 summarizes the results for 50 examinees from ages 13 through 18 ($M$ = 16.3 years; $SD$ = 1.8 years). In the ages 8 through 12 sample (Table 5-34), the KTEA-II composite scores range from 92.3 to 101.9; the WJ IV clusters range from 96.2 to 103.5 (with the exception of the mean score of 106.0 for the Phonetic Coding cluster). These mean scores suggest a sample of average achievement abilities. In the ages 13 through 18 sample (Table 5-35), both the KTEA-II and WJ IV means suggest a sample with above-average achievement abilities. The KTEA-II composite scores range from 108.2 to 111.1; the WJ IV clusters range from 104.5 to 110.8. With a few exceptions, the following interpretation focuses only on WJ IV cluster correlations with the KTEA-II composite measures.

In the ages 8 through 12 sample (Table 5-34), support for the concurrent validity of the three primary WJ IV OL clusters (Oral Language, Listening Comprehension, and Oral Expression) is present in the form of moderate to high correlations (.64 to .74) with the

***Table 5-34.***
*Summary Statistics and Correlations for WJ IV OL and WJ IV ACH Measures and KTEA-II Composites, Ages 8 Through 12 Sample*

| | | | KTEA-II Composite Measures | | | | | KTEA-II Reading Related Subtest Measures | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WJ IV Measures** | **Mean** | ***SD*** | **Oral Language** | **Reading** | **Math** | **Written Language** | **Comprehensive Achievement** | **Phonological Awareness** | **Nonsense Word Coding** | **Word Recognition Fluency** | **Decoding Fluency** | **Associational Fluency** | **Naming Facility** |
| **Oral Language Clusters** | | | | | | | | | | | | | |
| Oral Language | 96.7 | 12.7 | 0.64 | 0.73 | 0.64 | 0.69 | 0.75 | 0.50 | 0.64 | 0.74 | 0.63 | 0.47 | 0.15 |
| Oral Expression | 97.5 | 18.0 | 0.64 | 0.70 | 0.59 | 0.70 | 0.69 | 0.38 | 0.67 | 0.73 | 0.64 | 0.42 | 0.05 |
| Listening Comprehension | 97.1 | 14.2 | 0.74 | 0.76 | 0.80 | 0.69 | 0.84 | 0.48 | 0.67 | 0.72 | 0.69 | 0.41 | 0.12 |
| Phonetic Coding | 106.0 | 19.5 | 0.28 | 0.57 | 0.44 | 0.37 | 0.48 | 0.38 | 0.51 | 0.54 | 0.51 | 0.44 | 0.28 |
| Speed of Lexical Access | 100.1 | 10.9 | 0.01 | 0.23 | 0.19 | 0.23 | 0.20 | 0.32 | 0.26 | 0.28 | 0.37 | 0.32 | 0.59 |
| **Reading Achievement Clusters** | | | | | | | | | | | | | |
| Reading | 98.4 | 15.0 | 0.63 | 0.94 | 0.70 | 0.80 | 0.83 | 0.46 | 0.87 | 0.89 | 0.84 | 0.31 | 0.19 |
| Broad Reading | 97.7 | 13.8 | 0.66 | 0.92 | 0.73 | 0.79 | 0.85 | 0.45 | 0.85 | 0.88 | 0.83 | 0.33 | 0.25 |
| Basic Reading Skills | 98.8 | 15.3 | 0.62 | 0.93 | 0.68 | 0.82 | 0.82 | 0.46 | 0.89 | 0.86 | 0.85 | 0.26 | 0.17 |
| Reading Comprehension | 101.1 | 13.0 | 0.60 | 0.85 | 0.66 | 0.68 | 0.76 | 0.49 | 0.75 | 0.82 | 0.71 | 0.43 | 0.26 |
| Reading Fluency | 96.6 | 13.3 | 0.64 | 0.86 | 0.70 | 0.75 | 0.81 | 0.45 | 0.82 | 0.85 | 0.80 | 0.34 | 0.29 |
| Reading Speed | 96.2 | 13.1 | 0.53 | 0.78 | 0.65 | 0.66 | 0.73 | 0.43 | 0.68 | 0.75 | 0.71 | 0.30 | 0.27 |
| **Math Achievement Clusters** | | | | | | | | | | | | | |
| Mathematics | 98.7 | 12.5 | 0.72 | 0.77 | 0.94 | 0.68 | 0.88 | 0.51 | 0.66 | 0.60 | 0.56 | 0.39 | 0.08 |
| Broad Mathematics | 97.9 | 11.9 | 0.63 | 0.78 | 0.91 | 0.71 | 0.86 | 0.53 | 0.70 | 0.63 | 0.62 | 0.33 | 0.13 |
| Math Calculation | 98.4 | 10.9 | 0.54 | 0.73 | 0.83 | 0.69 | 0.79 | 0.47 | 0.67 | 0.61 | 0.62 | 0.28 | 0.12 |
| Math Problem Solving | 99.7 | 14.5 | 0.64 | 0.68 | 0.82 | 0.63 | 0.79 | 0.54 | 0.61 | 0.57 | 0.53 | 0.41 | 0.19 |
| **Written Language ACH Clusters** | | | | | | | | | | | | | |
| Written Language | 99.7 | 14.2 | 0.54 | 0.85 | 0.66 | 0.81 | 0.77 | 0.43 | 0.80 | 0.85 | 0.79 | 0.29 | 0.26 |
| Broad Writing | 100.9 | 13.2 | 0.59 | 0.86 | 0.68 | 0.84 | 0.79 | 0.43 | 0.78 | 0.86 | 0.79 | 0.27 | 0.24 |
| Basic Writing Skills | 97.9 | 15.6 | 0.64 | 0.90 | 0.72 | 0.91 | 0.84 | 0.43 | 0.86 | 0.83 | 0.81 | 0.24 | 0.15 |
| Written Expression | 103.5 | 11.5 | 0.53 | 0.68 | 0.61 | 0.65 | 0.67 | 0.37 | 0.56 | 0.74 | 0.61 | 0.28 | 0.29 |
| **Cross-Domain ACH Clusters** | | | | | | | | | | | | | |
| Academic Skills | 97.8 | 14.4 | 0.65 | 0.94 | 0.78 | 0.86 | 0.87 | 0.47 | 0.88 | 0.86 | 0.83 | 0.29 | 0.14 |
| Academic Fluency | 97.9 | 11.3 | 0.60 | 0.81 | 0.73 | 0.75 | 0.81 | 0.46 | 0.74 | 0.77 | 0.74 | 0.27 | 0.27 |
| Academic Applications | 99.8 | 13.7 | 0.68 | 0.87 | 0.84 | 0.74 | 0.87 | 0.52 | 0.75 | 0.80 | 0.71 | 0.43 | 0.25 |
| Brief Achievement | 97.1 | 15.1 | 0.65 | 0.94 | 0.78 | 0.85 | 0.88 | 0.50 | 0.87 | 0.85 | 0.82 | 0.29 | 0.18 |
| Broad Achievement | 98.4 | 13.5 | 0.68 | 0.94 | 0.83 | 0.84 | 0.91 | 0.51 | 0.85 | 0.87 | 0.82 | 0.34 | 0.23 |
| ***n*** | | | 49 | 49 | 49 | 47 | 47 | 48 | 49 | 48 | 48 | 49 | 49 |
| **Mean** | | | 92.3 | 101.9 | 98.1 | 95.0 | 97.7 | 105.8 | 103.1 | 101.8 | 101.3 | 111.0 | 100.4 |
| **Standard Deviation** | | | 14.7 | 17.2 | 16.3 | 16.5 | 16.9 | 13.9 | 16.1 | 17.1 | 15.7 | 13.6 | 13.9 |

*Note.* $N = 49$ for all WJ IV measures. All correlations are based on $N = 49$ except for correlations with KTEA-II measures with smaller *n*s; the sample sizes for these correlations are the sample sizes for the respective KTEA-II measure. Age range (years) = 8–12, $M = 9.8$, $SD = 1.2$

***Table 5-35.***
*Summary Statistics and Correlations for WJ IV OL and WJ IV ACH Measures and KTEA-II Composites, Ages 13 Through 18 Sample*

| | | | KTEA-II Composite Measures | | | | | KTEA-II Reading Related Subtest Measures | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WJ IV Measures** | **Mean** | ***SD*** | **Oral Language** | **Reading** | **Math** | **Written Language** | **Comprehensive Achievement** | **Nonsense Word Coding** | **Word Recognition Fluency** | **Decoding Fluency** | **Associational Fluency** | **Naming Facility** |
| **Oral Language Clusters** | | | | | | | | | | | | |
| Oral Language | 106.7 | 10.9 | 0.74 | 0.74 | 0.52 | 0.58 | 0.72 | 0.47 | 0.60 | 0.56 | 0.49 | 0.30 |
| Oral Expression | 104.5 | 14.9 | 0.64 | 0.63 | 0.45 | 0.46 | 0.61 | 0.43 | 0.57 | 0.49 | 0.35 | 0.39 |
| Listening Comprehension | 108.1 | 12.1 | 0.58 | 0.64 | 0.47 | 0.55 | 0.64 | 0.49 | 0.56 | 0.55 | 0.31 | 0.46 |
| Phonetic Coding | 109.9 | 13.7 | 0.45 | 0.51 | 0.28 | 0.38 | 0.43 | 0.43 | 0.52 | 0.53 | 0.40 | 0.22 |
| Speed of Lexical Access | 108.6 | 12.7 | 0.24 | 0.18 | 0.20 | 0.12 | 0.17 | 0.11 | 0.12 | 0.04 | 0.32 | 0.34 |
| **Reading Achievement Clusters** | | | | | | | | | | | | |
| Reading | 106.5 | 9.9 | 0.70 | 0.83 | 0.65 | 0.78 | 0.83 | 0.76 | 0.82 | 0.75 | 0.41 | 0.47 |
| Broad Reading | 108.3 | 12.4 | 0.63 | 0.78 | 0.64 | 0.74 | 0.80 | 0.68 | 0.78 | 0.70 | 0.42 | 0.50 |
| Basic Reading Skills | 107.0 | 11.5 | 0.62 | 0.81 | 0.60 | 0.80 | 0.80 | 0.86 | 0.88 | 0.86 | 0.41 | 0.49 |
| Reading Comprehension | 107.7 | 11.3 | 0.75 | 0.68 | 0.62 | 0.70 | 0.77 | 0.55 | 0.59 | 0.58 | 0.49 | 0.44 |
| Reading Fluency | 110.0 | 14.0 | 0.64 | 0.79 | 0.63 | 0.74 | 0.80 | 0.69 | 0.82 | 0.73 | 0.45 | 0.52 |
| Reading Speed | 110.1 | 13.6 | 0.55 | 0.65 | 0.62 | 0.68 | 0.71 | 0.62 | 0.69 | 0.59 | 0.42 | 0.53 |
| **Math Achievement Clusters** | | | | | | | | | | | | |
| Mathematics | 110.8 | 12.0 | 0.64 | 0.73 | 0.87 | 0.71 | 0.86 | 0.69 | 0.67 | 0.65 | 0.37 | 0.48 |
| Broad Mathematics | 109.5 | 12.6 | 0.55 | 0.63 | 0.86 | 0.69 | 0.79 | 0.66 | 0.64 | 0.59 | 0.37 | 0.55 |
| Math Calculation | 107.5 | 12.1 | 0.43 | 0.48 | 0.82 | 0.61 | 0.67 | 0.56 | 0.53 | 0.48 | 0.33 | 0.55 |
| Math Problem Solving | 109.6 | 14.1 | 0.65 | 0.80 | 0.69 | 0.63 | 0.80 | 0.64 | 0.66 | 0.66 | 0.35 | 0.53 |
| **Written Language ACH Clusters** | | | | | | | | | | | | |
| Written Language | 106.7 | 11.6 | 0.71 | 0.78 | 0.58 | 0.87 | 0.82 | 0.69 | 0.82 | 0.78 | 0.48 | 0.47 |
| Broad Writing | 108.7 | 11.6 | 0.71 | 0.79 | 0.60 | 0.85 | 0.83 | 0.72 | 0.84 | 0.80 | 0.48 | 0.49 |
| Basic Writing Skills | 107.5 | 13.2 | 0.70 | 0.84 | 0.60 | 0.89 | 0.85 | 0.71 | 0.84 | 0.81 | 0.48 | 0.46 |
| Written Expression | 108.1 | 10.4 | 0.67 | 0.66 | 0.47 | 0.66 | 0.69 | 0.56 | 0.70 | 0.60 | 0.44 | 0.43 |
| **Cross-Domain ACH Clusters** | | | | | | | | | | | | |
| Academic Skills | 107.8 | 10.9 | 0.66 | 0.83 | 0.79 | 0.87 | 0.90 | 0.81 | 0.84 | 0.81 | 0.42 | 0.53 |
| Academic Fluency | 108.1 | 12.3 | 0.50 | 0.64 | 0.68 | 0.67 | 0.72 | 0.61 | 0.68 | 0.59 | 0.38 | 0.57 |
| Academic Applications | 109.4 | 11.7 | 0.75 | 0.80 | 0.70 | 0.76 | 0.85 | 0.67 | 0.75 | 0.68 | 0.44 | 0.45 |
| Brief Achievement | 109.0 | 12.1 | 0.70 | 0.88 | 0.73 | 0.87 | 0.91 | 0.84 | 0.87 | 0.85 | 0.42 | 0.50 |
| Broad Achievement | 109.5 | 12.1 | 0.67 | 0.79 | 0.79 | 0.81 | 0.88 | 0.74 | 0.80 | 0.74 | 0.44 | 0.55 |
| ***n*** | | | 49 | 49 | 50 | 50 | 48 | 50 | 50 | 50 | 50 | 50 |
| **Mean** | | | 109.9 | 110.7 | 108.2 | 109.1 | 111.1 | 110.2 | 111.2 | 111.5 | 113.8 | 109.2 |
| **Standard Deviation** | | | 16.7 | 14.2 | 13.1 | 17.4 | 15.1 | 13.3 | 14.2 | 15.5 | 13.7 | 11.1 |

*Note.* $N = 50$ for all WJ IV measures. All correlations are based on $N = 50$ except for correlations with KTEA-II measures with smaller *n*s; the sample sizes for these correlations are the sample sizes for the respective KTEA-II measure. Age range (years) = 13–18, $M = 16.3$, $SD = 1.8$

KTEA-II Oral Language composite. High correlations for the primary WJ IV OL clusters with all KTEA-II achievement domains (primarily in the mid-.60 to mid-.70 range) provide support for the WJ IV OL clusters as measures of general language abilities with strong relations to school achievement.

The six WJ IV reading and four math clusters show their highest correlations with the measures of the same achievement domain composites in the KTEA-II, providing concurrent validity evidence for the WJ IV reading and math clusters. The six WJ IV reading clusters correlate highest (.78 to .94) with the KTEA-II Reading composite and lower with the KTEA-II nonreading composites; the four WJ IV math clusters correlate highest (.82 to .94) with the KTEA-II Math composite and lower with KTEA-II nonmath clusters. The four WJ IV written language clusters correlate at similar levels with the KTEA-II Reading (.68 to .90) and Written Language (.65 to .91) composites; this is a common finding when reading and writing tests are correlated (see the WJ IV cluster score intercorrelation matrices in Appendix F). The two highest correlations in Table 5-34 are between the WJ IV Reading cluster and the KTEA-II Reading composite (.94) and between the WJ IV Mathematics and KTEA-II Math composite (.94), providing strong concurrent validity evidence for these clusters in both batteries. Given the mixed reading, math, and writing test composition of the WJ IV cross-domain achievement clusters—which do not include measures of OL—the high correlations of these WJ IV cross-domain ACH clusters with the KTEA-II Reading, Math, Written Language, and Comprehensive Achievement composites, and lower correlations with the KTEA-II Oral Language composite, make sense. The global achievement measures from both batteries (KTEA-II Comprehensive Achievement and the WJ IV Brief and Broad Achievement) correlate at high levels (.88 and .91). Collectively the magnitude and differential pattern of the WJ IV and KTEA-II cluster and composite cluster correlations provide concurrent validity evidence for the WJ IV OL and WJ IV ACH clusters in the ages 8 through 12 sample.

Three sets of correlations with select KTEA-II reading-related subtests are worth noting. The low correlation (.38) between the WJ IV Phonetic Coding cluster and KTEA-II Phonological Awareness test indicates that these two measures of phonetic coding (*Ga*-PC) are not interchangeable—most likely because the WJ IV Phonetic Coding cluster is composed of two *Ga* tests (Segmentation and Sound Blending), while the KTEA-II measure is a single test of basic phonemic analysis skills. The high correlations (.71 to .85) between the WJ IV Reading Fluency and Reading Speed clusters and the KTEA-II Word Recognition Fluency and Decoding Fluency tests also provide concurrent validity evidence for the two WJ IV reading speed/fluency clusters. Finally, the WJ IV Speed of Lexical Access cluster shows very low correlations (.01 to .23) with all KTEA-II composite measures. However, the Speed of Lexical Access correlation of .59 with the KTEA-II Naming Facility test provides moderate concurrent validity evidence for both of these measures. The WJ IV Speed of Lexical Access cluster is composed of two fluency retrieval tests, one of which (Rapid Picture Naming) is considered to be a measure of naming facility (see Table 5-1).

The results for the ages 13 through 18 WJ IV and KTEA-II study (Table 5-35) are generally similar to those for the younger (ages 8 through 12) sample, although some differences are noted. In this sample, the three primary WJ IV OL clusters (Oral Language, Listening Comprehension, and Oral Expression) correlate at moderate to high levels with the KTEA-II Oral Language composite (.58 to .74) as well as with the KTEA-II Reading composite (.63 to .74). In contrast to the younger sample, the primary WJ IV OL clusters demonstrate more moderate correlations with KTEA-II Math (.45 to .52) and Written Language (.46 to .58) composites; this suggests that general oral language abilities are more closely related to all domains of achievement during the elementary years and are more differentially important with increasing age. Collectively, the primary WJ IV OL cluster correlations with the KTEA-II

Oral Language and Reading composites support the validity of these WJ IV OL clusters as being academically related measures of general language ability.

In Table 5-35, the six WJ IV reading clusters correlate the highest with the KTEA-II Reading (.65 to .83) and Written Language (.68 to .80) composites; the WJ IV reading cluster correlations with KTEA-II Math are noticeably lower (.60 to .65). The four WJ IV math clusters correlate the highest with the KTEA-II Math composite (.69 to .87). The explanation for the high correlation (.80) between WJ IV Math Problem Solving and KTEA-II Reading is currently unknown and is interpreted as a sample-specific finding. In contrast to the WJ IV/KTEA-II study with the ages 8 through 12 sample (presented in in Table 5-34), for the ages 13 through 18 sample the correlations between the four WJ IV written language clusters and the KTEA-II Written Language composite (.66 to 87; three of the four range from .85 to .89) are higher than the correlations between the WJ IV written language clusters and KTEA-II Reading composite. This might suggest there is more differentiation of reading and writing abilities during the secondary school years. WJ IV Brief and Broad Achievement clusters correlate highly (.91 and .88) with the KTEA-II Comprehensive Achievement composite. These high correlations between the global achievement measures from the two batteries, also noted in the ages 8 through 12 sample, provides strong concurrent validity evidence for the global achievement measures in each battery.

The correlation between the WJ IV Speed of Lexical Access cluster and the KTEA-II Naming Facility test is much lower (.34) in this sample than in the ages 8 through 12 sample. Also, the moderate to high correlations between the WJ IV Reading Fluency and Reading Speed clusters with the KTEA-II Word Recognition Fluency and Decoding Fluency tests (ranging from .59 to .82) provide concurrent validity evidence for these two WJ IV clusters, particularly the Reading Fluency cluster (.73 and .82 correlations).

### *Correlations With the WIAT-III*

Tables 5-36 and 5-37 present the means, standard deviations, and correlations for the WJ IV OL and WJ IV ACH clusters and WIAT-III composites in two samples differentiated by grade (grades 1 through 8 and grades 9 through 12). Table 5-36 summarizes the results for 51 grade 1 through 8 examinees who range in age from 6 through 14 years ($M$ = 11.0 years, $SD$ 2.2 = years). Table 5-37 summarizes the results for 49 grade 9 through 12 examinees who range in age from 13 through 18 years ($M$ = 16.1 years, $SD$ = 1.4 years). In the grades 1 through 8 sample (Table 5-36) both the WJ IV and WIAT-III mean scores suggest a sample with slightly above average achievement abilities; the mean WIAT-III composite scores range from 105.4 to 110.5, and the mean WJ IV cluster scores range from 104.4 to 106.3. In the grade 9 through 12 sample (Table 5-37) both the WIAT-III and WJ IV means also suggest a sample with above average achievement abilities; the mean WIAT-III composite scores range from 107.2 through 114.9, and the mean WJ IV cluster scores range from 103.6 to 109.5.

The magnitude and pattern of the correlations between the WJ IV OL and WJ IV ACH clusters and the WIAT-III measures provide concurrent validity for the WJ IV OL and WJ IV ACH clusters listed in Table 5-36. The three primary WJ IV OL clusters correlate from .57 to .82 with the WIAT-III Oral Language composite measure. With the exception of the WIAT-III Math Fluency composite, the moderate to high WJ IV OL correlations with all WIAT-III achievement domains (primarily in the .60 to mid-.70 range; .67 to .78 with the WIAT-III Total Achievement composite) indicate that the WJ IV OL clusters are measures of general language abilities with strong relations to school achievement.

***Table 5-36.***
*Summary Statistics and Correlations for WJ IV OL and WJ IV ACH Measures and WIAT-III Composites, Grades 1 Through 8 Sample*

| WJ IV Measures | Mean | *SD* | WIAT-III Measures: Oral Language | Total Reading | Basic Reading | Reading Comprehension & Fluency | Mathematics | Math Fluency | Written Expression | Total Achievement |
|---|---|---|---|---|---|---|---|---|---|---|
| **Oral Language Clusters** | | | | | | | | | | |
| Oral Language | 105.1 | 13.1 | 0.82 | 0.65 | 0.61 | 0.61 | 0.65 | 0.31 | 0.51 | 0.76 |
| Oral Expression | 104.7 | 12.5 | 0.57 | 0.64 | 0.69 | 0.51 | 0.55 | 0.30 | 0.54 | 0.67 |
| Listening Comprehension | 106.1 | 14.5 | 0.60 | 0.67 | 0.63 | 0.62 | 0.71 | 0.42 | 0.60 | 0.78 |
| **Reading Achievement Clusters** | | | | | | | | | | |
| Reading | 105.8 | 14.8 | 0.56 | 0.93 | 0.92 | 0.82 | 0.75 | 0.44 | 0.77 | 0.92 |
| Broad Reading | 105.6 | 15.8 | 0.54 | 0.89 | 0.87 | 0.82 | 0.73 | 0.55 | 0.75 | 0.88 |
| Basic Reading Skills | 105.8 | 13.9 | 0.49 | 0.93 | 0.94 | 0.78 | 0.67 | 0.44 | 0.80 | 0.88 |
| Reading Comprehension | 106.0 | 15.2 | 0.58 | 0.88 | 0.85 | 0.81 | 0.75 | 0.44 | 0.72 | 0.89 |
| Reading Fluency | 106.0 | 15.5 | 0.53 | 0.87 | 0.84 | 0.80 | 0.71 | 0.60 | 0.76 | 0.87 |
| Reading Speed | 104.7 | 14.8 | 0.39 | 0.67 | 0.62 | 0.64 | 0.60 | 0.63 | 0.63 | 0.69 |
| **Math Achievement Clusters** | | | | | | | | | | |
| Mathematics | 105.8 | 14.7 | 0.51 | 0.67 | 0.68 | 0.61 | 0.92 | 0.57 | 0.61 | 0.81 |
| Broad Mathematics | 105.5 | 13.6 | 0.46 | 0.67 | 0.67 | 0.58 | 0.90 | 0.79 | 0.63 | 0.79 |
| Math Calculation | 105.6 | 13.2 | 0.37 | 0.62 | 0.62 | 0.50 | 0.82 | 0.85 | 0.61 | 0.72 |
| Math Problem Solving | 105.2 | 16.8 | 0.44 | 0.53 | 0.58 | 0.44 | 0.83 | 0.53 | 0.53 | 0.69 |
| **Written Language ACH Clusters** | | | | | | | | | | |
| Written Language | 104.4 | 14.5 | 0.38 | 0.84 | 0.85 | 0.70 | 0.74 | 0.56 | 0.78 | 0.83 |
| Broad Writing | 105.1 | 14.4 | 0.37 | 0.83 | 0.83 | 0.68 | 0.72 | 0.59 | 0.77 | 0.80 |
| Basic Writing Skills | 105.9 | 15.2 | 0.44 | 0.88 | 0.90 | 0.74 | 0.75 | 0.52 | 0.79 | 0.87 |
| Written Expression | 104.3 | 13.3 | 0.29 | 0.69 | 0.68 | 0.53 | 0.63 | 0.60 | 0.62 | 0.65 |
| **Cross-Domain ACH Clusters** | | | | | | | | | | |
| Academic Skills | 105.8 | 14.4 | 0.48 | 0.88 | 0.89 | 0.74 | 0.83 | 0.54 | 0.83 | 0.92 |
| Academic Fluency | 104.8 | 14.4 | 0.42 | 0.71 | 0.69 | 0.62 | 0.68 | 0.77 | 0.63 | 0.72 |
| Academic Applications | 105.2 | 14.8 | 0.54 | 0.83 | 0.81 | 0.74 | 0.87 | 0.56 | 0.69 | 0.89 |
| Brief Achievement | 105.6 | 14.9 | 0.53 | 0.89 | 0.90 | 0.77 | 0.84 | 0.52 | 0.81 | 0.93 |
| Broad Achievement | 106.3 | 15.0 | 0.50 | 0.86 | 0.85 | 0.75 | 0.84 | 0.69 | 0.77 | 0.90 |
| ***n*** | | | 51 | 51 | 51 | 47 | 51 | 51 | 48 | 48 |
| **Mean** | | | 106.4 | 107.9 | 106.9 | 109.4 | 108.1 | 105.4 | 110.5 | 109.7 |
| **Standard Deviation** | | | 14.0 | 16.0 | 15.3 | 13.9 | 18.1 | 17.1 | 15.8 | 15.6 |

*Note.* $N = 51$ for all WJ IV measures. All correlations are based on $N = 51$ except for correlations with WIAT-III composites with smaller *n*s; the sample sizes for these correlations are the sample sizes for the respective WIAT-III measure. Age range (years) = 6–14, $M = 11.0$, $SD = 2.2$

***Table 5-37.***
*Summary Statistics and Correlations for WJ IV OL and WJ IV ACH Measures and WIAT-III Composites, Grades 9 Through 12 Sample*

| WJ IV Measures | Mean | *SD* | WIAT-III Measures: Oral Language | Total Reading | Basic Reading | Reading Comprehension & Fluency | Mathematics | Math Fluency | Written Expression | Total Achievement |
|---|---|---|---|---|---|---|---|---|---|---|
| **Oral Language Clusters** | | | | | | | | | | |
| Oral Language | 109.4 | 11.6 | 0.79 | 0.30 | 0.18 | 0.40 | 0.28 | 0.10 | 0.13 | 0.39 |
| Oral Expression | 104.9 | 14.0 | 0.68 | 0.41 | 0.38 | 0.42 | 0.38 | 0.31 | 0.29 | 0.48 |
| Listening Comprehension | 107.7 | 13.1 | 0.75 | 0.51 | 0.43 | 0.55 | 0.46 | 0.32 | 0.38 | 0.58 |
| **Reading Achievement Clusters** | | | | | | | | | | |
| Reading | 107.9 | 10.9 | 0.61 | 0.78 | 0.75 | 0.74 | 0.48 | 0.40 | 0.60 | 0.73 |
| Broad Reading | 107.9 | 13.3 | 0.67 | 0.79 | 0.72 | 0.80 | 0.52 | 0.55 | 0.65 | 0.78 |
| Basic Reading Skills | 107.9 | 13.1 | 0.45 | 0.86 | 0.86 | 0.74 | 0.51 | 0.44 | 0.68 | 0.77 |
| Reading Comprehension | 108.8 | 10.9 | 0.73 | 0.54 | 0.50 | 0.60 | 0.48 | 0.31 | 0.50 | 0.66 |
| Reading Fluency | 108.9 | 14.3 | 0.59 | 0.78 | 0.72 | 0.77 | 0.56 | 0.55 | 0.64 | 0.78 |
| Reading Speed | 108.0 | 15.4 | 0.60 | 0.66 | 0.61 | 0.72 | 0.50 | 0.56 | 0.62 | 0.70 |
| **Math Achievement Clusters** | | | | | | | | | | |
| Mathematics | 109.5 | 11.8 | 0.47 | 0.55 | 0.51 | 0.52 | 0.84 | 0.42 | 0.44 | 0.69 |
| Broad Mathematics | 109.5 | 11.1 | 0.47 | 0.53 | 0.53 | 0.49 | 0.76 | 0.68 | 0.53 | 0.66 |
| Math Calculation | 107.9 | 11.4 | 0.36 | 0.43 | 0.48 | 0.38 | 0.58 | 0.72 | 0.54 | 0.53 |
| Math Problem Solving | 108.5 | 13.3 | 0.51 | 0.54 | 0.44 | 0.55 | 0.79 | 0.45 | 0.50 | 0.70 |
| **Written Language ACH Clusters** | | | | | | | | | | |
| Written Language | 104.4 | 12.2 | 0.49 | 0.66 | 0.73 | 0.59 | 0.55 | 0.64 | 0.73 | 0.70 |
| Broad Writing | 105.5 | 11.9 | 0.52 | 0.73 | 0.74 | 0.68 | 0.59 | 0.68 | 0.76 | 0.77 |
| Basic Writing Skills | 109.3 | 14.2 | 0.47 | 0.80 | 0.76 | 0.77 | 0.59 | 0.57 | 0.77 | 0.80 |
| Written Expression | 103.6 | 9.9 | 0.57 | 0.53 | 0.51 | 0.55 | 0.51 | 0.53 | 0.52 | 0.60 |
| **Cross-Domain ACH Clusters** | | | | | | | | | | |
| Academic Skills | 107.7 | 12.2 | 0.46 | 0.80 | 0.83 | 0.71 | 0.66 | 0.60 | 0.76 | 0.83 |
| Academic Fluency | 106.7 | 13.1 | 0.53 | 0.58 | 0.56 | 0.60 | 0.46 | 0.74 | 0.63 | 0.63 |
| Academic Applications | 108.2 | 10.6 | 0.70 | 0.55 | 0.52 | 0.58 | 0.71 | 0.40 | 0.44 | 0.67 |
| Brief Achievement | 109.2 | 12.4 | 0.52 | 0.83 | 0.82 | 0.76 | 0.70 | 0.58 | 0.71 | 0.85 |
| Broad Achievement | 108.7 | 11.9 | 0.63 | 0.78 | 0.74 | 0.76 | 0.68 | 0.69 | 0.72 | 0.85 |
| ***n*** | | | 49 | 48 | 49 | 48 | 49 | 49 | 44 | 43 |
| **Mean** | | | 111.4 | 108.8 | 107.2 | 108.2 | 107.9 | 108.4 | 114.9 | 113.7 |
| **Standard Deviation** | | | 12.9 | 12.3 | 11.6 | 12.6 | 13.6 | 13.9 | 16.2 | 12.6 |

*Note.* $N = 49$ for all WJ IV measures. All correlations are based on $N = 49$ except for correlations with WIAT-III composites with smaller *n*s; the sample sizes for these correlations are the sample sizes for the respective WIAT-III measure. Age range (years) = 13–18, $M = 16.1$, $SD = 1.4$

Excluding the WIAT-III Total Achievement composite, all WJ IV reading, math, and written language clusters generally show their highest correlations with the measures of the same WIAT-III achievement domain composites, providing evidence supporting the use of the WJ IV ACH cluster scores as measures of domain-level achievement. The six WJ IV reading clusters correlate highest (.64 to .94 or .78 to .94 when Reading Speed is excluded) with the three WIAT-III Reading composites. The WJ IV Basic Reading Skills cluster correlates highest (.94) with the comparable WIAT-III Basic Reading composite. The WJ IV Reading Comprehension and Reading Fluency clusters correlate at similar levels (.81 and .80) with the WIAT-III Reading Comprehension and Fluency composite—a mixed measure of comprehension and oral ready fluency.

In Table 5-36 the four WJ IV math clusters correlate much higher (.82 to .92) with the WIAT-III Mathematics composite than with the WIAT-III Oral Language, Reading, and Written Expression composites. Consistent with the inclusion of the Math Fluency test (*Gs*) in the WJ IV Broad Math and Math Calculation clusters, these two clusters correlate noticeably higher (.79 and .85) with the WIAT-III Math Fluency cluster than do the two WJ IV math clusters that do not include a math fluency or speed test (namely, Mathematics and Math Problem Solving).

Given the mixed reading, math, and writing test composition of the WJ IV cross-domain achievement clusters, which do not include measures of OL, the moderate to high correlations of these WJ IV cross-domain ACH clusters with the WIAT-III reading, mathematics, written expression, and Total Achievement composites, and lower correlations with the WIAT-III Oral Language composite, make sense. The WJ IV Brief and Broad Achievement clusters correlate highly with the WIAT-III Total Achievement composite (.93 and .90, respectively). These high correlations provide strong concurrent validity evidence for the global achievement measures in each battery.

The WJ IV/WIAT-III study results for the grades 9 through 12 sample (Table 5-37) are similar to those reported for the grades 1 through 8 sample. The magnitude and pattern of WJ IV OL and WJ IV ACH and WIAT-III correlations provide concurrent validity for the WJ IV OL and WJ IV ACH clusters listed in Table 5-37. The three primary WJ IV OL clusters have high correlations (.68 to .79) with the WIAT-III Oral Language composite. The three primary WJ IV OL clusters in this sample of older examinees demonstrate low-to-moderate correlations with all WIAT-III achievement composites; these are generally even lower than those reported for the grades 1 through 8 sample. This finding is similar to the age-differentiated WJ IV/KTEA-II studies reported in Tables 5-34 and 5-35. Collectively, the primary WJ IV OL cluster correlations with the WAIT-III measures support the use of these cluster scores as measures of general language ability; however, in this high-school age sample there is a weaker relationship between WJ IV OL cluster scores and academic achievement than in the elementary school grades.

The pattern of WJ IV math achievement clusters with the two WIAT-III math clusters provides concurrent validity evidence that is similar to the evidence from the younger sample (grades 1 through 8). The WJ IV Mathematics, Broad Mathematics, and Math Problem Solving clusters correlate highest with WIAT-III Mathematics (.84, .76, and .79, respectively); the WJ IV Broad Mathematics and Math Calculation clusters correlate highest with the WIAT-III Math Fluency composite (.68 and .72). Three of the WJ IV written language clusters correlate highest with the WIAT-III Written Expression composite, supporting the construct validity of these WJ IV writing clusters. Interestingly, although they have similar names, the WJ IV and WIAT-III Written Expression measures only correlate at a moderate .52 level; this suggests that these measure different aspects of written expression and users should not expect to obtain similar scores on these composites for all individuals.

Finally, given the mixed reading, math, and writing test composition of the WJ IV cross-domain achievement clusters, their moderate to high correlations across the WIAT-III achievement composites indicate that these measures display no meaningful patterns of high or low divergent/convergent correlations that should be interpreted in depth. High correlations supporting the concurrent validity of the global achievement measures from the two batteries are reported in Table 5-37; WJ IV Brief and Broad Achievement clusters correlate highest with the WAIT-III Total Achievement composite (.85 for both).

### Correlations With the OWLS Written Expression

Table 5-38 presents the results of a study of 51 school-age examinees ranging in age from 7 through 17 ($M$ = 10.6 years, $SD$ = 2.5). The mean scores for the OWLS-WE (107.4) and the four WJ IV Written Language clusters (100.0 to 109.0) suggest a slightly above average sample with some moderate restriction in range of writing ability (*SD*s range from 11.1 to 12.8). Despite the moderate restriction in range of writing ability, which typically results in concurrent validity correlations that are underestimates of the population correlations, the four WJ IV Written Language clusters all demonstrate moderate to strong correlations (.65 to .75) with the OWLS Written Expression total score. These correlations provide concurrent validity evidence for the four WJ IV Written Language clusters as general measures of writing ability.

**Table 5-38.**
*Summary Statistics and Correlations for WJ IV Written Language Clusters and OWLS-WE Scale, Ages 7 Through 17 Sample*

| WJ IV Measures | Mean | *SD* | OWLS Written Expression |
|---|---|---|---|
| **Written Language Clusters** | | | |
| Written Language | 104.4 | 12.0 | 0.75 |
| Broad Written Language | 105.5 | 12.0 | 0.70 |
| Basic Writing Skills | 100.0 | 12.8 | 0.71 |
| Written Expression | 109.0 | 11.1 | 0.65 |
| **Mean** | | | 107.4 |
| **Standard Deviation** | | | 11.2 |

*Note.* $N$ = 51 for all measures. Age range (years) = 7–17, $M$ = 10.6, $SD$ = 2.5

## Performance of Clinical Samples on WJ IV Measures

The correlations between the WJ IV scores and scores from external measures of similar constructs provide one form of validity evidence; the relationship between WJ IV scores and group membership status (e.g., individuals with learning disabilities or individuals with intellectual disabilities) provides another form of test-criterion validity evidence. Selective tests were administered to individuals with the following nine clinical diagnoses: gifted, intellectual disabilities (ID)/mental retardation (MR), learning disabilities (LD; reading, math, and writing), language delay, attention deficit/hyperactivity disorder (ADHD), head injury, and autism spectrum disorders (ASD).

The WJ IV clinical validity study participants were drawn from a variety of educational and clinical settings. The study inclusion criteria are summarized in Table 5-39. Although study participants had to meet the minimum criteria for inclusion, given the variety of educational and clinical settings from which study participants were drawn, the criteria used for each participant's original diagnosis or classification likely varies within each study group. Because the clinical validity study participants were not randomly selected from the populations of each respective diagnostic group, the sample results presented in this section should not be considered precise statistical representations of each diagnostic group.

***Table 5-39.***
*Inclusion Criteria for Each Special Groups Study*

| Clinical Validity Group | Age Range | Inclusion Criteria |
|---|---|---|
| Learning Disability (LD)–Reading | 6–17 years | Documented learning disability in reading<br>Reading LD must be the primary diagnosis or eligibility category<br>Currently receiving special education services under SLD category |
| Learning Disability (LD)–Math | 6–17 years | Documented learning disability in math<br>Math LD must be the primary diagnosis or eligibility category<br>Currently receiving special education services under SLD category |
| Learning Disability (LD)–Writing | 6–17 years | Documented learning disability in writing<br>Writing LD must be the primary diagnosis or eligibility category<br>Currently receiving special education services under SLD category |
| Head Injury | 7–17 years | Documented traumatic brain injury (TBI)<br>TBI must be the primary diagnosis<br>Currently receiving special education services |
| Language Delay | 7–13 years | Documented language delay<br>Language delay must be the primary diagnosis<br>Currently receiving special education services |
| Autism Spectrum Disorder (ASD) | 6–17 years | Documented autism spectrum disorder[1]<br>ASD is the primary diagnosis<br>Currently receiving special education services |
| Attention Deficit Hyperactivity/Disorder (ADHD) | 7–12 years | Documented ADHD[2]<br>ADHD must be the primary diagnosis<br>Currently receiving special education services and/or 504 plan accommodations |
| Gifted[3] | 4–9 years | Currently participating in high ability or gifted and talented school curriculum<br>Currently receiving gifted services |
| Intellectual Disability (ID)/Mental Retardation (MR) | 6–12 years | Documented mental retardation<br>Mental retardation is the primary diagnosis<br>Currently receiving special education services |

[1] The Autism Spectrum Disorder group excluded individuals with a diagnosis of Asperger's Disorder.
[2] For the Attention Deficit/Hyperactivity Disorder (ADHD) study, a diagnosis of attention deficit disorder (ADD) was not sufficient for inclusion. The examinee had to have a diagnosis of ADHD.
[3] For the gifted study, examiners documented the specific qualifying criteria for the examinee's school on the Parental Consent form.

The comprehensiveness of the WJ IV battery made it impossible to administer all key tests and clusters to all clinical groups. To reduce examinee response burden, which is a significant concern in clinical groups, a diagnostic group-targeted approach to test selection was used. Based on clinical and research considerations, select WJ IV COG, WJ IV OL, and WJ IV ACH tests were administered to each clinical group. The selected tests are those hypothesized to be the most sensitive and diagnostically relevant for each clinical group. Thus, the set of tests administered was not uniform across all nine groups. The focus on selecting appropriate measures at the test level also limits the number of cluster-level scores that can be reported. This constraint-driven test selection design, although it provides useful information on the WJ IV tests most likely to be low for a diagnostic group, results in the inability to perform systematic formal statistical comparisons of WJ IV test or cluster scores across the nine clinical groups. This study design also does not allow for the interpretation of patterns of test or cluster strengths and weaknesses within and across the nine clinical groups. Therefore, the WJ IV clinical validity study data are reported as preliminary descriptive information; *the data are not sufficient for making important diagnostic decisions*.[46] The primary value of the WJ IV clinical validity evidence is to provide examiners with WJ IV test information that can be used in conjunction with all information relevant to the assessment of an individual to design selective referral-focused WJ IV assessments (McGrew & Wendling, 2010).

Another factor that contributed to the targeted test selection design decision was the goal to provide information that would contribute to the large ($n$ = 2,195) WJ III clinical database (CDB) described in the *WJ III Normative Update Technical Manual* (McGrew, Schrank, Woodcock, 2007).[47] Cluster-level results are reported in Tables 4-4 and 4-5 of the *WJ III Normative Update Technical Manual* for groups of individuals with the following diagnostic classifications: anxiety spectrum disorders, attention deficit/hyperactivity disorders, autism spectrum disorders, depressive spectrum disorders, gifted, head injury, language disorders, mathematics disorder, intellectual disabilities, reading disorders, and written expression disorders. Additionally, Schrank (2010) presents descriptive statistics for the 30 WJ III and WJ III COG DS tests (18 of which are retained in the WJ IV COG or WJ IV OL batteries as either tests or subtests) for the CDB sample ($n$ = 2,248) for the following clinical groups: anxiety spectrum disorders, attention deficit/hyperactivity disorders, autism spectrum disorders, depressive spectrum disorders, head injury, language disorders, mathematics disorder, intellectual disabilities, reading disorders, and written expression disorders.

Table 5-40 presents sample size and demographic information for all nine clinical validity studies. In addition to sample size, the age characteristics (range in years, mean, and *SD*), and percentages for sex, race, ethnicity, mother's level of education, and father's level of education are summarized.

Tables 5-41 and 5-42 present descriptive statistics for the WJ IV COG, WJ IV OL, and WJ IV ACH test and cluster scores available for the nine different clinical validity studies. A review of the information in Table 5-41 and 5-42 suggests the following general conclusions:

- The two groups for which general intellectual functioning is most pivotal to identification and diagnosis (Gifted and ID/MR), and that are at opposite ends of the general intelligence continuum, display large differences on all 21 WJ IV COG, WJ IV OL, and WJ IV ACH tests and the 10 cluster scores reported in Tables 5-41 and 5-42. The score *differences* between the Gifted and ID/MR groups on two of the three clusters intended to measure general intellectual functioning (BIA and *Gf-Gc* Composite) are 68.8 and 74.2 points, respectively. Most WJ IV COG and WJ IV OL scores for the group of individuals with ID/MR are in the 50 to 60 range (median across the 18 WJ IV COG and WJ IV OL tests = 61.3, median BIA = 46.9, median *Gf-Gc* Composite = 45.0). The cognitive cluster scores for this group are well below the accepted IQ score for the first prong of the diagnosis of intellectual disability (IQ = 70, with typical *SEM* confidence band range from 65 to 75) (American Association on Intellectual and Developmental Disabilities, 2010). In contrast, the individuals in the Gifted group consistently

[46] The one exception is in the discussion of the results related to the score differences on 21 tests and 10 clusters for the Gifted and ID/MR study participants.

[47] The CDB is an ongoing and expanding data collection project designed to facilitate research that contributes to a better understanding of the neuropsychological and cognitive bases of a variety of diagnosed cognitive, learning, and mental exceptionalities. The WJ IV tests reported here, as well as the WJ III NU test data already in the CDB, will eventually be placed on an equated common scale. Although the WJ III NU reported information was at the level of WJ III NU clusters, the primary unit of analysis for the ongoing CDB is at the level of tests (see Schrank, 2010). Information regarding the complete CDB can be accessed at: http://www.woodcock-munoz-foundation.org/research/clinicalDB.html. Woodcock and Miller (2012) published a set of WJ III test-focused tables, based on 6,000+ CDB examinees in 50 diagnostic groups, in a proposed "evidence-based neurocognitive assessment guide" (information available at: http://www.schoolneuropsych.com/index.php?id=577). This guide is intended "to provide clinicians with selective sets of WJ III tests that have been shown to be the most informative of cognitive and achievement weaknesses and strengths in known clinical groups" (Woodcock & Miller, 2012, p. 3). Many of the tests included in this proposed assessment system report are WJ III tests that also are included in the WJ IV.

***Table 5-40.***
*Demographic Characteristics of the WJ IV Clinical Validity Study Samples*

| | Clinical Diagnoses | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **LD–Reading** | **LD–Math** | **LD–Writing** | **Head Injury** | **Language Delay** | **ASD** | **ADHD** | **Gifted** | **ID/MR** |
| ***N*** | 79 | 73 | 75 | 12 | 75 | 50 | 50 | 53 | 50 |
| **Age (years)** | | | | | | | | | |
| Range | 7–17 | 6–17 | 6–18 | 6–19 | 7–13 | 6–18 | 7–12 | 5–9 | 6–13 |
| Mean | 12.1 | 12.9 | 13.5 | 13.5 | 9.9 | 11.2 | 10.7 | 8.1 | 9.7 |
| *SD* | 2.6 | 3.2 | 2.8 | 3.8 | 2.1 | 3.6 | 1.7 | 1.1 | 2.0 |
| **Sex** | | | | | | | | | |
| Male | 55.7 | 53.4 | 76.0 | 58.3 | 53.3 | 86.0 | 78.0 | 54.7 | 44.0 |
| Female | 44.3 | 46.6 | 24.0 | 41.7 | 46.7 | 14.0 | 22.0 | 45.3 | 56.0 |
| **Race** | | | | | | | | | |
| White | 63.3 | 74.0 | 81.3 | 75.0 | 74.7 | 86.0 | 78.0 | 83.0 | 92.0 |
| Black | 25.3 | 20.5 | 14.7 | 16.7 | 17.3 | 4.0 | 14.0 | 1.9 | 6.0 |
| Indian | 1.3 | 1.4 | 1.3 | — | 1.3 | 2.0 | — | — | — |
| Asian/Pacific Islander | 1.3 | 2.7 | 1.3 | 8.3 | 4.0 | 4.0 | 2.0 | 11.3 | 2.0 |
| Other/Mixed | 8.9 | 1.4 | 1.3 | — | 2.7 | 4.0 | 6.0 | 3.8 | — |
| **Ethnicity** | | | | | | | | | |
| Not Hispanic | 83.5 | 87.7 | 85.3 | 91.7 | 82.7 | 92.0 | 88.0 | 83.0 | 76.0 |
| Hispanic | 16.5 | 12.3 | 14.7 | 8.3 | 17.3 | 8.0 | 12.0 | 17.0 | 24.0 |
| **Mother's Education** | | | | | | | | | |
| No Information Provided | — | — | — | — | — | — | — | — | — |
| <HS Graduate | 19.0 | 8.2 | 9.3 | 16.7 | 12.0 | 4.0 | 4.0 | — | 24.0 |
| HS Graduate | 30.4 | 37.0 | 37.3 | 8.3 | 42.7 | 22.0 | 38.0 | 7.5 | 46.0 |
| >HS | 50.6 | 54.8 | 53.3 | 75.0 | 45.3 | 74.0 | 58.0 | 92.5 | 30.0 |
| **Father's Education** | | | | | | | | | |
| No Information Provided | 6.3 | 5.5 | 6.7 | — | 9.3 | 4.0 | 6.0 | — | 2.0 |
| <HS Graduate | 16.5 | 8.2 | 10.7 | 8.3 | 20.0 | 10.0 | 6.0 | — | 30.0 |
| HS Graduate | 40.5 | 39.7 | 45.3 | 25.0 | 42.7 | 34.0 | 38.0 | 13.2 | 44.0 |
| >HS | 36.7 | 46.6 | 37.3 | 66.7 | 28.0 | 52.0 | 50.0 | 86.8 | 24.0 |

*Note.* LD = Learning Disability; ASD = Autism Spectrum Disorder; ADHD = Attention Deficit/Hyperactivity Disorder; ID/MR = intellectual disability/mental retardation.

***Table 5-41.***
*Summary Statistics for Select WJ IV Tests for Clinical Validity Study Groups*

| Test | Clinical Diagnoses | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gifted | | | ID/MR | | | LD–Reading | | | LD–Math | | | LD–Writing | | | Language Delay | | | ADHD | | | Head Injury | | | ASD | | |
| | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* |
| **Cognitive Tests** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oral Vocabulary | **53** | **115.3** | **13.6** | **50** | **48.4** | **17.2** | 79 | 80.9 | 14.4 | 73 | 78.9 | 12.3 | 75 | 83.7 | 14.6 | 75 | 76.6 | 16.8 | 50 | 89.2 | 13.3 | 12 | 79.4 | 19.5 | 50 | 79.0 | 22.3 |
| Concept Formation | **53** | **117.7** | **11.4** | **50** | **60.8** | **16.7** | 79 | 86.9 | 14.9 | 73 | 82.9 | 11.5 | 75 | 86.4 | 15.7 | 75 | 82.9 | 14.5 | 50 | 89.0 | 14.1 | 12 | 82.2 | 20.8 | 50 | 85.2 | 25.5 |
| Number-Pattern Matching | **53** | **110.2** | **10.6** | **49** | **63.7** | **29.8** | 79 | 90.5 | 15.2 | 73 | 89.8 | 13.6 | 75 | 87.9 | 13.4 | 74 | 90.9 | 18.1 | 50 | 91.5 | 13.4 | 11 | 78.5 | 21.6 | 49 | 81.4 | 22.9 |
| Numbers Reversed | **53** | **112.7** | **11.9** | **50** | **56.8** | **20.3** | — | — | — | 73 | 84.4 | 15.9 | 75 | 85.7 | 13.2 | 75 | 85.4 | 18.9 | 50 | 91.2 | 13.3 | 12 | 88.8 | 16.7 | — | — | — |
| Object-Number Sequencing | — | — | — | — | — | — | 79 | 87.0 | 13.0 | 73 | 86.0 | 13.5 | 75 | 83.7 | 15.5 | 75 | 87.5 | 17.9 | 50 | 94.0 | 13.2 | — | — | — | 50 | 80.3 | 23.7 |
| Phonological Processing | **53** | **119.0** | **14.0** | **50** | **54.3** | **19.1** | 79 | 80.3 | 16.7 | — | — | — | — | — | — | 75 | 81.0 | 19.3 | 50 | 88.0 | 18.8 | 12 | 81.3 | 22.4 | — | — | — |
| Visual-Auditory Learning | **53** | **112.9** | **11.2** | **50** | **66.4** | **20.3** | 79 | 91.3 | 10.3 | — | — | — | — | — | — | — | — | — | 50 | 93.4 | 12.8 | 12 | 86.1 | 23.6 | — | — | — |
| Visualization | **53** | **113.0** | **10.0** | 44 | 75.9 | 21.2 | — | — | — | — | — | — | — | — | — | — | — | — | 50 | 94.5 | 14.6 | 12 | 90.1 | 14.4 | 49 | 97.0 | 24.4 |
| General Information | 53 | 108.2 | 10.4 | **50** | **60.5** | **18.1** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 12 | 86.1 | 19.5 | 50 | 80.6 | 21.7 |
| Letter-Pattern Matching | **53** | **115.3** | **12.8** | **49** | **66.7** | **25.3** | 79 | 92.9 | 13.7 | — | — | — | 75 | 89.1 | 13.6 | — | — | — | — | — | — | — | — | — | — | — | — |
| Number Series | **53** | **117.5** | **11.3** | **48** | **54.2** | **22.0** | — | — | — | 73 | 81.9 | 13.0 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Verbal Attention | 53 | 107.4 | 14.9 | **38** | **59.0** | **16.6** | — | — | — | — | — | — | — | — | — | 74 | 82.8 | 18.2 | — | — | — | — | — | — | — | — | — |
| Nonword Repetition | — | — | — | — | — | — | 79 | 84.0 | 11.1 | — | — | — | — | — | — | 75 | 86.8 | 11.4 | — | — | — | — | — | — | — | — | — |
| Story Recall | 53 | 109.9 | 15.3 | **48** | **61.8** | **23.6** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Pair Cancellation | — | — | — | | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 50 | 90.2 | 15.1 | — | — | — | 50 | 82.2 | 17.1 |
| Analysis-Synthesis | — | — | — | | — | — | — | — | — | 73 | 88.6 | 12.6 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Memory for Words | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 50 | 96.1 | 13.9 | — | — | — | — | — | — |
| **Oral Language Tests** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rapid Picture Naming | 53 | 108.7 | 12.2 | 48 | 72.4 | 27.0 | 79 | 90.0 | 13.3 | — | — | — | 75 | 89.0 | 13.9 | 74 | 91.9 | 13.9 | 50 | 92.5 | 11.8 | 12 | 76.5 | 29.7 | 50 | 86.3 | 19.3 |
| Sound Awareness | **53** | **116.7** | **10.9** | **49** | **51.2** | **24.0** | 79 | 80.3 | 16.2 | — | — | — | — | — | — | 74 | 80.7 | 17.1 | 50 | 90.6 | 16.1 | 12 | 85.6 | 22.5 | — | — | — |
| Sound Blending | **53** | **114.9** | **11.3** | 50 | 74.8 | 23.7 | — | — | — | — | — | — | — | — | — | 75 | 88.9 | 12.3 | — | — | — | 12 | 82.6 | 24.3 | 50 | 91.6 | 20.3 |
| Sentence Repetition | **53** | **112.6** | **11.5** | **49** | **59.4** | **24.1** | — | — | — | — | — | — | — | — | — | 75 | 81.2 | 14.1 | — | — | — | — | — | — | 50 | 85.5 | 22.4 |
| Picture Vocabulary | **53** | **113.7** | **10.0** | **44** | **66.2** | **21.6** | — | — | — | — | — | — | — | — | — | 75 | 81.7 | 16.2 | 50 | 94.1 | 11.4 | — | — | — | 49 | 91.5 | 23.1 |
| Oral Comprehension | — | — | — | — | — | — | 79 | 84.9 | 14.1 | — | — | — | 74 | 88.1 | 14.1 | 75 | 81.5 | 15.3 | — | — | — | — | — | — | 50 | 76.7 | 26.4 |
| Retrieval Fluency | 53 | 109.0 | 12.6 | **47** | **64.2** | **26.3** | 79 | 89.2 | 15.9 | — | — | — | — | — | — | 75 | 86.8 | 17.7 | — | — | — | — | — | — | — | — | — |
| Segmentation | — | — | — | — | — | — | 79 | 89.8 | 13.8 | — | — | — | 75 | 88.3 | 14.1 | — | — | — | — | — | — | — | — | — | — | — | — |
| Understanding Directions | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 75 | 82.0 | 12.6 | — | — | — | — | — | — | — | — | — |

***Table 5-41.*** *(cont.)*
*Summary Statistics for Select WJ IV Tests for Clinical Validity Study Groups*

| Test | Clinical Diagnoses | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gifted | | | ID/MR | | | LD–Reading | | | LD–Math | | | LD–Writing | | | Language Delay | | | ADHD | | | Head Injury | | | ASD | | |
| | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* |
| **Achievement Tests** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Letter-Word Identification | **53** | **115.1** | **10.9** | **46** | **57.4** | **23.0** | 79 | 72.4 | 14.9 | 73 | 86.2 | 10.8 | 75 | 81.7 | 13.5 | — | — | — | 50 | 89.7 | 15.2 | 12 | 76.2 | 27.5 | 50 | 88.1 | 22.9 |
| Applied Problems | **53** | **116.2** | **10.7** | **46** | **51.4** | **21.1** | 79 | 82.7 | 13.2 | 73 | 80.8 | 11.2 | 75 | 88.1 | 15.4 | — | — | — | 50 | 90.8 | 14.7 | 12 | 86.7 | 24.1 | 50 | 81.3 | 31.6 |
| Spelling | **53** | **114.1** | **13.5** | **43** | **62.5** | **19.6** | 79 | 74.2 | 13.8 | 73 | 85.9 | 11.7 | 75 | 76.6 | 15.4 | — | — | — | 50 | 87.9 | 14.8 | 12 | 79.2 | 27.2 | 49 | 87.9 | 26.6 |
| Calculation | — | — | — | — | — | — | 79 | 86.0 | 14.0 | 73 | 84.3 | 11.7 | 75 | 89.9 | 15.3 | — | — | — | — | — | — | 12 | 84.0 | 23.4 | 49 | 89.0 | 25.1 |
| Writing Samples | — | — | — | — | — | — | 79 | 83.7 | 10.7 | 73 | 91.8 | 8.9 | 75 | 83.5 | 14.5 | — | — | — | — | — | — | 12 | 78.1 | 26.5 | 48 | 87.2 | 21.4 |
| Passage Comprehension | — | — | — | — | — | — | 79 | 78.3 | 14.5 | 73 | 86.5 | 9.0 | 75 | 85.7 | 15.8 | — | — | — | — | — | — | 12 | 79.8 | 28.1 | 50 | 82.9 | 25.1 |
| Math Facts Fluency | — | — | — | — | — | — | — | — | — | 73 | 82.0 | 12.2 | — | — | — | — | — | — | — | — | — | 12 | 77.4 | 21.1 | 50 | 83.5 | 22.1 |
| Number Matrices | — | — | — | — | — | — | — | — | — | 73 | 83.1 | 15.8 | — | — | — | 75 | 86.2 | 18.0 | — | — | — | — | — | — | — | — | — |
| Editing | — | — | — | — | — | — | — | — | — | — | — | — | 75 | 80.2 | 13.9 | — | — | — | — | — | — | 12 | 75.2 | 27.4 | — | — | — |
| Word Attack | — | — | — | — | — | — | 79 | 76.7 | 12.8 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 50 | 92.1 | 25.8 |
| Oral Reading | — | — | — | — | — | — | 79 | 76.4 | 14.0 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Sentence Reading Fluency | — | — | — | — | — | — | 79 | 74.9 | 16.5 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Reading Recall | — | — | — | — | — | — | 78 | 82.6 | 18.8 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Word Reading Fluency | — | — | — | — | — | — | 79 | 76.8 | 17.9 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Reading Vocabulary | — | — | — | — | — | — | 78 | 75.2 | 15.6 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Sentence Writing Fluency | — | — | — | — | — | — | — | — | — | — | — | — | 75 | 84.5 | 14.2 | — | — | — | — | — | — | — | — | — | — | — | — |
| Spelling of Sounds | — | — | — | — | — | — | — | — | — | — | — | — | 75 | 83.3 | 15.8 | — | — | — | — | — | — | — | — | — | — | — | — |

*Note.* Within each battery the tests are ordered by (a) number of clinical groups with scores and then (b) CHC broad or achievement curricular areas.

**Red bold font = < 70**
Red font = 70–79
Blue font = 80–89
Black font = 90–109
**Black bold font = > 109**

***Table 5-42.***
*Summary Statistics for Select WJ IV Clusters for Clinical Validity Study Groups*

| Cluster | Clinical Diagnoses | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gifted | | | ID/MR | | | LD–Reading | | | LD–Math | | | LD–Writing | | | Language Delay | | | ADHD | | | Head Injury | | | ASD | | |
| | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* |
| **Cognitive Composite Clusters** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Brief Intellectual Ability (BIA) | **53** | **115.7** | **11.7** | **38** | **46.9** | **18.4** | | | | | | | | | | | | | | | | | | | | | |
| *Gf-Gc* Composite | **53** | **119.2** | **9.6** | **48** | **45.0** | **19.2** | | | | | | | | | | | | | | | | | | | | | |
| ***Gf-Gc* Factor Clusters** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Comprehension-Knowledge (*Gc*) | **53** | **111.2** | **11.3** | **50** | **50.1** | **17.7** | | | | | | | | | | | | | | | | 12 | 81.7 | 20.2 | 50 | 77.7 | 23.4 |
| Fluid Reasoning (*Gf*) | **53** | **119.7** | **9.8** | **48** | **51.6** | **19.6** | | | | 73 | 79.9 | 11.6 | | | | | | | | | | | | | | | |
| Short-Term Working Memory (*Gwm*) | | | | | | | | | | | | | | | | 74 | 82.4 | 17.7 | | | | | | | | | |
| Auditory Processing (*Ga*) | | | | | | | 79 | 78.6 | 12.8 | | | | | | | 75 | 80.9 | 15.4 | | | | | | | | | |
| **Narrow Ability & Other Clinical Clusters** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Quantitative Reasoning | | | | | | | | | | 73 | 82.8 | 12.5 | | | | | | | | | | | | | | | |
| Number Facility | **53** | **112.5** | **9.1** | **48** | **55.2** | **26.7** | | | | 73 | 84.8 | 13.7 | 75 | 84.0 | 13.8 | 74 | 86.6 | 18.6 | 50 | 89.4 | 12.3 | 11 | 81.3 | 19.2 | | | |
| Perceptual Speed | | | | | | | 79 | 90.4 | 15.5 | | | | 75 | 86.8 | 14.5 | | | | | | | | | | | | |
| Vocabulary | **53** | **115.2** | **10.8** | **44** | **56.7** | **16.5** | | | | | | | | | | 75 | 78.2 | 15.7 | 50 | 91.3 | 11.8 | | | | 49 | 84.8 | 23.4 |
| Cognitive Efficiency | | | | | | | | | | | | | 75 | 85.4 | 12.6 | | | | | | | | | | | | |
| **Oral Language Clusters** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oral Language | | | | | | | | | | | | | | | | 75 | 80.4 | 15.7 | | | | | | | 49 | 83.8 | 24.8 |
| Broad Oral Language | | | | | | | | | | | | | | | | 75 | 78.9 | 14.9 | | | | | | | | | |
| Oral Expression | **53** | **115.6** | **11.3** | **43** | **61.1** | **18.7** | | | | | | | | | | 75 | 78.3 | 15.3 | | | | | | | 49 | 86.7 | 23.9 |
| Listening Comprehension | | | | | | | | | | | | | | | | 75 | 79.2 | 14.3 | | | | | | | | | |
| Speed of Lexical Access | **53** | **110.5** | **12.2** | **45** | **68.4** | **24.5** | 79 | 88.0 | 14.1 | | | | | | | 74 | 89.1 | 13.8 | | | | | | | | | |
| **Reading Clusters** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reading | | | | | | | 79 | 74.0 | 14.4 | 73 | 85.9 | 9.1 | 75 | 83.0 | 13.6 | | | | | | | 12 | 77.3 | 28.4 | 50 | 85.5 | 24.4 |
| Broad Reading | | | | | | | 79 | 72.2 | 16.2 | | | | | | | | | | | | | | | | | | |
| Basic Reading Skills | | | | | | | 79 | 73.3 | 13.4 | | | | | | | | | | | | | | | | 50 | 89.6 | 24.2 |
| Reading Comprehension | | | | | | | 78 | 78.1 | 16.4 | | | | | | | | | | | | | | | | | | |
| Reading Fluency | | | | | | | 79 | 72.8 | 16.4 | | | | | | | | | | | | | | | | | | |
| Reading Rate | | | | | | | 79 | 74.4 | 17.3 | | | | | | | | | | | | | | | | | | |

***Table 5-42.*** *(cont.)*
*Summary Statistics for Select WJ IV Clusters for Clinical Validity Study Groups*

| Cluster | Clinical Diagnoses | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gifted | | | ID/MR | | | LD–Reading | | | LD–Math | | | LD–Writing | | | Language Delay | | | ADHD | | | Head Injury | | | ASD | | |
| | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* |
| **Mathematics Clusters** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mathematics | | | | | | | 79 | 83.2 | 13.6 | 73 | 81.3 | 10.9 | 75 | 88.0 | 15.6 | | | | | | | 12 | 83.8 | 24.4 | 49 | 84.8 | 28.4 |
| Broad Mathematics | | | | | | | | | | 73 | 79.5 | 11.4 | | | | | | | | | | 12 | 79.5 | 24.9 | 49 | 83.0 | 27.0 |
| Math Calculation Skills | | | | | | | | | | 73 | 82.0 | 11.5 | | | | | | | | | | 12 | 79.7 | 22.6 | 49 | 84.2 | 25.7 |
| Math Problem Solving | | | | | | | | | | 73 | 80.0 | 12.3 | | | | | | | | | | | | | | | |
| **Writing Clusters** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Written Language | | | | | | | 79 | 76.2 | 12.9 | 73 | 87.4 | 10.2 | 75 | 77.3 | 15.2 | | | | | | | 12 | 76.4 | 29.8 | 48 | 88.3 | 23.4 |
| Broad Written Language | | | | | | | | | | | | | 75 | 77.4 | 14.9 | | | | | | | | | | | | |
| Basic Writing Skills | | | | | | | | | | | | | 75 | 76.7 | 14.4 | | | | | | | 12 | 75.7 | 27.5 | | | |
| Written Expression | | | | | | | | | | | | | 75 | 82.3 | 14.3 | | | | | | | | | | | | |
| **Cross-Domain Clusters** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Academic Skills | | | | | | | 79 | 75.1 | 13.3 | 73 | 84.0 | 9.7 | 75 | 81.0 | 13.6 | | | | | | | 12 | 77.9 | 27.3 | 49 | 87.7 | 24.9 |
| Academic Applications | | | | | | | 79 | 77.5 | 13.3 | 73 | 83.5 | 7.9 | 74 | 84.0 | 12.7 | | | | | | | 12 | 78.5 | 30.2 | 48 | 83.7 | 25.4 |
| Phoneme-Grapheme Knowledge | | | | | | | | | | | | | | | | | | | | | | 12 | 83.5 | 22.7 | | | |
| Brief Achievement | **53** | **117.3** | **11.9** | **43** | **55.6** | **19.8** | 79 | 73.8 | 13.2 | 73 | 83.1 | 9.5 | 75 | 80.1 | 13.3 | | | | 50 | 88.7 | 13.6 | 12 | 78.8 | 26.3 | 49 | 86.2 | 26.3 |
| **Optional Clusters** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Comprehension-Knowledge–Ext. | **53** | **113.2** | **10.7** | **44** | **56.1** | **16.6** | | | | | | | 75 | 84.5 | 15.4 | | | | | | | | | | 50 | 81.0 | 24.7 |
| Fluid-Reasoning–Ext. | | | | | | | | | | 73 | 81.3 | 11.2 | 75 | 84.6 | 14.7 | | | | | | | | | | | | |
| Short-Term Working Memory–Ext. | | | | | | | | | | | | | 75 | 81.0 | 15.5 | 74 | 83.3 | 16.3 | | | | | | | | | |
| Cognitive Efficiency–Ext. | | | | | | | | | | | | | 75 | 82.8 | 14.3 | | | | | | | | | | | | |
| Reading Comprehension–Ext. | | | | | | | 77 | 76.1 | 15.7 | | | | 74 | 84.2 | 15.5 | | | | | | | | | | | | |
| Broad Achievement–Ext. | | | | | | | | | | | | | 75 | 80.8 | 13.4 | | | | | | | | | | | | |

**Red bold font = < 70**
Red font = 70–79
Blue font = 80–89
Black font = 90–109
**Black bold font = > 109**

displayed average scores approximately one standard deviation above the mean (115).[48] These large score differences on all WJ IV tests and clusters in Tables 5-41 and 5-42 support the validity of the WJ IV measures in the assessment of individuals who may be gifted or have an ID/MR.

- In the gifted sample, the mean Fluid Reasoning (*Gf*) cluster score is 8.5 points higher than the Comprehension-Knowledge (*Gc*) cluster score; in the ID/MR sample, the scores are approximately equal (51.6 and 50.1). Whether this *Gf-Gc* difference provides potentially important diagnostic information for these two groups, as well as other diagnostic groups, requires additional research.
- The ADHD group, which typically does not consist of individuals with serious general cognitive deficits per most diagnostic criteria, is the group with the second-highest mean (after the gifted group) WJ IV COG and WJ IV OL test scores. The mean scores for the 13 COG and OL tests reported in Table 5-41 range from the high-.80s to the mid-.90s (median = 91.2); this score range is typically interpreted to reflect low-average to average abilities. The achievement test scores for the ADHD group (87.9 to 90.8; Brief Achievement cluster mean = 88.7) are generally commensurate with the group's COG and OL scores. Because the diagnostic criteria for ADHD are not based primarily on serious deficits in general cognitive functioning, the low-average to average WJ IV scores obtained for the ADHD group in this study provide additional support for the conclusion presented above with regard to the gifted and ID/MR group differences. That is, the general pattern of mean scores displayed in Tables 5-41 and 5-42 (ID/MR < ADHD < gifted) is consistent with expectations for these groups.
- In Table 5-41, the three LD groups consistently display mean WJ IV COG and WJ IV OL test scores in the low average range (80 to 89). Consistent with a learning disability in reading and the study inclusion criteria, the LD–Reading group is the only LD group with mean WJ IV ACH reading scores consistently below 80 (seven of the eight reading test mean scores are <80; median = 76.5). In Table 5-42, all six WJ IV ACH reading cluster mean scores are also in the 70s. For the two reading tests that are common across the three LD group studies in Table 5-41 (Letter-Word Identification and Passage Comprehension), the LD–Reading group mean scores (72.4 and 78.3) are lower than the LD–Writing group mean scores (81.7 and 85.7), which in turn are lower than the LD–Math group mean scores (86.2 and 86.5). The Reading cluster mean scores in Table 5-42 reflect the same LD–Reading (74.0) < LD–Writing (83.0) < LD–Math (85.9) pattern. Additional research is needed to determine whether these differences are statistically and meaningfully different—and possibly diagnostically relevant.
- The lowest WJ IV ACH mean test score for the LD–Writing group is for Spelling (76.6), which is approximately 9 points lower than the Spelling mean score of 85.9 for the LD–Math group. However, the mean Spelling test score for the LD–Reading group (74.2) is similar to that for the LD–Writing group (76.6). The LD–Writing and

[48] The mean WJ IV scores for the Gifted and ID/MR groups are very similar to those reported for similar CDB diagnostic groups for the WJ III NU (McGrew et al., 2007). The observation that the two general intelligence–related composite scores reported (BIA and *Gf-Gc* Composite) are lower than the scores for the individual WJ IV COG tests for the ID/MR group (and conversely, generally higher for the Gifted group) is due to the now commonly understood statistical phenomenon of "the total does equal the sum of the parts" (McGrew, 1994; p. 243–246). This total-to-part score phenomenon is a function of the intercorrelations and number of component, or part, scores that contribute to the total score, and it occurs more often when a high number of these component test scores are far away from the mean (100) (see McGrew, 1994; Paik & Nebenzahl, 1987). The observation that the WJ IV COG cluster scores for the Gifted group are not close to, or above, the commonly used IQ criteria of >130 is due to a number of factors. First, there is considerable variability in the nature of different instruments and procedures used to identify students as gifted (or talented) across different programs (see Kaufman & Sternberg, 2008 for the issues in gifted identification). A review of the parent permission forms from the WJ IV gifted special study, on which parents self-report information, revealed a range of criteria used for placement (including IQ score greater than some specified score, a variety of different IQ tests, differential patterns of cognitive domain-specific strengths, performance on district or state achievement tests, gifted indicators checklists, and teacher recommendation). Also, both the ID/MR and Gifted sample mean scores are likely not accurate population estimates for these two diagnostic groups due to the presence of implicit sample preselection effects (i.e., when scores from a measure not used to identify a group on the basis of a trait, such as intelligence, are compared to the scores from instruments used to originally select the group, many of the resulting statistics will be skewed (see Gullikson, 1950; Lord & Novick, 1968; McGrew, 1994; Woodcock, 1984).

LD–Reading groups have similar mean scores for the Writing Samples test (83.5 and 83.7, respectively), which are approximately 8 points lower than the Writing Samples mean score for the LD–Math group (91.8). These findings suggest that for the two WJ IV ACH writing tests that are included in all three LD studies, the LD–Writing and LD–Reading groups are similar in average performance and that this performance is noticeably lower than that for the LD–Math group.

- The available WJ IV math achievement tests and clusters reported in Tables 5-41 and 5-42 do not reveal clear-cut LD-group differential math score differences. On the Mathematics cluster reported in Table 5-42, the LD–Math group mean score (81.3) is not noticeably different from the LD–Reading group mean score (83.2); however, the LD–Math group mean score is 6.7 points lower than the LD–Writing group mean score (88.0). Additional research is needed that includes all WJ IV math tests and math-achievement-associated cognitive abilities (e.g., fluid reasoning, quantitative reasoning, visual processing; McGrew & Wendling, 2010) administered across three similar diagnostic LD groups. The mean Fluid Reasoning (*Gf*; 79.9) and Auditory Processing (*Ga*; 78.6) cluster scores for the LD–Math and LD–Reading groups, respectively, are consistent with *Gf*-Math/*Ga*-Reading cognitive-achievement domain-specific research (McGrew, 2012; McGrew & Wendling, 2010). However, these results cannot currently translate to diagnostic validity until studies are conducted where similar diagnostic groups are compared across all WJ IV COG CHC factor and ACH scores.
- The Language Delay group generally displayed mean WJ IV COG test scores in the same range as the three LD groups (80 to 89 range) in Table 5-41. The lower mean score of 76.6 for Oral Vocabulary, when compared to the median of the seven other WJ IV COG tests for the Language Delay group, is consistent with the language-related nature of this group's primary diagnosis. With the exception of Rapid Picture Naming (mean = 91.9), the mean scores for the remaining WJ IV OL tests are consistently in the .80s (median = 81.8). With the exception of the mean Speed of Lexical Access cluster score (89.1), the four primary WJ IV OL cluster score means for the Language Delay group range from 78.3 to 80.4 in Table 5-42. Whether these low WJ IV OL test and cluster scores are diagnostically relevant when making differential diagnoses requires future research comparing individuals with language delays to groups with other disabilities (e.g., LD–Reading, LD–Math, LD–Writing) on all WJ IV OL measures.
- The observation of potentially meaningful test or cluster score patterns for the Head Injury and ASD groups is not clear from a review of WJ IV test and cluster scores reported in Tables 5-41 and 5-42. Across most WJ IV COG, WJ IV OL, and WJ IV ACH tests, the ASD group consistently performs in the 80- to 90-point score range. In contrast, the primary characteristics of the Head Injury group scores appear to be (a) more variable test and cluster scores, and (b) reading and writing ACH scores less than 80, with slightly higher math test scores. More extensive diagnostic group differential validity research, with common WJ IV COG, WJ IV OL, and WJ IV ACH test and cluster scores, is needed before meaningful and clinically relevant conclusions can be reached regarding WJ IV scores for individuals with head injuries or ASD.

## Chapter Summary

Validity is the most important consideration in test development, evaluation, and interpretation. This chapter presents several sources of validity evidence for the WJ IV. Throughout the development and the design of associated research studies, test standards as outlined in the *Standards for Educational and Psychological Testing* (AERA, APA, NCME, 2014) were followed carefully. Special efforts were made to provide all types of validity evidence that relate to the proposed uses and interpretations of scores from the WJ IV. The validity evidence presented in this manual is intended for use with other sources of validity information, including, where appropriate, contemporary CHC theory research (see Chapter 1 and Appendix A), an examination of the scope and sequence of test items in the Test Books, the test and cluster content descriptions found in Chapter 2 of the WJ IV ACH, WJ IV COG, and WJ IV OL Examiner's Manuals (Mather & Wendling, 2014a, 2014b, 2014c), and recommended interpretations found in Chapter 5 of all three WJ IV Examiner's Manuals. Taken together, these sources help assessment professionals evaluate the validity of the WJ IV based on test content, process and construct coverage, cognitive complexity demands, developmental patterns, internal structure, relationships to other measures, and performance of diagnostic groups. The procedures followed in developing and validating the WJ IV produced an assessment system that can be used with confidence in a variety of settings.

The representativeness of the WJ IV test content, process, and construct validity was addressed through specification of a test revision blueprint informed by contemporary CHC theory and cognitive neuroscience research (see Chapter 1 and Appendix A). The WJ IV battery blueprint focused particular attention on advancing CHC theory–based assessment from its initial articulation in the WJ-R and WJ III by providing more administration and interpretive options to meet contemporary assessment needs. Most WJ IV COG tests are designed to be primary measures of narrow abilities (or Stratum I abilities in CHC theory). To ensure that all items in each test measured the same narrow ability or trait, stringent fit criteria based on the Rasch model were employed during the process of item pool development and test construction (see Chapter 2). Some WJ III tests were revised and several new tests were developed, with the goal of moving "beyond CHC" theory vis-à-vis increasing either the factorial complexity or cognitive processing demands of the tests. Like the WJ III, the WJ IV provides broad cluster measures of the primary CHC cognitive factors; however, the WJ IV also provides construct-valid cluster measures of narrow CHC abilities important for most diagnostic and instructional-related assessments. Each WJ IV COG broad and narrow cluster is designed to include two qualitatively different narrow abilities subsumed by the respective broad or narrow ability as defined by CHC theory. In addition, the WJ IV COG clusters contain several new tests with item tasks that require a higher degree of cognitive complexity. The design of the WJ IV OL and WJ IV ACH batteries also were informed by CHC theory; however, in the WJ IV OL and WJ IV ACH batteries, test and cluster content also was aligned with core curricular areas, functional achievement or language domains, and domains specified in federal legislation.

Figures 5-3 through 5-8 present pictographic patterns of growth and decline among the general, broad, and narrow areas of academic achievement and the scholastic aptitudes to help establish the distinctiveness of each of the primary factor or cluster scores. These cross-sectional graphs display average score changes consistent with the developmental growth and decline of cognitive, oral language, and achievement abilities across the life span. The different growth and decline patterns for most WJ IV clusters substantiate the uniqueness of the different abilities measured.

Internal structure evidence was investigated through a scientifically sound and thorough split-sample, multistage, *exploratory* model generation and *confirmatory* cross-validation process (see Figure 5-9). This three-stage method for investigating internal, or structural, validity is the most comprehensive and scientifically sound approach presented to date for any collection of individually administered cognitive, oral language, and achievement tests. The final cross-validated broad CHC (Model 2; see Figure 5-13) and broad plus narrow CHC (Model 3; see Figure 5-14) structural models provide evidence supporting the WJ IV battery organization and the interpretation of the WJ IV test and cluster scores. In addition, the exploratory cluster and multidimensional scaling analyses suggest that more frequently used structural analysis methods (namely EFA and CFA) may fail to reveal potentially important structural dimensions (or characteristics of tests) in large test batteries. Although not evident in the CFA models, the exploratory cluster and MDS analyses revealed plausible factors (and thus, possible new WJ IV clusters that should be explored further) that further differentiate (a) *Gf* abilities by stimulus content dimensions (verbal versus quantitative), (b) *Gs* abilities by cognitive versus achievement dimensions, and (c) *Gwm* abilities by memory span (MS) and working memory (WM) dimensions. The multistage, multimethod approach used to investigate the internal structure of the WJ IV also provides support for proposed revisions to a number of narrow abilities in contemporary CHC theory; for example, memory for sound patterns (*Ga/Gwm*-UM). Several types of evidence also were uncovered to support a new CHC narrow ability—speed of lexical access (*Glr*-LA).

An important principle in the investigation of structural validity evidence is that confirmatory methods do not *confirm* or *prove* a model—they only fail to *disconfirm* it. Alternative structural WJ IV models would likely display comparable fit to the models described in this chapter. Independent structural research is encouraged. The presentation of the detailed results from the exploratory cluster analysis, principal component analysis, and multidimensional scaling analysis for all six age groups analyzed (see Appendices G through I) provide independent researchers with a rich multifaceted set of information to specify and explore alternative WJ IV structural models. Such internal structural research would be a welcome contribution to the ongoing accumulation of structural validity evidence for the WJ IV battery. Such structural research, with the large collection of 47 WJ IV tests, also could inform progress regarding evolving theories and models of human intelligence.

Fifteen concurrent validity studies show that the WJ IV tests and clusters correlate well with other tests and composite scores from batteries measuring similar constructs. The General Intellectual Ability (GIA), Brief Intellectual Ability (BIA), and *Gf-Gc* Composite cluster scores demonstrate consistently high (.70 to .80 range) correlations with the general intelligence (*g*) scores from other accepted and valid measures of intelligence (e.g., the Wechsler batteries, KABC-II, DAS-II, and SB5). Correlations of this range (.70s to .80s) are similar to those reported in other publications and test manuals between full scale or composite scores of other major intelligence batteries. These correlations support the interpretation of the WJ IV GIA first-principal component (*g*) cluster score as a valid measure of general intellectual ability. The BIA cluster score correlates in the same range with the same external measures of intelligence, providing support for its use as a screening measure of intellectual ability. The new *Gf-Gc* Composite, a combination of two *Gf* and two *Gc* tests, correlates at levels similar to the WJ IV GIA and BIA correlations with the g scores from external measures of intelligence. If there are reservations about the use of the GIA score (or a full-scale composite score from another battery), the *Gf-Gc* Composite appears to be a useful proxy for general intelligence as the best estimate of an individual's general intelligence due to an unusual pattern of strengths and weaknesses in either cognitive processing, memory, or speed abilities.

The WJ IV battery reintroduces the WJ and WJ-R style scholastic aptitude clusters (SAPTs). Although highly intercorrelated and highly correlated with the GIA cluster, the evidence from the developmental growth curves and achievement-domain correlations indicates that the SAPT clusters are strong predictors of academic achievement within their domain-relevant target achievement domains. When compared to the seven-test GIA cluster correlations with achievement, the four-test SAPT clusters are more efficient measures for making predictions about domain-specific expected achievement. Each SAPT cluster, which can be administered in less time than the GIA cluster, provides users with the ability to design more flexible, selective, referral-focused assessments (McGrew & Wendling, 2010). The validity evidence presented suggests that the WJ IV COG SAPTs fit well with contemporary pattern-of-strengths-and-weaknesses discrepancy models of SLD identification.

For the WJ IV OL and ACH batteries, the pattern and magnitude of the correlations suggest that the WJ IV OL and WJ IV ACH measure oral language and academic skills and abilities similar to those measured by other oral language and achievement test batteries. The WJ IV OL Oral Language cluster demonstrates strong validity evidence (correlations in the .60 to .80 range) with the global oral language scores from the CELF-4, CASL and OWLS, KTEA-II, and WIAT-III. Concurrent validity evidence supports the interpretation of the WJ IV OL clusters (Oral Language, Oral Expression, Listening Comprehension) as valid measures of aspects of oral language abilities. Nevertheless, the correlations between the WJ IV Oral Expression and Listening Comprehension clusters, and similarly named clusters from other batteries, suggest that the respective measures from other batteries are not always isomorphic with the WJ IV measures. Finally, the WJ IV OL Phonetic Coding and Speed of Lexical Access clusters demonstrate low to moderate correlations across all other external measures of cognitive and oral language functions, indicating that these two WJ IV OL clusters measure cognitive and language abilities not measured by other measures of general intelligence or oral language.

The WJ IV Broad Achievement score has correlations ranging from .85 to .91 across two studies with KTEA-II and WIAT-III. When comparing WJ IV scores within and across academic domain scores from the KTEA-II and WIAT-III, most correlations followed expected patterns of convergent and divergent validity. For example, the WJ IV Reading cluster correlates at .83 and .94 with the KTEA-II Reading composite in two age-differentiated samples and correlates at .78 and .93 with the WIAT-III Total Reading composite in two grade-differentiated samples. However, this was not the case in all comparisons. The WJ IV and WIAT-III Written Expression measures correlate at a moderate (.52 and .62) level, suggesting the need to examine the content and processes measured by each respective measure when comparing scores.

Select WJ IV test and cluster scores were reported for nine different clinical groups. In general, differences noted across groups provided preliminary validity evidence for the primary WJ IV clusters, either at the level of specific cluster scores or across a variety of tests. The most robust findings were (a) observed differences between groups known to differ in general intellectual ability, (i.e., intellectual disability group mean scores lower than ADHD group mean scores, and ADHD group mean scores lower than gifted group mean scores) and (b) performance of the SLD groups on reading and writing measures consistent with expectations for each disability group. The WJ IV clinical validity study data are provided in this chapter as preliminary descriptive information and should not be used diagnostically. The primary purpose for reporting this initial WJ IV clinical validity evidence is to provide examiners with WJ IV test information that can be used, in conjunction with other relevant information, to design selective referral-focused WJ IV assessments. The validation of test scores is an ongoing process of accumulating a network of validity evidence. Because the WJ IV clinical validity studies were limited in the breadth of WJ IV test and cluster scores reported, no formal statistical comparisons were computed. However, for the WJ IV tests or cluster measures that are similar in form and design to their WJ III counterparts, users should integrate the information reported here with information from the large and evolving WJ III- and WJ IV-based clinical database (reported by McGrew et al., 2007; Schrank, 2010; and Woodcock & Miller, 2012).

One of the WJ IV design objectives stated in Chapter 1 was to push the field of applied test development forward by using a variety of state-of-the-art research design and statistical procedures to evaluate the validity of the WJ IV battery. In the presentation of information regarding the representativeness of the WJ IV test content and processes, the following new forms of validity evidence are presented:

1. A comparison of the CHC classifications of the 39 WJ III tests that are retained in the WJ IV, by WJ IV authors and independent researchers (see Table 5-1)
2. Content analysis via multidimensional scaling (MDS) of the combined set of WJ IV COG, WJ IV OL, and WJ IV ACH tests across six age-differentiated norming sample groups (see Figures 5-2 and 5-12 and Appendix I)
3. Test cognitive complexity analysis by MDS, as well as through the traditional method of inspecting *g*-factor loadings (see Table 5-6).

The WJ IV split-sample, multiple-stage, exploratory-confirmatory approach is the most thorough scientific demonstration of the investigation of the structural validity of any contemporary battery of individually administered cognitive, language, and achievement tests to date. The use of multiple exploratory methods, such as cluster analysis, MDS, principal components analysis, and model-generating (exploratory) CFA demonstrates that multiple methodological lenses are required to understand the structural, content, and processing characteristics of a large battery of tests. The marriage of extensive exploratory model building with split-sample CFA cross-validation provides an example of the use of strong scientific methods to evaluate the generalizability of test and factor characteristics. It is hoped that the detailed explanation and description of the investigation of the WJ IV structural validity will serve as a model for more thorough exploration of the structural validity of new and soon-to-be revised batteries of individually administered cognitive, oral language, and achievement tests

NOTE

† Two sets of CFA model fit values are reported in Table 5-14. One set is based on the *maximum-likelihood* (ML) estimation algorithm; the second set is based on the *scale-free least squares* (SFLS) estimation algorithm (Arbuckle, 2012; Blunch, 2008). As presented in Table 5-14, the ML-based fit indices are significantly lower (higher in the case of the RMSEA) than the values typically suggested as representing good model fit. The absolute values of the ML fit indices in Table 5-14 reflect the fact that ML estimation is frequently unsuitable in situations where the models evaluated are complex, multicollinearity exists in the data set, the data contain Heywood cases, or the assumption of both univariate and multivariate normality in the data set is not met (Brown, 2006; Byrne, 2012; Kline, 2011; Schermelleh-Engel & Moosbrugger, 2003).

All these conditions exist in the WJ IV MD and MCV samples analyzed with CFA methods. The expected and explainable multicollinearity was discussed earlier in this chapter. The assumption of *multivariate normality* also was found untenable. For example, for the ages 9 through 13 MD sample, 15 test variables exhibit either significant skew or kurtosis. For the complete set of 51 variables, Mardia's (1970) coefficient of multivariate kurtosis is 27.6 (critical ratio = 5.26), indicating a violation of the assumption of multivariate normality. Similar results are found for all MD and MCV samples at all age groups. These conditions are often unavoidable in practice (Schermelleh-Engel & Moosbrugger, 2003), such as the case with the WJ IV data where a large number of tests are included in the complex CFA models that were evaluated (see Figures 5-13 and 5-14). Also, a number of WJ IV tests have non-normal distributions due to (a) bottom age limits on tests (e.g., Writing Samples) and, more importantly, (b) the WJ IV's unique method of *maintaining* the "real world" skew and kurtosis of test score distributions through the use of a combined linear and area score transformation procedure (see Chapter 3). Most other published tests typically transform the test score distributions to approximate the normal distribution via some variant of a normal curve area transformation to the test score distributions.

The presence of multicollinearity, non-normality, and complex models with large numbers of variables can result in biased ML-based standard errors and "poorly behaved" chi square tests and overall model fit (Brown, 2006; Byrne, 2012). When such conditions exist, the ML-based fit indices should be used cautiously; here they are used only for relative fit comparisons between the two respective models—the absolute magnitude of the fit indices is ignored. More importantly, these conditions (and others, such as outlier cases with significant leverage) suggest that alternative estimation algorithms that are not dependent on the assumption of multivariate normality should be used (Brown, 2006; Byrne, 2012; Kline, 2011; Yuan & Zhong, 2013). The SFLS method, which was used to compliment the ML-based fit indices, is conceptually similar to using the *unweighted least squares* (ULS) algorithm on input in the form of a correlation matrix. As a check on the appropriateness of the SFLS results, the respective ML and SFLS factor loadings were compared for the broad CHC model (Model 2) in the six MD samples. The illustrative results for the factor loading comparison for the ages 9 through 13 MD sample are presented in Appendix I. A review of the results in Appendix I reveals that, of the 81 latent factor loadings reported, the respective ML- and SFLS-based factor loadings differ only to the second decimal place (–.09 to +.07) for all but three of the 81 comparisons. As can be seen in Table 5-14, the SFLS-based AGFI and PNFI fit indices are in the .95 or higher and .87 to .91 ranges, respectively—values consistent with good model fit per the model fit rules of thumb that have been promulgated.

Finally, three other model estimators included in the M*plus* program (version 6.11; Muthén & Muthén, 1998–2011) were applied to the ages 9 through 13 final MD sample model (see Figure 5-13). The three suggested estimators for data with violations of multivariate normality are, in the terminology of M*plus*: MLM (also referred to as the Satorra-Bentler chi-square), MLMV, and WLF (also referred to as the ADF when analyzing continuous variables). Byrne (2012) recommends the MLM estimator as it provides the Satorra-Bentler chi-square and robust versions of the CFI, TLI, and RMSEA fit statistics. For the final ages 9 through 13 MD model (see Figure 5-13), the Satorra-Bentler chi-square of 13,580.88 is similar in magnitude to the ML chi-square value (13,642.57) reported for this age group in Table 5-14. The MLM-derived CFI (.638) and TLI (.610) values are identical to those reported for this sample in Table 5-14. The MLM RMSEA value is slightly lower (.116) than the ML-derived value (.123); a difference deemed not practically significant. The MLMV-based CFI and TLI values of .629 and .600, respectively, also are very similar to the ML-based (.638 and .610) and MLM-based values (.629 and .600) obtained for this age group. The WLS (ADF) estimator does not converge properly because the model specified requires a minimum sample size of at least 1,377 (the ages 9 through 13 MD sample $n = 785$). These alternative fit statistics do not differ appreciably from the ML values reported in Table 5-14, thus supporting the use and reporting of the ML and alternative SFLS fit statistics and model parameters for the WJ IV internal validity analysis.

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# *Appendix A*

# Cattell-Horn-Carroll Theory of Cognitive Abilities Definitions

The following description of broad and narrow Cattell-Horn-Carroll (CHC) definitions is abstracted from a lengthy narrative description of contemporary CHC theory in:

Schneider, W. J., & McGrew, K. S. (2012). The Cattell-Horn-Carroll model of intelligence. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (3rd ed., pp. 99–144). New York, NY: Guilford Press.[1]

The current definitions present the "bare bones" definitional information from the above-mentioned book chapter. Readers are encouraged to consult the Schneider and McGrew (2012) chapter for details. Additionally, as described and explained in Chapters 1 and 5 of this manual, a number of proposed changes to a small number of broad and narrow ability CHC codes (e.g., *Gwm* for *Gsm*) and definition revisions are incorporated in the definitions reported here. Support for these changes was gleaned from cognitive neuroscience research and from the structural validity analysis of the WJ IV tests (see Chapter 5). The most significant changes are found in the contemporary constructs of working memory (*Gwm*), attentional control (*Gwm*-AC), speed of lexical access (*Glr*-LA), and memory for speech sounds (*Ga*-UM). Proposed changes are designated by text in *italicized font*.

## Domain-Independent General Capacities

### Fluid Reasoning (*Gf*)

Fluid reasoning is 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. Fluid reasoning is a multidimensional construct but its parts are unified in their purpose: solving unfamiliar problems. Fluid reasoning is most evident in abstract reasoning that depends less on prior learning. However, it is also present in day-to-day problem solving. Fluid reasoning is typically employed in concert with background knowledge and automatized responses. That is, fluid reasoning is employed, even if for the briefest of moments, whenever current habits, scripts, and schemas are insufficient to meet

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the demands of a new situation. Fluid reasoning also is evident in inferential reasoning; concept formation; classification of unfamiliar stimuli; generalization of old solutions to new problems and contexts; hypothesis generation and confirmation; identification of relevant similarities; differences in, and relationships among, diverse objects and ideas; the perception of relevant consequences of newly acquired knowledge; and extrapolation of reasonable estimates in ambiguous situations.

- Induction (I): The ability to observe a phenomenon and discover the underlying principles or rules that determine its behavior.
- General sequential reasoning (RG): The ability to reason logically using known premises and principles. This ability also is referred to as deductive reasoning or rule application.
- Quantitative reasoning (RQ): The ability to reason, either with induction or deduction, with numbers, mathematical relations, and operators.

## *Short-Term Working Memory* (Gwm)

Short-term working memory is the ability to encode, maintain, and manipulate information in one's immediate awareness. *Gwm* refers to individual differences in both the capacity (size) of primary memory and to the efficiency of attentional control mechanisms that manipulate information within primary memory.

- Memory span (MS): The ability to encode information, maintain it in primary memory, and immediately reproduce the information in the same sequence in which it was represented.
- Working memory capacity (WM):[2] The ability to direct the focus of attention to perform relatively simple manipulations, combinations, and transformations of information within primary memory while avoiding distracting stimuli and engaging in strategic/controlled searches for information in secondary memory.
- *Attentional control (AC): The ability to focus on task-relevant stimuli and ignore task-irrelevant stimuli. The ability to regulate intentionality and direct cognitive processing. Sometimes referred to as spotlight or focal attention, focus, control of attention, executive controlled attention, or executive attention.*[3]

## Long-Term Storage and Retrieval (*Glr*)

Long-term storage and retrieval is the ability to store, consolidate, and retrieve information over periods of time measured in minutes, hours, days, and years. Short-term memory has to do with information that has been encoded seconds ago and must be retrieved while it is being actively maintained in primary memory. Short-term memory tests often involve information that is stored in long-term memory. What distinguishes *Gwm* from *Glr* is a continuous attempt to maintain awareness of that information. *Glr* involves information that has been put out of immediate awareness long enough for the contents of primary memory to be displaced completely. In *Glr*, continuous maintenance of information in primary memory is difficult, if not impossible.

[2] This factor was previously named *working memory*. However, as explained in McGrew (2005), this term does not refer to an individual difference variable but instead to a set of interrelated cognitive structures. *Working memory capacity* is an individual difference variable that is a property of the working memory system as a whole.

[3] Carroll (1993) identified factors that he referred to as the "ability to attend (AC)" and reported them in his chapter of "Miscellaneous Domains of Ability and Personal Characteristics." Carroll reported that "very few factor-analytic studies addressed attentional abilities" (p. 548). The proposed definition for *attentional control* (AC) is based on recent cognitive neuroscience research (see Chun, Golomb, & Turk-Browne, 2011; Derakshan & Eysenck, 2009; Engle, 2002; Gazzaley & Nobre, 2012; Petersen & Posner, 2012; Wass, Scerif, & Johnson, 2012). It is a convenient coincidence that Carroll's AC factor code also can stand for *attentional control*. It is suggested that the definition of *attentional control* proposed here, based on contemporary cognitive neuroscience research, use the Carroll AC code and should be defined to represent attentional control.

### *Glr-Learning Efficiency*

All tasks of learning efficiency must present more information than can be retained in *Gwm*.

- Associative memory (MA): The ability to remember previously unrelated information as having been paired.
- Meaningful memory (MM): The ability to remember narratives and other forms of semantically related information.
- Free recall memory (M6): The ability to recall lists in any order.

### *Glr-Retrieval Fluency*

*Glr*-retrieval fluency is the rate and fluency at which individuals can access information stored in long-term memory.

Fluency factors that involve the production of ideas:

- Ideational fluency (FI): The ability to rapidly produce a series of ideas, words, or phrases related to a specific condition or object. Quantity, not quality or response originality, is emphasized.
- Associational fluency (FA): The ability to rapidly produce a series of original or useful ideas related to a particular concept. In contrast to ideational fluency (FI), quality, rather quantity of production, is emphasized.
- Expressional fluency (FE): The ability to rapidly think of different ways of expressing an idea.
- Sensitivity to problems/alternative solution fluency (SP): The ability to rapidly think of a number of alternative solutions to a particular practical problem.
- Originality/creativity (FO): The ability to rapidly produce original, clever, and insightful responses (expressions, interpretations) to a given topic, situation, or task.

Fluency abilities that involve the recall of words:

- Naming facility (NA): The ability to rapidly call objects by their names. In contemporary reading research, this ability is called rapid automatic naming (RAN), or speed of lexical access.
- Word fluency (FW): The ability to rapidly produce words that share a *phonological (e.g., fluency of retrieval of words via a phonological cue) or semantic feature (e.g., fluency of retrieval of words via a meaning-based representation)*. Also includes the ability to rapidly produce words that share nonsemantic features (e.g., fluency of retrieval of words starting with the letter *T*).
- *Speed of lexical access (LA): The ability to rapidly and fluently retrieve words from an individual's lexicon; verbal efficiency or automaticity of lexical access.*

Fluency abilities related to figures:

- Figural fluency (FF): The ability to rapidly draw or sketch as many things (or elaborations) as possible when presented with a nonmeaningful visual stimulus (e.g., set of unique visual elements). Quantity is emphasized over quality.
- Figural flexibility (FX): The ability to rapidly draw different solutions to figural problems.

## Processing Speed (*Gs*)

Processing speed is the ability to perform both simple and complex repetitive cognitive tasks quickly and fluently. This ability is of secondary importance (compared to *Gf* and *Gc*) when predicting performance during the learning phase of skill acquisition. However, it becomes an important predictor of skilled performance once people know how to do a task. That is, once people know how to perform a task, they still differ in the speed and fluency with which they perform it. For example, two people may be equally accurate in their addition skills, but one may recall math facts with ease while the other may have to think about the answer for an extra half second and count on his or her fingers.

- Perceptual speed (P): The speed at which visual stimuli can be compared for similarities or differences. Much like induction (I) is at the core of *Gf*, perceptual speed (P) is at the core of *Gs*. Research (Ackerman, Beier, & Boyle, 2005; Ackerman & Cianciolo, 2000; McGrew, 2005) suggests that perceptual speed may be an intermediate stratum ability (between narrow and broad) defined by four narrow subabilities: (a) pattern recognition (Ppr)—the ability to quickly recognize simple visual patterns; (b) scanning (Ps)—the ability to scan, compare, and look up visual stimuli; (c) memory (Pm)—the ability to perform visual perceptual speed tasks that place significant demands on immediate *Gwm*; and (d) complex (Pc)—the ability to perform visual pattern recognition tasks that impose additional cognitive demands, such as spatial visualization, estimating and interpolating, and heightened memory span loads.
- Rate-of-test-taking (R9): The speed and fluency with which simple cognitive tests are completed. Through the lens of CHC theory, the definition of this factor has narrowed to simple tests that do not require visual comparison (so as not to overlap with perceptual speed [P]) or mental arithmetic (so as not to overlap with number facility [N]).
- Number facility (N): The ability to manipulate numbers in working memory, and the speed of number pattern comparison. It includes the speed at which basic arithmetic operations are performed accurately. Although this factor includes recall of math facts, number facility includes speeded performance of any simple calculation (e.g., subtracting 3 from a column of 2-digit numbers). Number facility does not involve understanding or organizing mathematical problems and is not a major component of mathematical/quantitative reasoning or higher mathematical skills.
- Reading speed (fluency) (RS): The rate of reading text with full comprehension. Also listed under *Grw*.
- Writing speed (fluency) (WS): The rate at which words or sentences can be generated or copied. Also listed under *Grw* and *Gps*.

## Reaction and Decision Speed (*Gt*)

Reaction and decision speed is the speed at which very simple decisions or judgments are made when items are presented one at a time. The primary use of *Gt* measures has been in research settings. Researchers are interested in *Gt* because it may provide insights into the nature of *g* and basic properties of the brain (e.g., neural efficiency). One of the interesting aspects of *Gt* is that not only is faster reaction time in these very simple tasks associated with complex reasoning but so is greater consistency of (i.e., less variability in) reaction time.

- Simple reaction time (R1): The reaction time to the onset of a single stimulus (visual or auditory). R1 frequently is divided into the phases of decision time (DT; e.g., the time it takes to decide to make a response and for the finger to leave a home button) and movement time (MT; e.g., the time it takes to move the finger from the home button to another button where the response is physically made and recorded).
- Choice reaction time (R2): The reaction time required when a very simple choice must be made. For example, an examinee sees two buttons and must press the one that lights up.
- Semantic processing speed (R4): The reaction time required when a decision requires simple encoding and mental manipulation of the stimulus content.

- Mental comparison speed (R7): The reaction time required when stimuli must be compared for a particular characteristic or attribute.
- Inspection time (IT): The speed at which differences in stimuli can be perceived.

### Psychomotor Speed (*Gps*)

Psychomotor speed is the speed and fluidity with which physical body movements can be made. In skill acquisition, *Gps* is the ability that determines performance differences after a comparable population (e.g., manual laborers in the same factory) has practiced a simple skill for a very long time.

- Speed of limb movement (R3): The speed of arm and leg movement. This speed is measured after the movement is initiated. Accuracy is not important.
- Writing speed (fluency) (WS): The speed at which written words can be copied. Also listed under *Grw* and *Gps*.
- Speed of articulation (PT): The ability to rapidly perform successive articulations with the speech musculature.
- Movement time (MT): The time taken to physically move a body part (e.g., a finger) to make the required response. Recent research suggests that MT may be an intermediate stratum ability (between narrow and broad strata) that represents the second phase of reaction time as measured by various elementary cognitive tasks (ECTs). MT also may measure the speed of finger, limb, or multilimb movements or vocal articulation (*diadochokinesis*; Greek for "successive movements") and also is listed under *Gt*.

## Acquired Knowledge Systems

### Comprehension-Knowledge (*Gc*)

Comprehension-knowledge is the depth and breadth of knowledge and skills that are valued by one's culture. Every culture values certain skills and knowledge over others. *Gc* reflects the degree to which a person has learned practically useful knowledge and mastered valued skills. Thus, by definition, it is impossible to measure *Gc* independent of culture. *Gc* is theoretically broader than what is measured by any existing cognitive battery.

- General (verbal) information (K0): The breadth and depth of knowledge that one's culture deems essential, practical, or otherwise worthwhile for everyone to know.
- Language development (LD): The general understanding of spoken language at the level of words, idioms, and sentences. In the same way that induction (I) is at the core of *Gf*, language development (LD) is at the core of *Gc*. Although listed as a distinct narrow ability in Carroll's model, his description of his analyses makes it clear that he meant Language Development as an intermediate category between *Gc* and more specific language-related abilities such as lexical knowledge (VL), grammatical sensitivity (MY), and listening ability (LS). Language development appears to be a label for all language abilities working together in concert.
- Lexical knowledge (VL): The knowledge of the definitions of words and the concepts that underlie them. Whereas language development (LD) is about understanding words in context, lexical knowledge (VL) is about understanding the definitions of words in isolation.
- Listening ability (LS): The ability to understand speech. Tests of listening ability typically have simple vocabulary but increasingly complex syntax or increasingly long speech samples to listen to.

- Communication ability (CM): The ability to use speech to communicate one's thoughts clearly. This ability is comparable to listening ability (LS) except that it is productive (expressive) rather than receptive.
- Grammatical sensitivity (MY): The awareness of the formal rules of grammar and morphology of words in speech. This factor is distinguished from English usage (EU) in that it is manifest in oral language instead of written language and that it reflects the awareness of grammar rules rather than correct usage.

## Domain-Specific Knowledge (*Gkn*)

Domain-specific knowledge is the depth, breadth, and mastery of specialized knowledge (knowledge not all members of a society are expected to have). Specialized knowledge is typically acquired via one's career, hobby, or other passionate interest (e.g., religion, sports).

- Foreign language proficiency (KL): this is similar to language development but it is proficiency in another language. This ability is distinguished from foreign language aptitude (LA) in that it represents achieved proficiency instead of potential proficiency. Presumably, most people with high foreign language proficiency have high foreign language aptitude (LA), but not all people with high foreign language aptitude (LA) have yet developed proficiency in any foreign language. This ability was previously classified as an aspect of *Gc*. However, since *Gkn* was added to CHC, it is clear that specialized knowledge of a particular language should be reclassified. Although knowledge of English as a second language (KE) was previously listed as a separate ability in *Gkn*, it now seems clear that it is a special case of the more general ability of foreign language proficiency. Note that this factor is unusual because it is not a single factor. There is a different foreign language proficiency factor for every language.
- Knowledge of signing (KF): The knowledge of finger spelling and signing (e.g., American Sign Language).
- Skill in lip reading (LP): Competence in the ability to understand communication from others by watching the movement of their mouths and expressions.
- Geography achievement (A5): The range of geography knowledge (e.g., capitals of countries).
- General science information (K1): The range of scientific knowledge (e.g., biology, physics, engineering, mechanics, electronics).
- Knowledge of culture (K2): The range of knowledge about the humanities (e.g., philosophy, religion, history, literature, music, and art).
- Mechanical knowledge (MK): Knowledge about the function, terminology, and operation of ordinary tools, machines, and equipment. There are many tests of mechanical knowledge and reasoning used for the purpose of personnel selection (e.g., *Armed Services Vocational Aptitude Battery* [ASVAB], *Wiesen Test of Mechanical Aptitude* [WTMA]).
- Knowledge of behavioral content (BC): Knowledge or sensitivity to nonverbal human communication/interaction systems (e.g., facial expressions and gestures). The field of emotional intelligence (EI) research is very large, but it is not yet clear which EI constructs should be included in CHC theory. CHC theory is about abilities rather than personality and thus the constructs within it are measured by tests in which there are correct answers (or speeded performance).

## Reading and Writing (*Grw*)

Reading and writing is the depth and breadth of knowledge and skills related to written language. People with high *Grw* read with little effort and write with little difficulty. When *Grw* is sufficiently high, reading and writing become windows for viewing a person's language development. Whatever difficulties they have understanding text or communicating clearly, it is most likely a function of *Gc* or *Gkn*. For people with low *Grw*, however, high language skills may not be evident in reading and writing performance. Although reading and writing are clearly distinct activities, the underlying sources of individual differences in reading and writing skills do not differentiate clearly between the two activities. It appears that the ability that is common across all reading skills also unites all writing skills.

- Verbal (print) language comprehension (V): The general development or understanding of words, sentences, and paragraphs in a native language, as measured by reading vocabulary and reading comprehension tests. Does not involve writing, listening to, or understanding spoken directions.
- Reading decoding (RD): The ability to identify words from text. Typically this ability is assessed by oral reading tests with words arranged in ascending order of difficulty. Tests can consist of phonetically regular words (words that are spelled how they sound, such as *bathtub* or *hanger*), phonetically irregular words (words that do not sound how they are spelled, such as *sugar* or *colonel*), or phonetically regular pseudowords (nonsense words that conform to regular spelling rules, such as *gobbish* or *choggy*).
- Reading comprehension (RC): The ability to understand written discourse. Reading comprehension is measured in a variety of ways.
- Reading speed (RS): The rate at which a person can read connected discourse with full comprehension. Reading Speed is classified as a mixed measure of *Gs* (cognitive speed) and *Grw* in a hierarchical speed model.
- Spelling ability (SG): The ability to spell words. This factor is typically measured with traditional written spelling tests. However, just as with reading decoding (RD), it also can be measured via spelling tests consisting of phonetically regular nonsense words (e.g., *grodding*). It is worth noting that Carroll (1993) considered this factor to be weakly defined and in need of additional research.
- English usage (EU): Knowledge of the mechanics of writing (e.g., capitalization, punctuation, and word usage).
- Writing ability (WA): The ability to use text to communicate ideas clearly.
- Writing speed (WS): The ability to copy or generate text quickly. Writing speed tasks are considered to measure both *Grw* and *Gps* (broad psychomotor speed) per a hierarchical speed taxonomy.

## Quantitative Knowledge (*Gq*)

Quantitative knowledge is the depth and breadth of knowledge related to mathematics. *Gq* is distinct from quantitative reasoning (RQ; a facet of *Gf*) in the same way that *Gc* is distinct from the nonquantitative aspects of *Gf*. It consists of acquired knowledge about mathematics, such as knowledge of mathematical symbols (e.g., $\int$, $\pi$, $\Sigma$, $\infty$, $\neq$, $\leq$, $+$, $-$, $\times$, $\div$, $\sqrt{}$, and many others), operations (e.g., addition/subtraction, multiplication/division, exponentiation/*n*th rooting, factorials, negation, and many others), computational procedures (e.g., long division, reducing fractions, quadratic formula, and many others), and other math-related skills (e.g., using a calculator, math software, and other math aids).

- Mathematical knowledge (KM): The range of general knowledge about mathematics. This factor is not about the performance of mathematical operations or the solving of math problems. Instead this factor is the "what" knowledge rather than the "how" knowledge (e.g., What does $\pi$ mean? What is the Pythagorean theorem?)

- Mathematical achievement (A3): Measured (tested) mathematics achievement.

# Sensory/Motor-Linked Abilities

## Visual Processing (*Gv*)

Visual processing is the ability to make use of simulated mental imagery (often in conjunction with currently perceived images) to solve problems. Once the eyes have transmitted visual information, the visual system of the brain automatically performs a large number of low-level computations (e.g., edge detection, light/dark perception, color differentiation, motion detection, and so forth). The results of these low-level computations are used by various higher-order processors to infer more complex aspects of the visual image (e.g., object recognition, constructing models of spatial configuration, motion prediction, and so forth).

- Visualization (Vz): The ability to perceive complex patterns and mentally simulate how they might look when transformed (e.g., rotated, changed in size, partially obscured, and so forth). In the same way that induction (I) is central to *Gf* and language development (LD) is central to *Gc*, this is the core ability of *Gv*.
- Speeded rotation (spatial relations; SR): The ability to solve problems quickly using mental rotation of simple images. This ability is similar to visualization (Vz) because it involves rotating mental images, but it is distinct because it involves the *speed* at which mental rotation tasks can be completed. Speeded rotation tasks typically involve fairly simple images.
- Closure speed (CS): The ability to quickly identify a familiar, meaningful visual object from incomplete (e.g., vague, partially obscured, disconnected) visual stimuli without knowing in advance what the object is. This ability is sometimes called *Gestalt perception* because it requires people to "fill in" unseen or missing parts of an image to visualize a single percept.
- Flexibility of closure (CF): The ability to identify a visual figure or pattern embedded in a complex distracting or disguised visual pattern or array when the pattern is known in advance.
- Visual memory (MV): The ability to remember complex images over short periods of time (less than 30 seconds). The tasks that define this factor involve being shown complex images and then identifying them soon after then stimulus is removed.
- Spatial scanning (SS): The ability to quickly and accurately survey (visually explore) a wide or complicated spatial field or pattern and to (a) identify a particular target configuration, or (b) identify a path through the field to a determined end point. It is not clear whether this ability is related to complex large-scale real-world navigation skills.
- Serial perceptual integration (PI): The ability to recognize an object after only parts of it are shown in rapid succession.
- Length estimation (LE): The ability to visually estimate the length of objects.
- Perceptual illusions (IL): The ability to not be fooled by visual illusions.
- Perceptual alternations (PN): Consistency in the rate of alternating between different visual perceptions.

- Imagery (IM): The ability to mentally imagine vivid images. Small-scale brain imaging studies have suggested that visual spatial imagery may not be a single faculty, but rather that visualizing spatial location and mentally transforming that location rely on distinct neural networks. This research suggests a transformational process versus memory for location substructure. An objective versus spatial imagery dichotomy also has been suggested as well as the possibility of quality and speed of imagery abilities.

## Auditory Processing (*Ga*)

Auditory processing is the ability to detect and process meaningful nonverbal information in sound. This definition may cause confusion because we do not have a well-developed vocabulary for talking about sound unless we are talking about speech sounds or music. *Ga* encompasses both of these domains but also much more. There are two common misperceptions about *Ga*. First, although *Ga* depends on sensory input, it is not sensory input itself. *Ga* is what the brain does with sensory information from the ear, sometimes long after a sound has been heard. The second common misconception is that *Ga* is oral language comprehension. It is true that one aspect of *Ga* (parsing speech sounds or phonetic coding [PC]) is related to oral language comprehension, but this is simply a precursor to comprehension, not comprehension itself.

- Phonetic coding (PC): The ability to hear phonemes distinctly. This ability also is referred to as phonological processing and phonological awareness. People with poor phonetic coding have difficulty hearing the internal structure of sound in words.
- Speech sound discrimination (US): The ability to detect and discriminate differences in speech sounds (other than phonemes) under conditions of little or no distraction or distortion. Poor speech sound discrimination can produce difficulty in the ability to distinguish variations in tone, timbre, and pitch in speech.
- Resistance to auditory stimulus distortion (UR): The ability to hear words correctly even under conditions of distortion or loud background noise.
- Memory for sound patterns (UM): The ability to retain (on a short-term basis) auditory *codes such as tones, tonal patterns, or speech sounds*.
- Maintaining and judging rhythm (U8): The ability to recognize and maintain a musical beat. This may be an aspect of memory for sound patterns (UM) as short-term memory is clearly involved. However, it is likely that there is something different about rhythm that warrants a distinction.
- Musical discrimination and judgment (U1 U9): The ability to discriminate and judge tonal patterns in music with respect to melodic, harmonic, and expressive aspects (phrasing, tempo, harmonic complexity, intensity variations).
- Absolute pitch (UP): The ability to perfectly identify the pitch of tones. (As an aside and historical tidbit, John Carroll had perfect pitch.)
- Sound localization (UL): The ability to localize heard sounds in space.

## Olfactory Abilities (*Go*)

Olfactory abilities is the ability to detect and process meaningful information in odors. *Go* refers not to the olfactory system's sensitivity but to an individual's cognition of whatever information the nose is able to send. The *Go* domain is likely to contain many more narrow abilities than are currently listed in the CHC model, as a cursory skim of *Go*-related research reveals reference to such abilities as olfactory memory, episodic odor memory, olfactory sensitivity, odor-specific abilities, odor identification and detection, odor naming, and olfactory imagery, to name a few.

- Olfactory memory (OM): The ability to recognize previously encountered distinctive odors. OM is involved in the oft-noted experience of smelling a distinctive smell and being flooded with vivid memories of the last time that odor was encountered. People tend to maintain memory for distinctive odors longer than other kinds of memory.

## Tactile Abilities (*Gh*)

Tactile abilities is the ability to detect and process meaningful information in haptic (touch) sensations. *Gh* refers not to sensitivity of touch but to an individual's cognition of tactile sensations. Because this ability is not yet well defined and understood, it is hard to describe it authoritatively. The domain may include such abilities as tactile visualization (object identification via palpation), tactile localization (i.e., where has one been touched), tactile memory (i.e., remembering where one has been touched), texture knowledge (naming surfaces and fabrics by touch), and many others. There are no well-supported narrow cognitive ability factors within *Gh* yet. Tactile sensitivity (TS), a sensory acuity ability, refers to the ability to make fine discriminations in haptic sensations (e.g., if two caliper points are placed on the skin simultaneously, an individual perceives them as a single point if they are close together. Some people are able to make finer discriminations than others).

## Kinesthetic Abilities (*Gk*)

Kinesthetic abilities is the ability to detect and process meaningful information in proprioceptive sensations. Proprioception refers to the ability to detect limb position and movement via *proprioceptors* (sensory organs in muscles and ligaments that detect stretching). *Gk* refers not to the sensitivity of proprioception but to an individual's cognition of proprioceptive sensations. There are no well-supported narrow cognitive ability factors within *Gk*; however, some research has suggested that *kinesthetic sensitivity* (KS), a sensory acuity ability, refers to the ability to make fine discriminations in proprioceptive sensations (e.g., whether and how much a limb has been moved).

## Psychomotor Abilities (*Gp*)

Psychomotor abilities is the ability to perform physical body motor movements (e.g., movement of fingers, hands, legs) with precision, coordination, or strength.

- Aiming (AI): The ability to precisely and fluently execute a sequence of eye-hand coordination movements for positioning purposes.
- Manual dexterity (P1): The ability to make precisely coordinated movements of a hand or a hand and the attached arm.
- Finger dexterity (P2): The ability to make precisely coordinated movements of the fingers (with or without the manipulation of objects).
- Static strength (P3): The ability to exert muscular force to move (push, lift, pull) a relatively heavy or immobile object.
- Gross body equilibrium (P4): The ability to maintain the body in an upright position in space or to regain balance after balance has been disturbed.
- Multilimb coordination (P6): The ability to make quick, specific, or discrete motor movements of the arms or legs.
- Arm-hand steadiness (P7): The ability to precisely and skillfully coordinate arm-hand positioning in space.
- Control precision (P8): The ability to exert precise control over muscle movements, typically in response to environmental feedback (e.g., changes in the speed or position of an object being manipulated).

*Appendix B*

# Test Summary and Reliability Statistics

***Table B-1.***
*Test Summary and Reliability Statistics*—WJ IV Tests of Cognitive Abilities

| Test | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | | |
| Test 1: Oral Vocabulary | *n* | — | — | 219.00 | 203.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 448.18 | 459.50 | 471.49 | 481.55 | 489.46 | 495.64 | 500.24 |
| | *SD* | — | — | 13.55 | 14.37 | 13.45 | 13.59 | 12.10 | 10.99 | 12.59 |
| | $r_{11}$ | — | — | 0.89 | 0.90 | 0.90 | 0.90 | 0.90 | 0.87 | 0.87 |
| | *SEM* (*W*) | — | — | 4.49 | 4.54 | 4.25 | 4.30 | 3.83 | 3.96 | 4.54 |
| | *SEM* (SS) | — | — | 4.97 | 4.74 | 4.74 | 4.74 | 4.74 | 5.41 | 5.41 |
| Test 2: Number Series | *n* | — | — | — | 204.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 411.84 | 440.56 | 463.93 | 477.41 | 488.25 | 496.41 |
| | *SD* | — | — | — | 28.25 | 24.55 | 23.34 | 20.81 | 17.98 | 19.25 |
| | $r_{11}$ | — | — | — | 0.91 | 0.91 | 0.92 | 0.92 | 0.90 | 0.90 |
| | *SEM* (*W*) | — | — | — | 8.31 | 7.22 | 6.47 | 5.77 | 5.72 | 6.12 |
| | *SEM* (SS) | — | — | — | 4.41 | 4.41 | 4.16 | 4.16 | 4.77 | 4.77 |
| Test 3: Verbal Attention | *n* | — | 144.00 | 198.00 | 199.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 432.23 | 442.29 | 454.74 | 468.36 | 479.92 | 487.80 | 495.29 | 499.81 |
| | *SD* | — | 11.00 | 14.75 | 18.27 | 16.94 | 17.40 | 16.69 | 15.04 | 15.31 |
| | $r_{11}$ | — | 0.88 | 0.88 | 0.90 | 0.90 | 0.89 | 0.89 | 0.82 | 0.82 |
| | *SEM* (*W*) | — | 3.81 | 5.11 | 5.89 | 5.46 | 5.74 | 5.51 | 6.32 | 6.43 |
| | *SEM* (SS) | — | 5.20 | 5.20 | 4.84 | 4.84 | 4.95 | 4.95 | 6.30 | 6.30 |
| Test 4: Letter-Pattern Matching[a] | *n* | — | — | 222.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 388.75 | 420.90 | 454.62 | 474.26 | 488.32 | 501.11 | 510.67 |
| | *SD* | — | — | 31.10 | 37.17 | 30.01 | 26.65 | 26.63 | 23.00 | 24.31 |
| Test 5: Phonological Processing | *n* | — | 138.00 | 209.00 | 200.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 444.10 | 450.21 | 463.32 | 476.91 | 486.10 | 492.11 | 497.47 | 499.79 |
| | *SD* | — | 8.40 | 11.75 | 16.24 | 12.70 | 12.51 | 11.87 | 10.86 | 11.01 |
| | $r_{11}$ | — | 0.77 | 0.77 | 0.85 | 0.85 | 0.83 | 0.83 | 0.80 | 0.80 |
| | *SEM* (*W*) | — | 4.03 | 5.64 | 6.29 | 4.92 | 5.16 | 4.90 | 4.86 | 4.93 |
| | *SEM* (SS) | — | 7.19 | 7.19 | 5.81 | 5.81 | 6.18 | 6.18 | 6.71 | 6.71 |

***Table B-1.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Cognitive Abilities

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test 6: Story Recall | *n* | 172.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 445.17 | 452.00 | 459.89 | 470.16 | 479.54 | 484.36 | 489.25 | 492.18 | 495.61 |
| | *SD* | 11.11 | 12.58 | 14.63 | 12.56 | 9.79 | 10.79 | 9.11 | 9.30 | 9.56 |
| | $r_{11}$ | 0.98 | 0.98 | 0.98 | 0.96 | 0.96 | 0.97 | 0.97 | 0.93 | 0.93 |
| | *SEM* (*W*) | 1.74 | 1.97 | 2.29 | 2.48 | 1.93 | 1.71 | 1.45 | 2.40 | 2.47 |
| | *SEM* (SS) | 2.35 | 2.35 | 2.35 | 2.96 | 2.96 | 2.38 | 2.38 | 3.88 | 3.88 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

| | | AGE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Statistic** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** |
| **Standard Battery** | | | | | | | | | | |
| Test 1: Oral Vocabulary | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 505.68 | 507.79 | 511.28 | 514.67 | 515.44 | 518.49 | 519.58 | 519.10 | 523.19 |
| | *SD* | 10.73 | 11.20 | 12.07 | 12.27 | 12.29 | 12.60 | 12.97 | 13.48 | 12.91 |
| | $r_{11}$ | 0.84 | 0.84 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 |
| | *SEM* (*W*) | 4.29 | 4.48 | 4.00 | 4.07 | 4.08 | 4.18 | 4.30 | 4.47 | 4.28 |
| | *SEM* (SS) | 6.00 | 6.00 | 4.97 | 4.97 | 4.97 | 4.97 | 4.97 | 4.97 | 4.97 |
| Test 2: Number Series | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.13 | 506.38 | 508.77 | 514.04 | 515.45 | 515.74 | 517.52 | 514.11 | 519.35 |
| | *SD* | 17.79 | 17.50 | 18.41 | 18.65 | 18.01 | 19.50 | 18.57 | 19.23 | 20.56 |
| | $r_{11}$ | 0.87 | 0.87 | 0.84 | 0.84 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 |
| | *SEM* (*W*) | 6.41 | 6.31 | 7.36 | 7.46 | 5.46 | 5.85 | 5.25 | 5.44 | 5.81 |
| | *SEM* (SS) | 5.41 | 5.41 | 6.00 | 6.00 | 4.55 | 4.50 | 4.24 | 4.24 | 4.24 |
| Test 3: Verbal Attention | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.09 | 507.98 | 510.13 | 512.58 | 513.99 | 516.21 | 517.27 | 517.01 | 518.74 |
| | *SD* | 13.94 | 13.94 | 14.98 | 14.36 | 14.64 | 15.50 | 16.43 | 15.49 | 16.22 |
| | $r_{11}$ | 0.86 | 0.86 | 0.83 | 0.83 | 0.85 | 0.85 | 0.91 | 0.91 | 0.91 |
| | *SEM* (*W*) | 5.30 | 5.30 | 6.15 | 5.90 | 5.65 | 5.98 | 5.01 | 4.73 | 4.95 |
| | *SEM* (SS) | 5.70 | 5.70 | 6.16 | 6.16 | 5.79 | 5.79 | 4.58 | 4.58 | 4.58 |
| Test 4: Letter-Pattern Matching[a] | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 518.91 | 525.83 | 530.06 | 534.10 | 539.61 | 543.71 | 544.65 | 541.52 | 546.48 |
| | *SD* | 22.14 | 22.05 | 22.97 | 22.16 | 20.88 | 23.02 | 21.92 | 24.30 | 25.22 |
| Test 5: Phonological Processing | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 502.46 | 504.91 | 505.89 | 508.48 | 509.03 | 511.61 | 511.32 | 511.37 | 514.23 |
| | *SD* | 9.81 | 10.55 | 11.39 | 11.49 | 11.72 | 11.67 | 11.19 | 11.99 | 12.27 |
| | $r_{11}$ | 0.78 | 0.78 | 0.81 | 0.81 | 0.83 | 0.83 | 0.85 | 0.85 | 0.85 |
| | *SEM* (*W*) | 4.60 | 4.95 | 4.97 | 5.01 | 4.83 | 4.81 | 4.33 | 4.64 | 4.75 |
| | *SEM* (SS) | 7.04 | 7.04 | 6.54 | 6.54 | 6.18 | 6.18 | 5.81 | 5.81 | 5.81 |
| Test 6: Story Recall | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 497.82 | 498.49 | 499.63 | 501.54 | 501.11 | 502.29 | 502.47 | 501.44 | 502.76 |
| | *SD* | 8.22 | 8.27 | 8.61 | 9.16 | 8.12 | 9.20 | 9.27 | 9.78 | 8.90 |
| | $r_{11}$ | 0.89 | 0.89 | 0.93 | 0.93 | 0.92 | 0.92 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 2.79 | 2.80 | 2.25 | 2.40 | 2.27 | 2.57 | 2.38 | 2.51 | 2.29 |
| | *SEM* (SS) | 5.09 | 5.09 | 3.93 | 3.93 | 4.19 | 4.19 | 3.86 | 3.86 | 3.86 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-1.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Cognitive Abilities

| Test | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | |
| Test 1: Oral Vocabulary | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 526.12 | 526.42 | 526.80 | 528.47 | 527.89 | 526.88 | 521.97 | |
| | *SD* | 13.13 | 13.89 | 15.12 | 14.25 | 16.51 | 12.97 | 17.13 | |
| | $r_{11}$ | 0.89 | 0.91 | 0.92 | 0.92 | 0.92 | 0.93 | 0.93 | 0.89 |
| | *SEM* (*W*) | 4.35 | 4.17 | 4.28 | 4.03 | 4.67 | 3.43 | 4.53 | |
| | *SEM* (SS) | 4.97 | 4.50 | 4.24 | 4.24 | 4.24 | 3.97 | 3.97 | |
| Test 2: Number Series | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 520.02 | 516.89 | 513.49 | 512.94 | 509.20 | 507.02 | 499.25 | |
| | *SD* | 17.81 | 19.73 | 19.99 | 20.40 | 22.09 | 18.74 | 23.91 | |
| | $r_{11}$ | 0.86 | 0.88 | 0.89 | 0.90 | 0.90 | 0.93 | 0.93 | 0.91 |
| | *SEM* (*W*) | 6.68 | 6.82 | 6.57 | 6.42 | 6.95 | 5.02 | 6.41 | |
| | *SEM* (SS) | 5.63 | 5.18 | 4.93 | 4.72 | 4.72 | 4.02 | 4.02 | |
| Test 3: Verbal Attention | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 521.57 | 520.24 | 519.33 | 516.70 | 515.80 | 513.70 | 506.65 | |
| | *SD* | 14.72 | 15.93 | 15.91 | 17.80 | 18.36 | 16.06 | 18.06 | |
| | $r_{11}$ | 0.82 | 0.86 | 0.87 | 0.83 | 0.83 | 0.82 | 0.82 | 0.86 |
| | *SEM* (*W*) | 6.18 | 5.92 | 5.81 | 7.34 | 7.57 | 6.81 | 7.65 | |
| | *SEM* (SS) | 6.30 | 5.57 | 5.48 | 6.19 | 6.19 | 6.36 | 6.36 | |
| Test 4: Letter-Pattern Matching[a] | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 549.92 | 548.79 | 541.17 | 539.31 | 532.56 | 525.10 | 509.51 | |
| | *SD* | 22.66 | 23.55 | 24.75 | 25.26 | 29.11 | 23.49 | 29.59 | |
| Test 5: Phonological Processing | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 516.22 | 516.08 | 514.01 | 511.25 | 509.12 | 504.57 | 499.75 | |
| | *SD* | 12.41 | 12.77 | 14.28 | 14.49 | 16.34 | 15.89 | 15.74 | |
| | $r_{11}$ | 0.87 | 0.88 | 0.89 | 0.90 | 0.90 | 0.90 | 0.90 | 0.84 |
| | *SEM* (*W*) | 4.47 | 4.42 | 4.73 | 4.58 | 5.17 | 5.02 | 4.98 | |
| | *SEM* (SS) | 5.41 | 5.20 | 4.97 | 4.74 | 4.74 | 4.74 | 4.74 | |
| Test 6: Story Recall | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 502.73 | 502.01 | 500.93 | 501.64 | 500.11 | 498.61 | 493.96 | |
| | *SD* | 8.83 | 9.09 | 9.07 | 8.36 | 9.52 | 9.20 | 10.15 | |
| | $r_{11}$ | 0.91 | 0.93 | 0.90 | 0.92 | 0.92 | 0.88 | 0.88 | 0.93 |
| | *SEM* (*W*) | 2.58 | 2.36 | 2.84 | 2.41 | 2.75 | 3.22 | 3.56 | |
| | *SEM* (SS) | 4.39 | 3.90 | 4.69 | 4.33 | 4.33 | 5.26 | 5.26 | |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-1.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Cognitive Abilities

| Test | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | | |
| Test 7: Visualization | *n* | 154.00 | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 432.77 | 444.97 | 458.74 | 466.84 | 478.63 | 484.42 | 489.35 | 495.35 | 496.75 |
| | *SD* | 15.00 | 15.55 | 15.46 | 13.82 | 12.31 | 12.84 | 11.44 | 10.19 | 11.64 |
| | $r_{11}$ | 0.90 | 0.90 | 0.90 | 0.87 | 0.87 | 0.83 | 0.83 | 0.79 | 0.79 |
| | *SEM* (*W*) | 4.74 | 4.92 | 4.89 | 4.98 | 4.44 | 5.30 | 4.72 | 4.67 | 5.33 |
| | *SEM* (SS) | 4.74 | 4.74 | 4.74 | 5.41 | 5.41 | 6.18 | 6.18 | 6.87 | 6.87 |
| Test 8: General Information | *n* | 119.00 | 186.00 | 220.00 | 205.00 | 308.00 | 309.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 433.13 | 441.09 | 460.17 | 464.65 | 473.14 | 482.86 | 488.98 | 495.54 | 500.11 |
| | *SD* | 14.28 | 14.88 | 14.99 | 16.55 | 15.26 | 16.21 | 15.32 | 15.37 | 16.00 |
| | $r_{11}$ | 0.90 | 0.90 | 0.90 | 0.84 | 0.84 | 0.83 | 0.83 | 0.83 | 0.83 |
| | *SEM* (*W*) | 4.52 | 4.70 | 4.74 | 6.62 | 6.11 | 6.68 | 6.32 | 6.34 | 6.60 |
| | *SEM* (SS) | 4.74 | 4.74 | 4.74 | 6.00 | 6.00 | 6.18 | 6.18 | 6.18 | 6.18 |
| Test 9: Concept Formation | *n* | 159.00 | 195.00 | 221.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 430.15 | 440.06 | 449.01 | 458.15 | 470.84 | 481.11 | 489.24 | 495.10 | 498.82 |
| | *SD* | 12.55 | 15.22 | 15.90 | 17.06 | 16.02 | 17.85 | 15.95 | 16.25 | 17.16 |
| | $r_{11}$ | 0.84 | 0.84 | 0.84 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 5.00 | 6.06 | 6.33 | 4.28 | 4.02 | 4.28 | 3.82 | 3.90 | 4.12 |
| | *SEM* (SS) | 5.97 | 5.97 | 5.97 | 3.76 | 3.76 | 3.60 | 3.60 | 3.60 | 3.60 |
| Test 10: Numbers Reversed | *n* | — | 172.00 | 210.00 | 198.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 420.06 | 431.92 | 445.66 | 467.90 | 478.23 | 486.58 | 494.49 | 500.86 |
| | *SD* | — | 14.99 | 21.26 | 23.49 | 20.19 | 20.62 | 19.88 | 17.24 | 17.78 |
| | $r_{11}$ | — | 0.80 | 0.80 | 0.83 | 0.83 | 0.84 | 0.84 | 0.82 | 0.82 |
| | *SEM* (*W*) | — | 6.74 | 9.56 | 9.71 | 8.35 | 8.16 | 7.87 | 7.29 | 7.52 |
| | *SEM* (SS) | — | 6.75 | 6.75 | 6.20 | 6.20 | 5.94 | 5.94 | 6.34 | 6.34 |
| **Extended Battery** | | | | | | | | | | |
| Test 11: Number-Pattern Matching[a] | *n* | — | 180.00 | 208.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 313.74 | 327.78 | 371.79 | 416.81 | 445.02 | 469.63 | 486.11 | 496.78 |
| | *SD* | — | 30.08 | 33.62 | 45.94 | 39.75 | 36.32 | 31.51 | 28.35 | 28.23 |
| Test 12: Nonword Repetition | *n* | — | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 451.06 | 463.25 | 472.70 | 483.32 | 487.16 | 493.99 | 496.48 | 501.19 |
| | *SD* | — | 17.77 | 16.42 | 16.86 | 15.15 | 15.75 | 16.47 | 14.92 | 15.54 |
| | $r_{11}$ | — | 0.94 | 0.94 | 0.94 | 0.94 | 0.93 | 0.93 | 0.90 | 0.90 |
| | *SEM* (*W*) | — | 4.21 | 3.89 | 4.20 | 3.77 | 4.19 | 4.38 | 4.64 | 4.83 |
| | *SEM* (SS) | — | 3.55 | 3.55 | 3.73 | 3.73 | 3.99 | 3.99 | 4.66 | 4.66 |
| Test 13: Visual-Auditory Learning | *n* | 168.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 454.64 | 463.05 | 468.80 | 476.23 | 484.74 | 490.34 | 494.26 | 497.06 | 498.37 |
| | *SD* | 13.23 | 12.84 | 12.80 | 13.24 | 12.39 | 11.53 | 11.25 | 10.75 | 11.10 |
| | $r_{11}$ | 0.98 | 0.98 | 0.98 | 0.99 | 0.99 | 0.97 | 0.97 | 0.95 | 0.95 |
| | *SEM* (*W*) | 1.74 | 1.68 | 1.68 | 1.61 | 1.51 | 2.04 | 1.99 | 2.33 | 2.40 |
| | *SEM* (SS) | 1.97 | 1.97 | 1.97 | 1.83 | 1.83 | 2.65 | 2.65 | 3.25 | 3.25 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

**Table B-1.** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Cognitive Abilities

| Test | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | | |
| Test 7: Visualization | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 499.78 | 501.09 | 502.83 | 504.89 | 505.51 | 507.26 | 507.06 | 505.98 | 508.12 |
| | *SD* | 10.77 | 11.15 | 12.09 | 11.82 | 10.81 | 11.25 | 11.15 | 12.73 | 11.65 |
| | $r_{11}$ | 0.81 | 0.81 | 0.84 | 0.84 | 0.82 | 0.82 | 0.85 | 0.89 | 0.85 |
| | *SEM* (*W*) | 4.69 | 4.86 | 4.84 | 4.73 | 4.59 | 4.77 | 4.32 | 4.32 | 4.51 |
| | *SEM* (SS) | 6.54 | 6.54 | 6.00 | 6.00 | 6.36 | 6.36 | 5.81 | 5.09 | 5.81 |
| Test 8: General Information | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.74 | 507.59 | 510.54 | 514.63 | 515.33 | 518.93 | 520.66 | 520.11 | 525.52 |
| | *SD* | 15.11 | 15.52 | 16.64 | 16.76 | 16.34 | 16.17 | 17.36 | 16.15 | 16.01 |
| | $r_{11}$ | 0.79 | 0.79 | 0.84 | 0.84 | 0.86 | 0.86 | 0.88 | 0.88 | 0.88 |
| | *SEM* (*W*) | 6.92 | 7.11 | 6.66 | 6.70 | 6.11 | 6.05 | 6.01 | 5.59 | 5.54 |
| | *SEM* (SS) | 6.87 | 6.87 | 6.00 | 6.00 | 5.61 | 5.61 | 5.20 | 5.20 | 5.20 |
| Test 9: Concept Formation | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.95 | 505.60 | 507.29 | 511.83 | 510.88 | 513.37 | 513.15 | 511.32 | 515.46 |
| | *SD* | 15.57 | 15.91 | 16.38 | 17.57 | 15.38 | 16.86 | 16.25 | 17.68 | 16.96 |
| | $r_{11}$ | 0.93 | 0.93 | 0.93 | 0.93 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 |
| | *SEM* (*W*) | 4.23 | 4.32 | 4.41 | 4.73 | 4.53 | 4.97 | 4.46 | 4.85 | 4.66 |
| | *SEM* (SS) | 4.07 | 4.07 | 4.04 | 4.04 | 4.42 | 4.42 | 4.12 | 4.12 | 4.12 |
| Test 10: Numbers Reversed | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.37 | 507.53 | 511.58 | 514.12 | 514.99 | 517.43 | 518.87 | 518.29 | 521.49 |
| | *SD* | 16.74 | 16.05 | 17.19 | 18.38 | 18.01 | 18.15 | 19.38 | 19.68 | 19.85 |
| | $r_{11}$ | 0.84 | 0.84 | 0.89 | 0.89 | 0.87 | 0.87 | 0.91 | 0.91 | 0.91 |
| | *SEM* (*W*) | 6.66 | 6.39 | 5.60 | 5.99 | 6.49 | 6.54 | 5.91 | 6.00 | 6.05 |
| | *SEM* (SS) | 5.97 | 5.97 | 4.89 | 4.89 | 5.41 | 5.41 | 4.57 | 4.57 | 4.57 |
| **Extended Battery** | | | | | | | | | | |
| Test 11: Number-Pattern Matching[a] | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 506.65 | 514.16 | 519.81 | 524.16 | 526.77 | 531.59 | 532.52 | 532.06 | 534.93 |
| | *SD* | 24.32 | 23.65 | 23.11 | 23.16 | 22.38 | 23.54 | 21.88 | 22.39 | 22.96 |
| Test 12: Nonword Repetition | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.35 | 504.81 | 506.74 | 510.16 | 510.99 | 513.01 | 513.82 | 511.05 | 512.24 |
| | *SD* | 15.63 | 15.41 | 15.27 | 15.18 | 15.23 | 16.56 | 15.38 | 16.46 | 15.82 |
| | $r_{11}$ | 0.89 | 0.89 | 0.90 | 0.90 | 0.90 | 0.90 | 0.91 | 0.91 | 0.91 |
| | *SEM* (*W*) | 5.16 | 5.09 | 4.85 | 4.82 | 4.72 | 5.13 | 4.56 | 4.88 | 4.69 |
| | *SEM* (SS) | 4.95 | 4.95 | 4.77 | 4.77 | 4.65 | 4.65 | 4.45 | 4.45 | 4.45 |
| Test 13: Visual-Auditory Learning | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 500.17 | 499.73 | 502.40 | 502.85 | 503.29 | 505.29 | 504.21 | 502.67 | 503.80 |
| | *SD* | 11.45 | 10.73 | 11.15 | 11.77 | 11.77 | 11.93 | 11.93 | 12.87 | 13.12 |
| | $r_{11}$ | 0.95 | 0.95 | 0.96 | 0.96 | 0.94 | 0.94 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 2.49 | 2.33 | 2.32 | 2.45 | 2.96 | 3.00 | 2.27 | 2.45 | 2.49 |
| | *SEM* (SS) | 3.26 | 3.26 | 3.12 | 3.12 | 3.77 | 3.77 | 2.85 | 2.85 | 2.85 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-1.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Cognitive Abilities

| Test | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | |
| Test 7: Visualization | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 509.81 | 509.04 | 506.47 | 504.96 | 502.35 | 500.32 | 497.29 | |
| | *SD* | 12.27 | 12.25 | 12.88 | 11.84 | 13.33 | 11.45 | 14.40 | |
| | $r_{11}$ | 0.83 | 0.85 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.85 |
| | *SEM* (*W*) | 5.06 | 4.75 | 4.64 | 4.27 | 4.81 | 4.13 | 5.19 | |
| | *SEM* (SS) | 6.18 | 5.81 | 5.41 | 5.41 | 5.41 | 5.41 | 5.41 | |
| Test 8: General Information | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 529.68 | 531.25 | 534.96 | 538.62 | 538.38 | 536.95 | 533.20 | |
| | *SD* | 17.32 | 17.97 | 19.16 | 18.47 | 21.80 | 17.33 | 21.20 | |
| | $r_{11}$ | 0.88 | 0.91 | 0.91 | 0.91 | 0.91 | 0.94 | 0.94 | 0.88 |
| | *SEM* (*W*) | 6.00 | 5.39 | 5.75 | 5.54 | 6.54 | 4.25 | 5.19 | |
| | *SEM* (SS) | 5.20 | 4.50 | 4.50 | 4.50 | 4.50 | 3.67 | 3.67 | |
| Test 9: Concept Formation | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 516.79 | 513.73 | 508.51 | 508.71 | 503.14 | 497.56 | 493.48 | |
| | *SD* | 17.31 | 18.16 | 19.19 | 16.46 | 18.09 | 17.78 | 21.38 | |
| | $r_{11}$ | 0.91 | 0.94 | 0.93 | 0.95 | 0.95 | 0.96 | 0.96 | 0.93 |
| | *SEM* (*W*) | 5.11 | 4.30 | 4.92 | 3.70 | 4.07 | 3.53 | 4.25 | |
| | *SEM* (SS) | 4.43 | 3.55 | 3.85 | 3.38 | 3.38 | 2.98 | 2.98 | |
| Test 10: Numbers Reversed | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 524.88 | 521.31 | 519.03 | 517.93 | 515.91 | 512.63 | 506.54 | |
| | *SD* | 19.10 | 20.15 | 21.73 | 21.31 | 20.86 | 17.13 | 21.83 | |
| | $r_{11}$ | 0.91 | 0.93 | 0.94 | 0.90 | 0.90 | 0.91 | 0.91 | 0.88 |
| | *SEM* (*W*) | 5.78 | 5.16 | 5.32 | 6.65 | 6.51 | 5.02 | 6.40 | |
| | *SEM* (SS) | 4.54 | 3.84 | 3.67 | 4.68 | 4.68 | 4.40 | 4.40 | |
| **Extended Battery** | | | | | | | | | |
| Test 11: Number-Pattern Matching[a] | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 537.05 | 536.40 | 529.91 | 525.37 | 520.06 | 512.54 | 500.82 | |
| | *SD* | 19.87 | 22.02 | 22.46 | 26.24 | 28.63 | 23.41 | 33.52 | |
| Test 12: Nonword Repetition | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 515.45 | 513.95 | 512.95 | 511.02 | 507.11 | 503.26 | 499.72 | |
| | *SD* | 16.07 | 16.16 | 16.61 | 17.08 | 16.71 | 17.50 | 19.77 | |
| | $r_{11}$ | 0.94 | 0.92 | 0.94 | 0.90 | 0.90 | 0.88 | 0.88 | 0.91 |
| | *SEM* (*W*) | 4.04 | 4.47 | 4.08 | 5.33 | 5.22 | 6.15 | 6.95 | |
| | *SEM* (SS) | 3.77 | 4.15 | 3.69 | 4.69 | 4.69 | 5.27 | 5.27 | |
| Test 13: Visual-Auditory Learning | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 504.11 | 502.40 | 498.26 | 498.39 | 494.29 | 489.70 | 485.07 | |
| | *SD* | 12.21 | 13.58 | 13.31 | 13.86 | 15.54 | 14.64 | 15.90 | |
| | $r_{11}$ | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.99 | 0.99 | 0.97 |
| | *SEM* (*W*) | 2.16 | 2.17 | 1.84 | 1.85 | 2.07 | 1.43 | 1.56 | |
| | *SEM* (SS) | 2.65 | 2.39 | 2.07 | 2.00 | 2.00 | 1.47 | 1.47 | |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-1.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Cognitive Abilities

| Test | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Test 14: Picture Recognition | *n* | 169.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 446.89 | 458.46 | 466.06 | 473.10 | 483.05 | 489.02 | 494.74 | 497.77 | 499.57 |
| | *SD* | 14.18 | 13.64 | 15.58 | 15.12 | 12.95 | 13.37 | 13.13 | 12.66 | 12.55 |
| | $r_{11}$ | 0.84 | 0.84 | 0.84 | 0.81 | 0.81 | 0.74 | 0.74 | 0.70 | 0.70 |
| | *SEM* (*W*) | 5.65 | 5.44 | 6.21 | 6.57 | 5.62 | 6.86 | 6.74 | 6.95 | 6.88 |
| | *SEM* (SS) | 5.98 | 5.98 | 5.98 | 6.51 | 6.51 | 7.70 | 7.70 | 8.23 | 8.23 |
| Test 15: Analysis-Synthesis | *n* | — | — | — | 176.00 | 302.00 | 307.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 457.87 | 469.80 | 479.21 | 486.71 | 493.98 | 498.41 |
| | *SD* | — | — | — | 16.23 | 17.14 | 19.65 | 17.18 | 17.10 | 17.76 |
| | $r_{11}$ | — | — | — | 0.95 | 0.95 | 0.96 | 0.96 | 0.92 | 0.92 |
| | *SEM* (*W*) | — | — | — | 3.68 | 3.89 | 4.12 | 3.60 | 4.88 | 5.07 |
| | *SEM* (SS) | — | — | — | 3.41 | 3.41 | 3.14 | 3.14 | 4.28 | 4.28 |
| Test 16: Object-Number Sequencing | *n* | — | — | — | 204.00 | 307.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 454.58 | 468.58 | 475.01 | 482.72 | 490.99 | 495.90 |
| | *SD* | — | — | — | 18.38 | 17.61 | 17.53 | 17.53 | 15.44 | 17.17 |
| | $r_{11}$ | — | — | — | 0.87 | 0.87 | 0.89 | 0.89 | 0.87 | 0.87 |
| | *SEM* (*W*) | — | — | — | 6.75 | 6.47 | 5.70 | 5.70 | 5.67 | 6.31 |
| | *SEM* (SS) | — | — | — | 5.51 | 5.51 | 4.88 | 4.88 | 5.51 | 5.51 |
| Test 17: Pair Cancellation[a] | *n* | — | — | 171.00 | 186.00 | 303.00 | 309.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 415.13 | 434.05 | 449.89 | 462.32 | 479.04 | 493.99 | 503.65 |
| | *SD* | — | — | 22.84 | 30.13 | 28.22 | 26.40 | 28.60 | 27.43 | 26.91 |
| Test 18: Memory for Words | *n* | 157.00 | 199.00 | 223.00 | 204.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 413.57 | 424.91 | 440.42 | 455.05 | 467.90 | 472.72 | 479.78 | 486.84 | 489.84 |
| | *SD* | 18.42 | 20.82 | 22.21 | 23.12 | 19.25 | 20.92 | 20.39 | 19.38 | 18.94 |
| | $r_{11}$ | 0.91 | 0.91 | 0.91 | 0.87 | 0.87 | 0.88 | 0.88 | 0.82 | 0.82 |
| | *SEM* (*W*) | 5.44 | 6.15 | 6.55 | 8.33 | 6.94 | 7.26 | 7.07 | 8.27 | 8.08 |
| | *SEM* (SS) | 4.43 | 4.43 | 4.43 | 5.41 | 5.41 | 5.20 | 5.20 | 6.40 | 6.40 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-1.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Cognitive Abilities

| Test | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Test 14: Picture Recognition | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 501.17 | 502.03 | 503.53 | 505.22 | 504.96 | 506.70 | 505.95 | 506.04 | 506.89 |
| | *SD* | 11.78 | 12.66 | 12.32 | 11.40 | 11.39 | 12.00 | 12.28 | 12.24 | 12.54 |
| | $r_{11}$ | 0.71 | 0.71 | 0.61 | 0.61 | 0.62 | 0.62 | 0.77 | 0.77 | 0.77 |
| | *SEM* (*W*) | 6.36 | 6.83 | 7.68 | 7.10 | 6.98 | 7.36 | 5.92 | 5.91 | 6.05 |
| | *SEM* (SS) | 8.09 | 8.09 | 9.35 | 9.35 | 9.19 | 9.19 | 7.24 | 7.24 | 7.24 |
| Test 15: Analysis-Synthesis | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.36 | 506.58 | 508.02 | 512.17 | 512.94 | 515.72 | 515.20 | 513.19 | 516.30 |
| | *SD* | 17.71 | 18.24 | 17.47 | 18.96 | 17.38 | 16.98 | 17.70 | 20.32 | 18.45 |
| | $r_{11}$ | 0.89 | 0.89 | 0.90 | 0.90 | 0.89 | 0.89 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 5.80 | 5.98 | 5.41 | 5.87 | 5.76 | 5.63 | 4.43 | 5.09 | 4.62 |
| | *SEM* (SS) | 4.92 | 4.92 | 4.64 | 4.64 | 4.97 | 4.97 | 3.76 | 3.76 | 3.76 |
| Test 16: Object-Number Sequencing | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 500.22 | 504.95 | 507.93 | 510.68 | 512.38 | 514.38 | 515.30 | 513.89 | 516.74 |
| | *SD* | 15.94 | 15.78 | 16.19 | 16.13 | 16.31 | 17.62 | 16.79 | 17.16 | 18.82 |
| | $r_{11}$ | 0.90 | 0.90 | 0.90 | 0.90 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 |
| | *SEM* (*W*) | 5.15 | 5.10 | 5.11 | 5.09 | 5.45 | 5.89 | 5.47 | 5.59 | 6.13 |
| | *SEM* (SS) | 4.85 | 4.85 | 4.74 | 4.74 | 5.01 | 5.01 | 4.89 | 4.89 | 4.89 |
| Test 17: Pair Cancellation[a] | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 512.79 | 518.93 | 524.50 | 530.90 | 535.64 | 541.03 | 543.41 | 539.93 | 544.88 |
| | *SD* | 25.70 | 24.56 | 24.90 | 27.03 | 24.26 | 27.58 | 28.08 | 29.86 | 28.91 |
| Test 18: Memory for Words | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 492.45 | 497.65 | 497.95 | 501.30 | 502.10 | 505.81 | 505.64 | 504.53 | 506.94 |
| | *SD* | 18.95 | 20.33 | 20.72 | 20.95 | 19.34 | 20.63 | 20.26 | 19.09 | 20.80 |
| | $r_{11}$ | 0.76 | 0.76 | 0.84 | 0.84 | 0.81 | 0.81 | 0.82 | 0.82 | 0.82 |
| | *SEM* (*W*) | 9.23 | 9.90 | 8.27 | 8.37 | 8.46 | 9.02 | 8.66 | 8.15 | 8.88 |
| | *SEM* (SS) | 7.31 | 7.31 | 5.99 | 5.99 | 6.56 | 6.56 | 6.41 | 6.41 | 6.41 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-1.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Cognitive Abilities

| Test | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| Test 14: Picture Recognition | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 508.97 | 508.69 | 507.10 | 507.01 | 503.21 | 500.82 | 495.08 | |
| | *SD* | 12.14 | 12.52 | 12.03 | 12.55 | 12.60 | 13.39 | 14.29 | |
| | $r_{11}$ | 0.74 | 0.67 | 0.71 | 0.73 | 0.73 | 0.82 | 0.82 | 0.74 |
| | *SEM* (*W*) | 6.21 | 7.16 | 6.46 | 6.55 | 6.58 | 5.70 | 6.08 | |
| | *SEM* (SS) | 7.68 | 8.57 | 8.05 | 7.83 | 7.83 | 6.38 | 6.38 | |
| Test 15: Analysis-Synthesis | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 116.00 | |
| | *M* | 517.14 | 515.24 | 510.34 | 508.49 | 505.79 | 498.40 | 490.21 | |
| | *SD* | 17.93 | 19.22 | 20.85 | 18.48 | 19.23 | 18.41 | 24.09 | |
| | $r_{11}$ | 0.85 | 0.94 | 0.95 | 0.91 | 0.91 | 0.94 | 0.94 | 0.93 |
| | *SEM* (*W*) | 7.02 | 4.79 | 4.89 | 5.39 | 5.61 | 4.43 | 5.80 | |
| | *SEM* (SS) | 5.87 | 3.73 | 3.52 | 4.38 | 4.38 | 3.61 | 3.61 | |
| Test 16: Object-Number Sequencing | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 519.18 | 517.51 | 514.75 | 511.76 | 506.92 | 501.12 | 493.13 | |
| | *SD* | 17.55 | 18.01 | 18.76 | 18.22 | 17.82 | 17.61 | 22.67 | |
| | $r_{11}$ | 0.88 | 0.92 | 0.93 | 0.87 | 0.87 | 0.86 | 0.86 | 0.89 |
| | *SEM* (*W*) | 6.08 | 5.03 | 5.13 | 6.59 | 6.45 | 6.49 | 8.36 | |
| | *SEM* (SS) | 5.20 | 4.18 | 4.10 | 5.43 | 5.43 | 5.53 | 5.53 | |
| Test 17: Pair Cancellation[a] | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 547.93 | 546.18 | 537.20 | 531.73 | 524.47 | 515.47 | 501.34 | |
| | *SD* | 26.89 | 26.77 | 28.48 | 27.80 | 31.05 | 28.54 | 34.43 | |
| Test 18: Memory for Words | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 510.26 | 509.38 | 505.25 | 503.07 | 497.91 | 493.88 | 488.11 | |
| | *SD* | 21.13 | 22.28 | 22.70 | 23.71 | 24.73 | 22.08 | 25.69 | |
| | $r_{11}$ | 0.80 | 0.80 | 0.87 | 0.82 | 0.82 | 0.83 | 0.83 | 0.82 |
| | *SEM* (*W*) | 9.35 | 10.01 | 8.15 | 10.11 | 10.54 | 9.23 | 10.74 | |
| | *SEM* (SS) | 6.64 | 6.74 | 5.38 | 6.39 | 6.39 | 6.27 | 6.27 | |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-2.***
*Test Summary and Reliability Statistics*—WJ IV Tests of Oral Language

| Test | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Test 1: Picture Vocabulary | *n* | 173.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 425.13 | 441.33 | 458.32 | 468.19 | 475.95 | 484.78 | 491.43 | 496.82 | 500.54 |
| | *SD* | 17.77 | 15.27 | 14.51 | 14.46 | 13.19 | 14.37 | 13.72 | 12.65 | 13.61 |
| | $r_{11}$ | 0.94 | 0.94 | 0.94 | 0.78 | 0.78 | 0.78 | 0.78 | 0.77 | 0.77 |
| | *SEM* (*W*) | 4.28 | 3.68 | 3.50 | 6.85 | 6.25 | 6.74 | 6.43 | 6.09 | 6.55 |
| | *SEM* (SS) | 3.62 | 3.62 | 3.62 | 7.10 | 7.10 | 7.03 | 7.03 | 7.22 | 7.22 |
| Test 2: Oral Comprehension | *n* | 163.00 | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 420.72 | 433.69 | 448.99 | 459.35 | 471.16 | 481.52 | 490.76 | 495.31 | 500.45 |
| | *SD* | 14.24 | 15.16 | 14.74 | 15.39 | 13.95 | 14.18 | 13.44 | 13.38 | 12.72 |
| | $r_{11}$ | 0.86 | 0.86 | 0.86 | 0.83 | 0.83 | 0.78 | 0.78 | 0.82 | 0.82 |
| | *SEM* (*W*) | 5.23 | 5.57 | 5.42 | 6.37 | 5.77 | 6.57 | 6.23 | 5.73 | 5.45 |
| | *SEM* (SS) | 5.51 | 5.51 | 5.51 | 6.20 | 6.20 | 6.96 | 6.96 | 6.43 | 6.43 |
| Test 3: Segmentation | *n* | — | 189.00 | 212.00 | 200.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 407.30 | 412.77 | 434.72 | 465.03 | 478.76 | 488.46 | 493.62 | 495.51 |
| | *SD* | — | 19.40 | 21.37 | 30.83 | 28.02 | 23.12 | 20.82 | 19.36 | 18.25 |
| | $r_{11}$ | — | 0.94 | 0.94 | 0.98 | 0.98 | 0.95 | 0.95 | 0.96 | 0.96 |
| | *SEM* (*W*) | — | 4.72 | 5.20 | 4.36 | 3.96 | 5.28 | 4.75 | 4.06 | 3.83 |
| | *SEM* (SS) | — | 3.65 | 3.65 | 2.12 | 2.12 | 3.42 | 3.42 | 3.15 | 3.15 |
| Test 4: Rapid Picture Naming[a] | *n* | 172.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 407.91 | 429.13 | 441.22 | 462.03 | 472.60 | 483.39 | 493.70 | 497.12 | 503.98 |
| | *SD* | 28.54 | 23.20 | 26.60 | 23.70 | 21.67 | 21.89 | 19.87 | 20.94 | 21.66 |
| Test 5: Sentence Repetition | *n* | 173.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 405.35 | 426.07 | 449.98 | 459.16 | 470.43 | 479.58 | 491.12 | 497.34 | 503.78 |
| | *SD* | 23.55 | 22.61 | 22.54 | 22.53 | 20.38 | 21.63 | 20.55 | 19.84 | 20.19 |
| | $r_{11}$ | 0.96 | 0.96 | 0.96 | 0.87 | 0.87 | 0.83 | 0.83 | 0.82 | 0.82 |
| | *SEM* (*W*) | 4.98 | 4.78 | 4.77 | 8.14 | 7.36 | 8.89 | 8.45 | 8.37 | 8.52 |
| | *SEM* (SS) | 3.17 | 3.17 | 3.17 | 5.42 | 5.42 | 6.17 | 6.17 | 6.33 | 6.33 |
| Test 6: Understanding Directions | *n* | 173.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 437.88 | 451.33 | 460.34 | 467.59 | 478.42 | 484.96 | 490.72 | 494.57 | 500.16 |
| | *SD* | 12.90 | 13.39 | 13.00 | 12.67 | 12.00 | 12.49 | 11.24 | 10.97 | 11.94 |
| | $r_{11}$ | 0.95 | 0.95 | 0.95 | 0.92 | 0.92 | 0.92 | 0.92 | 0.95 | 0.95 |
| | *SEM* (*W*) | 2.87 | 2.97 | 2.89 | 3.64 | 3.45 | 3.52 | 3.17 | 2.41 | 2.62 |
| | *SEM* (SS) | 3.33 | 3.33 | 3.33 | 4.31 | 4.31 | 4.23 | 4.23 | 3.30 | 3.30 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-2.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Oral Language

| Test | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Test 1: Picture Vocabulary | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 505.16 | 507.73 | 509.29 | 513.60 | 513.32 | 517.00 | 518.35 | 517.34 | 522.12 |
| | *SD* | 13.23 | 13.29 | 14.27 | 13.36 | 13.75 | 13.33 | 13.06 | 15.30 | 13.84 |
| | $r_{11}$ | 0.78 | 0.78 | 0.87 | 0.87 | 0.83 | 0.83 | 0.88 | 0.88 | 0.88 |
| | *SEM* (*W*) | 6.23 | 6.26 | 5.21 | 4.87 | 5.61 | 5.44 | 4.59 | 5.38 | 4.86 |
| | *SEM* (SS) | 7.06 | 7.06 | 5.47 | 5.47 | 6.12 | 6.12 | 5.27 | 5.27 | 5.27 |
| Test 2: Oral Comprehension | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.66 | 505.59 | 507.27 | 511.31 | 510.25 | 514.17 | 514.48 | 515.07 | 517.96 |
| | *SD* | 12.05 | 11.94 | 11.64 | 12.86 | 12.68 | 13.07 | 13.21 | 13.09 | 13.68 |
| | $r_{11}$ | 0.80 | 0.80 | 0.78 | 0.78 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 |
| | *SEM* (*W*) | 5.37 | 5.32 | 5.48 | 6.06 | 5.05 | 5.21 | 5.35 | 5.31 | 5.55 |
| | *SEM* (SS) | 6.68 | 6.68 | 7.06 | 7.06 | 5.98 | 5.98 | 6.08 | 6.08 | 6.08 |
| Test 3: Segmentation | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 500.35 | 500.88 | 503.41 | 503.82 | 506.40 | 508.91 | 505.72 | 505.61 | 508.53 |
| | *SD* | 18.01 | 19.26 | 17.89 | 19.36 | 18.45 | 19.69 | 18.84 | 20.19 | 19.88 |
| | $r_{11}$ | 0.93 | 0.93 | 0.92 | 0.92 | 0.91 | 0.91 | 0.90 | 0.90 | 0.90 |
| | *SEM* (*W*) | 4.80 | 5.13 | 4.94 | 5.35 | 5.40 | 5.76 | 5.86 | 6.27 | 6.18 |
| | *SEM* (SS) | 4.00 | 4.00 | 4.14 | 4.14 | 4.39 | 4.39 | 4.66 | 4.66 | 4.66 |
| Test 4: Rapid Picture Naming[a] | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 509.23 | 513.43 | 514.02 | 519.36 | 522.21 | 523.08 | 523.60 | 523.35 | 526.73 |
| | *SD* | 18.84 | 20.83 | 19.82 | 20.14 | 19.36 | 20.43 | 21.37 | 22.42 | 20.93 |
| Test 5: Sentence Repetition | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 509.37 | 513.04 | 513.81 | 519.81 | 520.62 | 523.77 | 525.47 | 523.78 | 529.28 |
| | *SD* | 19.64 | 20.61 | 20.76 | 22.29 | 20.85 | 22.34 | 21.55 | 21.42 | 21.92 |
| | $r_{11}$ | 0.78 | 0.78 | 0.81 | 0.81 | 0.90 | 0.90 | 0.83 | 0.83 | 0.83 |
| | *SEM* (*W*) | 9.28 | 9.74 | 8.97 | 9.63 | 6.53 | 7.00 | 8.76 | 8.70 | 8.91 |
| | *SEM* (SS) | 7.09 | 7.09 | 6.48 | 6.48 | 4.70 | 4.70 | 6.10 | 6.10 | 6.10 |
| Test 6: Understanding Directions | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.76 | 505.80 | 506.72 | 510.43 | 510.35 | 510.97 | 513.63 | 510.24 | 511.37 |
| | *SD* | 12.37 | 13.04 | 12.42 | 12.71 | 11.64 | 12.20 | 12.81 | 12.86 | 12.74 |
| | $r_{11}$ | 0.86 | 0.86 | 0.82 | 0.82 | 0.78 | 0.78 | 0.86 | 0.86 | 0.86 |
| | *SEM* (*W*) | 4.62 | 4.87 | 5.31 | 5.44 | 5.42 | 5.68 | 4.82 | 4.84 | 4.80 |
| | *SEM* (SS) | 5.60 | 5.60 | 6.42 | 6.42 | 6.99 | 6.99 | 5.65 | 5.65 | 5.65 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-2.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Oral Language

| Test | Statistic | AGE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **20–29** | **30–39** | **40–49** | **50–59** | **60–69** | **70–79** | **80+** | **Median** |
| Test 1: Picture Vocabulary | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 525.83 | 526.77 | 529.94 | 531.75 | 532.28 | 532.47 | 525.33 | |
| | *SD* | 14.64 | 15.09 | 15.90 | 15.40 | 17.65 | 15.22 | 18.10 | |
| | $r_{11}$ | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.88 | 0.88 | 0.88 |
| | *SEM* (*W*) | 4.83 | 5.11 | 5.27 | 5.21 | 5.97 | 5.26 | 6.26 | |
| | *SEM* (SS) | 4.95 | 5.08 | 4.97 | 5.08 | 5.08 | 5.19 | 5.19 | |
| Test 2: Oral Comprehension | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 521.45 | 521.92 | 523.09 | 523.42 | 522.94 | 522.03 | 515.07 | |
| | *SD* | 13.64 | 14.27 | 14.62 | 14.96 | 15.64 | 12.85 | 15.84 | |
| | $r_{11}$ | 0.75 | 0.80 | 0.85 | 0.82 | 0.82 | 0.76 | 0.76 | 0.82 |
| | *SEM* (*W*) | 6.75 | 6.40 | 5.72 | 6.30 | 6.59 | 6.33 | 7.80 | |
| | *SEM* (SS) | 7.43 | 6.72 | 5.87 | 6.32 | 6.32 | 7.39 | 7.39 | |
| Test 3: Segmentation | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 511.33 | 509.79 | 506.50 | 503.02 | 498.67 | 492.10 | 483.22 | |
| | *SD* | 19.20 | 21.54 | 21.85 | 20.93 | 25.57 | 24.96 | 26.18 | |
| | $r_{11}$ | 0.93 | 0.94 | 0.95 | 0.94 | 0.94 | 0.96 | 0.96 | 0.94 |
| | *SEM* (*W*) | 4.94 | 5.12 | 4.99 | 5.18 | 6.32 | 5.06 | 5.30 | |
| | *SEM* (SS) | 3.86 | 3.56 | 3.42 | 3.71 | 3.71 | 3.04 | 3.04 | |
| Test 4: Rapid Picture Naming[a] | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 527.82 | 529.89 | 528.18 | 525.74 | 520.59 | 515.64 | 505.32 | |
| | *SD* | 21.07 | 23.01 | 21.82 | 21.77 | 20.44 | 19.29 | 23.30 | |
| Test 5: Sentence Repetition | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 532.32 | 530.88 | 529.45 | 528.76 | 526.83 | 524.75 | 514.93 | |
| | *SD* | 22.16 | 22.84 | 22.60 | 24.50 | 25.46 | 22.92 | 22.25 | |
| | $r_{11}$ | 0.88 | 0.92 | 0.88 | 0.90 | 0.90 | 0.77 | 0.77 | 0.83 |
| | *SEM* (*W*) | 7.77 | 6.62 | 7.68 | 7.93 | 8.24 | 10.97 | 10.65 | |
| | *SEM* (SS) | 5.26 | 4.35 | 5.10 | 4.85 | 4.85 | 7.18 | 7.18 | |
| Test 6: Understanding Directions | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 513.25 | 512.84 | 509.80 | 509.02 | 504.99 | 501.87 | 494.11 | |
| | *SD* | 13.18 | 13.96 | 13.51 | 12.92 | 13.51 | 12.67 | 15.21 | |
| | $r_{11}$ | 0.86 | 0.90 | 0.87 | 0.87 | 0.87 | 0.88 | 0.88 | 0.87 |
| | *SEM* (*W*) | 4.97 | 4.31 | 4.93 | 4.61 | 4.82 | 4.33 | 5.20 | |
| | *SEM* (SS) | 5.66 | 4.63 | 5.48 | 5.35 | 5.35 | 5.12 | 5.12 | |

[a] Reliabilities for speeded tests are reported in Table 4-3.

**Table B-2.** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Oral Language

| Test | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Test 7: Sound Blending | *n* | 163.00 | 194.00 | 220.00 | 204.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 441.01 | 449.42 | 456.72 | 466.99 | 486.32 | 491.87 | 496.55 | 500.57 | 500.80 |
| | *SD* | 16.59 | 16.20 | 17.27 | 19.52 | 17.45 | 16.61 | 14.30 | 14.65 | 14.09 |
| | $r_{11}$ | 0.89 | 0.89 | 0.89 | 0.93 | 0.93 | 0.88 | 0.88 | 0.86 | 0.86 |
| | *SEM* (*W*) | 5.51 | 5.38 | 5.73 | 5.05 | 4.51 | 5.76 | 4.96 | 5.43 | 5.22 |
| | *SEM* (SS) | 4.98 | 4.98 | 4.98 | 3.88 | 3.88 | 5.21 | 5.21 | 5.56 | 5.56 |
| Test 8: Retrieval Fluency | *n* | 171.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 446.59 | 458.73 | 469.07 | 479.02 | 484.38 | 489.62 | 495.57 | 498.78 | 501.56 |
| | *SD* | 13.71 | 12.26 | 12.95 | 11.38 | 9.67 | 10.12 | 10.08 | 10.38 | 10.48 |
| | $r_{11}$ | 0.74 | 0.74 | 0.74 | 0.78 | 0.78 | 0.80 | 0.80 | 0.78 | 0.78 |
| | *SEM* (*W*) | 6.99 | 6.25 | 6.60 | 5.34 | 4.54 | 4.53 | 4.51 | 4.87 | 4.92 |
| | *SEM* (SS) | 7.65 | 7.65 | 7.65 | 7.04 | 7.04 | 6.71 | 6.71 | 7.04 | 7.04 |
| Test 9: Sound Awareness | *n* | — | 188.00 | 218.00 | 202.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 429.10 | 440.45 | 455.77 | 471.68 | 484.10 | 492.12 | 497.16 | 499.32 |
| | *SD* | — | 11.67 | 17.60 | 18.38 | 16.88 | 14.91 | 12.89 | 11.97 | 12.19 |
| | $r_{11}$ | — | 0.95 | 0.95 | 0.94 | 0.94 | 0.92 | 0.92 | 0.82 | 0.82 |
| | *SEM* (*W*) | — | 2.61 | 3.94 | 4.50 | 4.13 | 4.22 | 3.64 | 5.08 | 5.17 |
| | *SEM* (SS) | — | 3.35 | 3.35 | 3.67 | 3.67 | 4.24 | 4.24 | 6.36 | 6.36 |

| Test | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Test 7: Sound Blending | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.42 | 505.87 | 507.81 | 511.26 | 511.83 | 514.12 | 513.77 | 513.66 | 515.67 |
| | *SD* | 15.15 | 14.96 | 14.53 | 16.47 | 15.79 | 16.23 | 16.20 | 16.81 | 18.40 |
| | $r_{11}$ | 0.86 | 0.86 | 0.84 | 0.84 | 0.89 | 0.89 | 0.90 | 0.90 | 0.90 |
| | *SEM* (*W*) | 5.72 | 5.65 | 5.80 | 6.58 | 5.20 | 5.34 | 5.11 | 5.31 | 5.81 |
| | *SEM* (SS) | 5.67 | 5.67 | 5.99 | 5.99 | 4.94 | 4.94 | 4.74 | 4.74 | 4.74 |
| Test 8: Retrieval Fluency | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.94 | 507.14 | 507.06 | 509.84 | 509.02 | 511.72 | 512.08 | 511.95 | 514.06 |
| | *SD* | 9.34 | 9.56 | 10.34 | 10.61 | 9.38 | 9.76 | 10.68 | 10.33 | 10.23 |
| | $r_{11}$ | 0.79 | 0.79 | 0.84 | 0.84 | 0.80 | 0.80 | 0.85 | 0.85 | 0.85 |
| | *SEM* (*W*) | 4.28 | 4.38 | 4.14 | 4.24 | 4.20 | 4.37 | 4.13 | 4.00 | 3.96 |
| | *SEM* (SS) | 6.87 | 6.87 | 6.00 | 6.00 | 6.71 | 6.71 | 5.81 | 5.81 | 5.81 |
| Test 9: Sound Awareness | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 502.70 | 503.53 | 504.70 | 506.79 | 507.21 | 508.01 | 508.23 | 507.40 | 509.74 |
| | *SD* | 10.72 | 10.37 | 10.37 | 10.22 | 10.26 | 10.38 | 9.49 | 11.04 | 10.03 |
| | $r_{11}$ | 0.72 | 0.72 | 0.60 | 0.60 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 |
| | *SEM* (*W*) | 5.67 | 5.49 | 6.56 | 6.46 | 5.62 | 5.69 | 5.20 | 6.05 | 5.49 |
| | *SEM* (SS) | 7.94 | 7.94 | 9.49 | 9.49 | 8.22 | 8.22 | 8.22 | 8.22 | 8.22 |

***Table B-2.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Oral Language

| Test | Statistic | AGE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **20–29** | **30–39** | **40–49** | **50–59** | **60–69** | **70–79** | **80+** | **Median** |
| Test 7: Sound Blending | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 518.75 | 516.65 | 513.87 | 510.73 | 505.84 | 497.79 | 493.76 | |
| | *SD* | 18.48 | 19.44 | 19.95 | 20.57 | 20.54 | 20.44 | 27.55 | |
| | $r_{11}$ | 0.88 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.89 |
| | *SEM* (*W*) | 6.33 | 4.72 | 4.94 | 4.91 | 4.90 | 4.91 | 6.61 | |
| | *SEM* (SS) | 5.14 | 3.64 | 3.71 | 3.58 | 3.58 | 3.60 | 3.60 | |
| Test 8: Retrieval Fluency | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 515.09 | 515.90 | 514.13 | 512.57 | 511.64 | 508.44 | 502.94 | |
| | *SD* | 10.27 | 10.62 | 11.67 | 10.60 | 10.03 | 10.09 | 12.52 | |
| | $r_{11}$ | 0.86 | 0.87 | 0.87 | 0.86 | 0.86 | 0.87 | 0.87 | 0.80 |
| | *SEM* (*W*) | 3.84 | 3.83 | 4.21 | 3.97 | 3.75 | 3.64 | 4.52 | |
| | *SEM* (SS) | 5.61 | 5.41 | 5.41 | 5.61 | 5.61 | 5.41 | 5.41 | |
| Test 9: Sound Awareness | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 511.23 | 510.09 | 509.17 | 507.11 | 504.94 | 501.06 | 496.38 | |
| | *SD* | 9.30 | 10.68 | 11.66 | 11.84 | 14.04 | 13.15 | 15.19 | |
| | $r_{11}$ | 0.61 | 0.61 | 0.83 | 0.86 | 0.86 | 0.90 | 0.90 | 0.82 |
| | *SEM* (*W*) | 5.81 | 6.67 | 4.81 | 4.43 | 5.25 | 4.16 | 4.80 | |
| | *SEM* (SS) | 9.37 | 9.37 | 6.18 | 5.61 | 5.61 | 4.74 | 4.74 | |

***Table B-3.***
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | | |
| Test 1: Letter-Word Identification | *n* | 167.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 292.40 | 319.07 | 344.70 | 380.36 | 418.99 | 454.60 | 476.61 | 487.60 | 497.36 |
| | *SD* | 29.11 | 29.56 | 33.36 | 38.84 | 35.28 | 30.70 | 27.86 | 24.44 | 25.70 |
| | $r_{11}$ | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.96 | 0.96 | 0.94 | 0.94 |
| | *SEM* (*W*) | 4.86 | 4.93 | 5.57 | 5.52 | 5.01 | 6.13 | 5.56 | 6.03 | 6.34 |
| | *SEM* (SS) | 2.50 | 2.50 | 2.50 | 2.13 | 2.13 | 3.00 | 3.00 | 3.70 | 3.70 |
| Test 2: Applied Problems | *n* | 160.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 368.76 | 390.27 | 413.81 | 428.87 | 448.04 | 464.82 | 480.80 | 491.69 | 499.74 |
| | *SD* | 18.14 | 21.71 | 18.07 | 19.97 | 19.22 | 19.34 | 18.98 | 16.62 | 17.28 |
| | $r_{11}$ | 0.93 | 0.93 | 0.93 | 0.92 | 0.92 | 0.92 | 0.92 | 0.90 | 0.90 |
| | *SEM* (*W*) | 4.78 | 5.72 | 4.76 | 5.69 | 5.48 | 5.32 | 5.22 | 5.33 | 5.55 |
| | *SEM* (SS) | 3.95 | 3.95 | 3.95 | 4.27 | 4.27 | 4.13 | 4.13 | 4.81 | 4.81 |
| Test 3: Spelling | *n* | 164.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 332.83 | 357.55 | 385.80 | 412.13 | 438.15 | 462.07 | 479.22 | 490.63 | 499.43 |
| | *SD* | 22.95 | 25.50 | 24.80 | 27.65 | 24.08 | 24.52 | 24.13 | 21.79 | 23.34 |
| | $r_{11}$ | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.92 | 0.92 |
| | *SEM* (*W*) | 5.95 | 6.61 | 6.42 | 7.10 | 6.19 | 6.50 | 6.40 | 5.99 | 6.42 |
| | *SEM* (SS) | 3.89 | 3.89 | 3.89 | 3.85 | 3.85 | 3.98 | 3.98 | 4.13 | 4.13 |
| Test 4: Passage Comprehension | *n* | 170.00 | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 342.75 | 362.37 | 374.76 | 403.38 | 439.48 | 467.65 | 483.46 | 491.44 | 499.36 |
| | *SD* | 29.33 | 27.60 | 28.83 | 35.02 | 30.18 | 25.33 | 20.95 | 16.92 | 19.08 |
| | $r_{11}$ | 0.87 | 0.87 | 0.87 | 0.98 | 0.98 | 0.93 | 0.93 | 0.89 | 0.89 |
| | *SEM* (*W*) | 10.44 | 9.83 | 10.26 | 4.97 | 4.28 | 6.47 | 5.35 | 5.66 | 6.38 |
| | *SEM* (SS) | 5.34 | 5.34 | 5.34 | 2.13 | 2.13 | 3.83 | 3.83 | 5.02 | 5.02 |
| Test 5: Calculation | *n* | — | — | — | 188.00 | 307.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 401.47 | 427.37 | 452.76 | 473.81 | 488.14 | 498.85 |
| | *SD* | — | — | — | 26.57 | 27.55 | 25.55 | 23.93 | 19.68 | 21.48 |
| | $r_{11}$ | — | — | — | 0.93 | 0.93 | 0.94 | 0.94 | 0.91 | 0.91 |
| | *SEM* (*W*) | — | — | — | 6.98 | 7.24 | 6.51 | 6.10 | 5.93 | 6.47 |
| | *SEM* (SS) | — | — | — | 3.94 | 3.94 | 3.82 | 3.82 | 4.52 | 4.52 |
| Test 6: Writing Samples | *n* | — | — | 222.00 | 204.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 345.86 | 396.13 | 441.33 | 467.67 | 484.51 | 490.00 | 497.81 |
| | *SD* | — | — | 41.27 | 46.50 | 35.88 | 29.77 | 22.08 | 17.36 | 20.93 |
| | $r_{11}$ | — | — | 0.88 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| | *SEM* (*W*) | — | — | 14.29 | 14.71 | 11.43 | 9.48 | 6.98 | 5.49 | 6.62 |
| | *SEM* (SS) | — | — | 5.20 | 4.74 | 4.78 | 4.78 | 4.74 | 4.74 | 4.74 |

***Table B-3.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | | |
| Test 1: Letter-Word Identification | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 507.57 | 512.52 | 516.70 | 523.39 | 525.07 | 528.93 | 531.43 | 529.67 | 535.48 |
| | *SD* | 21.03 | 20.37 | 22.07 | 22.71 | 21.52 | 20.93 | 22.96 | 22.72 | 23.64 |
| | $r_{11}$ | 0.92 | 0.92 | 0.88 | 0.88 | 0.90 | 0.90 | 0.91 | 0.91 | 0.91 |
| | *SEM* (*W*) | 5.91 | 5.72 | 7.67 | 7.89 | 6.68 | 6.50 | 6.84 | 6.77 | 7.04 |
| | *SEM* (SS) | 4.21 | 4.21 | 5.21 | 5.21 | 4.66 | 4.66 | 4.47 | 4.47 | 4.47 |
| Test 2: Applied Problems | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 507.53 | 509.36 | 512.73 | 519.19 | 519.40 | 523.87 | 524.73 | 521.67 | 528.65 |
| | *SD* | 16.40 | 17.23 | 18.09 | 18.47 | 18.37 | 19.88 | 18.95 | 19.92 | 21.07 |
| | $r_{11}$ | 0.88 | 0.88 | 0.90 | 0.90 | 0.91 | 0.91 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 5.62 | 5.90 | 5.73 | 5.85 | 5.58 | 6.04 | 4.99 | 5.25 | 5.55 |
| | *SEM* (SS) | 5.14 | 5.14 | 4.75 | 4.75 | 4.56 | 4.56 | 3.95 | 3.95 | 3.95 |
| Test 3: Spelling | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 509.53 | 514.34 | 518.61 | 523.63 | 525.88 | 530.21 | 532.01 | 529.90 | 535.20 |
| | *SD* | 20.05 | 20.11 | 20.11 | 22.23 | 20.27 | 20.35 | 21.13 | 21.20 | 21.54 |
| | $r_{11}$ | 0.91 | 0.91 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| | *SEM* (*W*) | 6.07 | 6.09 | 6.51 | 7.20 | 6.31 | 6.33 | 6.73 | 6.76 | 6.86 |
| | *SEM* (SS) | 4.54 | 4.54 | 4.86 | 4.86 | 4.67 | 4.67 | 4.78 | 4.78 | 4.78 |
| Test 4: Passage Comprehension | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 506.75 | 508.94 | 511.39 | 517.12 | 517.56 | 521.90 | 522.79 | 521.37 | 527.16 |
| | *SD* | 16.70 | 15.56 | 17.11 | 17.82 | 17.57 | 19.15 | 18.34 | 18.87 | 20.65 |
| | $r_{11}$ | 0.81 | 0.81 | 0.84 | 0.84 | 0.87 | 0.87 | 0.89 | 0.89 | 0.89 |
| | *SEM* (*W*) | 7.35 | 6.85 | 6.93 | 7.22 | 6.45 | 7.04 | 6.12 | 6.29 | 6.89 |
| | *SEM* (SS) | 6.60 | 6.60 | 6.08 | 6.08 | 5.51 | 5.51 | 5.00 | 5.00 | 5.00 |
| Test 5: Calculation | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 508.39 | 513.25 | 519.29 | 525.01 | 526.84 | 530.24 | 531.65 | 528.12 | 534.44 |
| | *SD* | 18.82 | 18.46 | 20.58 | 22.61 | 20.84 | 22.67 | 23.18 | 23.62 | 23.83 |
| | $r_{11}$ | 0.89 | 0.89 | 0.89 | 0.89 | 0.93 | 0.93 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 6.27 | 6.15 | 6.85 | 7.52 | 5.37 | 5.84 | 5.57 | 5.67 | 5.72 |
| | *SEM* (SS) | 5.00 | 5.00 | 4.99 | 4.99 | 3.87 | 3.87 | 3.60 | 3.60 | 3.60 |
| Test 6: Writing Samples | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.30 | 505.94 | 509.05 | 512.13 | 513.61 | 515.08 | 516.06 | 514.18 | 517.65 |
| | *SD* | 17.29 | 16.90 | 17.30 | 16.93 | 17.62 | 17.66 | 18.01 | 17.14 | 18.51 |
| | $r_{11}$ | 0.91 | 0.91 | 0.90 | 0.90 | 0.91 | 0.91 | 0.90 | 0.90 | 0.90 |
| | *SEM* (*W*) | 5.19 | 5.07 | 5.47 | 5.35 | 5.29 | 5.30 | 5.70 | 5.42 | 5.85 |
| | *SEM* (SS) | 4.50 | 4.50 | 4.74 | 4.74 | 4.50 | 4.50 | 4.74 | 4.74 | 4.74 |

**Table B-3.** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | |
| Test 1: Letter-Word Identification | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 541.03 | 541.71 | 540.18 | 540.87 | 539.51 | 538.02 | 532.45 | |
| | *SD* | 21.46 | 23.99 | 25.18 | 28.42 | 31.03 | 23.34 | 29.15 | |
| | $r_{11}$ | 0.91 | 0.91 | 0.93 | 0.95 | 0.95 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 6.43 | 7.10 | 6.65 | 6.31 | 6.89 | 5.88 | 7.34 | |
| | *SEM* (SS) | 4.49 | 4.44 | 3.96 | 3.33 | 3.33 | 3.78 | 3.78 | |
| Test 2: Applied Problems | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 530.83 | 528.66 | 525.56 | 526.85 | 522.12 | 522.52 | 516.21 | |
| | *SD* | 19.39 | 20.43 | 20.51 | 19.39 | 20.04 | 17.13 | 23.97 | |
| | $r_{11}$ | 0.93 | 0.92 | 0.91 | 0.91 | 0.91 | 0.94 | 0.94 | 0.92 |
| | *SEM* (*W*) | 5.30 | 5.60 | 6.18 | 5.65 | 5.84 | 4.03 | 5.64 | |
| | *SEM* (SS) | 4.10 | 4.11 | 4.52 | 4.37 | 4.37 | 3.53 | 3.53 | |
| Test 3: Spelling | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 539.55 | 539.05 | 536.36 | 537.12 | 534.37 | 532.13 | 526.42 | |
| | *SD* | 20.04 | 21.21 | 23.59 | 25.28 | 28.31 | 22.01 | 24.64 | |
| | $r_{11}$ | 0.91 | 0.91 | 0.91 | 0.94 | 0.94 | 0.93 | 0.93 | 0.92 |
| | *SEM* (*W*) | 6.09 | 6.47 | 7.17 | 6.07 | 6.80 | 5.64 | 6.32 | |
| | *SEM* (SS) | 4.56 | 4.57 | 4.56 | 3.60 | 3.60 | 3.85 | 3.85 | |
| Test 4: Passage Comprehension | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 531.30 | 530.52 | 529.56 | 529.72 | 528.68 | 526.17 | 516.08 | |
| | *SD* | 18.56 | 20.53 | 20.98 | 21.70 | 26.22 | 18.35 | 24.38 | |
| | $r_{11}$ | 0.91 | 0.90 | 0.90 | 0.91 | 0.91 | 0.93 | 0.93 | 0.89 |
| | *SEM* (*W*) | 5.66 | 6.41 | 6.52 | 6.38 | 7.71 | 4.76 | 6.33 | |
| | *SEM* (SS) | 4.57 | 4.69 | 4.66 | 4.41 | 4.41 | 3.89 | 3.89 | |
| Test 5: Calculation | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 534.03 | 530.26 | 525.16 | 524.34 | 521.88 | 519.53 | 513.80 | |
| | *SD* | 21.78 | 23.05 | 24.01 | 23.66 | 20.94 | 20.05 | 28.25 | |
| | $r_{11}$ | 0.93 | 0.93 | 0.95 | 0.93 | 0.93 | 0.94 | 0.94 | 0.93 |
| | *SEM* (*W*) | 5.74 | 5.92 | 5.50 | 6.07 | 5.37 | 5.01 | 7.05 | |
| | *SEM* (SS) | 3.95 | 3.85 | 3.43 | 3.85 | 3.85 | 3.74 | 3.74 | |
| Test 6: Writing Samples | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 518.86 | 517.53 | 515.55 | 514.13 | 512.57 | 510.83 | 501.71 | |
| | *SD* | 16.50 | 17.76 | 18.38 | 20.16 | 24.11 | 18.12 | 23.21 | |
| | $r_{11}$ | 0.91 | 0.89 | 0.89 | 0.89 | 0.89 | 0.95 | 0.95 | 0.90 |
| | *SEM* (*W*) | 4.95 | 5.89 | 6.09 | 6.69 | 8.00 | 4.05 | 5.19 | |
| | *SEM* (SS) | 4.50 | 4.97 | 4.97 | 4.97 | 4.97 | 3.35 | 3.35 | |

***Table B-3.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | | |
| Test 7: Word Attack | *n* | — | — | — | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 431.89 | 456.72 | 476.32 | 486.35 | 491.39 | 496.46 |
| | *SD* | — | — | — | 26.38 | 23.00 | 19.28 | 17.73 | 15.70 | 16.25 |
| | $r_{11}$ | — | — | — | 0.96 | 0.96 | 0.94 | 0.94 | 0.92 | 0.92 |
| | *SEM* (*W*) | — | — | — | 5.44 | 4.74 | 4.77 | 4.39 | 4.43 | 4.59 |
| | *SEM* (SS) | — | — | — | 3.09 | 3.09 | 3.71 | 3.71 | 4.23 | 4.23 |
| Test 8: Oral Reading | *n* | — | — | — | 191.00 | 303.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 425.70 | 450.09 | 472.01 | 484.65 | 493.30 | 497.80 |
| | *SD* | — | — | — | 23.93 | 24.55 | 22.39 | 19.78 | 18.16 | 19.17 |
| | $r_{11}$ | — | — | — | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 |
| | *SEM* (*W*) | — | — | — | 4.14 | 4.25 | 3.17 | 2.80 | 2.57 | 2.71 |
| | *SEM* (SS) | — | — | — | 2.60 | 2.60 | 2.12 | 2.12 | 2.12 | 2.12 |
| Test 9: Sentence Reading Fluency[a] | *n* | — | — | — | 102.00 | 259.00 | 300.00 | 333.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 386.55 | 404.18 | 436.24 | 465.94 | 482.15 | 496.53 |
| | *SD* | — | — | — | 37.04 | 35.90 | 39.20 | 38.50 | 36.68 | 39.06 |
| Test 10: Math Facts Fluency[a] | *n* | — | — | — | 150.00 | 293.00 | 308.00 | 335.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 415.39 | 431.46 | 456.62 | 478.87 | 493.32 | 504.43 |
| | *SD* | — | — | — | 23.96 | 26.97 | 28.85 | 28.35 | 26.41 | 26.30 |
| Test 11: Sentence Writing Fluency[a] | *n* | — | — | — | 143.00 | 291.00 | 307.00 | 335.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 446.62 | 459.09 | 474.76 | 486.51 | 494.11 | 498.53 |
| | *SD* | — | — | — | 15.22 | 16.84 | 17.39 | 15.91 | 13.54 | 14.02 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-3.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | | |
| Test 7: Word Attack | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 501.09 | 503.34 | 505.63 | 508.81 | 510.64 | 511.55 | 513.39 | 510.83 | 513.20 |
| | *SD* | 14.59 | 15.13 | 15.16 | 15.41 | 15.48 | 14.80 | 15.68 | 16.82 | 16.21 |
| | $r_{11}$ | 0.90 | 0.90 | 0.89 | 0.89 | 0.86 | 0.86 | 0.88 | 0.88 | 0.88 |
| | *SEM* (*W*) | 4.62 | 4.79 | 5.08 | 5.16 | 5.71 | 5.46 | 5.53 | 5.93 | 5.72 |
| | *SEM* (SS) | 4.75 | 4.75 | 5.03 | 5.03 | 5.54 | 5.54 | 5.29 | 5.29 | 5.29 |
| Test 8: Oral Reading | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.43 | 507.85 | 511.00 | 516.16 | 516.56 | 520.02 | 523.07 | 520.09 | 524.62 |
| | *SD* | 17.62 | 16.81 | 16.46 | 17.85 | 16.83 | 17.48 | 16.88 | 18.87 | 18.31 |
| | $r_{11}$ | 0.97 | 0.97 | 0.95 | 0.95 | 0.96 | 0.96 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 3.05 | 2.91 | 3.68 | 3.99 | 3.37 | 3.50 | 3.77 | 4.22 | 4.09 |
| | *SEM* (SS) | 2.60 | 2.60 | 3.35 | 3.35 | 3.00 | 3.00 | 3.35 | 3.35 | 3.35 |
| Test 9: Sentence Reading Fluency[a] | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 513.82 | 519.46 | 525.59 | 535.72 | 536.31 | 544.11 | 548.41 | 542.39 | 552.58 |
| | *SD* | 32.16 | 32.54 | 32.41 | 32.73 | 30.44 | 32.77 | 32.32 | 32.78 | 34.63 |
| Test 10: Math Facts Fluency[a] | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 514.72 | 520.44 | 525.30 | 532.06 | 533.63 | 537.81 | 540.57 | 537.87 | 543.38 |
| | *SD* | 23.69 | 24.89 | 25.13 | 25.39 | 21.98 | 23.82 | 24.38 | 25.91 | 24.80 |
| Test 11: Sentence Writing Fluency[a] | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.49 | 506.08 | 509.04 | 512.15 | 512.10 | 514.79 | 516.21 | 513.71 | 515.82 |
| | *SD* | 13.13 | 11.97 | 12.44 | 12.78 | 11.54 | 12.20 | 11.38 | 11.30 | 12.29 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-3.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| **Standard Battery** | | | | | | | | | |
| Test 7: Word Attack | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 517.54 | 516.42 | 514.10 | 511.27 | 510.22 | 507.76 | 501.80 | |
| | *SD* | 15.69 | 16.41 | 16.83 | 18.96 | 20.66 | 17.33 | 18.64 | |
| | $r_{11}$ | 0.88 | 0.86 | 0.87 | 0.94 | 0.94 | 0.93 | 0.93 | 0.90 |
| | *SEM* (*W*) | 5.43 | 6.18 | 6.07 | 4.71 | 5.14 | 4.72 | 5.08 | |
| | *SEM* (SS) | 5.20 | 5.65 | 5.41 | 3.73 | 3.73 | 4.09 | 4.09 | |
| Test 8: Oral Reading | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 528.64 | 527.78 | 526.85 | 526.66 | 526.61 | 523.44 | 519.06 | |
| | *SD* | 18.06 | 18.52 | 20.87 | 21.60 | 21.57 | 18.36 | 22.97 | |
| | $r_{11}$ | 0.94 | 0.92 | 0.93 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 4.42 | 5.24 | 5.52 | 4.83 | 4.82 | 3.67 | 4.59 | |
| | *SEM* (SS) | 3.67 | 4.24 | 3.97 | 3.35 | 3.35 | 3.00 | 3.00 | |
| Test 9: Sentence Reading Fluency[a] | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 556.33 | 556.25 | 547.07 | 548.72 | 541.82 | 532.46 | 518.71 | |
| | *SD* | 32.11 | 33.81 | 37.30 | 38.43 | 36.51 | 30.67 | 37.72 | |
| Test 10: Math Facts Fluency[a] | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 544.79 | 545.38 | 542.86 | 543.17 | 539.58 | 532.57 | 525.48 | |
| | *SD* | 23.88 | 26.51 | 26.45 | 27.51 | 25.54 | 21.10 | 28.34 | |
| Test 11: Sentence Writing Fluency[a] | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 517.48 | 516.35 | 512.53 | 510.91 | 508.25 | 503.87 | 499.92 | |
| | *SD* | 11.45 | 11.59 | 12.78 | 14.62 | 13.51 | 12.77 | 15.66 | |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-3.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Extended Battery** | | | | | | | | | | |
| Test 12: Reading Recall | *n* | — | — | — | 173.00 | 299.00 | 310.00 | 335.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 450.00 | 463.93 | 479.40 | 488.30 | 493.71 | 496.41 |
| | *SD* | — | — | — | 16.41 | 18.73 | 16.19 | 13.79 | 12.07 | 12.39 |
| | $r_{11}$ | — | — | — | 0.97 | 0.97 | 0.98 | 0.98 | 0.97 | 0.97 |
| | *SEM* (*W*) | — | — | — | 2.90 | 3.31 | 2.45 | 2.08 | 2.20 | 2.25 |
| | *SEM* (SS) | — | — | — | 2.65 | 2.65 | 2.27 | 2.27 | 2.73 | 2.73 |
| Test 13: Number Matrices | *n* | — | — | — | 196.00 | 307.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 451.46 | 461.20 | 472.72 | 482.03 | 492.17 | 498.04 |
| | *SD* | — | — | — | 17.68 | 17.82 | 17.69 | 18.56 | 17.99 | 18.82 |
| | $r_{11}$ | — | — | — | 0.78 | 0.78 | 0.91 | 0.91 | 0.94 | 0.94 |
| | *SEM* (*W*) | — | — | — | 8.29 | 8.36 | 5.27 | 5.53 | 4.56 | 4.77 |
| | *SEM* (SS) | — | — | — | 7.04 | 7.04 | 4.47 | 4.47 | 3.80 | 3.80 |
| Test 14: Editing | *n* | — | — | — | — | — | 293.00 | 333.00 | 306.00 | 313.00 |
| | *M* | — | — | — | — | — | 469.75 | 480.36 | 490.35 | 497.68 |
| | *SD* | — | — | — | — | — | 16.90 | 18.92 | 17.20 | 17.48 |
| | $r_{11}$ | — | — | — | — | — | 0.89 | 0.89 | 0.91 | 0.91 |
| | *SEM* (*W*) | — | — | — | — | — | 5.63 | 6.31 | 5.27 | 5.36 |
| | *SEM* (SS) | — | — | — | — | — | 5.00 | 5.00 | 4.60 | 4.60 |
| Test 15: Word Reading Fluency[a] | *n* | — | — | — | 135.00 | 269.00 | 299.00 | 333.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 386.52 | 402.82 | 433.23 | 455.46 | 474.93 | 489.20 |
| | *SD* | — | — | — | 33.20 | 32.77 | 36.97 | 39.88 | 35.92 | 36.37 |
| Test 16: Spelling of Sounds | *n* | — | — | — | 199.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 445.31 | 465.55 | 479.83 | 488.32 | 492.42 | 496.06 |
| | *SD* | — | — | — | 20.23 | 18.49 | 15.44 | 13.70 | 12.52 | 13.45 |
| | $r_{11}$ | — | — | — | 0.97 | 0.97 | 0.94 | 0.94 | 0.90 | 0.90 |
| | *SEM* (*W*) | — | — | — | 3.39 | 3.10 | 3.65 | 3.24 | 3.94 | 4.24 |
| | *SEM* (SS) | — | — | — | 2.51 | 2.51 | 3.55 | 3.55 | 4.72 | 4.72 |
| Test 17: Reading Vocabulary | *n* | — | — | — | 163.00 | 297.00 | 308.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 446.97 | 459.60 | 475.00 | 486.01 | 493.47 | 498.84 |
| | *SD* | — | — | — | 15.68 | 16.31 | 16.67 | 15.71 | 14.70 | 15.27 |
| | $r_{11}$ | — | — | — | 0.92 | 0.92 | 0.90 | 0.90 | 0.89 | 0.89 |
| | *SEM* (*W*) | — | — | — | 4.44 | 4.61 | 5.27 | 4.97 | 4.88 | 5.07 |
| | *SEM* (SS) | — | — | — | 4.24 | 4.24 | 4.74 | 4.74 | 4.97 | 4.97 |
| Test 18: Science | *n* | 173.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 406.84 | 423.25 | 440.06 | 454.96 | 468.32 | 477.85 | 487.73 | 493.90 | 501.00 |
| | *SD* | 18.06 | 17.43 | 21.21 | 19.19 | 17.02 | 18.93 | 16.46 | 15.87 | 16.74 |
| | $r_{11}$ | 0.90 | 0.90 | 0.90 | 0.83 | 0.83 | 0.71 | 0.71 | 0.70 | 0.70 |
| | *SEM* (*W*) | 5.65 | 5.45 | 6.64 | 7.91 | 7.01 | 10.20 | 8.87 | 8.70 | 9.17 |
| | *SEM* (SS) | 4.69 | 4.69 | 4.69 | 6.18 | 6.18 | 8.08 | 8.08 | 8.22 | 8.22 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

**Table B-3.** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Extended Battery** | | | | | | | | | | |
| Test 12: Reading Recall | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 500.69 | 501.25 | 502.29 | 504.50 | 504.34 | 505.13 | 505.68 | 504.37 | 507.12 |
| | *SD* | 10.48 | 10.15 | 11.66 | 10.77 | 10.17 | 11.05 | 10.97 | 10.89 | 11.68 |
| | $r_{11}$ | 0.96 | 0.96 | 0.97 | 0.97 | 0.88 | 0.88 | 0.92 | 0.92 | 0.92 |
| | *SEM* (*W*) | 2.04 | 1.98 | 2.04 | 1.88 | 3.46 | 3.76 | 3.18 | 3.15 | 3.38 |
| | *SEM* (SS) | 2.93 | 2.93 | 2.62 | 2.62 | 5.10 | 5.10 | 4.34 | 4.34 | 4.34 |
| Test 13: Number Matrices | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 505.06 | 507.49 | 509.48 | 514.30 | 514.92 | 518.15 | 519.24 | 514.39 | 520.95 |
| | *SD* | 18.24 | 18.91 | 19.67 | 18.89 | 18.16 | 19.14 | 18.29 | 19.13 | 20.28 |
| | $r_{11}$ | 0.91 | 0.91 | 0.94 | 0.94 | 0.89 | 0.89 | 0.92 | 0.92 | 0.92 |
| | *SEM* (*W*) | 5.48 | 5.69 | 4.92 | 4.73 | 6.00 | 6.33 | 5.25 | 5.49 | 5.82 |
| | *SEM* (SS) | 4.51 | 4.51 | 3.75 | 3.75 | 4.96 | 4.96 | 4.31 | 4.31 | 4.31 |
| Test 14: Editing | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.42 | 507.58 | 511.17 | 515.89 | 516.50 | 520.20 | 522.00 | 519.92 | 525.69 |
| | *SD* | 15.72 | 15.50 | 16.20 | 18.03 | 17.11 | 18.31 | 18.07 | 19.42 | 18.49 |
| | $r_{11}$ | 0.89 | 0.89 | 0.90 | 0.90 | 0.90 | 0.90 | 0.92 | 0.92 | 0.92 |
| | *SEM* (*W*) | 5.27 | 5.20 | 5.24 | 5.83 | 5.29 | 5.67 | 5.25 | 5.64 | 5.37 |
| | *SEM* (SS) | 5.03 | 5.03 | 4.85 | 4.85 | 4.64 | 4.64 | 4.36 | 4.36 | 4.36 |
| Test 15: Word Reading Fluency[a] | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.05 | 510.28 | 514.72 | 525.23 | 526.68 | 535.59 | 537.02 | 531.50 | 541.77 |
| | *SD* | 32.53 | 35.24 | 31.51 | 32.75 | 31.89 | 32.81 | 27.96 | 31.82 | 31.55 |
| Test 16: Spelling of Sounds | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 500.33 | 501.67 | 502.57 | 505.96 | 507.07 | 508.44 | 509.36 | 507.28 | 509.96 |
| | *SD* | 11.46 | 12.20 | 12.04 | 13.19 | 12.28 | 12.85 | 12.93 | 13.18 | 14.26 |
| | $r_{11}$ | 0.85 | 0.85 | 0.85 | 0.85 | 0.82 | 0.82 | 0.88 | 0.88 | 0.88 |
| | *SEM* (*W*) | 4.37 | 4.65 | 4.73 | 5.18 | 5.25 | 5.49 | 4.43 | 4.51 | 4.88 |
| | *SEM* (SS) | 5.72 | 5.72 | 5.89 | 5.89 | 6.41 | 6.41 | 5.13 | 5.13 | 5.13 |
| Test 17: Reading Vocabulary | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.89 | 506.95 | 509.91 | 514.09 | 514.54 | 517.91 | 518.77 | 517.84 | 522.80 |
| | *SD* | 13.57 | 12.84 | 14.24 | 14.67 | 14.35 | 14.86 | 14.62 | 15.66 | 15.54 |
| | $r_{11}$ | 0.85 | 0.85 | 0.82 | 0.82 | 0.79 | 0.79 | 0.85 | 0.85 | 0.85 |
| | *SEM* (*W*) | 5.26 | 4.97 | 6.04 | 6.22 | 6.58 | 6.81 | 5.66 | 6.06 | 6.02 |
| | *SEM* (SS) | 5.81 | 5.81 | 6.36 | 6.36 | 6.87 | 6.87 | 5.81 | 5.81 | 5.81 |
| Test 18: Science | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 506.15 | 508.60 | 511.12 | 515.35 | 515.24 | 517.82 | 518.24 | 517.13 | 522.86 |
| | *SD* | 15.68 | 16.91 | 16.14 | 16.77 | 19.10 | 18.23 | 17.99 | 18.68 | 17.80 |
| | $r_{11}$ | 0.70 | 0.70 | 0.76 | 0.76 | 0.84 | 0.84 | 0.87 | 0.87 | 0.87 |
| | *SEM* (*W*) | 8.56 | 9.23 | 7.95 | 8.26 | 7.53 | 7.19 | 6.60 | 6.86 | 6.53 |
| | *SEM* (SS) | 8.19 | 8.19 | 7.39 | 7.39 | 5.91 | 5.91 | 5.51 | 5.51 | 5.51 |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-3.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| **Extended Battery** | | | | | | | | | |
| Test 12: Reading Recall | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 507.51 | 506.31 | 504.44 | 504.21 | 503.21 | 501.89 | 498.02 | |
| | *SD* | 10.68 | 11.41 | 11.32 | 12.17 | 11.31 | 11.99 | 15.53 | |
| | $r_{11}$ | 0.85 | 0.87 | 0.91 | 0.86 | 0.86 | 0.82 | 0.82 | 0.92 |
| | *SEM* (*W*) | 4.10 | 4.04 | 3.42 | 4.52 | 4.20 | 5.13 | 6.64 | |
| | *SEM* (SS) | 5.77 | 5.31 | 4.52 | 5.57 | 5.57 | 6.42 | 6.42 | |
| Test 13: Number Matrices | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 521.48 | 518.66 | 515.36 | 514.43 | 511.85 | 508.02 | 501.21 | |
| | *SD* | 18.66 | 19.63 | 22.33 | 19.98 | 20.69 | 20.47 | 26.83 | |
| | $r_{11}$ | 0.90 | 0.92 | 0.91 | 0.95 | 0.95 | 0.93 | 0.93 | 0.92 |
| | *SEM* (*W*) | 5.77 | 5.65 | 6.56 | 4.66 | 4.82 | 5.54 | 7.25 | |
| | *SEM* (SS) | 4.64 | 4.32 | 4.41 | 3.50 | 3.50 | 4.06 | 4.06 | |
| Test 14: Editing | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 529.72 | 529.38 | 528.55 | 528.06 | 530.06 | 527.40 | 521.43 | |
| | *SD* | 17.41 | 18.46 | 20.49 | 20.38 | 20.47 | 17.80 | 21.69 | |
| | $r_{11}$ | 0.92 | 0.87 | 0.95 | 0.92 | 0.92 | 0.96 | 0.96 | 0.91 |
| | *SEM* (*W*) | 4.78 | 6.66 | 4.71 | 5.75 | 5.78 | 3.62 | 4.42 | |
| | *SEM* (SS) | 4.11 | 5.41 | 3.45 | 4.23 | 4.23 | 3.05 | 3.05 | |
| Test 15: Word Reading Fluency[a] | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 116.00 | |
| | *M* | 544.68 | 546.00 | 537.70 | 539.30 | 531.33 | 522.66 | 509.93 | |
| | *SD* | 32.47 | 33.24 | 33.71 | 38.18 | 37.38 | 31.54 | 37.05 | |
| Test 16: Spelling of Sounds | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 511.43 | 509.60 | 507.14 | 504.42 | 501.25 | 499.83 | 494.23 | |
| | *SD* | 12.92 | 14.15 | 14.43 | 16.33 | 18.97 | 14.21 | 17.49 | |
| | $r_{11}$ | 0.84 | 0.92 | 0.92 | 0.94 | 0.94 | 0.86 | 0.86 | 0.88 |
| | *SEM* (*W*) | 5.19 | 3.96 | 4.10 | 4.12 | 4.79 | 5.30 | 6.52 | |
| | *SEM* (SS) | 6.02 | 4.20 | 4.26 | 3.79 | 3.79 | 5.59 | 5.59 | |
| Test 17: Reading Vocabulary | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 525.20 | 524.93 | 525.17 | 527.04 | 526.16 | 524.48 | 518.68 | |
| | *SD* | 15.12 | 15.86 | 17.55 | 18.41 | 20.33 | 16.58 | 19.87 | |
| | $r_{11}$ | 0.87 | 0.85 | 0.90 | 0.92 | 0.92 | 0.92 | 0.92 | 0.88 |
| | *SEM* (*W*) | 5.45 | 6.14 | 5.55 | 5.21 | 5.75 | 4.69 | 5.62 | |
| | *SEM* (SS) | 5.41 | 5.81 | 4.74 | 4.24 | 4.24 | 4.24 | 4.24 | |
| Test 18: Science | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 524.20 | 521.49 | 521.98 | 522.50 | 521.09 | 520.88 | 513.05 | |
| | *SD* | 18.58 | 18.25 | 19.40 | 19.54 | 18.57 | 17.53 | 23.56 | |
| | $r_{11}$ | 0.86 | 0.87 | 0.85 | 0.80 | 0.80 | 0.86 | 0.86 | 0.84 |
| | *SEM* (*W*) | 6.94 | 6.46 | 7.40 | 8.65 | 8.22 | 6.48 | 8.71 | |
| | *SEM* (SS) | 5.61 | 5.31 | 5.72 | 6.64 | 6.64 | 5.55 | 5.55 | |

[a] Reliabilities for speeded tests are reported in Table 4-3.

***Table B-3.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Extended Battery** | | | | | | | | | | |
| Test 19: Social Studies | *n* | 172.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 399.10 | 414.86 | 435.95 | 452.16 | 466.17 | 477.88 | 489.62 | 497.76 | 503.72 |
| | *SD* | 18.14 | 18.99 | 20.97 | 20.60 | 17.89 | 19.14 | 17.07 | 17.47 | 16.93 |
| | $r_{11}$ | 0.92 | 0.92 | 0.92 | 0.80 | 0.80 | 0.82 | 0.82 | 0.78 | 0.78 |
| | *SEM* (*W*) | 5.17 | 5.42 | 5.98 | 9.16 | 7.96 | 8.01 | 7.15 | 8.14 | 7.88 |
| | *SEM* (SS) | 4.28 | 4.28 | 4.28 | 6.67 | 6.67 | 6.28 | 6.28 | 6.99 | 6.99 |
| Test 20: Humanities | *n* | 166.00 | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 420.27 | 436.78 | 455.21 | 463.58 | 473.78 | 481.99 | 490.20 | 496.73 | 500.43 |
| | *SD* | 17.07 | 17.24 | 17.59 | 16.86 | 15.88 | 16.08 | 15.91 | 15.45 | 15.90 |
| | $r_{11}$ | 0.91 | 0.91 | 0.91 | 0.79 | 0.79 | 0.84 | 0.84 | 0.83 | 0.83 |
| | *SEM* (*W*) | 5.21 | 5.26 | 5.37 | 7.75 | 7.30 | 6.51 | 6.44 | 6.43 | 6.61 |
| | *SEM* (SS) | 4.58 | 4.58 | 4.58 | 6.90 | 6.90 | 6.08 | 6.08 | 6.24 | 6.24 |

| Test | Statistic | AGE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| **Extended Battery** | | | | | | | | | | |
| Test 19: Social Studies | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 510.03 | 513.84 | 518.48 | 522.87 | 523.35 | 526.20 | 528.89 | 527.67 | 532.51 |
| | *SD* | 16.17 | 16.90 | 16.40 | 17.91 | 17.90 | 18.34 | 18.14 | 18.82 | 17.63 |
| | $r_{11}$ | 0.79 | 0.79 | 0.80 | 0.80 | 0.87 | 0.87 | 0.89 | 0.89 | 0.89 |
| | *SEM* (*W*) | 7.37 | 7.70 | 7.39 | 8.07 | 6.54 | 6.70 | 5.91 | 6.13 | 5.74 |
| | *SEM* (SS) | 6.84 | 6.84 | 6.76 | 6.76 | 5.48 | 5.48 | 4.89 | 4.89 | 4.89 |
| Test 20: Humanities | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 505.85 | 509.63 | 512.72 | 517.03 | 517.42 | 519.56 | 522.63 | 520.15 | 524.98 |
| | *SD* | 15.58 | 15.62 | 16.08 | 17.35 | 16.68 | 16.51 | 17.08 | 16.64 | 16.95 |
| | $r_{11}$ | 0.86 | 0.86 | 0.85 | 0.85 | 0.90 | 0.90 | 0.87 | 0.87 | 0.87 |
| | *SEM* (*W*) | 5.21 | 5.41 | 5.48 | 5.58 | 5.85 | 6.02 | 6.38 | 6.59 | 6.43 |
| | *SEM* (SS) | 7.15 | 7.62 | 7.96 | 8.29 | 7.96 | 8.44 | 8.22 | 7.68 | 9.74 |

***Table B-3.*** *(cont.)*
*Test Summary and Reliability Statistics*—WJ IV Tests of Achievement

| Test | Statistic | AGE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
| **Extended Battery** | | | | | | | | | |
| Test 19: Social Studies | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 536.16 | 535.40 | 536.92 | 538.07 | 537.92 | 535.53 | 529.44 | |
| | *SD* | 18.60 | 18.91 | 20.12 | 20.01 | 19.52 | 17.80 | 23.07 | |
| | $r_{11}$ | 0.88 | 0.89 | 0.92 | 0.90 | 0.90 | 0.81 | 0.81 | 0.87 |
| | *SEM* (*W*) | 6.38 | 6.21 | 5.77 | 6.23 | 6.08 | 7.68 | 9.95 | |
| | *SEM* (SS) | 5.15 | 4.93 | 4.30 | 4.67 | 4.67 | 6.47 | 6.47 | |
| Test 20: Humanities | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 528.54 | 528.15 | 528.51 | 529.47 | 528.51 | 524.94 | 522.39 | |
| | *SD* | 17.63 | 19.49 | 20.43 | 21.08 | 19.71 | 17.40 | 23.14 | |
| | $r_{11}$ | 0.87 | 0.91 | 0.93 | 0.94 | 0.94 | 0.94 | 0.94 | 0.87 |
| | *SEM* (*W*) | 6.25 | 5.76 | 5.33 | 5.30 | 4.95 | 4.19 | 5.58 | |
| | *SEM* (SS) | 5.32 | 4.43 | 3.91 | 3.77 | 3.77 | 3.62 | 3.62 | |

## Appendix C

# WJ IV Cluster Summary and Reliability Statistics

***Table C-1.***
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| General Intellectual Ability | *n* | — | — | — | 193.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 450.99 | 467.16 | 479.22 | 487.67 | 495.04 | 499.90 |
| | *SD* | — | — | — | 14.57 | 12.57 | 12.35 | 11.09 | 9.23 | 10.43 |
| | $r_{cc}$ | — | — | — | 0.97 | 0.97 | 0.97 | 0.97 | 0.96 | 0.96 |
| | *SEM* (*W*) | — | — | — | 2.52 | 2.18 | 2.14 | 1.92 | 1.85 | 2.09 |
| | *SEM* (SS) | — | — | — | 2.60 | 2.60 | 2.60 | 2.60 | 3.00 | 3.00 |
| Brief Intellectual Ability | *n* | — | — | — | 197.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 442.78 | 460.13 | 475.13 | 484.89 | 493.06 | 498.82 |
| | *SD* | — | — | — | 16.44 | 15.07 | 15.15 | 13.30 | 11.78 | 12.81 |
| | $r_{cc}$ | — | — | — | 0.95 | 0.95 | 0.95 | 0.95 | 0.93 | 0.93 |
| | *SEM* (*W*) | — | — | — | 3.68 | 3.37 | 3.39 | 2.97 | 3.12 | 3.39 |
| | *SEM* (SS) | — | — | — | 3.35 | 3.35 | 3.35 | 3.35 | 3.97 | 3.97 |
| *Gf-Gc* Composite | *n* | — | — | — | 202.00 | 308.00 | 309.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 448.94 | 464.01 | 477.42 | 486.27 | 493.63 | 498.90 |
| | *SD* | — | — | — | 14.15 | 13.29 | 13.70 | 12.35 | 11.31 | 12.90 |
| | $r_{cc}$ | — | — | — | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 | 0.95 |
| | *SEM* (*W*) | — | — | — | 2.83 | 2.66 | 2.74 | 2.47 | 2.53 | 2.88 |
| | *SEM* (SS) | — | — | — | 3.00 | 3.00 | 3.00 | 3.00 | 3.35 | 3.35 |
| Comprehension-Knowledge | *n* | — | — | 217.00 | 203.00 | 308.00 | 309.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 454.44 | 462.27 | 472.31 | 482.27 | 489.22 | 495.59 | 500.18 |
| | *SD* | — | — | 12.42 | 13.80 | 12.92 | 13.43 | 12.80 | 12.11 | 13.43 |
| | $r_{cc}$ | — | — | 0.93 | 0.93 | 0.93 | 0.92 | 0.92 | 0.91 | 0.91 |
| | *SEM* (*W*) | — | — | 3.28 | 3.65 | 3.42 | 3.80 | 3.62 | 3.63 | 4.03 |
| | *SEM* (SS) | — | — | 3.97 | 3.97 | 3.97 | 4.24 | 4.24 | 4.50 | 4.50 |
| Comprehension-Knowledge–Extended | *n* | — | — | 217.00 | 203.00 | 308.00 | 309.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 455.92 | 464.34 | 473.52 | 483.16 | 489.96 | 496.00 | 500.30 |
| | *SD* | — | — | 11.80 | 13.13 | 12.22 | 12.84 | 12.29 | 11.55 | 12.64 |
| | $r_{cc}$ | — | — | 0.96 | 0.93 | 0.93 | 0.93 | 0.93 | 0.92 | 0.92 |
| | *SEM* (*W*) | — | — | 2.36 | 3.47 | 3.23 | 3.40 | 3.25 | 3.27 | 3.57 |
| | *SEM* (SS) | — | — | 3.00 | 3.97 | 3.97 | 3.97 | 3.97 | 4.24 | 4.24 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fluid Reasoning | *n* | — | — | — | 204.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 435.10 | 455.70 | 472.52 | 483.32 | 491.68 | 497.61 |
| | *SD* | — | — | — | 19.01 | 17.62 | 17.92 | 16.01 | 14.55 | 15.82 |
| | $r_{cc}$ | — | — | — | 0.94 | 0.94 | 0.95 | 0.95 | 0.94 | 0.94 |
| | *SEM* (*W*) | — | — | — | 4.66 | 4.32 | 4.01 | 3.58 | 3.56 | 3.88 |
| | *SEM* (SS) | — | — | — | 3.67 | 3.67 | 3.35 | 3.35 | 3.67 | 3.67 |

| | | AGE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Cluster** | **Statistic** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** |
| General Intellectual Ability | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.55 | 507.50 | 509.80 | 512.90 | 514.31 | 516.47 | 517.13 | 515.79 | 518.98 |
| | *SD* | 8.79 | 8.91 | 9.71 | 9.87 | 9.34 | 10.49 | 9.66 | 10.73 | 11.17 |
| | $r_{cc}$ | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | 1.97 | 1.99 | 1.94 | 1.97 | 1.87 | 2.10 | 1.67 | 1.86 | 1.94 |
| | *SEM* (SS) | 3.35 | 3.35 | 3.00 | 3.00 | 3.00 | 3.00 | 2.60 | 2.60 | 2.60 |
| Brief Intellectual Ability | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.30 | 507.38 | 510.06 | 513.76 | 514.96 | 516.81 | 518.12 | 516.74 | 520.43 |
| | *SD* | 11.06 | 11.21 | 11.98 | 11.81 | 11.94 | 13.21 | 12.73 | 12.94 | 13.61 |
| | $r_{cc}$ | 0.92 | 0.92 | 0.92 | 0.92 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 3.13 | 3.17 | 3.39 | 3.34 | 2.92 | 3.24 | 2.85 | 2.89 | 3.04 |
| | *SEM* (SS) | 4.24 | 4.24 | 4.24 | 4.24 | 3.67 | 3.67 | 3.35 | 3.35 | 3.35 |
| *Gf-Gc* Composite | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.87 | 506.84 | 509.47 | 513.79 | 514.28 | 516.63 | 517.73 | 516.16 | 520.88 |
| | *SD* | 10.70 | 11.10 | 12.19 | 12.56 | 11.99 | 12.92 | 12.78 | 13.07 | 13.13 |
| | $r_{cc}$ | 0.94 | 0.94 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 2.62 | 2.72 | 2.73 | 2.81 | 2.40 | 2.58 | 2.56 | 2.61 | 2.63 |
| | *SEM* (SS) | 3.67 | 3.67 | 3.35 | 3.35 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Comprehension-Knowledge | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 505.21 | 507.69 | 510.91 | 514.65 | 515.38 | 518.71 | 520.12 | 519.60 | 524.35 |
| | *SD* | 11.87 | 12.29 | 13.47 | 13.54 | 13.36 | 13.40 | 14.25 | 13.85 | 13.51 |
| | $r_{cc}$ | 0.89 | 0.89 | 0.92 | 0.92 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 3.94 | 4.08 | 3.81 | 3.83 | 3.54 | 3.54 | 3.77 | 3.66 | 3.57 |
| | *SEM* (SS) | 4.97 | 4.97 | 4.24 | 4.24 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 |
| Comprehension-Knowledge–Extended | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 505.19 | 507.70 | 510.37 | 514.30 | 514.70 | 518.14 | 519.53 | 518.85 | 523.61 |
| | *SD* | 11.59 | 11.85 | 12.99 | 12.81 | 12.70 | 12.66 | 13.05 | 13.72 | 12.86 |
| | $r_{cc}$ | 0.92 | 0.92 | 0.94 | 0.94 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 3.28 | 3.35 | 3.18 | 3.14 | 3.11 | 3.10 | 2.92 | 3.07 | 2.88 |
| | *SEM* (SS) | 4.24 | 4.24 | 3.67 | 3.67 | 3.67 | 3.67 | 3.35 | 3.35 | 3.35 |
| Fluid Reasoning | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.54 | 505.99 | 508.03 | 512.94 | 513.17 | 514.55 | 515.33 | 512.72 | 517.40 |
| | *SD* | 13.82 | 13.85 | 14.74 | 15.59 | 14.40 | 15.86 | 15.11 | 15.76 | 16.48 |
| | $r_{cc}$ | 0.93 | 0.93 | 0.92 | 0.92 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 3.66 | 3.66 | 4.17 | 4.41 | 3.53 | 3.89 | 3.38 | 3.52 | 3.69 |
| | *SEM* (SS) | 3.97 | 3.97 | 4.24 | 4.24 | 3.67 | 3.67 | 3.35 | 3.35 | 3.35 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| General Intellectual Ability | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 520.91 | 519.92 | 517.46 | 516.47 | 513.86 | 510.89 | 504.05 | |
| | *SD* | 9.95 | 11.10 | 11.95 | 11.97 | 13.89 | 11.43 | 14.06 | |
| | $r_{cc}$ | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | 1.99 | 2.22 | 2.07 | 2.07 | 2.41 | 1.98 | 2.43 | |
| | *SEM* (SS) | 3.00 | 3.00 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | |
| Brief Intellectual Ability | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 522.57 | 521.18 | 519.87 | 519.37 | 517.63 | 515.87 | 509.29 | |
| | *SD* | 11.83 | 13.78 | 14.25 | 14.52 | 16.28 | 13.08 | 16.41 | |
| | $r_{cc}$ | 0.92 | 0.94 | 0.95 | 0.94 | 0.94 | 0.95 | 0.95 | 0.94 |
| | *SEM* (*W*) | 3.35 | 3.38 | 3.19 | 3.56 | 3.99 | 2.92 | 3.67 | |
| | *SEM* (SS) | 4.24 | 3.67 | 3.35 | 3.67 | 3.67 | 3.35 | 3.35 | |
| *Gf-Gc* Composite | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 523.15 | 522.07 | 520.94 | 522.18 | 519.65 | 517.10 | 511.98 | |
| | *SD* | 12.57 | 14.31 | 15.07 | 13.88 | 16.39 | 13.00 | 16.21 | |
| | $r_{cc}$ | 0.95 | 0.97 | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.96 |
| | *SEM* (*W*) | 2.81 | 2.48 | 2.61 | 2.40 | 2.84 | 1.84 | 2.29 | |
| | *SEM* (SS) | 3.35 | 2.60 | 2.60 | 2.60 | 2.60 | 2.12 | 2.12 | |
| Comprehension-Knowledge | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 527.90 | 528.84 | 530.88 | 533.54 | 533.14 | 531.91 | 527.58 | |
| | *SD* | 14.28 | 15.09 | 16.25 | 15.39 | 18.24 | 14.20 | 18.23 | |
| | $r_{cc}$ | 0.93 | 0.95 | 0.95 | 0.95 | 0.95 | 0.96 | 0.96 | 0.93 |
| | *SEM* (*W*) | 3.78 | 3.37 | 3.63 | 3.44 | 4.08 | 2.84 | 3.65 | |
| | *SEM* (SS) | 3.97 | 3.35 | 3.35 | 3.35 | 3.35 | 3.00 | 3.00 | |
| Comprehension-Knowledge–Extended | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 527.21 | 528.15 | 530.57 | 532.94 | 532.85 | 532.10 | 526.83 | |
| | *SD* | 13.67 | 14.34 | 15.46 | 14.48 | 17.17 | 13.65 | 17.18 | |
| | $r_{cc}$ | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.94 |
| | *SEM* (*W*) | 3.06 | 2.87 | 3.09 | 2.90 | 3.43 | 2.36 | 2.98 | |
| | *SEM* (SS) | 3.35 | 3.00 | 3.00 | 3.00 | 3.00 | 2.60 | 2.60 | |
| Fluid Reasoning | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 518.41 | 515.31 | 511.00 | 510.82 | 506.17 | 502.29 | 496.37 | |
| | *SD* | 14.88 | 16.64 | 17.26 | 15.97 | 17.49 | 15.73 | 19.60 | |
| | $r_{cc}$ | 0.92 | 0.94 | 0.94 | 0.95 | 0.95 | 0.96 | 0.96 | 0.94 |
| | *SEM* (*W*) | 4.21 | 4.08 | 4.23 | 3.57 | 3.91 | 3.15 | 3.92 | |
| | *SEM* (SS) | 4.24 | 3.67 | 3.67 | 3.35 | 3.35 | 3.00 | 3.00 | |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Fluid Reasoning–Extended | *n* | — | — | — | 175.00 | 302.00 | 307.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 445.05 | 460.75 | 475.00 | 484.45 | 492.44 | 497.88 |
| | *SD* | — | — | — | 15.28 | 15.16 | 16.51 | 14.44 | 13.69 | 14.83 |
| | $r_{cc}$ | — | — | — | 0.96 | 0.96 | 0.97 | 0.97 | 0.96 | 0.96 |
| | *SEM* (*W*) | — | — | — | 3.06 | 3.03 | 2.86 | 2.50 | 2.74 | 2.97 |
| | *SEM* (SS) | — | — | — | 3.00 | 3.00 | 2.60 | 2.60 | 3.00 | 3.00 |
| Short-Term Working Memory | *n* | — | 121.00 | 189.00 | 192.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 428.29 | 438.46 | 450.84 | 468.13 | 479.08 | 487.19 | 494.89 | 500.33 |
| | *SD* | — | 11.48 | 15.89 | 17.92 | 16.49 | 16.16 | 16.09 | 13.54 | 14.28 |
| | $r_{cc}$ | — | 0.88 | 0.88 | 0.90 | 0.90 | 0.91 | 0.91 | 0.88 | 0.88 |
| | *SEM* (*W*) | — | 3.98 | 5.51 | 5.67 | 5.21 | 4.85 | 4.83 | 4.69 | 4.95 |
| | *SEM* (SS) | — | 5.20 | 5.20 | 4.74 | 4.74 | 4.50 | 4.50 | 5.20 | 5.20 |
| Short-Term Working Memory–Extended | *n* | — | — | — | 191.00 | 307.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 452.67 | 468.29 | 477.72 | 485.70 | 493.59 | 498.86 |
| | *SD* | — | — | — | 16.41 | 15.25 | 15.30 | 15.15 | 12.64 | 14.09 |
| | $r_{cc}$ | — | — | — | 0.94 | 0.94 | 0.94 | 0.94 | 0.91 | 0.91 |
| | *SEM* (*W*) | — | — | — | 4.02 | 3.73 | 3.75 | 3.71 | 3.79 | 4.23 |
| | *SEM* (SS) | — | — | — | 3.67 | 3.67 | 3.67 | 3.67 | 4.50 | 4.50 |
| Cognitive Processing Speed | *n* | — | — | 171.00 | 186.00 | 303.00 | 309.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 405.42 | 429.91 | 452.67 | 468.39 | 483.68 | 497.55 | 507.16 |
| | *SD* | — | — | 22.75 | 28.57 | 25.43 | 23.38 | 25.15 | 22.57 | 22.99 |
| | $r_{cc}$ | — | — | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | — | — | 5.57 | 7.00 | 6.23 | 5.73 | 6.16 | 5.53 | 5.63 |
| | *SEM* (SS) | — | — | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 |
| Auditory Processing | *n* | — | 138.00 | 209.00 | 200.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 448.49 | 456.62 | 468.24 | 480.12 | 486.63 | 493.05 | 496.97 | 500.49 |
| | *SD* | — | 10.87 | 12.12 | 13.41 | 11.51 | 12.08 | 12.28 | 10.44 | 11.12 |
| | $r_{cc}$ | — | 0.91 | 0.91 | 0.93 | 0.93 | 0.92 | 0.92 | 0.90 | 0.90 |
| | *SEM* (*W*) | — | 3.26 | 3.64 | 3.55 | 3.05 | 3.42 | 3.47 | 3.30 | 3.52 |
| | *SEM* (SS) | — | 4.50 | 4.50 | 3.97 | 3.97 | 4.24 | 4.24 | 4.74 | 4.74 |
| Long-Term Retrieval | *n* | 167.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 450.10 | 457.53 | 464.35 | 473.19 | 482.14 | 487.35 | 491.76 | 494.62 | 496.99 |
| | *SD* | 10.51 | 10.00 | 11.63 | 10.79 | 9.66 | 9.19 | 8.27 | 8.37 | 8.60 |
| | $r_{cc}$ | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.96 | 0.96 |
| | *SEM* (*W*) | 1.49 | 1.41 | 1.65 | 1.53 | 1.37 | 1.30 | 1.17 | 1.67 | 1.72 |
| | *SEM* (SS) | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 3.00 | 3.00 |

**Table C-1.** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Fluid Reasoning–Extended | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.15 | 506.19 | 508.03 | 512.68 | 513.09 | 514.94 | 515.29 | 512.87 | 517.04 |
| | *SD* | 13.25 | 13.79 | 13.91 | 14.90 | 13.91 | 14.40 | 14.01 | 15.43 | 15.46 |
| | $r_{cc}$ | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 2.96 | 3.08 | 3.11 | 3.33 | 3.11 | 3.22 | 2.80 | 3.09 | 3.09 |
| | *SEM* (SS) | 3.35 | 3.35 | 3.35 | 3.35 | 3.35 | 3.35 | 3.00 | 3.00 | 3.00 |
| Short-Term Working Memory | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.23 | 507.76 | 510.85 | 513.35 | 514.49 | 516.82 | 518.07 | 517.65 | 520.12 |
| | *SD* | 13.03 | 12.61 | 13.57 | 14.13 | 13.53 | 14.72 | 15.41 | 15.30 | 15.88 |
| | $r_{cc}$ | 0.89 | 0.89 | 0.91 | 0.91 | 0.91 | 0.91 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 4.32 | 4.18 | 4.07 | 4.24 | 4.06 | 4.42 | 3.77 | 3.75 | 3.89 |
| | *SEM* (SS) | 4.97 | 4.97 | 4.50 | 4.50 | 4.50 | 4.50 | 3.67 | 3.67 | 3.67 |
| Short-Term Working Memory–Extended | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 502.23 | 506.82 | 509.88 | 512.46 | 513.79 | 516.00 | 517.15 | 516.40 | 518.99 |
| | *SD* | 12.47 | 12.09 | 12.89 | 13.52 | 12.79 | 14.21 | 14.37 | 14.29 | 15.35 |
| | $r_{cc}$ | 0.92 | 0.92 | 0.93 | 0.93 | 0.93 | 0.93 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 3.53 | 3.42 | 3.41 | 3.58 | 3.38 | 3.76 | 3.21 | 3.19 | 3.43 |
| | *SEM* (SS) | 4.24 | 4.24 | 3.97 | 3.97 | 3.97 | 3.97 | 3.35 | 3.35 | 3.35 |
| Cognitive Processing Speed | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 515.85 | 522.38 | 527.28 | 532.50 | 537.63 | 542.37 | 544.03 | 540.73 | 545.68 |
| | *SD* | 21.46 | 20.78 | 21.16 | 21.67 | 19.57 | 22.70 | 22.16 | 24.44 | 24.46 |
| | $r_{cc}$ | 0.94 | 0.94 | 0.94 | 0.94 | 0.93 | 0.93 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 5.26 | 5.09 | 5.18 | 5.31 | 5.18 | 6.01 | 5.43 | 5.99 | 5.99 |
| | *SEM* (SS) | 3.67 | 3.67 | 3.67 | 3.67 | 3.97 | 3.97 | 3.67 | 3.67 | 3.67 |
| Auditory Processing | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.41 | 504.86 | 506.32 | 509.32 | 510.01 | 512.31 | 512.57 | 511.21 | 513.23 |
| | *SD* | 10.70 | 10.83 | 10.70 | 11.20 | 10.99 | 11.82 | 11.12 | 11.55 | 11.75 |
| | $r_{cc}$ | 0.89 | 0.89 | 0.90 | 0.90 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 |
| | *SEM* (*W*) | 3.55 | 3.59 | 3.38 | 3.54 | 3.30 | 3.55 | 3.15 | 3.27 | 3.32 |
| | *SEM* (SS) | 4.97 | 4.97 | 4.74 | 4.74 | 4.50 | 4.50 | 4.24 | 4.24 | 4.24 |
| Long-Term Retrieval | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 499.00 | 499.11 | 501.02 | 502.20 | 502.20 | 503.79 | 503.34 | 502.05 | 503.28 |
| | *SD* | 7.91 | 7.64 | 7.98 | 8.80 | 7.98 | 8.79 | 8.80 | 9.33 | 8.94 |
| | $r_{cc}$ | 0.94 | 0.94 | 0.96 | 0.96 | 0.95 | 0.95 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | 1.94 | 1.87 | 1.60 | 1.76 | 1.78 | 1.97 | 1.52 | 1.62 | 1.55 |
| | *SEM* (SS) | 3.67 | 3.67 | 3.00 | 3.00 | 3.35 | 3.35 | 2.60 | 2.60 | 2.60 |

**Table C-1.** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| Fluid Reasoning–Extended | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 116.00 | |
| | *M* | 517.99 | 515.28 | 510.78 | 510.05 | 506.05 | 501.00 | 494.65 | |
| | *SD* | 14.14 | 15.99 | 16.99 | 15.06 | 16.03 | 15.05 | 19.06 | |
| | $r_{cc}$ | 0.94 | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.96 |
| | *SEM* (*W*) | 3.46 | 3.20 | 3.40 | 3.01 | 3.21 | 2.61 | 3.30 | |
| | *SEM* (SS) | 3.67 | 3.00 | 3.00 | 3.00 | 3.00 | 2.60 | 2.60 | |
| Short-Term Working Memory | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 523.23 | 520.78 | 519.18 | 517.32 | 515.85 | 513.17 | 506.59 | |
| | *SD* | 14.63 | 15.92 | 16.75 | 17.28 | 17.72 | 14.29 | 17.31 | |
| | $r_{cc}$ | 0.92 | 0.94 | 0.95 | 0.92 | 0.92 | 0.92 | 0.92 | 0.91 |
| | *SEM* (*W*) | 4.14 | 3.90 | 3.75 | 4.89 | 5.01 | 4.04 | 4.90 | |
| | *SEM* (SS) | 4.24 | 3.67 | 3.35 | 4.24 | 4.24 | 4.24 | 4.24 | |
| Short-Term Working Memory–Extended | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 521.88 | 519.69 | 517.70 | 515.46 | 512.88 | 509.15 | 502.10 | |
| | *SD* | 14.22 | 15.25 | 16.03 | 16.13 | 16.62 | 13.88 | 17.95 | |
| | $r_{cc}$ | 0.93 | 0.95 | 0.95 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 3.76 | 3.41 | 3.59 | 4.27 | 4.40 | 3.67 | 4.75 | |
| | *SEM* (SS) | 3.97 | 3.35 | 3.35 | 3.97 | 3.97 | 3.97 | 3.97 | |
| Cognitive Processing Speed | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 548.93 | 547.49 | 539.19 | 535.52 | 528.52 | 520.28 | 505.43 | |
| | *SD* | 21.93 | 22.17 | 24.11 | 23.65 | 27.28 | 22.29 | 28.94 | |
| | $r_{cc}$ | 0.93 | 0.93 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 5.80 | 5.86 | 5.91 | 5.79 | 6.68 | 5.46 | 7.09 | |
| | *SEM* (SS) | 3.97 | 3.97 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | |
| Auditory Processing | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 515.84 | 515.01 | 513.48 | 511.13 | 508.11 | 503.91 | 499.73 | |
| | *SD* | 11.76 | 12.15 | 13.12 | 13.25 | 14.42 | 14.46 | 14.96 | |
| | $r_{cc}$ | 0.94 | 0.93 | 0.94 | 0.93 | 0.93 | 0.92 | 0.92 | 0.92 |
| | *SEM* (*W*) | 2.88 | 3.21 | 3.21 | 3.50 | 3.81 | 4.09 | 4.23 | |
| | *SEM* (SS) | 3.67 | 3.97 | 3.67 | 3.97 | 3.97 | 4.24 | 4.24 | |
| Long-Term Retrieval | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 503.42 | 502.20 | 499.59 | 500.02 | 497.20 | 494.16 | 489.52 | |
| | *SD* | 8.91 | 9.64 | 9.48 | 9.59 | 10.71 | 10.12 | 11.44 | |
| | $r_{cc}$ | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 | 0.97 |
| | *SEM* (*W*) | 1.54 | 1.67 | 1.64 | 1.36 | 1.51 | 1.43 | 1.62 | |
| | *SEM* (SS) | 2.60 | 2.60 | 2.60 | 2.12 | 2.12 | 2.12 | 2.12 | |

**Table C-1.** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Visual Processing | *n* | 153.00 | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 440.35 | 451.77 | 462.40 | 469.97 | 480.84 | 486.72 | 492.04 | 496.56 | 498.16 |
| | *SD* | 11.72 | 12.65 | 13.56 | 12.06 | 10.96 | 11.39 | 10.79 | 9.37 | 10.42 |
| | $r_{cc}$ | 0.91 | 0.91 | 0.91 | 0.89 | 0.89 | 0.85 | 0.85 | 0.82 | 0.82 |
| | *SEM* (*W*) | 3.51 | 3.79 | 4.07 | 4.00 | 3.64 | 4.41 | 4.18 | 3.97 | 4.42 |
| | *SEM* (SS) | 4.50 | 4.50 | 4.50 | 4.97 | 4.97 | 5.81 | 5.81 | 6.36 | 6.36 |
| Quantitative Reasoning | *n* | — | — | — | 175.00 | 302.00 | 307.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 437.32 | 455.51 | 471.80 | 482.06 | 491.12 | 497.41 |
| | *SD* | — | — | — | 18.11 | 17.37 | 18.48 | 16.02 | 15.09 | 16.09 |
| | $r_{cc}$ | — | — | — | 0.94 | 0.94 | 0.96 | 0.96 | 0.94 | 0.94 |
| | *SEM* (*W*) | — | — | — | 4.44 | 4.25 | 3.70 | 3.20 | 3.70 | 3.94 |
| | *SEM* (SS) | — | — | — | 3.67 | 3.67 | 3.00 | 3.00 | 3.67 | 3.67 |
| Auditory Memory Span | *n* | 157.00 | 199.00 | 223.00 | 204.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 410.75 | 425.77 | 445.20 | 457.09 | 469.17 | 476.15 | 485.45 | 492.09 | 496.81 |
| | *SD* | 17.41 | 18.32 | 19.08 | 19.47 | 16.46 | 18.94 | 17.64 | 16.81 | 16.90 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.91 | 0.91 | 0.90 | 0.90 | 0.88 | 0.88 |
| | *SEM* (*W*) | 3.48 | 3.66 | 3.82 | 5.84 | 4.94 | 5.99 | 5.58 | 5.82 | 5.85 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 4.50 | 4.50 | 4.74 | 4.74 | 5.20 | 5.20 |
| Number Facility | *n* | — | 160.00 | 201.00 | 198.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 366.75 | 379.91 | 409.22 | 442.35 | 461.63 | 478.10 | 490.30 | 498.82 |
| | *SD* | — | 21.11 | 23.27 | 30.05 | 26.13 | 24.63 | 22.06 | 18.86 | 19.37 |
| | $r_{cc}$ | — | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 |
| | *SEM* (*W*) | — | 7.31 | 8.06 | 10.41 | 9.05 | 8.53 | 7.64 | 6.53 | 6.71 |
| | *SEM* (SS) | — | 5.20 | 5.20 | 5.20 | 5.20 | 5.20 | 5.20 | 5.20 | 5.20 |
| Perceptual Speed | *n* | — | — | 208.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 359.89 | 396.35 | 435.72 | 459.64 | 478.97 | 493.61 | 503.72 |
| | *SD* | — | — | 28.73 | 39.11 | 32.39 | 29.56 | 26.57 | 23.21 | 23.85 |
| | $r_{cc}$ | — | — | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| | *SEM* (*W*) | — | — | 8.12 | 11.06 | 9.16 | 8.36 | 7.51 | 6.56 | 6.75 |
| | *SEM* (SS) | — | — | 4.24 | 4.24 | 4.24 | 4.24 | 4.24 | 4.24 | 4.24 |
| Cognitive Efficiency | *n* | — | — | 209.00 | 198.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 411.45 | 434.27 | 461.26 | 476.24 | 487.45 | 497.80 | 505.76 |
| | *SD* | — | — | 22.66 | 26.39 | 22.07 | 20.76 | 20.50 | 16.68 | 18.10 |
| | $r_{cc}$ | — | — | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.91 | 0.91 |
| | *SEM* (*W*) | — | — | 6.41 | 7.46 | 6.24 | 5.87 | 5.80 | 5.00 | 5.43 |
| | *SEM* (SS) | — | — | 4.24 | 4.24 | 4.24 | 4.24 | 4.24 | 4.50 | 4.50 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Visual Processing | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 500.47 | 501.56 | 503.18 | 505.06 | 505.24 | 506.98 | 506.50 | 506.01 | 507.51 |
| | *SD* | 9.58 | 10.22 | 10.26 | 9.71 | 9.10 | 9.77 | 9.49 | 10.56 | 10.13 |
| | $r_{cc}$ | 0.83 | 0.83 | 0.81 | 0.81 | 0.80 | 0.80 | 0.86 | 0.86 | 0.86 |
| | *SEM* (*W*) | 3.95 | 4.21 | 4.47 | 4.23 | 4.07 | 4.37 | 3.55 | 3.95 | 3.79 |
| | *SEM* (SS) | 6.18 | 6.18 | 6.54 | 6.54 | 6.71 | 6.71 | 5.61 | 5.61 | 5.61 |
| Quantitative Reasoning | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.74 | 506.48 | 508.39 | 513.10 | 514.19 | 515.73 | 516.36 | 513.65 | 517.83 |
| | *SD* | 14.38 | 15.34 | 15.08 | 15.97 | 15.51 | 15.46 | 15.02 | 16.83 | 16.96 |
| | $r_{cc}$ | 0.92 | 0.92 | 0.91 | 0.91 | 0.93 | 0.93 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 4.07 | 4.34 | 4.52 | 4.79 | 4.10 | 4.09 | 3.36 | 3.76 | 3.79 |
| | *SEM* (SS) | 4.24 | 4.24 | 4.50 | 4.50 | 3.97 | 3.97 | 3.35 | 3.35 | 3.35 |
| Auditory Memory Span | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 500.91 | 505.34 | 505.88 | 510.56 | 511.36 | 514.79 | 515.55 | 514.15 | 518.11 |
| | *SD* | 16.48 | 17.64 | 18.14 | 18.88 | 17.38 | 18.37 | 17.89 | 17.42 | 18.62 |
| | $r_{cc}$ | 0.84 | 0.84 | 0.88 | 0.88 | 0.91 | 0.91 | 0.88 | 0.88 | 0.88 |
| | *SEM* (*W*) | 6.59 | 7.05 | 6.29 | 6.54 | 5.21 | 5.51 | 6.20 | 6.04 | 6.45 |
| | *SEM* (SS) | 6.00 | 6.00 | 5.20 | 5.20 | 4.50 | 4.50 | 5.20 | 5.20 | 5.20 |
| Number Facility | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 505.01 | 510.85 | 515.70 | 519.14 | 520.88 | 524.51 | 525.69 | 525.18 | 528.21 |
| | *SD* | 16.74 | 15.88 | 16.40 | 17.44 | 15.99 | 17.43 | 17.01 | 17.08 | 18.15 |
| | $r_{cc}$ | 0.88 | 0.88 | 0.90 | 0.90 | 0.90 | 0.90 | 0.92 | 0.92 | 0.92 |
| | *SEM* (*W*) | 5.80 | 5.50 | 5.19 | 5.52 | 5.06 | 5.51 | 4.81 | 4.83 | 5.13 |
| | *SEM* (SS) | 5.20 | 5.20 | 4.74 | 4.74 | 4.74 | 4.74 | 4.24 | 4.24 | 4.24 |
| Perceptual Speed | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 512.78 | 519.99 | 524.93 | 529.13 | 533.19 | 537.65 | 538.59 | 536.79 | 540.71 |
| | *SD* | 20.51 | 20.61 | 20.36 | 20.28 | 18.65 | 21.05 | 19.19 | 20.70 | 21.69 |
| | $r_{cc}$ | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 5.43 | 5.45 | 5.39 | 5.37 | 4.93 | 5.57 | 5.08 | 5.48 | 5.74 |
| | *SEM* (SS) | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 |
| Cognitive Efficiency | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 511.14 | 516.68 | 520.82 | 524.11 | 527.30 | 530.57 | 531.76 | 529.91 | 533.99 |
| | *SD* | 16.65 | 15.64 | 17.16 | 17.75 | 15.52 | 17.60 | 17.49 | 18.80 | 19.65 |
| | $r_{cc}$ | 0.92 | 0.92 | 0.93 | 0.93 | 0.92 | 0.92 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 4.71 | 4.42 | 4.54 | 4.70 | 4.39 | 4.98 | 4.28 | 4.60 | 4.81 |
| | *SEM* (SS) | 4.24 | 4.24 | 3.97 | 3.97 | 4.24 | 4.24 | 3.67 | 3.67 | 3.67 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| Visual Processing | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 509.39 | 508.86 | 506.79 | 505.99 | 502.78 | 500.57 | 496.19 | |
| | *SD* | 10.12 | 10.73 | 10.66 | 10.47 | 11.29 | 10.55 | 12.52 | |
| | $r_{cc}$ | 0.85 | 0.83 | 0.86 | 0.86 | 0.86 | 0.89 | 0.89 | 0.86 |
| | *SEM* (*W*) | 3.92 | 4.42 | 3.99 | 3.92 | 4.22 | 3.50 | 4.15 | |
| | *SEM* (SS) | 5.81 | 6.18 | 5.61 | 5.61 | 5.61 | 4.97 | 4.97 | |
| Quantitative Reasoning | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 116.00 | |
| | *M* | 518.58 | 516.06 | 511.92 | 510.72 | 507.50 | 502.71 | 495.12 | |
| | *SD* | 15.02 | 17.00 | 17.95 | 16.69 | 17.49 | 16.02 | 20.36 | |
| | $r_{cc}$ | 0.90 | 0.94 | 0.95 | 0.94 | 0.94 | 0.96 | 0.96 | 0.94 |
| | *SEM* (*W*) | 4.75 | 4.16 | 4.01 | 4.09 | 4.28 | 3.20 | 4.07 | |
| | *SEM* (SS) | 4.74 | 3.67 | 3.35 | 3.67 | 3.67 | 3.00 | 3.00 | |
| Auditory Memory Span | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 521.29 | 520.13 | 517.35 | 515.91 | 512.37 | 509.32 | 501.52 | |
| | *SD* | 18.53 | 19.60 | 19.99 | 20.69 | 22.86 | 19.96 | 20.82 | |
| | $r_{cc}$ | 0.90 | 0.91 | 0.92 | 0.91 | 0.91 | 0.87 | 0.87 | 0.90 |
| | *SEM* (*W*) | 5.86 | 5.88 | 5.65 | 6.21 | 6.86 | 7.20 | 7.51 | |
| | *SEM* (SS) | 4.74 | 4.50 | 4.24 | 4.50 | 4.50 | 5.41 | 5.41 | |
| Number Facility | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 530.96 | 528.85 | 524.47 | 521.65 | 517.99 | 512.59 | 503.68 | |
| | *SD* | 16.10 | 17.27 | 18.77 | 20.41 | 20.81 | 16.60 | 23.63 | |
| | $r_{cc}$ | 0.92 | 0.93 | 0.93 | 0.91 | 0.91 | 0.91 | 0.91 | 0.90 |
| | *SEM* (*W*) | 4.55 | 4.57 | 4.97 | 6.12 | 6.24 | 4.98 | 7.09 | |
| | *SEM* (SS) | 4.24 | 3.97 | 3.97 | 4.50 | 4.50 | 4.50 | 4.50 | |
| Perceptual Speed | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 543.49 | 542.60 | 535.54 | 532.34 | 526.31 | 518.82 | 505.17 | |
| | *SD* | 19.00 | 20.44 | 21.22 | 23.59 | 26.62 | 21.19 | 29.12 | |
| | $r_{cc}$ | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.92 | 0.92 | 0.93 |
| | *SEM* (*W*) | 5.03 | 5.41 | 5.61 | 6.24 | 7.04 | 5.99 | 8.24 | |
| | *SEM* (SS) | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 4.24 | 4.24 | |
| Cognitive Efficiency | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 537.40 | 535.05 | 530.10 | 528.62 | 524.24 | 518.87 | 508.02 | |
| | *SD* | 17.79 | 18.62 | 20.04 | 20.60 | 21.96 | 17.64 | 22.69 | |
| | $r_{cc}$ | 0.94 | 0.95 | 0.95 | 0.94 | 0.94 | 0.94 | 0.94 | 0.93 |
| | *SEM* (*W*) | 4.36 | 4.16 | 4.48 | 5.05 | 5.38 | 4.32 | 5.56 | |
| | *SEM* (SS) | 3.67 | 3.35 | 3.35 | 3.67 | 3.67 | 3.67 | 3.67 | |

**Table C-1.** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cognitive Efficiency–Extended | *n* | — | — | 181.00 | 192.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 400.78 | 425.01 | 451.92 | 469.36 | 483.08 | 494.25 | 502.03 |
| | *SD* | — | — | 19.89 | 25.43 | 21.82 | 20.58 | 18.89 | 15.59 | 16.68 |
| | $r_{cc}$ | — | — | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.93 | 0.93 |
| | *SEM* (*W*) | — | — | 4.87 | 6.23 | 5.35 | 5.04 | 4.63 | 4.12 | 4.41 |
| | *SEM* (SS) | — | — | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.97 | 3.97 |
| Reading Aptitude A | *n* | — | — | 183.00 | 193.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 432.84 | 448.50 | 464.33 | 477.88 | 486.70 | 494.16 | 499.06 |
| | *SD* | — | — | 12.48 | 15.30 | 13.68 | 13.71 | 12.19 | 10.65 | 11.52 |
| | $r_{cc}$ | — | — | 0.95 | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | — | — | 2.79 | 4.05 | 5.12 | 4.33 | 4.56 | 3.53 | 3.99 |
| | *SEM* (SS) | — | — | 3.35 | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |
| Reading Aptitude B | *n* | — | 107.00 | 204.00 | 198.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 430.15 | 436.13 | 451.89 | 467.12 | 478.99 | 487.06 | 493.38 | 498.01 |
| | *SD* | — | 8.87 | 12.44 | 14.56 | 12.33 | 12.29 | 10.70 | 9.38 | 10.30 |
| | $r_{cc}$ | — | 0.95 | 0.95 | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | — | 1.98 | 2.78 | 3.85 | 4.61 | 3.89 | 4.00 | 3.11 | 3.57 |
| | *SEM* (SS) | — | 3.35 | 3.35 | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |
| Math Aptitude A | *n* | — | — | — | 171.00 | 302.00 | 307.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 461.44 | 472.32 | 481.42 | 488.33 | 495.06 | 498.80 |
| | *SD* | — | — | — | 10.56 | 10.69 | 11.86 | 10.71 | 9.45 | 10.77 |
| | $r_{cc}$ | — | — | — | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | — | — | — | 2.79 | 4.00 | 3.75 | 4.01 | 3.13 | 3.73 |
| | *SEM* (SS) | — | — | — | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |
| Math Aptitude B | *n* | — | — | — | 197.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 451.30 | 468.27 | 480.04 | 488.73 | 496.85 | 501.87 |
| | *SD* | — | — | — | 15.72 | 13.48 | 13.04 | 12.17 | 9.96 | 11.65 |
| | $r_{cc}$ | — | — | — | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | — | — | — | 4.16 | 5.04 | 4.12 | 4.55 | 3.30 | 4.03 |
| | *SEM* (SS) | — | — | — | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |
| Writing Aptitude A | *n* | — | — | 183.00 | 193.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 432.84 | 448.50 | 464.33 | 477.88 | 486.70 | 494.16 | 499.06 |
| | *SD* | — | — | 12.48 | 15.30 | 13.68 | 13.71 | 12.19 | 10.65 | 11.52 |
| | $r_{cc}$ | — | — | 0.95 | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | — | — | 2.79 | 4.05 | 5.12 | 4.33 | 4.56 | 3.53 | 3.99 |
| | *SEM* (SS) | — | — | 3.35 | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cognitive Efficiency–Extended | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 508.00 | 513.88 | 517.89 | 521.24 | 523.84 | 527.23 | 528.33 | 527.22 | 530.41 |
| | *SD* | 14.32 | 13.90 | 14.66 | 15.11 | 13.44 | 15.76 | 14.74 | 15.40 | 16.51 |
| | $r_{cc}$ | 0.94 | 0.94 | 0.95 | 0.95 | 0.94 | 0.94 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 3.51 | 3.41 | 3.28 | 3.38 | 3.29 | 3.86 | 2.95 | 3.08 | 3.30 |
| | *SEM* (SS) | 3.67 | 3.67 | 3.35 | 3.35 | 3.67 | 3.67 | 3.00 | 3.00 | 3.00 |
| Reading Aptitude A | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.84 | 506.77 | 509.02 | 512.44 | 513.48 | 515.51 | 516.42 | 515.40 | 518.88 |
| | *SD* | 9.94 | 10.10 | 10.92 | 10.83 | 11.07 | 11.92 | 11.59 | 11.82 | 12.54 |
| | $r_{cc}$ | 0.93 | 0.95 | 0.95 | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | 2.63 | 2.26 | 2.44 | 2.87 | 4.14 | 3.77 | 4.34 | 3.92 | 4.34 |
| | *SEM* (SS) | 3.97 | 3.35 | 3.35 | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |
| Reading Aptitude B | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 502.52 | 504.39 | 506.39 | 509.68 | 510.26 | 512.03 | 512.72 | 511.51 | 514.88 |
| | *SD* | 8.67 | 8.71 | 9.48 | 9.91 | 9.65 | 10.39 | 10.11 | 10.74 | 10.91 |
| | $r_{cc}$ | 0.93 | 0.95 | 0.95 | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | 2.29 | 1.95 | 2.12 | 2.62 | 3.61 | 3.28 | 3.78 | 3.56 | 3.78 |
| | *SEM* (SS) | 3.97 | 3.35 | 3.35 | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |
| Math Aptitude A | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 502.98 | 505.86 | 508.07 | 511.08 | 511.97 | 514.42 | 514.78 | 513.82 | 516.59 |
| | *SD* | 9.64 | 10.18 | 10.31 | 10.63 | 10.19 | 10.62 | 10.68 | 11.68 | 11.04 |
| | $r_{cc}$ | 0.93 | 0.95 | 0.95 | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | 2.55 | 2.28 | 2.30 | 2.81 | 3.81 | 3.36 | 4.00 | 3.87 | 3.82 |
| | *SEM* (SS) | 3.97 | 3.35 | 3.35 | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |
| Math Aptitude B | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 506.86 | 510.67 | 513.57 | 516.56 | 518.64 | 521.42 | 522.14 | 520.90 | 524.13 |
| | *SD* | 9.94 | 10.16 | 10.93 | 11.03 | 10.12 | 11.63 | 10.64 | 11.97 | 12.23 |
| | $r_{cc}$ | 0.93 | 0.95 | 0.95 | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | 2.63 | 2.27 | 2.44 | 2.92 | 3.79 | 3.68 | 3.98 | 3.97 | 4.24 |
| | *SEM* (SS) | 3.97 | 3.35 | 3.35 | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |
| Writing Aptitude A | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.84 | 506.77 | 509.02 | 512.44 | 513.48 | 515.51 | 516.42 | 515.40 | 518.88 |
| | *SD* | 9.94 | 10.10 | 10.92 | 10.83 | 11.07 | 11.92 | 11.59 | 11.82 | 12.54 |
| | $r_{cc}$ | 0.93 | 0.95 | 0.95 | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | 2.63 | 2.26 | 2.44 | 2.87 | 4.14 | 3.77 | 4.34 | 3.92 | 4.34 |
| | *SEM* (SS) | 3.97 | 3.35 | 3.35 | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| Cognitive Efficiency–Extended | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 533.36 | 531.69 | 527.36 | 524.83 | 521.08 | 515.99 | 505.88 | |
| | *SD* | 14.41 | 15.67 | 16.75 | 18.22 | 19.66 | 15.44 | 20.66 | |
| | $r_{cc}$ | 0.95 | 0.96 | 0.96 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 3.22 | 3.13 | 3.35 | 4.07 | 4.40 | 3.45 | 4.62 | |
| | *SEM* (SS) | 3.35 | 3.00 | 3.00 | 3.35 | 3.35 | 3.35 | 3.35 | |
| Reading Aptitude A | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 520.98 | 519.91 | 518.41 | 517.34 | 515.50 | 513.04 | 506.91 | |
| | *SD* | 11.10 | 12.61 | 13.53 | 13.65 | 15.53 | 13.03 | 15.60 | |
| | $r_{cc}$ | 0.89 | 0.83 | 0.86 | 0.91 | 0.93 | 0.87 | 0.95 | 0.89 |
| | *SEM* (*W*) | 3.68 | 5.20 | 5.06 | 4.10 | 4.11 | 4.70 | 3.49 | |
| | *SEM* (SS) | 4.97 | 6.18 | 5.61 | 4.50 | 3.97 | 5.41 | 3.35 | |
| Reading Aptitude B | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 516.27 | 515.35 | 513.81 | 513.57 | 511.58 | 509.27 | 503.73 | |
| | *SD* | 9.94 | 11.07 | 11.99 | 11.58 | 13.51 | 11.61 | 14.07 | |
| | $r_{cc}$ | 0.89 | 0.83 | 0.86 | 0.91 | 0.93 | 0.87 | 0.95 | 0.90 |
| | *SEM* (*W*) | 3.30 | 4.56 | 4.49 | 3.47 | 3.58 | 4.19 | 3.15 | |
| | *SEM* (SS) | 4.97 | 6.18 | 5.61 | 4.50 | 3.97 | 5.41 | 3.35 | |
| Math Aptitude A | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 116.00 | |
| | *M* | 518.66 | 517.73 | 515.74 | 514.66 | 512.96 | 509.83 | 504.39 | |
| | *SD* | 10.79 | 12.26 | 12.83 | 12.01 | 13.38 | 11.43 | 13.99 | |
| | $r_{cc}$ | 0.89 | 0.83 | 0.86 | 0.91 | 0.93 | 0.87 | 0.95 | 0.89 |
| | *SEM* (*W*) | 3.58 | 5.06 | 4.80 | 3.60 | 3.54 | 4.12 | 3.13 | |
| | *SEM* (SS) | 4.97 | 6.18 | 5.61 | 4.50 | 3.97 | 5.41 | 3.35 | |
| Math Aptitude B | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 526.86 | 526.12 | 523.44 | 522.36 | 519.65 | 516.50 | 508.86 | |
| | *SD* | 11.21 | 12.36 | 13.06 | 13.22 | 15.48 | 12.18 | 15.26 | |
| | $r_{cc}$ | 0.89 | 0.83 | 0.86 | 0.91 | 0.93 | 0.87 | 0.95 | 0.89 |
| | *SEM* (*W*) | 3.72 | 5.10 | 4.89 | 3.97 | 4.10 | 4.39 | 3.41 | |
| | *SEM* (SS) | 4.97 | 6.18 | 5.61 | 4.50 | 3.97 | 5.41 | 3.35 | |
| Writing Aptitude A | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 520.98 | 519.91 | 518.41 | 517.34 | 515.50 | 513.04 | 506.91 | |
| | *SD* | 11.10 | 12.61 | 13.53 | 13.65 | 15.53 | 13.03 | 15.60 | |
| | $r_{cc}$ | 0.89 | 0.83 | 0.86 | 0.91 | 0.93 | 0.87 | 0.95 | 0.89 |
| | *SEM* (*W*) | 3.68 | 5.20 | 5.06 | 4.10 | 4.11 | 4.70 | 3.49 | |
| | *SEM* (SS) | 4.97 | 6.18 | 5.61 | 4.50 | 3.97 | 5.41 | 3.35 | |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Writing Aptitude B | *n* | — | 107.00 | 204.00 | 198.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 430.15 | 436.13 | 451.89 | 467.12 | 478.99 | 487.06 | 493.38 | 498.01 |
| | *SD* | — | 8.87 | 12.44 | 14.56 | 12.33 | 12.29 | 10.70 | 9.38 | 10.30 |
| | $r_{cc}$ | — | 0.95 | 0.95 | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | — | 1.98 | 2.78 | 3.85 | 4.61 | 3.89 | 4.00 | 3.11 | 3.57 |
| | *SEM* (SS) | — | 3.35 | 3.35 | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |
| Oral Language | *n* | 163.00 | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 423.41 | 437.56 | 453.66 | 463.77 | 473.56 | 483.15 | 491.09 | 496.06 | 500.49 |
| | *SD* | 14.01 | 13.97 | 13.27 | 13.43 | 12.35 | 13.10 | 12.38 | 11.98 | 12.07 |
| | $r_{cc}$ | 0.94 | 0.94 | 0.94 | 0.88 | 0.88 | 0.87 | 0.87 | 0.87 | 0.87 |
| | *SEM* (*W*) | 3.43 | 3.42 | 3.25 | 4.65 | 4.28 | 4.72 | 4.46 | 4.32 | 4.35 |
| | *SEM* (SS) | 3.67 | 3.67 | 3.67 | 5.20 | 5.20 | 5.41 | 5.41 | 5.41 | 5.41 |
| Broad Oral Language | *n* | 163.00 | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 428.48 | 442.20 | 455.88 | 465.04 | 475.18 | 483.76 | 490.97 | 495.57 | 500.38 |
| | *SD* | 12.29 | 12.35 | 11.85 | 11.96 | 10.93 | 11.45 | 10.66 | 10.46 | 10.71 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.92 | 0.92 | 0.91 | 0.91 | 0.92 | 0.92 |
| | *SEM* (*W*) | 2.46 | 2.47 | 2.37 | 3.38 | 3.09 | 3.43 | 3.20 | 2.96 | 3.03 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 4.24 | 4.24 | 4.50 | 4.50 | 4.24 | 4.24 |
| Oral Expression | *n* | 173.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 415.24 | 433.70 | 454.15 | 463.68 | 473.19 | 482.18 | 491.28 | 497.08 | 502.16 |
| | *SD* | 17.92 | 16.27 | 15.52 | 15.61 | 14.08 | 15.64 | 14.86 | 14.22 | 14.56 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.89 | 0.89 | 0.87 | 0.87 | 0.86 | 0.86 |
| | *SEM* (*W*) | 3.58 | 3.25 | 3.10 | 5.18 | 4.67 | 5.64 | 5.36 | 5.32 | 5.45 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 4.97 | 4.97 | 5.41 | 5.41 | 5.61 | 5.61 |
| Listening Comprehension | *n* | 163.00 | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 429.66 | 442.58 | 454.66 | 463.47 | 474.79 | 483.24 | 490.74 | 494.94 | 500.31 |
| | *SD* | 11.69 | 12.31 | 12.29 | 12.41 | 11.36 | 11.59 | 10.64 | 10.60 | 10.70 |
| | $r_{cc}$ | 0.94 | 0.94 | 0.94 | 0.91 | 0.91 | 0.90 | 0.90 | 0.92 | 0.92 |
| | *SEM* (*W*) | 2.86 | 3.01 | 3.01 | 3.72 | 3.41 | 3.66 | 3.37 | 3.00 | 3.03 |
| | *SEM* (SS) | 3.67 | 3.67 | 3.67 | 4.50 | 4.50 | 4.74 | 4.74 | 4.24 | 4.24 |
| Phonetic Coding | *n* | — | 182.00 | 210.00 | 199.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | 428.76 | 434.98 | 451.28 | 475.68 | 485.32 | 492.50 | 497.10 | 498.15 |
| | *SD* | — | 14.86 | 16.36 | 22.32 | 20.38 | 17.23 | 14.55 | 14.64 | 13.18 |
| | $r_{cc}$ | — | 0.95 | 0.95 | 0.98 | 0.98 | 0.95 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | — | 3.32 | 3.66 | 3.16 | 2.88 | 3.85 | 3.25 | 3.27 | 2.95 |
| | *SEM* (SS) | — | 3.35 | 3.35 | 2.12 | 2.12 | 3.35 | 3.35 | 3.35 | 3.35 |

**Table C-1.** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Writing Aptitude B | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 502.52 | 504.39 | 506.39 | 509.68 | 510.26 | 512.03 | 512.72 | 511.51 | 514.88 |
| | *SD* | 8.67 | 8.71 | 9.48 | 9.91 | 9.65 | 10.39 | 10.11 | 10.74 | 10.91 |
| | $r_{cc}$ | 0.93 | 0.95 | 0.95 | 0.93 | 0.86 | 0.90 | 0.86 | 0.89 | 0.88 |
| | *SEM* (*W*) | 2.29 | 1.95 | 2.12 | 2.62 | 3.61 | 3.28 | 3.78 | 3.56 | 3.78 |
| | *SEM* (SS) | 3.97 | 3.35 | 3.35 | 3.97 | 5.61 | 4.74 | 5.61 | 4.97 | 5.20 |
| Oral Language | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.41 | 506.66 | 508.28 | 512.46 | 511.79 | 515.59 | 516.42 | 516.20 | 520.04 |
| | *SD* | 11.37 | 11.18 | 11.79 | 11.94 | 12.02 | 12.03 | 11.93 | 13.02 | 12.70 |
| | $r_{cc}$ | 0.87 | 0.87 | 0.90 | 0.90 | 0.90 | 0.90 | 0.91 | 0.91 | 0.91 |
| | *SEM* (*W*) | 4.10 | 4.03 | 3.73 | 3.78 | 3.80 | 3.81 | 3.58 | 3.90 | 3.81 |
| | *SEM* (SS) | 5.41 | 5.41 | 4.74 | 4.74 | 4.74 | 4.74 | 4.50 | 4.50 | 4.50 |
| Broad Oral Language | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.19 | 506.37 | 507.76 | 511.78 | 511.31 | 514.05 | 515.49 | 514.22 | 517.15 |
| | *SD* | 10.08 | 10.13 | 10.28 | 10.63 | 10.17 | 10.48 | 10.45 | 11.39 | 11.07 |
| | $r_{cc}$ | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 3.02 | 3.04 | 3.08 | 3.19 | 3.05 | 3.14 | 2.76 | 3.01 | 2.93 |
| | *SEM* (SS) | 4.50 | 4.50 | 4.50 | 4.50 | 4.50 | 4.50 | 3.97 | 3.97 | 3.97 |
| Oral Expression | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 507.27 | 510.38 | 511.55 | 516.71 | 516.97 | 520.39 | 521.91 | 520.56 | 525.70 |
| | *SD* | 13.97 | 14.08 | 14.56 | 15.46 | 14.73 | 15.33 | 14.97 | 15.97 | 15.39 |
| | $r_{cc}$ | 0.84 | 0.84 | 0.88 | 0.88 | 0.92 | 0.92 | 0.89 | 0.89 | 0.89 |
| | *SEM* (*W*) | 5.59 | 5.63 | 5.04 | 5.36 | 4.17 | 4.33 | 4.96 | 5.30 | 5.10 |
| | *SEM* (SS) | 6.00 | 6.00 | 5.20 | 5.20 | 4.24 | 4.24 | 4.97 | 4.97 | 4.97 |
| Listening Comprehension | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.71 | 505.69 | 507.00 | 510.87 | 510.30 | 512.57 | 514.06 | 512.65 | 514.66 |
| | *SD* | 10.25 | 10.48 | 10.12 | 10.80 | 10.08 | 10.69 | 11.06 | 11.02 | 11.11 |
| | $r_{cc}$ | 0.88 | 0.88 | 0.86 | 0.86 | 0.87 | 0.87 | 0.89 | 0.89 | 0.89 |
| | *SEM* (*W*) | 3.55 | 3.63 | 3.79 | 4.04 | 3.63 | 3.85 | 3.67 | 3.65 | 3.69 |
| | *SEM* (SS) | 5.20 | 5.20 | 5.61 | 5.61 | 5.41 | 5.41 | 4.97 | 4.97 | 4.97 |
| Phonetic Coding | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 501.88 | 503.38 | 505.61 | 507.54 | 509.12 | 511.51 | 509.74 | 509.64 | 512.10 |
| | *SD* | 13.91 | 14.65 | 13.68 | 15.27 | 14.64 | 14.88 | 15.05 | 15.88 | 16.54 |
| | $r_{cc}$ | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 3.68 | 3.88 | 3.62 | 4.04 | 3.87 | 3.94 | 3.98 | 4.20 | 4.38 |
| | *SEM* (SS) | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| Writing Aptitude B | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 516.27 | 515.35 | 513.81 | 513.57 | 511.58 | 509.27 | 503.73 | |
| | *SD* | 9.94 | 11.07 | 11.99 | 11.58 | 13.51 | 11.61 | 14.07 | |
| | $r_{cc}$ | 0.89 | 0.83 | 0.86 | 0.91 | 0.93 | 0.87 | 0.95 | 0.90 |
| | *SEM* (*W*) | 3.30 | 4.56 | 4.49 | 3.47 | 3.58 | 4.19 | 3.15 | |
| | *SEM* (SS) | 4.97 | 6.18 | 5.61 | 4.50 | 3.97 | 5.41 | 3.35 | |
| Oral Language | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 523.64 | 524.35 | 526.52 | 527.58 | 527.61 | 527.25 | 520.20 | |
| | *SD* | 12.96 | 13.55 | 14.11 | 14.15 | 15.43 | 12.63 | 15.33 | |
| | $r_{cc}$ | 0.90 | 0.91 | 0.92 | 0.92 | 0.92 | 0.91 | 0.91 | 0.90 |
| | *SEM* (*W*) | 4.10 | 4.07 | 3.99 | 4.00 | 4.36 | 3.79 | 4.60 | |
| | *SEM* (SS) | 4.74 | 4.50 | 4.24 | 4.24 | 4.24 | 4.50 | 4.50 | |
| Broad Oral Language | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 520.18 | 520.51 | 520.95 | 521.40 | 520.07 | 518.79 | 511.51 | |
| | *SD* | 11.40 | 12.20 | 12.52 | 12.39 | 13.53 | 11.21 | 13.78 | |
| | $r_{cc}$ | 0.92 | 0.93 | 0.94 | 0.94 | 0.94 | 0.93 | 0.93 | 0.92 |
| | *SEM* (*W*) | 3.22 | 3.23 | 3.07 | 3.04 | 3.31 | 2.97 | 3.65 | |
| | *SEM* (SS) | 4.24 | 3.97 | 3.67 | 3.67 | 3.67 | 3.97 | 3.97 | |
| Oral Expression | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 529.08 | 528.82 | 529.69 | 530.25 | 529.55 | 528.61 | 520.13 | |
| | *SD* | 16.10 | 16.81 | 16.91 | 17.71 | 18.72 | 16.23 | 17.49 | |
| | $r_{cc}$ | 0.92 | 0.94 | 0.92 | 0.93 | 0.93 | 0.88 | 0.88 | 0.89 |
| | *SEM* (*W*) | 4.55 | 4.12 | 4.78 | 4.69 | 4.95 | 5.62 | 6.06 | |
| | *SEM* (SS) | 4.24 | 3.67 | 4.24 | 3.97 | 3.97 | 5.20 | 5.20 | |
| Listening Comprehension | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 517.35 | 517.38 | 516.45 | 516.22 | 513.97 | 511.95 | 504.59 | |
| | *SD* | 11.38 | 12.23 | 12.30 | 12.32 | 13.03 | 11.12 | 13.84 | |
| | $r_{cc}$ | 0.87 | 0.90 | 0.91 | 0.90 | 0.90 | 0.89 | 0.89 | 0.90 |
| | *SEM* (*W*) | 4.10 | 3.87 | 3.69 | 3.90 | 4.12 | 3.69 | 4.59 | |
| | *SEM* (SS) | 5.41 | 4.74 | 4.50 | 4.74 | 4.74 | 4.97 | 4.97 | |
| Phonetic Coding | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 515.04 | 513.22 | 510.18 | 506.87 | 502.25 | 494.95 | 488.49 | |
| | *SD* | 16.35 | 18.16 | 18.28 | 18.34 | 20.59 | 19.25 | 24.01 | |
| | $r_{cc}$ | 0.94 | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.95 |
| | *SEM* (*W*) | 4.01 | 3.63 | 3.66 | 3.67 | 4.12 | 3.33 | 4.16 | |
| | *SEM* (SS) | 3.67 | 3.00 | 3.00 | 3.00 | 3.00 | 2.60 | 2.60 | |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Speed of Lexical Access | *n* | 171.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 427.29 | 443.93 | 455.15 | 470.52 | 478.49 | 486.50 | 494.63 | 497.95 | 502.77 |
| | *SD* | 18.71 | 14.92 | 18.04 | 15.27 | 13.95 | 14.06 | 12.92 | 13.76 | 14.12 |
| | $r_{cc}$ | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 |
| | *SEM* (*W*) | 6.20 | 4.95 | 5.98 | 5.07 | 4.63 | 4.66 | 4.29 | 4.56 | 4.68 |
| | *SEM* (SS) | 4.97 | 4.97 | 4.97 | 4.97 | 4.97 | 4.97 | 4.97 | 4.97 | 4.97 |
| Vocabulary | *n* | — | — | 219.00 | 203.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 453.51 | 463.98 | 473.72 | 483.17 | 490.45 | 496.23 | 500.39 |
| | *SD* | — | — | 12.11 | 12.99 | 12.27 | 12.83 | 11.96 | 10.95 | 12.12 |
| | $r_{cc}$ | — | — | 0.95 | 0.91 | 0.91 | 0.90 | 0.90 | 0.89 | 0.89 |
| | *SEM* (*W*) | — | — | 2.71 | 3.90 | 3.68 | 4.06 | 3.78 | 3.63 | 4.02 |
| | *SEM* (SS) | — | — | 4.97 | 4.24 | 4.50 | 4.97 | 5.20 | 4.50 | 4.74 |
| Reading | *n* | 166.00 | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 318.04 | 340.88 | 359.73 | 391.87 | 429.23 | 461.13 | 480.04 | 489.52 | 498.36 |
| | *SD* | 24.99 | 23.99 | 28.28 | 35.26 | 31.38 | 26.82 | 23.30 | 19.23 | 21.17 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.99 | 0.99 | 0.97 | 0.97 | 0.95 | 0.95 |
| | *SEM* (*W*) | 5.00 | 4.80 | 5.66 | 3.53 | 3.14 | 4.65 | 4.04 | 4.30 | 4.73 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 1.50 | 1.50 | 2.60 | 2.60 | 3.35 | 3.35 |
| Broad Reading | *n* | — | — | — | 102.00 | 259.00 | 300.00 | 333.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 402.58 | 425.89 | 454.28 | 475.80 | 487.06 | 497.75 |
| | *SD* | — | — | — | 32.34 | 27.21 | 27.46 | 25.90 | 23.08 | 25.26 |
| | $r_{cc}$ | — | — | — | 0.99 | 0.99 | 0.97 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | — | — | — | 3.23 | 2.72 | 4.76 | 4.49 | 4.00 | 4.38 |
| | *SEM* (SS) | — | — | — | 1.50 | 1.50 | 2.60 | 2.60 | 2.60 | 2.60 |
| Basic Reading Skills | *n* | — | — | — | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 406.13 | 437.85 | 465.46 | 481.48 | 489.50 | 496.91 |
| | *SD* | — | — | — | 31.50 | 27.86 | 23.86 | 21.51 | 18.82 | 19.69 |
| | $r_{cc}$ | — | — | — | 0.98 | 0.98 | 0.97 | 0.97 | 0.96 | 0.96 |
| | *SEM* (*W*) | — | — | — | 4.46 | 3.94 | 4.13 | 3.73 | 3.76 | 3.94 |
| | *SEM* (SS) | — | — | — | 2.12 | 2.12 | 2.60 | 2.60 | 3.00 | 3.00 |
| Reading Comprehension | *n* | — | — | — | 173.00 | 299.00 | 310.00 | 335.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 430.42 | 452.65 | 473.52 | 486.00 | 492.57 | 497.89 |
| | *SD* | — | — | — | 22.03 | 21.85 | 19.43 | 15.82 | 13.08 | 14.52 |
| | $r_{cc}$ | — | — | — | 0.99 | 0.99 | 0.97 | 0.97 | 0.94 | 0.94 |
| | *SEM* (*W*) | — | — | — | 2.20 | 2.18 | 3.37 | 2.74 | 3.20 | 3.56 |
| | *SEM* (SS) | — | — | — | 1.50 | 1.50 | 2.60 | 2.60 | 3.67 | 3.67 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Speed of Lexical Access | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 506.58 | 510.28 | 510.54 | 514.60 | 515.61 | 517.40 | 517.84 | 517.65 | 520.39 |
| | *SD* | 12.09 | 13.40 | 13.02 | 13.13 | 12.49 | 13.11 | 14.06 | 14.26 | 13.49 |
| | $r_{cc}$ | 0.89 | 0.89 | 0.90 | 0.90 | 0.89 | 0.89 | 0.90 | 0.90 | 0.90 |
| | *SEM* (*W*) | 4.01 | 4.45 | 4.12 | 4.15 | 4.14 | 4.35 | 4.45 | 4.51 | 4.27 |
| | *SEM* (SS) | 5.41 | 4.97 | 4.97 | 4.24 | 4.50 | 4.97 | 5.20 | 4.50 | 4.74 |
| Vocabulary | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 505.42 | 507.76 | 510.29 | 514.14 | 514.38 | 517.75 | 518.96 | 518.22 | 522.66 |
| | *SD* | 11.03 | 11.18 | 12.27 | 11.86 | 12.02 | 12.05 | 12.01 | 13.55 | 12.29 |
| | $r_{cc}$ | 0.89 | 0.89 | 0.93 | 0.93 | 0.92 | 0.92 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 3.66 | 3.71 | 3.25 | 3.14 | 3.40 | 3.41 | 3.18 | 3.59 | 3.25 |
| | *SEM* (SS) | 5.41 | 4.97 | 4.97 | 4.24 | 4.50 | 4.97 | 5.20 | 4.50 | 4.74 |
| Reading | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 507.16 | 510.73 | 514.05 | 520.25 | 521.32 | 525.41 | 527.11 | 525.52 | 531.32 |
| | *SD* | 17.40 | 16.59 | 18.06 | 19.04 | 17.84 | 18.46 | 19.38 | 19.26 | 20.96 |
| | $r_{cc}$ | 0.93 | 0.93 | 0.92 | 0.92 | 0.93 | 0.93 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 4.60 | 4.39 | 5.11 | 5.38 | 4.72 | 4.88 | 4.75 | 4.72 | 5.13 |
| | *SEM* (SS) | 3.97 | 3.97 | 4.24 | 4.24 | 3.97 | 3.97 | 3.67 | 3.67 | 3.67 |
| Broad Reading | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 509.38 | 513.64 | 517.89 | 525.41 | 526.31 | 531.65 | 534.21 | 531.14 | 538.40 |
| | *SD* | 20.16 | 19.73 | 21.15 | 21.78 | 20.22 | 21.39 | 21.22 | 21.62 | 23.20 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 4.03 | 3.95 | 4.73 | 4.87 | 4.04 | 4.28 | 4.24 | 4.32 | 4.64 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.35 | 3.35 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Basic Reading Skills | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.33 | 507.93 | 511.16 | 516.10 | 517.85 | 520.24 | 522.41 | 520.25 | 524.34 |
| | *SD* | 16.41 | 16.40 | 17.30 | 17.73 | 17.25 | 16.71 | 17.87 | 18.55 | 18.78 |
| | $r_{cc}$ | 0.95 | 0.95 | 0.93 | 0.93 | 0.93 | 0.93 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 3.67 | 3.67 | 4.58 | 4.69 | 4.56 | 4.42 | 4.38 | 4.54 | 4.60 |
| | *SEM* (SS) | 3.35 | 3.35 | 3.97 | 3.97 | 3.97 | 3.97 | 3.67 | 3.67 | 3.67 |
| Reading Comprehension | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.72 | 505.09 | 506.84 | 510.81 | 510.95 | 513.51 | 514.23 | 512.87 | 517.14 |
| | *SD* | 12.19 | 11.29 | 12.89 | 12.77 | 12.01 | 13.44 | 12.93 | 13.37 | 14.63 |
| | $r_{cc}$ | 0.91 | 0.91 | 0.92 | 0.92 | 0.91 | 0.91 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 3.66 | 3.39 | 3.65 | 3.61 | 3.60 | 4.03 | 3.42 | 3.54 | 3.87 |
| | *SEM* (SS) | 4.50 | 4.50 | 4.24 | 4.24 | 4.50 | 4.50 | 3.97 | 3.97 | 3.97 |

**Table C-1.** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
| Speed of Lexical Access | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 521.46 | 522.89 | 521.16 | 519.15 | 516.12 | 512.04 | 504.13 | |
| | *SD* | 13.38 | 14.76 | 14.49 | 14.28 | 13.15 | 12.48 | 16.31 | |
| | $r_{cc}$ | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.89 |
| | *SEM* (*W*) | 4.23 | 4.67 | 4.58 | 4.52 | 4.16 | 3.95 | 5.16 | |
| | *SEM* (SS) | 4.74 | 4.74 | 4.74 | 4.74 | 4.74 | 4.74 | 4.74 | |
| Vocabulary | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 525.98 | 526.59 | 528.37 | 530.11 | 530.08 | 529.68 | 523.65 | |
| | *SD* | 12.96 | 13.53 | 14.59 | 13.72 | 15.82 | 12.83 | 16.18 | |
| | $r_{cc}$ | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.93 |
| | *SEM* (*W*) | 3.17 | 3.31 | 3.57 | 3.36 | 3.87 | 3.14 | 3.96 | |
| | *SEM* (SS) | 5.41 | 4.97 | 4.97 | 4.24 | 4.50 | 4.97 | 5.20 | |
| Reading | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 536.16 | 536.12 | 534.87 | 535.29 | 534.09 | 532.09 | 524.26 | |
| | *SD* | 18.52 | 20.85 | 21.70 | 23.62 | 27.65 | 19.59 | 25.36 | |
| | $r_{cc}$ | 0.95 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 |
| | *SEM* (*W*) | 4.14 | 4.66 | 4.85 | 4.72 | 5.53 | 3.92 | 5.07 | |
| | *SEM* (SS) | 3.35 | 3.35 | 3.35 | 3.00 | 3.00 | 3.00 | 3.00 | |
| Broad Reading | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 542.88 | 542.83 | 538.94 | 539.77 | 537.40 | 532.21 | 522.41 | |
| | *SD* | 20.91 | 23.20 | 25.15 | 26.71 | 26.38 | 21.30 | 27.25 | |
| | $r_{cc}$ | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | 4.18 | 4.64 | 4.36 | 4.63 | 4.57 | 3.69 | 4.72 | |
| | *SEM* (SS) | 3.00 | 3.00 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | |
| Basic Reading Skills | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 529.28 | 529.07 | 527.14 | 526.07 | 524.87 | 522.89 | 517.12 | |
| | *SD* | 17.33 | 18.89 | 19.76 | 22.62 | 24.83 | 19.18 | 22.64 | |
| | $r_{cc}$ | 0.94 | 0.94 | 0.95 | 0.97 | 0.97 | 0.96 | 0.96 | 0.95 |
| | *SEM* (*W*) | 4.25 | 4.63 | 4.42 | 3.92 | 4.30 | 3.84 | 4.53 | |
| | *SEM* (SS) | 3.67 | 3.67 | 3.35 | 2.60 | 2.60 | 3.00 | 3.00 | |
| Reading Comprehension | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 519.41 | 518.41 | 517.00 | 516.96 | 516.46 | 514.03 | 507.05 | |
| | *SD* | 12.77 | 14.41 | 14.66 | 15.46 | 15.62 | 13.44 | 18.52 | |
| | $r_{cc}$ | 0.93 | 0.93 | 0.94 | 0.93 | 0.93 | 0.94 | 0.94 | 0.93 |
| | *SEM* (*W*) | 3.38 | 3.81 | 3.59 | 4.09 | 4.13 | 3.29 | 4.54 | |
| | *SEM* (SS) | 3.97 | 3.97 | 3.67 | 3.97 | 3.97 | 3.67 | 3.67 | |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Reading Comprehension–Extended | *n* | — | — | — | 147.00 | 289.00 | 308.00 | 335.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 438.70 | 455.80 | 474.20 | 486.06 | 492.87 | 498.21 |
| | *SD* | — | — | — | 18.41 | 18.43 | 17.35 | 14.62 | 12.56 | 13.86 |
| | $r_{cc}$ | — | — | — | 0.99 | 0.99 | 0.98 | 0.98 | 0.97 | 0.97 |
| | *SEM* (*W*) | — | — | — | 1.84 | 1.84 | 2.45 | 2.07 | 2.17 | 2.40 |
| | *SEM* (SS) | — | — | — | 1.50 | 1.50 | 2.12 | 2.12 | 2.60 | 2.60 |
| Reading Fluency | *n* | — | — | — | 101.00 | 259.00 | 300.00 | 333.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 411.10 | 429.44 | 454.92 | 475.52 | 487.73 | 497.17 |
| | *SD* | — | — | — | 29.27 | 26.77 | 28.15 | 26.89 | 24.98 | 27.13 |
| | $r_{cc}$ | — | — | — | 0.97 | 0.97 | 0.96 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | — | — | — | 5.07 | 4.64 | 5.63 | 5.38 | 5.00 | 5.43 |
| | *SEM* (SS) | — | — | — | 2.60 | 2.60 | 3.00 | 3.00 | 3.00 | 3.00 |
| Reading Rate | *n* | — | — | — | 90.00 | 248.00 | 293.00 | 332.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 391.93 | 405.33 | 436.14 | 460.83 | 478.54 | 492.87 |
| | *SD* | — | — | — | 35.99 | 32.30 | 35.19 | 37.44 | 34.50 | 35.91 |
| | $r_{cc}$ | — | — | — | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | — | — | — | 7.20 | 6.46 | 7.04 | 7.49 | 6.90 | 7.18 |
| | *SEM* (SS) | — | — | — | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Mathematics | *n* | — | — | — | 188.00 | 307.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 416.81 | 437.80 | 458.79 | 477.30 | 489.92 | 499.29 |
| | *SD* | — | — | — | 19.89 | 21.60 | 21.14 | 20.26 | 16.83 | 18.14 |
| | $r_{cc}$ | — | — | — | 0.96 | 0.96 | 0.96 | 0.96 | 0.94 | 0.94 |
| | *SEM* (*W*) | — | — | — | 3.98 | 4.32 | 4.23 | 4.05 | 4.12 | 4.44 |
| | *SEM* (SS) | — | — | — | 3.00 | 3.00 | 3.00 | 3.00 | 3.67 | 3.67 |
| Broad Mathematics | *n* | — | — | — | 147.00 | 293.00 | 308.00 | 335.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 419.46 | 436.83 | 458.25 | 478.01 | 491.05 | 501.01 |
| | *SD* | — | — | — | 19.48 | 21.04 | 22.07 | 21.00 | 18.40 | 19.35 |
| | $r_{cc}$ | — | — | — | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | — | — | — | 3.37 | 3.64 | 3.82 | 3.64 | 3.19 | 3.35 |
| | *SEM* (SS) | — | — | — | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 |
| Math Calculation Skills | *n* | — | — | — | 147.00 | 293.00 | 308.00 | 335.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 411.74 | 430.41 | 454.87 | 476.50 | 490.73 | 501.64 |
| | *SD* | — | — | — | 23.13 | 25.04 | 25.25 | 24.07 | 21.21 | 21.97 |
| | $r_{cc}$ | — | — | — | 0.96 | 0.96 | 0.97 | 0.97 | 0.96 | 0.96 |
| | *SEM* (*W*) | — | — | — | 4.63 | 5.01 | 4.37 | 4.17 | 4.24 | 4.39 |
| | *SEM* (SS) | — | — | — | 3.00 | 3.00 | 2.60 | 2.60 | 3.00 | 3.00 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Reading Comprehension–Extended | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 504.11 | 505.71 | 507.86 | 511.90 | 512.15 | 514.98 | 515.75 | 514.53 | 519.03 |
| | *SD* | 11.76 | 10.89 | 12.39 | 12.48 | 11.72 | 13.08 | 12.56 | 13.10 | 13.95 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.96 | 0.93 | 0.93 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 2.35 | 2.18 | 2.48 | 2.50 | 3.10 | 3.46 | 2.81 | 2.93 | 3.12 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 3.00 | 3.97 | 3.97 | 3.35 | 3.35 | 3.35 |
| Reading Fluency | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 509.12 | 513.65 | 518.29 | 525.94 | 526.44 | 532.07 | 535.74 | 531.24 | 538.60 |
| | *SD* | 22.72 | 22.27 | 22.37 | 23.18 | 21.32 | 23.06 | 22.01 | 23.38 | 23.96 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 4.54 | 4.45 | 4.47 | 4.64 | 4.26 | 4.61 | 4.40 | 4.68 | 4.79 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Reading Rate | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 508.43 | 514.87 | 520.15 | 530.47 | 531.50 | 539.85 | 542.71 | 536.95 | 547.18 |
| | *SD* | 30.52 | 31.58 | 29.63 | 30.64 | 28.64 | 30.52 | 28.01 | 30.02 | 30.75 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 6.10 | 6.32 | 5.93 | 6.13 | 5.73 | 6.10 | 5.60 | 6.00 | 6.15 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Mathematics | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 507.96 | 511.31 | 516.01 | 522.10 | 523.12 | 527.06 | 528.19 | 524.89 | 531.55 |
| | *SD* | 16.43 | 16.54 | 17.97 | 19.46 | 18.49 | 20.25 | 19.99 | 20.65 | 21.51 |
| | $r_{cc}$ | 0.93 | 0.93 | 0.94 | 0.94 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 4.35 | 4.38 | 4.40 | 4.77 | 3.70 | 4.05 | 4.00 | 4.13 | 4.30 |
| | *SEM* (SS) | 3.97 | 3.97 | 3.67 | 3.67 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Broad Mathematics | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 510.21 | 514.35 | 519.11 | 525.42 | 526.62 | 530.64 | 532.32 | 529.22 | 535.49 |
| | *SD* | 17.12 | 17.67 | 18.84 | 19.97 | 17.73 | 19.88 | 19.83 | 20.57 | 20.84 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 |
| | *SEM* (*W*) | 3.42 | 3.53 | 3.77 | 3.99 | 3.07 | 3.44 | 2.80 | 2.91 | 2.95 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 3.00 | 2.60 | 2.60 | 2.12 | 2.12 | 2.12 |
| Math Calculation Skills | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 511.56 | 516.85 | 522.30 | 528.53 | 530.23 | 534.03 | 536.11 | 532.99 | 538.91 |
| | *SD* | 19.33 | 19.87 | 21.21 | 22.19 | 19.28 | 21.37 | 21.87 | 22.83 | 22.30 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.95 | 0.95 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | 3.87 | 3.97 | 4.74 | 4.96 | 3.34 | 3.70 | 3.79 | 3.95 | 3.86 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.35 | 3.35 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| Reading Comprehension–Extended | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 521.34 | 520.59 | 519.72 | 520.32 | 519.87 | 517.51 | 510.93 | |
| | *SD* | 12.49 | 13.95 | 14.82 | 15.52 | 15.98 | 13.57 | 18.01 | |
| | $r_{cc}$ | 0.93 | 0.94 | 0.96 | 0.94 | 0.94 | 0.93 | 0.93 | 0.96 |
| | *SEM* (*W*) | 3.31 | 3.42 | 2.96 | 3.80 | 3.91 | 3.59 | 4.77 | |
| | *SEM* (SS) | 3.97 | 3.67 | 3.00 | 3.67 | 3.67 | 3.97 | 3.97 | |
| Reading Fluency | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 542.48 | 542.01 | 536.96 | 537.69 | 534.21 | 527.95 | 518.89 | |
| | *SD* | 22.88 | 24.04 | 27.00 | 28.09 | 26.91 | 21.66 | 28.11 | |
| | $r_{cc}$ | 0.96 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 4.58 | 5.38 | 6.04 | 5.62 | 5.38 | 4.33 | 5.62 | |
| | *SEM* (SS) | 3.00 | 3.35 | 3.35 | 3.00 | 3.00 | 3.00 | 3.00 | |
| Reading Rate | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 116.00 | |
| | *M* | 550.50 | 551.12 | 542.38 | 544.01 | 536.57 | 527.56 | 514.78 | |
| | *SD* | 30.28 | 31.79 | 33.51 | 36.68 | 34.49 | 29.15 | 34.91 | |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 6.06 | 6.36 | 6.70 | 7.34 | 6.90 | 5.83 | 6.98 | |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | |
| Mathematics | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 532.43 | 529.46 | 525.36 | 525.60 | 522.33 | 521.02 | 515.01 | |
| | *SD* | 19.49 | 20.54 | 21.38 | 20.62 | 18.54 | 17.66 | 25.19 | |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.96 |
| | *SEM* (*W*) | 3.90 | 4.11 | 4.28 | 4.12 | 3.71 | 3.06 | 4.36 | |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 2.60 | 2.60 | |
| Broad Mathematics | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 536.55 | 534.77 | 531.19 | 531.45 | 528.08 | 524.87 | 518.50 | |
| | *SD* | 19.09 | 20.75 | 21.45 | 21.29 | 19.40 | 16.93 | 24.20 | |
| | $r_{cc}$ | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.97 |
| | *SEM* (*W*) | 3.31 | 3.59 | 3.72 | 3.69 | 3.36 | 2.39 | 3.42 | |
| | *SEM* (SS) | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | 2.12 | 2.12 | |
| Math Calculation Skills | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 539.41 | 537.82 | 534.01 | 533.76 | 530.73 | 526.05 | 519.64 | |
| | *SD* | 20.67 | 22.81 | 23.51 | 23.72 | 21.58 | 18.37 | 26.05 | |
| | $r_{cc}$ | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | 4.13 | 4.56 | 4.07 | 4.11 | 3.74 | 3.18 | 4.51 | |
| | *SEM* (SS) | 3.00 | 3.00 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Math Problem Solving | *n* | — | — | — | 196.00 | 307.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 440.38 | 454.67 | 468.77 | 481.41 | 491.93 | 498.89 |
| | *SD* | — | — | — | 15.89 | 16.38 | 16.59 | 16.72 | 15.33 | 16.18 |
| | $r_{cc}$ | — | — | — | 0.91 | 0.91 | 0.95 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | — | — | — | 4.77 | 4.91 | 3.71 | 3.74 | 3.43 | 3.62 |
| | *SEM* (SS) | — | — | — | 4.50 | 4.50 | 3.35 | 3.35 | 3.35 | 3.35 |
| Written Language | *n* | — | — | 222.00 | 204.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 365.85 | 404.30 | 439.74 | 464.87 | 481.87 | 490.32 | 498.62 |
| | *SD* | — | — | 29.91 | 34.03 | 27.41 | 24.68 | 21.05 | 17.12 | 19.79 |
| | $r_{cc}$ | — | — | 0.94 | 0.94 | 0.94 | 0.95 | 0.95 | 0.94 | 0.94 |
| | *SEM* (*W*) | — | — | 7.33 | 8.34 | 6.71 | 5.52 | 4.71 | 4.19 | 4.85 |
| | *SEM* (SS) | — | — | 3.67 | 3.67 | 3.67 | 3.35 | 3.35 | 3.67 | 3.67 |
| Broad Written Language | *n* | — | — | — | 143.00 | 291.00 | 307.00 | 335.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 426.91 | 447.84 | 468.56 | 483.60 | 491.58 | 498.59 |
| | *SD* | — | — | — | 23.11 | 21.35 | 20.77 | 17.87 | 14.87 | 16.96 |
| | $r_{cc}$ | — | — | — | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | — | — | — | 5.17 | 4.77 | 4.64 | 4.00 | 3.33 | 3.79 |
| | *SEM* (SS) | — | — | — | 3.35 | 3.35 | 3.35 | 3.35 | 3.35 | 3.35 |
| Basic Writing Skills | *n* | — | — | — | — | — | 293.00 | 333.00 | 306.00 | 313.00 |
| | *M* | — | — | — | — | — | 467.09 | 480.12 | 490.49 | 498.67 |
| | *SD* | — | — | — | — | — | 18.73 | 19.77 | 18.21 | 19.07 |
| | $r_{cc}$ | — | — | — | — | — | 0.95 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | — | — | — | — | — | 4.19 | 4.42 | 4.07 | 4.26 |
| | *SEM* (SS) | — | — | — | — | — | 3.35 | 3.35 | 3.35 | 3.35 |
| Written Expression | *n* | — | — | — | 143.00 | 291.00 | 307.00 | 335.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 429.37 | 451.74 | 471.54 | 485.66 | 492.05 | 498.17 |
| | *SD* | — | — | — | 25.45 | 22.87 | 21.40 | 16.71 | 13.46 | 15.61 |
| | $r_{cc}$ | — | — | — | 0.92 | 0.92 | 0.92 | 0.92 | 0.91 | 0.91 |
| | *SEM* (*W*) | — | — | — | 7.20 | 6.47 | 6.05 | 4.73 | 4.04 | 4.68 |
| | *SEM* (SS) | — | — | — | 4.24 | 4.24 | 4.24 | 4.24 | 4.50 | 4.50 |
| Academic Skills | *n* | — | — | — | 188.00 | 307.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 400.39 | 428.38 | 456.48 | 476.55 | 488.79 | 498.55 |
| | *SD* | — | — | — | 27.57 | 26.20 | 24.62 | 23.10 | 19.53 | 21.59 |
| | $r_{cc}$ | — | — | — | 0.98 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 |
| | *SEM* (*W*) | — | — | — | 3.90 | 3.71 | 3.48 | 3.27 | 3.38 | 3.74 |
| | *SEM* (SS) | — | — | — | 2.12 | 2.12 | 2.12 | 2.12 | 2.60 | 2.60 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Math Problem Solving | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 506.29 | 508.42 | 511.10 | 516.74 | 517.16 | 521.01 | 521.98 | 518.03 | 524.80 |
| | *SD* | 15.12 | 15.80 | 16.55 | 16.70 | 16.52 | 17.64 | 16.83 | 17.38 | 18.86 |
| | $r_{cc}$ | 0.93 | 0.93 | 0.95 | 0.95 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 4.00 | 4.18 | 3.70 | 3.73 | 4.05 | 4.32 | 3.76 | 3.89 | 4.22 |
| | *SEM* (SS) | 3.97 | 3.97 | 3.35 | 3.35 | 3.67 | 3.67 | 3.35 | 3.35 | 3.35 |
| Written Language | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 506.41 | 510.14 | 513.83 | 517.88 | 519.74 | 522.64 | 524.04 | 522.04 | 526.43 |
| | *SD* | 15.75 | 16.20 | 16.35 | 16.90 | 16.62 | 16.60 | 17.23 | 16.75 | 17.53 |
| | $r_{cc}$ | 0.94 | 0.94 | 0.93 | 0.93 | 0.94 | 0.94 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 3.86 | 3.97 | 4.33 | 4.47 | 4.07 | 4.07 | 4.56 | 4.43 | 4.64 |
| | *SEM* (SS) | 3.67 | 3.67 | 3.97 | 3.97 | 3.67 | 3.67 | 3.97 | 3.97 | 3.97 |
| Broad Written Language | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 505.44 | 508.79 | 512.23 | 515.97 | 517.20 | 520.02 | 521.43 | 519.27 | 522.89 |
| | *SD* | 13.74 | 13.67 | 14.01 | 14.45 | 13.85 | 14.13 | 14.07 | 13.77 | 14.61 |
| | $r_{cc}$ | 0.95 | 0.95 | 0.94 | 0.94 | 0.95 | 0.95 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 3.07 | 3.06 | 3.43 | 3.54 | 3.10 | 3.16 | 3.45 | 3.37 | 3.58 |
| | *SEM* (SS) | 3.35 | 3.35 | 3.67 | 3.67 | 3.35 | 3.35 | 3.67 | 3.67 | 3.67 |
| Basic Writing Skills | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 506.97 | 510.96 | 514.89 | 519.76 | 521.19 | 525.21 | 527.00 | 524.91 | 530.44 |
| | *SD* | 16.75 | 16.70 | 16.97 | 18.97 | 17.35 | 18.23 | 18.36 | 18.98 | 18.74 |
| | $r_{cc}$ | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 4.10 | 4.09 | 4.16 | 4.65 | 4.25 | 4.46 | 4.11 | 4.24 | 4.19 |
| | *SEM* (SS) | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.35 | 3.35 | 3.35 |
| Written Expression | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 503.39 | 506.01 | 509.05 | 512.14 | 512.85 | 514.93 | 516.14 | 513.95 | 516.74 |
| | *SD* | 13.17 | 12.56 | 13.07 | 12.85 | 12.67 | 13.20 | 12.69 | 12.38 | 13.28 |
| | $r_{cc}$ | 0.91 | 0.91 | 0.91 | 0.91 | 0.92 | 0.92 | 0.91 | 0.91 | 0.91 |
| | *SEM* (*W*) | 3.95 | 3.77 | 3.92 | 3.86 | 3.58 | 3.73 | 3.81 | 3.71 | 3.98 |
| | *SEM* (SS) | 4.50 | 4.50 | 4.50 | 4.50 | 4.24 | 4.24 | 4.50 | 4.50 | 4.50 |
| Academic Skills | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 508.50 | 513.37 | 518.20 | 524.01 | 525.93 | 529.79 | 531.70 | 529.23 | 535.04 |
| | *SD* | 17.53 | 17.39 | 18.48 | 20.09 | 18.49 | 18.87 | 20.06 | 19.67 | 20.52 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.95 | 0.95 | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | 3.51 | 3.48 | 4.13 | 4.49 | 3.70 | 3.77 | 3.47 | 3.41 | 3.55 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.35 | 3.35 | 3.00 | 3.00 | 2.60 | 2.60 | 2.60 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| Math Problem Solving | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 526.15 | 523.66 | 520.46 | 520.64 | 516.98 | 515.27 | 508.71 | |
| | *SD* | 17.10 | 18.44 | 19.64 | 17.71 | 18.59 | 16.84 | 23.53 | |
| | $r_{cc}$ | 0.95 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 |
| | *SEM* (*W*) | 3.82 | 4.12 | 4.39 | 3.54 | 3.72 | 3.37 | 4.71 | |
| | *SEM* (SS) | 3.35 | 3.35 | 3.35 | 3.00 | 3.00 | 3.00 | 3.00 | |
| Written Language | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 529.21 | 528.29 | 525.96 | 525.63 | 523.47 | 521.48 | 514.07 | |
| | *SD* | 15.74 | 17.01 | 18.86 | 20.61 | 24.13 | 17.96 | 21.84 | |
| | $r_{cc}$ | 0.94 | 0.93 | 0.94 | 0.95 | 0.95 | 0.96 | 0.96 | 0.94 |
| | *SEM* (*W*) | 3.86 | 4.50 | 4.62 | 4.61 | 5.40 | 3.59 | 4.37 | |
| | *SEM* (SS) | 3.67 | 3.97 | 3.67 | 3.35 | 3.35 | 3.00 | 3.00 | |
| Broad Written Language | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 525.30 | 524.31 | 521.48 | 520.72 | 519.02 | 515.61 | 509.35 | |
| | *SD* | 13.22 | 14.24 | 15.87 | 17.75 | 17.52 | 14.91 | 18.64 | |
| | $r_{cc}$ | 0.95 | 0.94 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 |
| | *SEM* (*W*) | 2.96 | 3.49 | 3.55 | 3.55 | 3.50 | 2.98 | 3.73 | |
| | *SEM* (SS) | 3.35 | 3.67 | 3.35 | 3.00 | 3.00 | 3.00 | 3.00 | |
| Basic Writing Skills | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 534.64 | 534.21 | 532.46 | 532.59 | 532.67 | 529.77 | 523.92 | |
| | *SD* | 17.35 | 18.69 | 20.87 | 21.91 | 22.02 | 18.52 | 22.14 | |
| | $r_{cc}$ | 0.95 | 0.94 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.95 |
| | *SEM* (*W*) | 3.88 | 4.58 | 4.17 | 4.38 | 4.40 | 3.21 | 3.83 | |
| | *SEM* (SS) | 3.35 | 3.67 | 3.00 | 3.00 | 3.00 | 2.60 | 2.60 | |
| Written Expression | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 518.17 | 516.94 | 514.04 | 512.52 | 510.88 | 507.35 | 500.81 | |
| | *SD* | 12.05 | 13.00 | 13.80 | 15.76 | 15.40 | 13.58 | 17.89 | |
| | $r_{cc}$ | 0.92 | 0.91 | 0.92 | 0.92 | 0.92 | 0.94 | 0.94 | 0.92 |
| | *SEM* (*W*) | 3.41 | 3.90 | 3.90 | 4.46 | 4.36 | 3.33 | 4.38 | |
| | *SEM* (SS) | 4.24 | 4.50 | 4.24 | 4.24 | 4.24 | 3.67 | 3.67 | |
| Academic Skills | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 538.20 | 537.01 | 533.90 | 534.11 | 532.61 | 529.89 | 524.22 | |
| | *SD* | 18.49 | 20.52 | 22.10 | 23.82 | 22.57 | 19.22 | 24.83 | |
| | $r_{cc}$ | 0.96 | 0.97 | 0.97 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | 3.70 | 3.55 | 3.83 | 3.37 | 3.19 | 3.33 | 4.30 | |
| | *SEM* (SS) | 3.00 | 2.60 | 2.60 | 2.12 | 2.12 | 2.60 | 2.60 | |

**Table C-1.** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Academic Applications | *n* | — | — | 222.00 | 204.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | 378.19 | 409.65 | 442.95 | 466.71 | 482.93 | 491.04 | 498.97 |
| | *SD* | — | — | 23.99 | 29.94 | 24.59 | 21.80 | 18.07 | 13.82 | 16.21 |
| | $r_{cc}$ | — | — | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 | 0.95 |
| | *SEM* (*W*) | — | — | 4.80 | 5.99 | 4.92 | 4.36 | 3.61 | 3.09 | 3.62 |
| | *SEM* (SS) | — | — | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.35 | 3.35 |
| Academic Fluency | *n* | — | — | — | 95.00 | 254.00 | 298.00 | 333.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 419.61 | 434.09 | 456.87 | 477.27 | 489.86 | 499.83 |
| | *SD* | — | — | — | 25.20 | 23.34 | 25.15 | 24.96 | 23.22 | 24.41 |
| | $r_{cc}$ | — | — | — | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | — | — | — | 4.36 | 4.04 | 4.36 | 4.32 | 4.02 | 4.23 |
| | *SEM* (SS) | — | — | — | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 |
| Academic Knowledge | *n* | 166.00 | 202.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 409.39 | 425.08 | 443.74 | 456.90 | 469.42 | 479.24 | 489.19 | 496.13 | 501.72 |
| | *SD* | 15.14 | 15.88 | 17.94 | 17.11 | 14.77 | 16.12 | 14.64 | 14.19 | 14.41 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.92 | 0.92 | 0.91 | 0.91 | 0.90 | 0.90 |
| | *SEM* (*W*) | 3.03 | 3.18 | 3.59 | 4.84 | 4.18 | 4.84 | 4.39 | 4.49 | 4.56 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 4.24 | 4.24 | 4.50 | 4.50 | 4.74 | 4.74 |
| Phoneme-Grapheme Knowledge | *n* | — | — | — | 199.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 439.29 | 461.14 | 478.07 | 487.34 | 491.91 | 496.26 |
| | *SD* | — | — | — | 21.73 | 19.67 | 16.37 | 14.54 | 12.83 | 13.51 |
| | $r_{cc}$ | — | — | — | 0.98 | 0.98 | 0.97 | 0.97 | 0.95 | 0.95 |
| | *SEM* (*W*) | — | — | — | 3.07 | 2.78 | 2.84 | 2.52 | 2.87 | 3.02 |
| | *SEM* (SS) | — | — | — | 2.12 | 2.12 | 2.60 | 2.60 | 3.35 | 3.35 |
| Brief Achievement | *n* | 155.00 | 203.00 | 223.00 | 205.00 | 308.00 | 310.00 | 336.00 | 306.00 | 314.00 |
| | *M* | 332.21 | 355.63 | 381.44 | 407.12 | 435.06 | 460.50 | 478.88 | 489.97 | 498.84 |
| | *SD* | 19.61 | 22.22 | 22.39 | 26.29 | 23.55 | 22.62 | 21.56 | 18.68 | 20.14 |
| | $r_{cc}$ | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 |
| | *SEM* (*W*) | 2.77 | 3.14 | 3.17 | 3.72 | 3.33 | 3.20 | 3.05 | 3.23 | 3.49 |
| | *SEM* (SS) | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.60 | 2.60 |
| Broad Achievement | *n* | — | — | — | 95.00 | 254.00 | 298.00 | 333.00 | 306.00 | 314.00 |
| | *M* | — | — | — | 419.87 | 439.53 | 461.35 | 479.30 | 489.90 | 499.12 |
| | *SD* | — | — | — | 25.04 | 20.10 | 21.00 | 20.11 | 17.44 | 19.34 |
| | $r_{cc}$ | — | — | — | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| | *SEM* (*W*) | — | — | — | 2.50 | 2.01 | 2.10 | 2.01 | 1.74 | 1.93 |
| | *SEM* (SS) | — | — | — | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |

***Table C-1.*** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Academic Applications | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 505.86 | 508.08 | 511.06 | 516.15 | 516.86 | 520.28 | 521.20 | 519.07 | 524.49 |
| | *SD* | 13.82 | 13.49 | 14.52 | 14.64 | 14.86 | 16.18 | 15.41 | 16.06 | 17.39 |
| | $r_{cc}$ | 0.93 | 0.93 | 0.94 | 0.94 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 3.66 | 3.57 | 3.56 | 3.59 | 3.32 | 3.62 | 3.08 | 3.21 | 3.48 |
| | *SEM* (SS) | 3.97 | 3.97 | 3.67 | 3.67 | 3.35 | 3.35 | 3.00 | 3.00 | 3.00 |
| Academic Fluency | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 510.68 | 515.33 | 519.98 | 526.64 | 527.35 | 532.24 | 535.06 | 531.33 | 537.26 |
| | *SD* | 20.58 | 20.81 | 20.89 | 21.24 | 18.47 | 20.20 | 20.04 | 20.48 | 21.23 |
| | $r_{cc}$ | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 3.56 | 3.60 | 3.62 | 3.68 | 3.20 | 3.50 | 4.01 | 4.10 | 4.25 |
| | *SEM* (SS) | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | 3.00 | 3.00 | 3.00 |
| Academic Knowledge | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 507.35 | 510.69 | 514.10 | 518.41 | 518.67 | 521.19 | 523.25 | 521.65 | 526.78 |
| | *SD* | 13.84 | 14.58 | 14.24 | 15.47 | 15.90 | 15.75 | 15.87 | 16.31 | 15.62 |
| | $r_{cc}$ | 0.91 | 0.91 | 0.92 | 0.92 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 4.15 | 4.37 | 4.03 | 4.38 | 3.90 | 3.86 | 3.55 | 3.65 | 3.49 |
| | *SEM* (SS) | 4.50 | 4.50 | 4.24 | 4.24 | 3.67 | 3.67 | 3.35 | 3.35 | 3.35 |
| Phoneme-Grapheme Knowledge | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 500.71 | 502.50 | 504.10 | 507.39 | 508.85 | 510.00 | 511.38 | 509.06 | 511.58 |
| | *SD* | 11.80 | 12.30 | 12.37 | 13.02 | 12.60 | 12.58 | 13.02 | 13.59 | 13.89 |
| | $r_{cc}$ | 0.93 | 0.93 | 0.92 | 0.92 | 0.91 | 0.91 | 0.93 | 0.93 | 0.93 |
| | *SEM* (*W*) | 3.12 | 3.25 | 3.50 | 3.68 | 3.78 | 3.77 | 3.44 | 3.60 | 3.68 |
| | *SEM* (SS) | 3.97 | 3.97 | 4.24 | 4.24 | 4.50 | 4.50 | 3.97 | 3.97 | 3.97 |
| Brief Achievement | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 508.21 | 512.08 | 516.01 | 522.07 | 523.45 | 527.67 | 529.39 | 527.08 | 533.11 |
| | *SD* | 16.75 | 16.86 | 17.56 | 18.68 | 17.69 | 18.12 | 18.70 | 18.73 | 19.62 |
| | $r_{cc}$ | 0.96 | 0.96 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| | *SEM* (*W*) | 3.35 | 3.37 | 3.93 | 4.18 | 3.54 | 3.62 | 3.74 | 3.75 | 3.92 |
| | *SEM* (SS) | 3.00 | 3.00 | 3.35 | 3.35 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Broad Achievement | *n* | 329.00 | 317.00 | 307.00 | 299.00 | 277.00 | 284.00 | 254.00 | 276.00 | 295.00 |
| | *M* | 508.34 | 512.26 | 516.41 | 522.27 | 523.38 | 527.44 | 529.32 | 526.54 | 532.26 |
| | *SD* | 15.68 | 15.67 | 16.63 | 17.27 | 15.76 | 17.03 | 16.86 | 17.11 | 18.07 |
| | $r_{cc}$ | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.99 | 0.99 | 0.99 |
| | *SEM* (*W*) | 2.22 | 2.22 | 2.35 | 2.44 | 2.23 | 2.41 | 1.69 | 1.71 | 1.81 |
| | *SEM* (SS) | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 1.50 | 1.50 | 1.50 |

**Table C-1.** *(cont.)*
*WJ IV Cluster Summary and Reliability Statistics*

| Cluster | Statistic | AGE 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
|---|---|---|---|---|---|---|---|---|---|
| Academic Applications | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 526.99 | 525.57 | 523.56 | 523.57 | 521.12 | 519.84 | 511.33 | |
| | *SD* | 15.13 | 16.63 | 17.41 | 17.70 | 21.13 | 15.24 | 21.29 | |
| | $r_{cc}$ | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.96 |
| | *SEM* (*W*) | 3.03 | 3.33 | 3.48 | 3.54 | 4.23 | 2.64 | 3.69 | |
| | *SEM* (SS) | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 2.60 | 2.60 | |
| Academic Fluency | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 539.53 | 539.33 | 534.15 | 534.27 | 529.88 | 522.97 | 514.70 | |
| | *SD* | 19.91 | 21.42 | 23.33 | 24.54 | 22.93 | 18.81 | 24.54 | |
| | $r_{cc}$ | 0.96 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | 3.98 | 3.71 | 4.04 | 4.25 | 3.97 | 3.26 | 4.25 | |
| | *SEM* (SS) | 3.00 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | |
| Academic Knowledge | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 529.63 | 528.35 | 529.14 | 530.01 | 529.17 | 527.12 | 521.63 | |
| | *SD* | 16.47 | 17.16 | 18.21 | 18.40 | 17.49 | 15.57 | 21.42 | |
| | $r_{cc}$ | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 | 0.95 | 0.95 |
| | *SEM* (*W*) | 3.68 | 3.43 | 3.64 | 3.68 | 3.50 | 3.48 | 4.79 | |
| | *SEM* (SS) | 3.35 | 3.00 | 3.00 | 3.00 | 3.00 | 3.35 | 3.35 | |
| Phoneme-Grapheme Knowledge | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 514.48 | 513.01 | 510.62 | 507.85 | 505.74 | 503.79 | 498.02 | |
| | *SD* | 13.03 | 13.98 | 14.34 | 16.59 | 18.61 | 14.43 | 16.80 | |
| | $r_{cc}$ | 0.92 | 0.93 | 0.94 | 0.96 | 0.96 | 0.94 | 0.94 | 0.94 |
| | *SEM* (*W*) | 3.68 | 3.70 | 3.51 | 3.32 | 3.72 | 3.54 | 4.12 | |
| | *SEM* (SS) | 4.24 | 3.97 | 3.67 | 3.00 | 3.00 | 3.67 | 3.67 | |
| Brief Achievement | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 164.00 | 132.00 | 117.00 | |
| | *M* | 537.13 | 536.47 | 534.04 | 534.95 | 532.00 | 530.89 | 525.03 | |
| | *SD* | 17.74 | 19.57 | 20.96 | 22.29 | 24.68 | 18.37 | 23.14 | |
| | $r_{cc}$ | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| | *SEM* (*W*) | 3.55 | 3.91 | 3.63 | 3.86 | 4.28 | 3.18 | 4.01 | |
| | *SEM* (SS) | 3.00 | 3.00 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 | |
| Broad Achievement | *n* | 759.00 | 492.00 | 462.00 | 274.00 | 163.00 | 132.00 | 117.00 | |
| | *M* | 534.91 | 533.97 | 530.54 | 530.65 | 528.17 | 524.23 | 516.75 | |
| | *SD* | 16.22 | 18.03 | 19.56 | 20.66 | 19.82 | 16.29 | 21.93 | |
| | $r_{cc}$ | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| | *SEM* (*W*) | 1.62 | 1.80 | 1.96 | 2.07 | 1.98 | 1.63 | 2.19 | |
| | *SEM* (SS) | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | |

*Appendix D*

# General Intellectual Ability Average (Smoothed) g Weights by Technical Age Groups

***Table D-1.***
*General Intellectual Ability Average (Smoothed)* g *Weights by Technical Age Groups*

| Test | CHC Domain | AGE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Oral Vocabulary | *Gc* | 0.16 | 0.16 | 0.16 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.18 |
| Number Series | *Gf* | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| Verbal Attention | *Gwm* | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 | 0.14 |
| Letter-Pattern Matching | *Gs* | 0.17 | 0.16 | 0.16 | 0.15 | 0.14 | 0.12 | 0.11 | 0.11 | 0.10 |
| Phonological Processing | *Ga* | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.17 |
| Story Recall | *Glr* | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |
| Visualization | *Gv* | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.09 | 0.10 | 0.10 | 0.11 |

| Test | CHC Domain | AGE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** |
| Oral Vocabulary | *Gc* | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| Number Series | *Gf* | 0.18 | 0.18 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Verbal Attention | *Gwm* | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| Letter-Pattern Matching | *Gs* | 0.10 | 0.10 | 0.10 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| Phonological Processing | *Ga* | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Story Recall | *Glr* | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| Visualization | *Gv* | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |

***Table D-1.*** *(cont.)*
*General Intellectual Ability*
*Average (Smoothed)* g *Weights*
*by Technical Age Groups*

| Test | CHC Domain | AGE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80+ | Median |
| Oral Vocabulary | *Gc* | 0.18 | 0.18 | 0.18 | 0.18 | 0.17 | 0.16 | 0.16 | 0.18 |
| Number Series | *Gf* | 0.16 | 0.16 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.17 |
| Verbal Attention | *Gwm* | 0.13 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | 0.15 | 0.14 |
| Letter-Pattern Matching | *Gs* | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| Phonological Processing | *Ga* | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 | 0.17 |
| Story Recall | *Glr* | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.13 | 0.12 |
| Visualization | *Gv* | 0.13 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |

# Appendix E

# Test Score Intercorrelations

**Table E-1.**
*Test Score Intercorrelations—Ages 3 Through 5 (n = 435)*

| Test | $n$[a] | Oral Vocabulary | Verbal Attention | Phonological Processing | Story Recall | Visualization | General Information | Concept Formation | Numbers Reversed | Number-Pattern Matching | Nonword Repetition | Visual-Auditory Learning | Picture Recognition | Memory for Words | Picture Vocabulary | Oral Comprehension | Segmentation | Rapid Picture Naming | Sentence Repetition | Understanding Directions | Sound Blending | Retrieval Fluency | Sound Awareness | Letter-Word Identification | Applied Problems | Spelling | Passage Comprehension | Science | Social Studies | Humanities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Oral Vocabulary** | 205 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Verbal Attention** | 541 | 0.48 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Phonological Processing** | 547 | 0.60 | 0.50 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Story Recall** | 631 | 0.40 | 0.38 | 0.29 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Visualization** | 630 | 0.27 | 0.12 | 0.27 | 0.36 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| **General Information** | 612 | 0.54 | 0.29 | 0.26 | 0.22 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| **Concept Formation** | 621 | 0.41 | 0.23 | 0.42 | 0.26 | 0.40 | 0.21 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| **Numbers Reversed** | 580 | 0.47 | 0.48 | 0.50 | 0.30 | 0.28 | 0.26 | 0.37 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| **Number-Pattern Matching** | 593 | 0.40 | 0.41 | 0.41 | 0.34 | 0.25 | 0.14 | 0.30 | 0.42 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| **Nonword Repetition** | 630 | 0.35 | 0.41 | 0.34 | 0.30 | 0.27 | 0.21 | 0.29 | 0.34 | 0.22 | 1.00 | | | | | | | | | | | | | | | | | | | |
| **Visual-Auditory Learning** | 631 | 0.42 | 0.22 | 0.37 | 0.35 | 0.42 | 0.14 | 0.44 | 0.36 | 0.23 | 0.21 | 1.00 | | | | | | | | | | | | | | | | | | |
| **Picture Recognition** | 631 | 0.31 | 0.22 | 0.22 | 0.38 | 0.46 | 0.22 | 0.27 | 0.33 | 0.32 | 0.32 | 0.39 | 1.00 | | | | | | | | | | | | | | | | | |
| **Memory for Words** | 626 | 0.41 | 0.52 | 0.47 | 0.36 | 0.32 | 0.15 | 0.31 | 0.42 | 0.21 | 0.45 | 0.33 | 0.32 | 1.00 | | | | | | | | | | | | | | | | |
| **Picture Vocabulary** | 631 | 0.53 | 0.29 | 0.30 | 0.39 | 0.29 | 0.65 | 0.19 | 0.23 | 0.18 | 0.25 | 0.26 | 0.29 | 0.24 | 1.00 | | | | | | | | | | | | | | | |
| **Oral Comprehension** | 630 | 0.59 | 0.38 | 0.39 | 0.45 | 0.25 | 0.51 | 0.30 | 0.35 | 0.39 | 0.28 | 0.31 | 0.46 | 0.28 | 0.63 | 1.00 | | | | | | | | | | | | | | |
| **Segmentation** | 601 | 0.47 | 0.33 | 0.59 | 0.37 | 0.39 | 0.20 | 0.35 | 0.41 | 0.43 | 0.29 | 0.41 | 0.30 | 0.39 | 0.18 | 0.31 | 1.00 | | | | | | | | | | | | | |
| **Rapid Picture Naming** | 631 | 0.36 | 0.34 | 0.33 | 0.18 | 0.10 | 0.15 | 0.30 | 0.25 | 0.45 | 0.30 | 0.27 | 0.44 | 0.31 | 0.39 | 0.41 | 0.27 | 1.00 | | | | | | | | | | | | |
| **Sentence Repetition** | 631 | 0.39 | 0.40 | 0.40 | 0.19 | 0.30 | 0.35 | 0.25 | 0.25 | 0.15 | 0.50 | 0.18 | 0.31 | 0.45 | 0.40 | 0.49 | 0.30 | 0.29 | 1.00 | | | | | | | | | | | |
| **Understanding Directions** | 631 | 0.46 | 0.37 | 0.35 | 0.41 | 0.40 | 0.30 | 0.35 | 0.32 | 0.30 | 0.40 | 0.35 | 0.44 | 0.35 | 0.47 | 0.53 | 0.40 | 0.45 | 0.49 | 1.00 | | | | | | | | | | |
| **Sound Blending** | 618 | 0.42 | 0.23 | 0.46 | 0.25 | 0.41 | 0.29 | 0.35 | 0.37 | 0.21 | 0.35 | 0.46 | 0.33 | 0.38 | 0.32 | 0.35 | 0.44 | 0.22 | 0.24 | 0.38 | 1.00 | | | | | | | | | |
| **Retrieval Fluency** | 631 | 0.46 | 0.41 | 0.46 | 0.36 | 0.18 | 0.18 | 0.19 | 0.29 | 0.37 | 0.21 | 0.18 | 0.39 | 0.47 | 0.35 | 0.39 | 0.27 | 0.47 | 0.28 | 0.30 | 0.20 | 1.00 | | | | | | | | |
| **Sound Awareness** | 608 | 0.53 | 0.50 | 0.63 | 0.46 | 0.40 | 0.34 | 0.38 | 0.48 | 0.40 | 0.39 | 0.39 | 0.40 | 0.39 | 0.33 | 0.48 | 0.49 | 0.31 | 0.41 | 0.46 | 0.52 | 0.36 | 1.00 | | | | | | | |
| **Letter-Word Identification** | 631 | 0.51 | 0.37 | 0.44 | 0.31 | 0.28 | 0.29 | 0.32 | 0.43 | 0.48 | 0.23 | 0.31 | 0.38 | 0.25 | 0.47 | 0.55 | 0.33 | 0.40 | 0.28 | 0.43 | 0.36 | 0.30 | 0.48 | 1.00 | | | | | | |
| **Applied Problems** | 631 | 0.57 | 0.35 | 0.39 | 0.36 | 0.50 | 0.44 | 0.46 | 0.44 | 0.43 | 0.20 | 0.36 | 0.36 | 0.30 | 0.48 | 0.52 | 0.30 | 0.22 | 0.33 | 0.46 | 0.38 | 0.31 | 0.45 | 0.61 | 1.00 | | | | | |
| **Spelling** | 631 | 0.45 | 0.47 | 0.47 | 0.38 | 0.36 | 0.35 | 0.31 | 0.46 | 0.54 | 0.38 | 0.30 | 0.36 | 0.33 | 0.41 | 0.49 | 0.34 | 0.28 | 0.45 | 0.36 | 0.34 | 0.33 | 0.48 | 0.72 | 0.59 | 1.00 | | | | |
| **Passage Comprehension** | 630 | 0.49 | 0.30 | 0.44 | 0.34 | 0.36 | 0.45 | 0.32 | 0.38 | 0.45 | 0.14 | 0.31 | 0.33 | 0.16 | 0.42 | 0.58 | 0.51 | 0.24 | 0.38 | 0.48 | 0.36 | 0.29 | 0.53 | 0.61 | 0.47 | 0.52 | 1.00 | | | |
| **Science** | 631 | 0.53 | 0.46 | 0.47 | 0.57 | 0.18 | 0.33 | 0.27 | 0.43 | 0.25 | 0.31 | 0.23 | 0.27 | 0.34 | 0.60 | 0.54 | 0.32 | 0.39 | 0.40 | 0.48 | 0.27 | 0.43 | 0.46 | 0.47 | 0.55 | 0.45 | 0.34 | 1.00 | | |
| **Social Studies** | 631 | 0.65 | 0.37 | 0.48 | 0.54 | 0.22 | 0.44 | 0.34 | 0.31 | 0.28 | 0.26 | 0.22 | 0.28 | 0.32 | 0.65 | 0.57 | 0.25 | 0.40 | 0.38 | 0.44 | 0.35 | 0.44 | 0.43 | 0.53 | 0.55 | 0.45 | 0.33 | 0.77 | 1.00 | |
| **Humanities** | 630 | 0.56 | 0.40 | 0.40 | 0.36 | 0.23 | 0.55 | 0.18 | 0.37 | 0.18 | 0.28 | 0.21 | 0.25 | 0.38 | 0.62 | 0.55 | 0.25 | 0.32 | 0.43 | 0.41 | 0.43 | 0.44 | 0.40 | 0.40 | 0.53 | 0.43 | 0.26 | 0.66 | 0.67 | 1.00 |

[a] Due to the smaller sample size for Oral Vocabulary scores, the expectation-maximization (EM) missing data imputation algorithm was used to calculate the correlation matrix.

## *Table E-2.*

*Test Score Intercorrelations—Ages 6 Through 8 (n = 825)*

| Test | Oral Vocabulary | Number Series | Verbal Attention | Letter-Pattern Matching | Phonological Processing | Story Recall | Visualization | General Information | Concept Formation | Numbers Reversed | Number-Pattern Matching | Nonword Repetition | Visual-Auditory Learning | Picture Recognition | Analysis-Synthesis | Object-Number Sequencing | Pair Cancellation | Memory for Words | Picture Vocabulary | Oral Comprehension | Segmentation | Rapid Picture Naming | Sentence Repetition | Understanding Directions | Sound Blending | Retrieval Fluency | Sound Awareness | Letter-Word Identification | Applied Problems | Spelling | Passage Comprehension | Calculation | Writing Samples | Word Attack | Oral Reading | Sentence Reading Fluency | Math Facts Fluency | Sentence Writing Fluency | Reading Recall | Number Matrices | Editing | Word Reading Fluency | Spelling of Sounds | Reading Vocabulary | Science | Social Studies | Humanities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oral Vocabulary | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Number Series | 0.44 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Verbal Attention | 0.41 | 0.43 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Letter-Pattern Matching | 0.36 | 0.42 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Phonological Processing | 0.59 | 0.49 | 0.48 | 0.40 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Story Recall | 0.42 | 0.41 | 0.36 | 0.24 | 0.37 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Visualization | 0.33 | 0.37 | 0.21 | 0.27 | 0.41 | 0.37 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| General Information | 0.65 | 0.18 | 0.25 | 0.19 | 0.36 | 0.25 | 0.28 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Concept Formation | 0.45 | 0.46 | 0.30 | 0.23 | 0.50 | 0.31 | 0.48 | 0.32 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Numbers Reversed | 0.36 | 0.43 | 0.46 | 0.47 | 0.42 | 0.27 | 0.34 | 0.25 | 0.39 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Number-Pattern Matching | 0.30 | 0.52 | 0.38 | 0.64 | 0.35 | 0.29 | 0.28 | 0.10 | 0.25 | 0.38 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nonword Repetition | 0.40 | 0.28 | 0.46 | 0.15 | 0.43 | 0.37 | 0.37 | 0.25 | 0.37 | 0.30 | 0.23 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Visual-Auditory Learning | 0.31 | 0.21 | 0.23 | 0.29 | 0.38 | 0.36 | 0.46 | 0.21 | 0.42 | 0.29 | 0.17 | 0.26 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Picture Recognition | 0.29 | 0.22 | 0.21 | 0.29 | 0.31 | 0.39 | 0.50 | 0.24 | 0.32 | 0.31 | 0.23 | 0.33 | 0.42 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Analysis-Synthesis | 0.36 | 0.43 | 0.38 | 0.37 | 0.37 | 0.43 | 0.46 | 0.27 | 0.48 | 0.40 | 0.34 | 0.21 | 0.38 | 0.40 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Object-Number Sequencing | 0.38 | 0.34 | 0.55 | 0.45 | 0.52 | 0.43 | 0.39 | 0.24 | 0.43 | 0.51 | 0.42 | 0.49 | 0.33 | 0.36 | 0.44 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pair Cancellation | 0.28 | 0.21 | 0.26 | 0.58 | 0.35 | 0.14 | 0.20 | 0.15 | 0.25 | 0.29 | 0.55 | 0.16 | 0.16 | 0.11 | 0.27 | 0.38 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Memory for Words | 0.35 | 0.26 | 0.47 | 0.19 | 0.50 | 0.38 | 0.38 | 0.22 | 0.36 | 0.40 | 0.25 | 0.44 | 0.32 | 0.31 | 0.40 | 0.51 | 0.17 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Picture Vocabulary | 0.65 | 0.22 | 0.25 | 0.20 | 0.44 | 0.35 | 0.31 | 0.63 | 0.33 | 0.20 | 0.10 | 0.28 | 0.28 | 0.25 | 0.17 | 0.27 | 0.16 | 0.24 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oral Comprehension | 0.59 | 0.37 | 0.44 | 0.11 | 0.45 | 0.46 | 0.34 | 0.47 | 0.38 | 0.30 | 0.29 | 0.35 | 0.29 | 0.45 | 0.29 | 0.36 | 0.18 | 0.29 | 0.62 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Segmentation | 0.44 | 0.42 | 0.36 | 0.27 | 0.63 | 0.39 | 0.45 | 0.25 | 0.44 | 0.33 | 0.34 | 0.43 | 0.42 | 0.37 | 0.41 | 0.41 | 0.20 | 0.42 | 0.23 | 0.34 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rapid Picture Naming | 0.31 | 0.20 | 0.35 | 0.31 | 0.30 | 0.16 | 0.16 | 0.19 | 0.32 | 0.28 | 0.33 | 0.30 | 0.20 | 0.30 | 0.17 | 0.41 | 0.37 | 0.28 | 0.37 | 0.36 | 0.17 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sentence Repetition | 0.47 | 0.18 | 0.42 | 0.16 | 0.48 | 0.26 | 0.32 | 0.31 | 0.33 | 0.26 | 0.12 | 0.49 | 0.24 | 0.30 | 0.14 | 0.36 | 0.21 | 0.46 | 0.43 | 0.51 | 0.33 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| Understanding Directions | 0.44 | 0.44 | 0.47 | 0.26 | 0.43 | 0.38 | 0.42 | 0.26 | 0.47 | 0.37 | 0.24 | 0.45 | 0.38 | 0.41 | 0.37 | 0.44 | 0.25 | 0.35 | 0.41 | 0.47 | 0.40 | 0.44 | 0.48 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| Sound Blending | 0.35 | 0.21 | 0.20 | 0.26 | 0.45 | 0.28 | 0.36 | 0.26 | 0.40 | 0.29 | 0.14 | 0.34 | 0.47 | 0.34 | 0.40 | 0.36 | 0.17 | 0.40 | 0.27 | 0.29 | 0.43 | 0.21 | 0.21 | 0.35 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| Retrieval Fluency | 0.42 | 0.24 | 0.32 | 0.30 | 0.49 | 0.29 | 0.22 | 0.23 | 0.26 | 0.28 | 0.36 | 0.18 | 0.19 | 0.30 | 0.37 | 0.45 | 0.33 | 0.40 | 0.39 | 0.37 | 0.27 | 0.44 | 0.27 | 0.29 | 0.22 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| Sound Awareness | 0.43 | 0.54 | 0.47 | 0.38 | 0.61 | 0.45 | 0.43 | 0.31 | 0.44 | 0.38 | 0.35 | 0.45 | 0.39 | 0.43 | 0.33 | 0.37 | 0.24 | 0.39 | 0.34 | 0.42 | 0.55 | 0.26 | 0.41 | 0.48 | 0.44 | 0.31 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| Letter-Word Identification | 0.54 | 0.64 | 0.44 | 0.39 | 0.52 | 0.27 | 0.32 | 0.36 | 0.37 | 0.37 | 0.50 | 0.35 | 0.27 | 0.32 | 0.24 | 0.22 | 0.25 | 0.28 | 0.42 | 0.53 | 0.43 | 0.30 | 0.41 | 0.40 | 0.28 | 0.29 | 0.59 | 1.00 | | | | | | | | | | | | | | | | | | | |
| Applied Problems | 0.54 | 0.67 | 0.37 | 0.37 | 0.46 | 0.35 | 0.54 | 0.39 | 0.52 | 0.43 | 0.40 | 0.23 | 0.35 | 0.32 | 0.45 | 0.38 | 0.31 | 0.30 | 0.40 | 0.51 | 0.41 | 0.16 | 0.37 | 0.43 | 0.31 | 0.32 | 0.44 | 0.58 | 1.00 | | | | | | | | | | | | | | | | | | |
| Spelling | 0.50 | 0.58 | 0.50 | 0.43 | 0.50 | 0.32 | 0.37 | 0.36 | 0.35 | 0.40 | 0.51 | 0.40 | 0.27 | 0.31 | 0.28 | 0.35 | 0.30 | 0.34 | 0.32 | 0.49 | 0.40 | 0.22 | 0.46 | 0.34 | 0.26 | 0.29 | 0.54 | 0.82 | 0.59 | 1.00 | | | | | | | | | | | | | | | | | |
| Passage Comprehension | 0.59 | 0.63 | 0.38 | 0.42 | 0.52 | 0.32 | 0.39 | 0.42 | 0.44 | 0.37 | 0.49 | 0.32 | 0.29 | 0.34 | 0.28 | 0.27 | 0.22 | 0.23 | 0.44 | 0.53 | 0.54 | 0.28 | 0.41 | 0.46 | 0.30 | 0.32 | 0.58 | 0.78 | 0.55 | 0.67 | 1.00 | | | | | | | | | | | | | | | | |
| Calculation | 0.48 | 0.69 | 0.35 | 0.52 | 0.49 | 0.37 | 0.39 | 0.26 | 0.41 | 0.40 | 0.59 | 0.19 | 0.28 | 0.16 | 0.37 | 0.37 | 0.41 | 0.24 | 0.28 | 0.29 | 0.38 | 0.22 | 0.29 | 0.34 | 0.24 | 0.34 | 0.42 | 0.62 | 0.72 | 0.64 | 0.60 | 1.00 | | | | | | | | | | | | | | | |
| Writing Samples | 0.37 | 0.62 | 0.37 | 0.38 | 0.43 | 0.48 | 0.28 | 0.16 | 0.28 | 0.29 | 0.49 | 0.32 | 0.25 | 0.35 | 0.31 | 0.22 | 0.13 | 0.23 | 0.26 | 0.37 | 0.45 | 0.21 | 0.22 | 0.33 | 0.27 | 0.27 | 0.54 | 0.68 | 0.42 | 0.58 | 0.69 | 0.52 | 1.00 | | | | | | | | | | | | | | |
| Word Attack | 0.46 | 0.61 | 0.42 | 0.26 | 0.52 | 0.33 | 0.37 | 0.21 | 0.38 | 0.34 | 0.33 | 0.42 | 0.33 | 0.37 | 0.29 | 0.24 | 0.13 | 0.32 | 0.39 | 0.50 | 0.49 | 0.31 | 0.41 | 0.47 | 0.35 | 0.29 | 0.60 | 0.77 | 0.45 | 0.66 | 0.68 | 0.47 | 0.66 | 1.00 | | | | | | | | | | | | | |
| Oral Reading | 0.48 | 0.49 | 0.37 | 0.38 | 0.50 | 0.25 | 0.38 | 0.37 | 0.34 | 0.39 | 0.43 | 0.41 | 0.28 | 0.21 | 0.25 | 0.26 | 0.23 | 0.26 | 0.40 | 0.38 | 0.36 | 0.18 | 0.40 | 0.36 | 0.36 | 0.17 | 0.54 | 0.78 | 0.49 | 0.69 | 0.69 | 0.52 | 0.53 | 0.64 | 1.00 | | | | | | | | | | | | |
| Sentence Reading Fluency | 0.43 | 0.49 | 0.30 | 0.54 | 0.41 | 0.26 | 0.31 | 0.35 | 0.40 | 0.40 | 0.63 | 0.27 | 0.26 | 0.29 | 0.25 | 0.33 | 0.44 | 0.27 | 0.28 | 0.35 | 0.27 | 0.37 | 0.39 | 0.34 | 0.21 | 0.34 | 0.55 | 0.71 | 0.50 | 0.71 | 0.63 | 0.56 | 0.49 | 0.50 | 0.67 | 1.00 | | | | | | | | | | | |
| Math Facts Fluency | 0.37 | 0.57 | 0.38 | 0.59 | 0.40 | 0.29 | 0.28 | 0.30 | 0.28 | 0.39 | 0.61 | 0.16 | 0.15 | 0.27 | 0.26 | 0.36 | 0.41 | 0.16 | 0.21 | 0.28 | 0.23 | 0.30 | 0.28 | 0.29 | 0.17 | 0.30 | 0.50 | 0.58 | 0.57 | 0.63 | 0.48 | 0.71 | 0.44 | 0.38 | 0.51 | 0.67 | 1.00 | | | | | | | | | | |
| Sentence Writing Fluency | 0.33 | 0.54 | 0.42 | 0.53 | 0.46 | 0.24 | 0.32 | 0.13 | 0.28 | 0.45 | 0.63 | 0.31 | 0.28 | 0.27 | 0.27 | 0.35 | 0.40 | 0.18 | 0.13 | 0.30 | 0.28 | 0.26 | 0.32 | 0.34 | 0.17 | 0.27 | 0.52 | 0.67 | 0.46 | 0.67 | 0.61 | 0.59 | 0.59 | 0.50 | 0.66 | 0.74 | 0.64 | 1.00 | | | | | | | | | |
| Reading Recall | 0.40 | 0.61 | 0.40 | 0.35 | 0.52 | 0.34 | 0.32 | 0.11 | 0.47 | 0.31 | 0.36 | 0.29 | 0.25 | 0.35 | 0.27 | 0.29 | 0.07 | 0.17 | 0.31 | 0.33 | 0.39 | 0.25 | 0.30 | 0.39 | 0.20 | 0.31 | 0.55 | 0.67 | 0.46 | 0.55 | 0.68 | 0.55 | 0.59 | 0.58 | 0.64 | 0.55 | 0.47 | 0.60 | 1.00 | | | | | | | | |
| Number Matrices | 0.44 | 0.60 | 0.42 | 0.26 | 0.51 | 0.30 | 0.33 | 0.29 | 0.44 | 0.39 | 0.29 | 0.31 | 0.30 | 0.14 | 0.44 | 0.38 | 0.29 | 0.34 | 0.29 | 0.27 | 0.41 | 0.19 | 0.36 | 0.38 | 0.29 | 0.32 | 0.41 | 0.40 | 0.55 | 0.49 | 0.37 | 0.56 | 0.26 | 0.34 | 0.33 | 0.38 | 0.45 | 0.32 | 0.35 | 1.00 | | | | | | | |
| Editing | 0.56 | 0.57 | 0.53 | 0.37 | 0.53 | 0.34 | 0.38 | 0.35 | 0.29 | 0.48 | 0.47 | 0.36 | 0.14 | 0.18 | 0.32 | 0.32 | 0.26 | 0.32 | 0.41 | 0.49 | 0.39 | 0.18 | 0.41 | 0.40 | 0.23 | 0.32 | 0.58 | 0.72 | 0.56 | 0.73 | 0.63 | 0.57 | 0.52 | 0.58 | 0.68 | 0.63 | 0.53 | 0.65 | 0.59 | 0.51 | 1.00 | | | | | | |
| Word Reading Fluency | 0.33 | 0.44 | 0.27 | 0.62 | 0.40 | 0.16 | 0.31 | 0.25 | 0.30 | 0.29 | 0.70 | 0.19 | 0.22 | 0.17 | 0.21 | 0.37 | 0.45 | 0.21 | 0.30 | 0.28 | 0.18 | 0.35 | 0.25 | 0.25 | 0.11 | 0.41 | 0.38 | 0.57 | 0.45 | 0.61 | 0.51 | 0.54 | 0.40 | 0.37 | 0.58 | 0.78 | 0.68 | 0.71 | 0.46 | 0.31 | 0.55 | 1.00 | | | | | |
| Spelling of Sounds | 0.40 | 0.60 | 0.41 | 0.34 | 0.56 | 0.31 | 0.43 | 0.23 | 0.43 | 0.42 | 0.33 | 0.43 | 0.38 | 0.25 | 0.32 | 0.34 | 0.25 | 0.35 | 0.26 | 0.37 | 0.58 | 0.25 | 0.38 | 0.40 | 0.43 | 0.23 | 0.66 | 0.67 | 0.51 | 0.66 | 0.63 | 0.52 | 0.60 | 0.71 | 0.62 | 0.57 | 0.46 | 0.54 | 0.53 | 0.47 | 0.54 | 0.44 | 1.00 | | | | |
| Reading Vocabulary | 0.70 | 0.53 | 0.36 | 0.36 | 0.64 | 0.44 | 0.37 | 0.51 | 0.36 | 0.35 | 0.36 | 0.36 | 0.30 | 0.26 | 0.28 | 0.32 | 0.23 | 0.33 | 0.56 | 0.63 | 0.48 | 0.25 | 0.51 | 0.38 | 0.32 | 0.37 | 0.57 | 0.71 | 0.57 | 0.67 | 0.68 | 0.57 | 0.50 | 0.56 | 0.68 | 0.61 | 0.47 | 0.56 | 0.57 | 0.45 | 0.71 | 0.51 | 0.50 | 1.00 | | | |
| Science | 0.53 | 0.48 | 0.39 | 0.14 | 0.48 | 0.48 | 0.23 | 0.36 | 0.35 | 0.41 | 0.10 | 0.27 | 0.24 | 0.20 | 0.33 | 0.37 | 0.22 | 0.29 | 0.58 | 0.55 | 0.28 | 0.27 | 0.43 | 0.45 | 0.26 | 0.38 | 0.40 | 0.40 | 0.53 | 0.41 | 0.39 | 0.45 | 0.38 | 0.45 | 0.28 | 0.27 | 0.21 | 0.27 | 0.35 | 0.39 | 0.43 | 0.19 | 0.36 | 0.57 | 1.00 | | |
| Social Studies | 0.66 | 0.41 | 0.31 | 0.21 | 0.49 | 0.43 | 0.20 | 0.50 | 0.38 | 0.31 | 0.20 | 0.21 | 0.19 | 0.19 | 0.36 | 0.35 | 0.31 | 0.30 | 0.64 | 0.58 | 0.23 | 0.32 | 0.43 | 0.37 | 0.31 | 0.39 | 0.32 | 0.47 | 0.46 | 0.40 | 0.41 | 0.47 | 0.37 | 0.46 | 0.39 | 0.31 | 0.32 | 0.29 | 0.28 | 0.37 | 0.41 | 0.26 | 0.31 | 0.56 | 0.70 | 1.00 | |
| Humanities | 0.59 | 0.27 | 0.29 | 0.20 | 0.45 | 0.33 | 0.27 | 0.56 | 0.28 | 0.32 | 0.09 | 0.27 | 0.25 | 0.22 | 0.35 | 0.38 | 0.20 | 0.35 | 0.57 | 0.50 | 0.28 | 0.25 | 0.44 | 0.37 | 0.42 | 0.40 | 0.36 | 0.36 | 0.45 | 0.38 | 0.32 | 0.38 | 0.23 | 0.32 | 0.29 | 0.27 | 0.25 | 0.25 | 0.19 | 0.45 | 0.40 | 0.22 | 0.33 | 0.55 | 0.62 | 0.62 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

## *Table E-3.*

*Test Score Intercorrelations—Ages 9 Through 13 (n = 1,572)*

| Test | Oral Vocabulary | Number Series | Verbal Attention | Letter-Pattern Matching | Phonological Processing | Story Recall | Visualization | General Information | Concept Formation | Numbers Reversed | Number-Pattern Matching | Nonword Repetition | Visual-Auditory Learning | Picture Recognition | Analysis-Synthesis | Object-Number Sequencing | Pair Cancellation | Memory for Words | Picture Vocabulary | Oral Comprehension | Segmentation | Rapid Picture Naming | Sentence Repetition | Understanding Directions | Sound Blending | Retrieval Fluency | Sound Awareness | Letter-Word Identification | Applied Problems | Spelling | Passage Comprehension | Calculation | Writing Samples | Word Attack | Oral Reading | Sentence Reading Fluency | Math Facts Fluency | Sentence Writing Fluency | Reading Recall | Number Matrices | Editing | Word Reading Fluency | Spelling of Sounds | Reading Vocabulary | Science | Social Studies | Humanities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Oral Vocabulary** | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Number Series** | 0.44 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Verbal Attention** | 0.45 | 0.41 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Letter-Pattern Matching** | 0.32 | 0.40 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Phonological Processing** | 0.48 | 0.45 | 0.46 | 0.32 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Story Recall** | 0.38 | 0.36 | 0.31 | 0.22 | 0.24 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Visualization** | 0.32 | 0.33 | 0.23 | 0.22 | 0.31 | 0.33 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **General Information** | 0.71 | 0.27 | 0.33 | 0.22 | 0.34 | 0.29 | 0.30 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Concept Formation** | 0.43 | 0.42 | 0.30 | 0.23 | 0.38 | 0.32 | 0.42 | 0.33 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Numbers Reversed** | 0.35 | 0.41 | 0.43 | 0.41 | 0.36 | 0.24 | 0.32 | 0.31 | 0.34 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Number-Pattern Matching** | 0.26 | 0.48 | 0.32 | 0.60 | 0.29 | 0.28 | 0.28 | 0.14 | 0.25 | 0.31 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Nonword Repetition** | 0.40 | 0.24 | 0.44 | 0.14 | 0.34 | 0.30 | 0.33 | 0.29 | 0.36 | 0.24 | 0.18 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Visual-Auditory Learning** | 0.27 | 0.20 | 0.22 | 0.23 | 0.33 | 0.32 | 0.40 | 0.21 | 0.42 | 0.28 | 0.15 | 0.21 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Picture Recognition** | 0.24 | 0.14 | 0.15 | 0.28 | 0.18 | 0.31 | 0.43 | 0.24 | 0.21 | 0.26 | 0.24 | 0.26 | 0.30 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Analysis-Synthesis** | 0.39 | 0.43 | 0.34 | 0.33 | 0.33 | 0.38 | 0.46 | 0.31 | 0.52 | 0.34 | 0.34 | 0.19 | 0.37 | 0.34 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Object-Number Sequencing** | 0.38 | 0.33 | 0.55 | 0.43 | 0.43 | 0.39 | 0.36 | 0.30 | 0.42 | 0.45 | 0.35 | 0.45 | 0.30 | 0.32 | 0.38 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pair Cancellation** | 0.27 | 0.27 | 0.23 | 0.59 | 0.30 | 0.20 | 0.23 | 0.16 | 0.27 | 0.25 | 0.57 | 0.19 | 0.11 | 0.18 | 0.28 | 0.35 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Memory for Words** | 0.33 | 0.23 | 0.50 | 0.18 | 0.51 | 0.34 | 0.34 | 0.24 | 0.36 | 0.39 | 0.20 | 0.42 | 0.30 | 0.20 | 0.38 | 0.47 | 0.13 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Picture Vocabulary** | 0.70 | 0.32 | 0.34 | 0.23 | 0.39 | 0.37 | 0.31 | 0.68 | 0.33 | 0.27 | 0.16 | 0.29 | 0.24 | 0.20 | 0.25 | 0.34 | 0.21 | 0.29 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Oral Comprehension** | 0.62 | 0.35 | 0.42 | 0.13 | 0.39 | 0.45 | 0.32 | 0.53 | 0.34 | 0.30 | 0.30 | 0.31 | 0.26 | 0.39 | 0.30 | 0.36 | 0.20 | 0.28 | 0.64 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Segmentation** | 0.31 | 0.30 | 0.31 | 0.16 | 0.58 | 0.26 | 0.36 | 0.20 | 0.37 | 0.24 | 0.26 | 0.32 | 0.36 | 0.21 | 0.33 | 0.31 | 0.18 | 0.39 | 0.18 | 0.28 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Rapid Picture Naming** | 0.32 | 0.19 | 0.34 | 0.30 | 0.26 | 0.19 | 0.19 | 0.26 | 0.31 | 0.23 | 0.32 | 0.29 | 0.16 | 0.35 | 0.20 | 0.38 | 0.38 | 0.28 | 0.40 | 0.39 | 0.15 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Sentence Repetition** | 0.46 | 0.25 | 0.47 | 0.22 | 0.44 | 0.25 | 0.28 | 0.30 | 0.27 | 0.26 | 0.17 | 0.51 | 0.16 | 0.25 | 0.18 | 0.37 | 0.22 | 0.48 | 0.42 | 0.48 | 0.27 | 0.29 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| **Understanding Directions** | 0.41 | 0.45 | 0.44 | 0.28 | 0.32 | 0.41 | 0.38 | 0.28 | 0.42 | 0.29 | 0.24 | 0.44 | 0.31 | 0.32 | 0.34 | 0.40 | 0.24 | 0.35 | 0.40 | 0.44 | 0.28 | 0.37 | 0.48 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| **Sound Blending** | 0.28 | 0.13 | 0.19 | 0.15 | 0.43 | 0.18 | 0.30 | 0.25 | 0.31 | 0.24 | 0.08 | 0.28 | 0.39 | 0.21 | 0.32 | 0.29 | 0.10 | 0.37 | 0.22 | 0.27 | 0.42 | 0.12 | 0.12 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| **Retrieval Fluency** | 0.41 | 0.28 | 0.28 | 0.28 | 0.45 | 0.28 | 0.18 | 0.27 | 0.24 | 0.26 | 0.34 | 0.18 | 0.14 | 0.30 | 0.39 | 0.39 | 0.34 | 0.41 | 0.39 | 0.40 | 0.21 | 0.46 | 0.26 | 0.26 | 0.17 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| **Sound Awareness** | 0.38 | 0.48 | 0.42 | 0.30 | 0.56 | 0.35 | 0.37 | 0.32 | 0.35 | 0.35 | 0.29 | 0.40 | 0.32 | 0.28 | 0.26 | 0.31 | 0.24 | 0.35 | 0.31 | 0.39 | 0.44 | 0.23 | 0.40 | 0.41 | 0.40 | 0.24 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| **Letter-Word Identification** | 0.58 | 0.61 | 0.44 | 0.36 | 0.45 | 0.24 | 0.25 | 0.45 | 0.30 | 0.37 | 0.46 | 0.32 | 0.19 | 0.22 | 0.25 | 0.21 | 0.30 | 0.27 | 0.49 | 0.53 | 0.29 | 0.29 | 0.41 | 0.36 | 0.20 | 0.32 | 0.48 | 1.00 | | | | | | | | | | | | | | | | | | | |
| **Applied Problems** | 0.58 | 0.68 | 0.39 | 0.37 | 0.38 | 0.34 | 0.50 | 0.48 | 0.53 | 0.44 | 0.42 | 0.24 | 0.31 | 0.27 | 0.50 | 0.38 | 0.35 | 0.29 | 0.47 | 0.52 | 0.31 | 0.24 | 0.33 | 0.43 | 0.24 | 0.37 | 0.38 | 0.58 | 1.00 | | | | | | | | | | | | | | | | | | |
| **Spelling** | 0.55 | 0.56 | 0.51 | 0.42 | 0.47 | 0.29 | 0.29 | 0.48 | 0.34 | 0.39 | 0.47 | 0.42 | 0.21 | 0.22 | 0.30 | 0.32 | 0.35 | 0.32 | 0.46 | 0.49 | 0.29 | 0.25 | 0.47 | 0.35 | 0.22 | 0.32 | 0.49 | 0.80 | 0.58 | 1.00 | | | | | | | | | | | | | | | | | |
| **Passage Comprehension** | 0.62 | 0.59 | 0.39 | 0.36 | 0.44 | 0.32 | 0.33 | 0.52 | 0.37 | 0.32 | 0.44 | 0.32 | 0.24 | 0.24 | 0.28 | 0.27 | 0.23 | 0.26 | 0.49 | 0.56 | 0.42 | 0.27 | 0.43 | 0.42 | 0.24 | 0.32 | 0.51 | 0.71 | 0.55 | 0.64 | 1.00 | | | | | | | | | | | | | | | | |
| **Calculation** | 0.48 | 0.69 | 0.37 | 0.47 | 0.39 | 0.39 | 0.37 | 0.33 | 0.44 | 0.38 | 0.53 | 0.22 | 0.26 | 0.13 | 0.41 | 0.35 | 0.43 | 0.24 | 0.33 | 0.31 | 0.27 | 0.23 | 0.31 | 0.35 | 0.18 | 0.31 | 0.39 | 0.61 | 0.72 | 0.62 | 0.58 | 1.00 | | | | | | | | | | | | | | | |
| **Writing Samples** | 0.35 | 0.56 | 0.31 | 0.36 | 0.33 | 0.43 | 0.21 | 0.20 | 0.24 | 0.23 | 0.49 | 0.25 | 0.18 | 0.25 | 0.28 | 0.15 | 0.20 | 0.20 | 0.28 | 0.34 | 0.32 | 0.21 | 0.22 | 0.27 | 0.15 | 0.27 | 0.40 | 0.62 | 0.39 | 0.51 | 0.61 | 0.51 | 1.00 | | | | | | | | | | | | | | |
| **Word Attack** | 0.45 | 0.54 | 0.43 | 0.28 | 0.46 | 0.19 | 0.32 | 0.27 | 0.28 | 0.32 | 0.29 | 0.42 | 0.22 | 0.24 | 0.26 | 0.24 | 0.18 | 0.31 | 0.39 | 0.43 | 0.36 | 0.28 | 0.44 | 0.42 | 0.29 | 0.28 | 0.53 | 0.72 | 0.42 | 0.64 | 0.59 | 0.44 | 0.52 | 1.00 | | | | | | | | | | | | | |
| **Oral Reading** | 0.50 | 0.42 | 0.35 | 0.32 | 0.40 | 0.18 | 0.30 | 0.50 | 0.26 | 0.39 | 0.35 | 0.36 | 0.23 | 0.07 | 0.24 | 0.24 | 0.20 | 0.26 | 0.46 | 0.34 | 0.18 | 0.13 | 0.34 | 0.27 | 0.35 | 0.19 | 0.46 | 0.68 | 0.47 | 0.66 | 0.58 | 0.47 | 0.39 | 0.58 | 1.00 | | | | | | | | | | | | |
| **Sentence Reading Fluency** | 0.47 | 0.49 | 0.31 | 0.57 | 0.34 | 0.31 | 0.25 | 0.44 | 0.39 | 0.37 | 0.61 | 0.29 | 0.26 | 0.25 | 0.26 | 0.35 | 0.47 | 0.25 | 0.35 | 0.36 | 0.15 | 0.40 | 0.38 | 0.39 | 0.14 | 0.36 | 0.49 | 0.64 | 0.52 | 0.68 | 0.59 | 0.56 | 0.45 | 0.48 | 0.63 | 1.00 | | | | | | | | | | | |
| **Math Facts Fluency** | 0.42 | 0.56 | 0.36 | 0.58 | 0.34 | 0.29 | 0.25 | 0.40 | 0.28 | 0.40 | 0.54 | 0.21 | 0.13 | 0.26 | 0.26 | 0.36 | 0.45 | 0.15 | 0.30 | 0.31 | 0.12 | 0.34 | 0.31 | 0.36 | 0.12 | 0.32 | 0.48 | 0.55 | 0.57 | 0.62 | 0.45 | 0.67 | 0.39 | 0.37 | 0.49 | 0.70 | 1.00 | | | | | | | | | | |
| **Sentence Writing Fluency** | 0.36 | 0.54 | 0.39 | 0.53 | 0.42 | 0.22 | 0.29 | 0.25 | 0.27 | 0.43 | 0.60 | 0.30 | 0.27 | 0.25 | 0.28 | 0.32 | 0.43 | 0.21 | 0.19 | 0.29 | 0.18 | 0.28 | 0.35 | 0.34 | 0.11 | 0.30 | 0.45 | 0.60 | 0.49 | 0.64 | 0.54 | 0.58 | 0.51 | 0.43 | 0.55 | 0.73 | 0.66 | 1.00 | | | | | | | | | |
| **Reading Recall** | 0.36 | 0.55 | 0.35 | 0.31 | 0.38 | 0.31 | 0.20 | 0.18 | 0.40 | 0.27 | 0.32 | 0.23 | 0.19 | 0.25 | 0.27 | 0.26 | 0.10 | 0.19 | 0.30 | 0.28 | 0.20 | 0.23 | 0.26 | 0.30 | 0.10 | 0.33 | 0.39 | 0.57 | 0.43 | 0.49 | 0.59 | 0.54 | 0.52 | 0.45 | 0.53 | 0.49 | 0.42 | 0.52 | 1.00 | | | | | | | | |
| **Number Matrices** | 0.42 | 0.65 | 0.38 | 0.26 | 0.49 | 0.28 | 0.28 | 0.32 | 0.41 | 0.34 | 0.30 | 0.28 | 0.29 | 0.14 | 0.44 | 0.31 | 0.32 | 0.29 | 0.37 | 0.29 | 0.33 | 0.26 | 0.39 | 0.35 | 0.20 | 0.37 | 0.40 | 0.41 | 0.54 | 0.52 | 0.38 | 0.56 | 0.27 | 0.29 | 0.33 | 0.42 | 0.48 | 0.40 | 0.38 | 1.00 | | | | | | | |
| **Editing** | 0.59 | 0.57 | 0.52 | 0.35 | 0.51 | 0.33 | 0.33 | 0.46 | 0.26 | 0.51 | 0.46 | 0.34 | 0.13 | 0.09 | 0.31 | 0.33 | 0.29 | 0.34 | 0.52 | 0.53 | 0.28 | 0.22 | 0.43 | 0.39 | 0.21 | 0.38 | 0.54 | 0.71 | 0.58 | 0.75 | 0.63 | 0.57 | 0.47 | 0.55 | 0.66 | 0.61 | 0.52 | 0.61 | 0.51 | 0.53 | 1.00 | | | | | | |
| **Word Reading Fluency** | 0.37 | 0.46 | 0.28 | 0.63 | 0.38 | 0.19 | 0.23 | 0.32 | 0.33 | 0.30 | 0.67 | 0.21 | 0.22 | 0.13 | 0.24 | 0.35 | 0.48 | 0.24 | 0.38 | 0.29 | 0.11 | 0.39 | 0.29 | 0.31 | 0.05 | 0.44 | 0.33 | 0.52 | 0.45 | 0.59 | 0.46 | 0.48 | 0.37 | 0.36 | 0.52 | 0.76 | 0.64 | 0.67 | 0.41 | 0.39 | 0.55 | 1.00 | | | | | |
| **Spelling of Sounds** | 0.37 | 0.53 | 0.39 | 0.29 | 0.50 | 0.22 | 0.33 | 0.26 | 0.33 | 0.40 | 0.25 | 0.37 | 0.31 | 0.06 | 0.28 | 0.29 | 0.24 | 0.34 | 0.26 | 0.30 | 0.49 | 0.18 | 0.35 | 0.32 | 0.41 | 0.19 | 0.61 | 0.56 | 0.43 | 0.59 | 0.49 | 0.46 | 0.44 | 0.64 | 0.53 | 0.49 | 0.44 | 0.43 | 0.35 | 0.43 | 0.49 | 0.38 | 1.00 | | | | |
| **Reading Vocabulary** | 0.70 | 0.53 | 0.37 | 0.33 | 0.56 | 0.39 | 0.31 | 0.59 | 0.33 | 0.35 | 0.35 | 0.34 | 0.29 | 0.17 | 0.32 | 0.30 | 0.24 | 0.31 | 0.61 | 0.65 | 0.38 | 0.28 | 0.48 | 0.37 | 0.28 | 0.41 | 0.51 | 0.68 | 0.58 | 0.66 | 0.70 | 0.55 | 0.44 | 0.52 | 0.65 | 0.60 | 0.47 | 0.54 | 0.50 | 0.49 | 0.72 | 0.52 | 0.43 | 1.00 | | | |
| **Science** | 0.54 | 0.51 | 0.40 | 0.16 | 0.42 | 0.46 | 0.21 | 0.40 | 0.36 | 0.41 | 0.17 | 0.28 | 0.21 | 0.16 | 0.36 | 0.36 | 0.29 | 0.28 | 0.63 | 0.57 | 0.26 | 0.31 | 0.42 | 0.43 | 0.21 | 0.39 | 0.38 | 0.46 | 0.55 | 0.45 | 0.44 | 0.47 | 0.38 | 0.43 | 0.29 | 0.32 | 0.24 | 0.30 | 0.34 | 0.41 | 0.49 | 0.28 | 0.35 | 0.58 | 1.00 | | |
| **Social Studies** | 0.70 | 0.46 | 0.33 | 0.22 | 0.41 | 0.43 | 0.22 | 0.58 | 0.38 | 0.33 | 0.22 | 0.23 | 0.14 | 0.16 | 0.43 | 0.34 | 0.32 | 0.30 | 0.68 | 0.58 | 0.18 | 0.34 | 0.42 | 0.37 | 0.23 | 0.40 | 0.33 | 0.54 | 0.52 | 0.50 | 0.46 | 0.49 | 0.38 | 0.44 | 0.43 | 0.40 | 0.39 | 0.34 | 0.29 | 0.43 | 0.50 | 0.35 | 0.30 | 0.60 | 0.69 | 1.00 | |
| **Humanities** | 0.60 | 0.36 | 0.36 | 0.24 | 0.44 | 0.32 | 0.30 | 0.60 | 0.29 | 0.37 | 0.16 | 0.27 | 0.21 | 0.18 | 0.36 | 0.37 | 0.21 | 0.35 | 0.64 | 0.55 | 0.24 | 0.30 | 0.41 | 0.40 | 0.41 | 0.42 | 0.37 | 0.45 | 0.51 | 0.46 | 0.41 | 0.40 | 0.26 | 0.33 | 0.38 | 0.32 | 0.34 | 0.33 | 0.23 | 0.45 | 0.50 | 0.31 | 0.35 | 0.60 | 0.61 | 0.64 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

**Table E-4.**

*Test Score Intercorrelations—*
*Ages 14 Through 19 (n = 1,685)*

| Test | Oral Vocabulary | Number Series | Verbal Attention | Letter-Pattern Matching | Phonological Processing | Story Recall | Visualization | General Information | Concept Formation | Numbers Reversed | Number-Pattern Matching | Nonword Repetition | Visual-Auditory Learning | Picture Recognition | Analysis-Synthesis | Object-Number Sequencing | Pair Cancellation | Memory for Words | Picture Vocabulary | Oral Comprehension | Segmentation | Rapid Picture Naming | Sentence Repetition | Understanding Directions | Sound Blending | Retrieval Fluency | Sound Awareness | Letter-Word Identification | Applied Problems | Spelling | Passage Comprehension | Calculation | Writing Samples | Word Attack | Oral Reading | Sentence Reading Fluency | Math Facts Fluency | Sentence Writing Fluency | Reading Recall | Number Matrices | Editing | Word Reading Fluency | Spelling of Sounds | Reading Vocabulary | Science | Social Studies | Humanities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oral Vocabulary | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Number Series | 0.51 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Verbal Attention | 0.50 | 0.41 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Letter-Pattern Matching | 0.37 | 0.40 | 0.30 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Phonological Processing | 0.58 | 0.49 | 0.47 | 0.39 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Story Recall | 0.42 | 0.41 | 0.33 | 0.29 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Visualization | 0.36 | 0.41 | 0.25 | 0.30 | 0.37 | 0.41 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| General Information | 0.74 | 0.36 | 0.40 | 0.29 | 0.45 | 0.35 | 0.35 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Concept Formation | 0.49 | 0.50 | 0.30 | 0.30 | 0.45 | 0.39 | 0.48 | 0.36 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Numbers Reversed | 0.42 | 0.47 | 0.49 | 0.45 | 0.45 | 0.32 | 0.39 | 0.37 | 0.40 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Number-Pattern Matching | 0.33 | 0.45 | 0.36 | 0.57 | 0.32 | 0.31 | 0.29 | 0.21 | 0.26 | 0.36 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nonword Repetition | 0.41 | 0.26 | 0.45 | 0.22 | 0.36 | 0.34 | 0.34 | 0.29 | 0.35 | 0.30 | 0.22 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Visual-Auditory Learning | 0.38 | 0.23 | 0.21 | 0.30 | 0.37 | 0.34 | 0.39 | 0.28 | 0.46 | 0.31 | 0.11 | 0.23 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Picture Recognition | 0.17 | 0.09 | 0.13 | 0.26 | 0.12 | 0.33 | 0.39 | 0.19 | 0.20 | 0.23 | 0.16 | 0.25 | 0.27 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Analysis-Synthesis | 0.40 | 0.46 | 0.37 | 0.37 | 0.36 | 0.43 | 0.51 | 0.35 | 0.52 | 0.37 | 0.34 | 0.22 | 0.34 | 0.34 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Object-Number Sequencing | 0.45 | 0.41 | 0.57 | 0.50 | 0.48 | 0.45 | 0.41 | 0.36 | 0.46 | 0.49 | 0.40 | 0.45 | 0.34 | 0.30 | 0.45 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pair Cancellation | 0.36 | 0.29 | 0.30 | 0.58 | 0.40 | 0.20 | 0.25 | 0.26 | 0.33 | 0.33 | 0.56 | 0.21 | 0.21 | 0.11 | 0.32 | 0.38 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Memory for Words | 0.36 | 0.28 | 0.53 | 0.30 | 0.48 | 0.38 | 0.37 | 0.28 | 0.37 | 0.47 | 0.25 | 0.44 | 0.27 | 0.26 | 0.38 | 0.52 | 0.22 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Picture Vocabulary | 0.72 | 0.39 | 0.39 | 0.31 | 0.51 | 0.40 | 0.39 | 0.72 | 0.39 | 0.36 | 0.22 | 0.32 | 0.34 | 0.19 | 0.31 | 0.39 | 0.28 | 0.34 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oral Comprehension | 0.67 | 0.41 | 0.47 | 0.17 | 0.53 | 0.45 | 0.33 | 0.56 | 0.40 | 0.40 | 0.33 | 0.32 | 0.31 | 0.32 | 0.34 | 0.40 | 0.26 | 0.34 | 0.67 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Segmentation | 0.41 | 0.35 | 0.33 | 0.28 | 0.58 | 0.31 | 0.44 | 0.31 | 0.43 | 0.37 | 0.32 | 0.37 | 0.42 | 0.25 | 0.39 | 0.37 | 0.28 | 0.40 | 0.29 | 0.37 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rapid Picture Naming | 0.27 | 0.18 | 0.31 | 0.33 | 0.28 | 0.18 | 0.20 | 0.24 | 0.32 | 0.26 | 0.30 | 0.30 | 0.20 | 0.35 | 0.21 | 0.40 | 0.37 | 0.30 | 0.36 | 0.33 | 0.23 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sentence Repetition | 0.48 | 0.27 | 0.51 | 0.28 | 0.50 | 0.29 | 0.31 | 0.32 | 0.33 | 0.31 | 0.21 | 0.50 | 0.20 | 0.24 | 0.22 | 0.42 | 0.26 | 0.49 | 0.46 | 0.52 | 0.34 | 0.28 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| Understanding Directions | 0.41 | 0.48 | 0.46 | 0.34 | 0.36 | 0.43 | 0.40 | 0.26 | 0.45 | 0.32 | 0.25 | 0.46 | 0.31 | 0.31 | 0.39 | 0.45 | 0.30 | 0.39 | 0.39 | 0.42 | 0.33 | 0.38 | 0.49 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| Sound Blending | 0.40 | 0.26 | 0.29 | 0.26 | 0.52 | 0.24 | 0.34 | 0.34 | 0.40 | 0.34 | 0.17 | 0.36 | 0.41 | 0.17 | 0.37 | 0.38 | 0.27 | 0.40 | 0.34 | 0.37 | 0.45 | 0.20 | 0.19 | 0.34 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| Retrieval Fluency | 0.43 | 0.27 | 0.31 | 0.33 | 0.47 | 0.27 | 0.27 | 0.30 | 0.31 | 0.31 | 0.37 | 0.22 | 0.21 | 0.29 | 0.45 | 0.45 | 0.36 | 0.46 | 0.42 | 0.44 | 0.26 | 0.44 | 0.29 | 0.28 | 0.28 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| Sound Awareness | 0.47 | 0.50 | 0.42 | 0.36 | 0.59 | 0.39 | 0.42 | 0.38 | 0.43 | 0.42 | 0.29 | 0.43 | 0.36 | 0.24 | 0.31 | 0.37 | 0.31 | 0.36 | 0.42 | 0.44 | 0.49 | 0.26 | 0.40 | 0.44 | 0.45 | 0.32 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| Letter-Word Identification | 0.63 | 0.60 | 0.45 | 0.36 | 0.53 | 0.26 | 0.31 | 0.52 | 0.34 | 0.43 | 0.45 | 0.33 | 0.23 | 0.18 | 0.26 | 0.26 | 0.33 | 0.32 | 0.57 | 0.58 | 0.40 | 0.23 | 0.44 | 0.37 | 0.34 | 0.31 | 0.50 | 1.00 | | | | | | | | | | | | | | | | | | | |
| Applied Problems | 0.66 | 0.71 | 0.44 | 0.40 | 0.50 | 0.39 | 0.55 | 0.56 | 0.56 | 0.51 | 0.42 | 0.28 | 0.37 | 0.21 | 0.50 | 0.46 | 0.41 | 0.35 | 0.55 | 0.57 | 0.40 | 0.19 | 0.38 | 0.44 | 0.39 | 0.40 | 0.45 | 0.59 | 1.00 | | | | | | | | | | | | | | | | | | |
| Spelling | 0.62 | 0.54 | 0.52 | 0.42 | 0.53 | 0.32 | 0.36 | 0.54 | 0.36 | 0.43 | 0.46 | 0.43 | 0.24 | 0.16 | 0.32 | 0.37 | 0.37 | 0.36 | 0.53 | 0.55 | 0.37 | 0.19 | 0.50 | 0.36 | 0.35 | 0.33 | 0.49 | 0.80 | 0.62 | 1.00 | | | | | | | | | | | | | | | | | |
| Passage Comprehension | 0.67 | 0.62 | 0.45 | 0.42 | 0.53 | 0.39 | 0.42 | 0.58 | 0.46 | 0.43 | 0.46 | 0.30 | 0.33 | 0.19 | 0.34 | 0.37 | 0.31 | 0.33 | 0.58 | 0.61 | 0.52 | 0.25 | 0.46 | 0.44 | 0.38 | 0.35 | 0.52 | 0.73 | 0.62 | 0.66 | 1.00 | | | | | | | | | | | | | | | | |
| Calculation | 0.59 | 0.72 | 0.42 | 0.46 | 0.48 | 0.44 | 0.47 | 0.44 | 0.50 | 0.45 | 0.54 | 0.25 | 0.31 | 0.07 | 0.45 | 0.45 | 0.45 | 0.28 | 0.44 | 0.41 | 0.37 | 0.21 | 0.35 | 0.41 | 0.36 | 0.34 | 0.44 | 0.61 | 0.80 | 0.63 | 0.63 | 1.00 | | | | | | | | | | | | | | | |
| Writing Samples | 0.45 | 0.57 | 0.36 | 0.40 | 0.40 | 0.48 | 0.31 | 0.31 | 0.32 | 0.33 | 0.47 | 0.29 | 0.26 | 0.26 | 0.34 | 0.28 | 0.23 | 0.28 | 0.38 | 0.39 | 0.43 | 0.19 | 0.27 | 0.35 | 0.30 | 0.27 | 0.46 | 0.61 | 0.45 | 0.52 | 0.66 | 0.53 | 1.00 | | | | | | | | | | | | | | |
| Word Attack | 0.51 | 0.55 | 0.44 | 0.31 | 0.51 | 0.24 | 0.37 | 0.33 | 0.33 | 0.38 | 0.30 | 0.42 | 0.28 | 0.21 | 0.29 | 0.29 | 0.25 | 0.37 | 0.47 | 0.49 | 0.46 | 0.28 | 0.47 | 0.46 | 0.39 | 0.31 | 0.53 | 0.73 | 0.46 | 0.64 | 0.62 | 0.49 | 0.57 | 1.00 | | | | | | | | | | | | | |
| Oral Reading | 0.55 | 0.43 | 0.38 | 0.34 | 0.46 | 0.24 | 0.37 | 0.53 | 0.32 | 0.42 | 0.35 | 0.35 | 0.26 | 0.00 | 0.26 | 0.28 | 0.28 | 0.26 | 0.54 | 0.39 | 0.27 | 0.09 | 0.36 | 0.28 | 0.46 | 0.19 | 0.47 | 0.70 | 0.52 | 0.66 | 0.63 | 0.52 | 0.45 | 0.58 | 1.00 | | | | | | | | | | | | |
| Sentence Reading Fluency | 0.52 | 0.47 | 0.32 | 0.56 | 0.39 | 0.35 | 0.29 | 0.47 | 0.43 | 0.40 | 0.58 | 0.27 | 0.27 | 0.19 | 0.28 | 0.42 | 0.50 | 0.30 | 0.43 | 0.41 | 0.23 | 0.35 | 0.41 | 0.37 | 0.25 | 0.38 | 0.48 | 0.63 | 0.53 | 0.67 | 0.61 | 0.54 | 0.45 | 0.43 | 0.61 | 1.00 | | | | | | | | | | | |
| Math Facts Fluency | 0.44 | 0.56 | 0.36 | 0.54 | 0.38 | 0.33 | 0.31 | 0.42 | 0.29 | 0.39 | 0.53 | 0.20 | 0.14 | 0.20 | 0.29 | 0.40 | 0.45 | 0.19 | 0.32 | 0.32 | 0.17 | 0.29 | 0.29 | 0.36 | 0.22 | 0.35 | 0.45 | 0.50 | 0.60 | 0.57 | 0.43 | 0.68 | 0.38 | 0.32 | 0.47 | 0.64 | 1.00 | | | | | | | | | | |
| Sentence Writing Fluency | 0.40 | 0.49 | 0.37 | 0.52 | 0.45 | 0.23 | 0.33 | 0.28 | 0.30 | 0.44 | 0.57 | 0.28 | 0.28 | 0.17 | 0.28 | 0.37 | 0.46 | 0.23 | 0.29 | 0.34 | 0.24 | 0.22 | 0.35 | 0.36 | 0.22 | 0.29 | 0.42 | 0.59 | 0.51 | 0.61 | 0.53 | 0.56 | 0.49 | 0.42 | 0.56 | 0.70 | 0.60 | 1.00 | | | | | | | | | |
| Reading Recall | 0.34 | 0.51 | 0.28 | 0.31 | 0.36 | 0.32 | 0.29 | 0.17 | 0.44 | 0.27 | 0.28 | 0.18 | 0.22 | 0.23 | 0.26 | 0.27 | 0.07 | 0.17 | 0.32 | 0.27 | 0.23 | 0.20 | 0.27 | 0.33 | 0.17 | 0.29 | 0.42 | 0.53 | 0.40 | 0.42 | 0.55 | 0.49 | 0.52 | 0.41 | 0.51 | 0.48 | 0.38 | 0.50 | 1.00 | | | | | | | | |
| Number Matrices | 0.53 | 0.68 | 0.43 | 0.30 | 0.56 | 0.33 | 0.35 | 0.42 | 0.45 | 0.42 | 0.32 | 0.31 | 0.31 | 0.08 | 0.48 | 0.39 | 0.36 | 0.32 | 0.45 | 0.40 | 0.37 | 0.21 | 0.39 | 0.36 | 0.33 | 0.40 | 0.43 | 0.45 | 0.63 | 0.55 | 0.44 | 0.62 | 0.35 | 0.36 | 0.36 | 0.42 | 0.49 | 0.38 | 0.33 | 1.00 | | | | | | | |
| Editing | 0.65 | 0.57 | 0.55 | 0.38 | 0.58 | 0.36 | 0.40 | 0.51 | 0.29 | 0.56 | 0.46 | 0.37 | 0.14 | 0.03 | 0.34 | 0.39 | 0.33 | 0.40 | 0.59 | 0.57 | 0.35 | 0.16 | 0.45 | 0.39 | 0.33 | 0.41 | 0.56 | 0.71 | 0.62 | 0.75 | 0.65 | 0.62 | 0.50 | 0.56 | 0.66 | 0.59 | 0.50 | 0.59 | 0.47 | 0.59 | 1.00 | | | | | | |
| Word Reading Fluency | 0.40 | 0.41 | 0.29 | 0.61 | 0.39 | 0.16 | 0.26 | 0.35 | 0.32 | 0.27 | 0.61 | 0.17 | 0.21 | 0.05 | 0.24 | 0.38 | 0.47 | 0.25 | 0.42 | 0.30 | 0.14 | 0.33 | 0.29 | 0.28 | 0.14 | 0.43 | 0.30 | 0.48 | 0.45 | 0.55 | 0.45 | 0.46 | 0.32 | 0.31 | 0.49 | 0.73 | 0.61 | 0.64 | 0.36 | 0.38 | 0.51 | 1.00 | | | | | |
| Spelling of Sounds | 0.48 | 0.56 | 0.42 | 0.36 | 0.58 | 0.28 | 0.42 | 0.35 | 0.42 | 0.49 | 0.31 | 0.40 | 0.37 | 0.07 | 0.35 | 0.37 | 0.37 | 0.37 | 0.37 | 0.40 | 0.57 | 0.24 | 0.38 | 0.38 | 0.52 | 0.27 | 0.59 | 0.61 | 0.52 | 0.61 | 0.58 | 0.54 | 0.52 | 0.65 | 0.59 | 0.52 | 0.45 | 0.45 | 0.37 | 0.48 | 0.51 | 0.39 | 1.00 | | | | |
| Reading Vocabulary | 0.75 | 0.56 | 0.41 | 0.34 | 0.62 | 0.40 | 0.38 | 0.66 | 0.40 | 0.42 | 0.36 | 0.33 | 0.33 | 0.13 | 0.34 | 0.36 | 0.29 | 0.34 | 0.68 | 0.70 | 0.44 | 0.22 | 0.52 | 0.35 | 0.37 | 0.40 | 0.55 | 0.72 | 0.65 | 0.70 | 0.73 | 0.61 | 0.49 | 0.55 | 0.67 | 0.61 | 0.46 | 0.54 | 0.47 | 0.55 | 0.73 | 0.50 | 0.49 | 1.00 | | | |
| Science | 0.62 | 0.59 | 0.46 | 0.25 | 0.54 | 0.47 | 0.32 | 0.51 | 0.43 | 0.51 | 0.25 | 0.31 | 0.29 | 0.16 | 0.41 | 0.45 | 0.35 | 0.33 | 0.67 | 0.64 | 0.36 | 0.29 | 0.48 | 0.45 | 0.35 | 0.38 | 0.49 | 0.53 | 0.64 | 0.55 | 0.55 | 0.58 | 0.46 | 0.50 | 0.39 | 0.41 | 0.31 | 0.36 | 0.33 | 0.50 | 0.57 | 0.30 | 0.44 | 0.67 | 1.00 | | |
| Social Studies | 0.74 | 0.53 | 0.40 | 0.28 | 0.53 | 0.45 | 0.31 | 0.63 | 0.46 | 0.41 | 0.29 | 0.26 | 0.23 | 0.13 | 0.47 | 0.43 | 0.41 | 0.36 | 0.71 | 0.65 | 0.28 | 0.29 | 0.45 | 0.40 | 0.39 | 0.43 | 0.41 | 0.58 | 0.61 | 0.55 | 0.53 | 0.59 | 0.44 | 0.51 | 0.49 | 0.44 | 0.42 | 0.38 | 0.28 | 0.52 | 0.56 | 0.36 | 0.39 | 0.65 | 0.72 | 1.00 | |
| Humanities | 0.66 | 0.42 | 0.43 | 0.28 | 0.53 | 0.36 | 0.36 | 0.66 | 0.36 | 0.44 | 0.22 | 0.32 | 0.28 | 0.16 | 0.40 | 0.44 | 0.27 | 0.40 | 0.68 | 0.61 | 0.34 | 0.28 | 0.45 | 0.40 | 0.48 | 0.44 | 0.43 | 0.51 | 0.60 | 0.54 | 0.47 | 0.50 | 0.35 | 0.41 | 0.45 | 0.38 | 0.37 | 0.38 | 0.25 | 0.52 | 0.56 | 0.35 | 0.42 | 0.66 | 0.67 | 0.70 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

## *Table E-5.*

*Test Score Intercorrelations—*
*Ages 20 Through 39 (n = 1,251)*

| Test | Oral Vocabulary | Number Series | Verbal Attention | Letter-Pattern Matching | Phonological Processing | Story Recall | Visualization | General Information | Concept Formation | Numbers Reversed | Number-Pattern Matching | Nonword Repetition | Visual-Auditory Learning | Picture Recognition | Analysis-Synthesis | Object-Number Sequencing | Pair Cancellation | Memory for Words | Picture Vocabulary | Oral Comprehension | Segmentation | Rapid Picture Naming | Sentence Repetition | Understanding Directions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oral Vocabulary | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| Number Series | 0.48 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| Verbal Attention | 0.53 | 0.39 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| Letter-Pattern Matching | 0.38 | 0.39 | 0.28 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| Phonological Processing | 0.61 | 0.46 | 0.45 | 0.42 | 1.00 | | | | | | | | | | | | | | | | | | | |
| Story Recall | 0.44 | 0.37 | 0.33 | 0.22 | 0.29 | 1.00 | | | | | | | | | | | | | | | | | | |
| Visualization | 0.41 | 0.42 | 0.31 | 0.32 | 0.44 | 0.39 | 1.00 | | | | | | | | | | | | | | | | | |
| General Information | 0.77 | 0.34 | 0.43 | 0.26 | 0.49 | 0.39 | 0.39 | 1.00 | | | | | | | | | | | | | | | | |
| Concept Formation | 0.53 | 0.48 | 0.35 | 0.30 | 0.50 | 0.36 | 0.56 | 0.45 | 1.00 | | | | | | | | | | | | | | | |
| Numbers Reversed | 0.47 | 0.44 | 0.52 | 0.44 | 0.48 | 0.29 | 0.43 | 0.41 | 0.45 | 1.00 | | | | | | | | | | | | | | |
| Number-Pattern Matching | 0.30 | 0.44 | 0.34 | 0.59 | 0.34 | 0.29 | 0.35 | 0.19 | 0.29 | 0.35 | 1.00 | | | | | | | | | | | | | |
| Nonword Repetition | 0.41 | 0.22 | 0.45 | 0.20 | 0.37 | 0.34 | 0.35 | 0.34 | 0.34 | 0.29 | 0.22 | 1.00 | | | | | | | | | | | | |
| Visual-Auditory Learning | 0.45 | 0.25 | 0.28 | 0.34 | 0.43 | 0.42 | 0.50 | 0.34 | 0.51 | 0.37 | 0.22 | 0.27 | 1.00 | | | | | | | | | | | |
| Picture Recognition | 0.25 | 0.14 | 0.22 | 0.29 | 0.22 | 0.31 | 0.42 | 0.26 | 0.30 | 0.28 | 0.23 | 0.27 | 0.37 | 1.00 | | | | | | | | | | |
| Analysis-Synthesis | 0.47 | 0.46 | 0.41 | 0.39 | 0.38 | 0.41 | 0.53 | 0.40 | 0.56 | 0.43 | 0.39 | 0.18 | 0.41 | 0.42 | 1.00 | | | | | | | | | |
| Object-Number Sequencing | 0.50 | 0.38 | 0.60 | 0.45 | 0.53 | 0.41 | 0.45 | 0.44 | 0.52 | 0.54 | 0.38 | 0.49 | 0.36 | 0.34 | 0.47 | 1.00 | | | | | | | | |
| Pair Cancellation | 0.33 | 0.28 | 0.27 | 0.56 | 0.44 | 0.19 | 0.35 | 0.25 | 0.35 | 0.32 | 0.54 | 0.20 | 0.26 | 0.18 | 0.36 | 0.37 | 1.00 | | | | | | | |
| Memory for Words | 0.44 | 0.27 | 0.56 | 0.30 | 0.52 | 0.34 | 0.40 | 0.37 | 0.40 | 0.52 | 0.26 | 0.44 | 0.38 | 0.27 | 0.41 | 0.59 | 0.22 | 1.00 | | | | | | |
| Picture Vocabulary | 0.74 | 0.35 | 0.42 | 0.33 | 0.54 | 0.41 | 0.44 | 0.73 | 0.47 | 0.40 | 0.22 | 0.35 | 0.43 | 0.26 | 0.35 | 0.45 | 0.35 | 0.38 | 1.00 | | | | | |
| Oral Comprehension | 0.69 | 0.37 | 0.47 | 0.19 | 0.57 | 0.46 | 0.42 | 0.64 | 0.48 | 0.41 | 0.30 | 0.34 | 0.40 | 0.40 | 0.39 | 0.46 | 0.29 | 0.38 | 0.69 | 1.00 | | | | |
| Segmentation | 0.49 | 0.36 | 0.37 | 0.27 | 0.62 | 0.37 | 0.45 | 0.42 | 0.45 | 0.41 | 0.33 | 0.38 | 0.45 | 0.27 | 0.41 | 0.44 | 0.27 | 0.47 | 0.41 | 0.45 | 1.00 | | | |
| Rapid Picture Naming | 0.27 | 0.17 | 0.32 | 0.33 | 0.30 | 0.12 | 0.22 | 0.24 | 0.33 | 0.24 | 0.36 | 0.30 | 0.23 | 0.33 | 0.22 | 0.41 | 0.40 | 0.31 | 0.39 | 0.35 | 0.24 | 1.00 | | |
| Sentence Repetition | 0.50 | 0.26 | 0.50 | 0.30 | 0.52 | 0.27 | 0.37 | 0.41 | 0.36 | 0.34 | 0.22 | 0.48 | 0.29 | 0.29 | 0.22 | 0.44 | 0.33 | 0.48 | 0.52 | 0.57 | 0.34 | 0.31 | 1.00 | |
| Understanding Directions | 0.48 | 0.45 | 0.47 | 0.38 | 0.44 | 0.40 | 0.45 | 0.35 | 0.48 | 0.36 | 0.30 | 0.48 | 0.40 | 0.33 | 0.38 | 0.49 | 0.35 | 0.39 | 0.45 | 0.46 | 0.38 | 0.40 | 0.54 | 1.00 |
| Sound Blending | 0.48 | 0.23 | 0.34 | 0.28 | 0.57 | 0.27 | 0.40 | 0.44 | 0.46 | 0.40 | 0.20 | 0.40 | 0.47 | 0.26 | 0.44 | 0.47 | 0.28 | 0.49 | 0.45 | 0.47 | 0.53 | 0.27 | 0.28 | 0.42 |
| Retrieval Fluency | 0.44 | 0.24 | 0.33 | 0.33 | 0.50 | 0.25 | 0.28 | 0.31 | 0.30 | 0.33 | 0.36 | 0.20 | 0.26 | 0.30 | 0.45 | 0.47 | 0.38 | 0.45 | 0.39 | 0.41 | 0.30 | 0.42 | 0.27 | 0.26 |
| Sound Awareness | 0.52 | 0.47 | 0.45 | 0.36 | 0.66 | 0.38 | 0.46 | 0.45 | 0.52 | 0.44 | 0.34 | 0.43 | 0.44 | 0.30 | 0.37 | 0.44 | 0.34 | 0.44 | 0.48 | 0.51 | 0.56 | 0.31 | 0.46 | 0.47 |
| Letter-Word Identification | 0.63 | 0.62 | 0.47 | 0.42 | 0.55 | 0.27 | 0.36 | 0.52 | 0.40 | 0.46 | 0.46 | 0.37 | 0.31 | 0.24 | 0.33 | 0.33 | 0.35 | 0.37 | 0.55 | 0.55 | 0.43 | 0.28 | 0.49 | 0.42 |
| Applied Problems | 0.66 | 0.71 | 0.43 | 0.38 | 0.53 | 0.37 | 0.59 | 0.58 | 0.58 | 0.51 | 0.38 | 0.23 | 0.40 | 0.24 | 0.54 | 0.45 | 0.39 | 0.36 | 0.58 | 0.58 | 0.43 | 0.16 | 0.43 | 0.44 |
| Spelling | 0.59 | 0.51 | 0.51 | 0.46 | 0.53 | 0.30 | 0.36 | 0.53 | 0.37 | 0.43 | 0.45 | 0.44 | 0.29 | 0.22 | 0.33 | 0.40 | 0.38 | 0.40 | 0.49 | 0.49 | 0.37 | 0.21 | 0.54 | 0.39 |
| Passage Comprehension | 0.71 | 0.60 | 0.46 | 0.42 | 0.58 | 0.37 | 0.46 | 0.62 | 0.51 | 0.45 | 0.43 | 0.33 | 0.40 | 0.26 | 0.40 | 0.41 | 0.30 | 0.36 | 0.61 | 0.64 | 0.57 | 0.25 | 0.50 | 0.50 |
| Calculation | 0.56 | 0.71 | 0.39 | 0.42 | 0.48 | 0.40 | 0.49 | 0.42 | 0.49 | 0.43 | 0.48 | 0.21 | 0.32 | 0.09 | 0.46 | 0.40 | 0.44 | 0.29 | 0.44 | 0.39 | 0.37 | 0.18 | 0.38 | 0.41 |
| Writing Samples | 0.43 | 0.58 | 0.36 | 0.37 | 0.40 | 0.46 | 0.27 | 0.31 | 0.28 | 0.31 | 0.45 | 0.31 | 0.28 | 0.26 | 0.31 | 0.26 | 0.19 | 0.25 | 0.35 | 0.36 | 0.41 | 0.21 | 0.27 | 0.34 |
| Word Attack | 0.52 | 0.56 | 0.45 | 0.36 | 0.54 | 0.23 | 0.42 | 0.37 | 0.37 | 0.41 | 0.33 | 0.44 | 0.35 | 0.29 | 0.33 | 0.34 | 0.29 | 0.37 | 0.49 | 0.49 | 0.47 | 0.33 | 0.46 | 0.45 |
| Oral Reading | 0.57 | 0.44 | 0.39 | 0.40 | 0.49 | 0.24 | 0.40 | 0.53 | 0.38 | 0.44 | 0.36 | 0.41 | 0.33 | 0.09 | 0.31 | 0.34 | 0.29 | 0.34 | 0.55 | 0.41 | 0.35 | 0.14 | 0.44 | 0.37 |
| Sentence Reading Fluency | 0.49 | 0.44 | 0.31 | 0.59 | 0.43 | 0.30 | 0.30 | 0.45 | 0.44 | 0.39 | 0.58 | 0.29 | 0.33 | 0.22 | 0.31 | 0.40 | 0.48 | 0.33 | 0.42 | 0.37 | 0.25 | 0.40 | 0.47 | 0.43 |
| Math Facts Fluency | 0.43 | 0.56 | 0.38 | 0.53 | 0.42 | 0.27 | 0.32 | 0.40 | 0.36 | 0.37 | 0.50 | 0.24 | 0.20 | 0.24 | 0.30 | 0.39 | 0.41 | 0.23 | 0.35 | 0.32 | 0.18 | 0.33 | 0.37 | 0.41 |
| Sentence Writing Fluency | 0.37 | 0.48 | 0.37 | 0.57 | 0.45 | 0.21 | 0.36 | 0.26 | 0.33 | 0.42 | 0.58 | 0.27 | 0.31 | 0.24 | 0.31 | 0.36 | 0.45 | 0.24 | 0.27 | 0.31 | 0.23 | 0.27 | 0.41 | 0.41 |
| Reading Recall | 0.36 | 0.52 | 0.28 | 0.32 | 0.34 | 0.30 | 0.30 | 0.17 | 0.46 | 0.27 | 0.29 | 0.17 | 0.27 | 0.24 | 0.29 | 0.25 | 0.10 | 0.15 | 0.30 | 0.24 | 0.22 | 0.19 | 0.24 | 0.32 |
| Number Matrices | 0.53 | 0.67 | 0.46 | 0.32 | 0.55 | 0.33 | 0.40 | 0.45 | 0.50 | 0.44 | 0.32 | 0.30 | 0.37 | 0.20 | 0.51 | 0.42 | 0.39 | 0.37 | 0.49 | 0.42 | 0.39 | 0.26 | 0.45 | 0.41 |
| Editing | 0.67 | 0.53 | 0.57 | 0.39 | 0.58 | 0.35 | 0.44 | 0.55 | 0.38 | 0.58 | 0.44 | 0.37 | 0.24 | 0.09 | 0.41 | 0.45 | 0.35 | 0.44 | 0.59 | 0.57 | 0.42 | 0.19 | 0.50 | 0.44 |
| Word Reading Fluency | 0.37 | 0.38 | 0.27 | 0.66 | 0.41 | 0.16 | 0.30 | 0.31 | 0.36 | 0.27 | 0.63 | 0.20 | 0.28 | 0.12 | 0.27 | 0.37 | 0.47 | 0.28 | 0.40 | 0.28 | 0.18 | 0.39 | 0.36 | 0.33 |
| Spelling of Sounds | 0.47 | 0.53 | 0.40 | 0.38 | 0.58 | 0.28 | 0.43 | 0.37 | 0.43 | 0.48 | 0.32 | 0.41 | 0.40 | 0.13 | 0.35 | 0.42 | 0.34 | 0.43 | 0.40 | 0.41 | 0.58 | 0.28 | 0.39 | 0.37 |
| Reading Vocabulary | 0.76 | 0.52 | 0.39 | 0.38 | 0.63 | 0.40 | 0.38 | 0.66 | 0.42 | 0.41 | 0.35 | 0.31 | 0.38 | 0.17 | 0.36 | 0.37 | 0.32 | 0.36 | 0.66 | 0.71 | 0.50 | 0.23 | 0.54 | 0.38 |
| Science | 0.63 | 0.53 | 0.45 | 0.22 | 0.53 | 0.46 | 0.34 | 0.53 | 0.42 | 0.51 | 0.19 | 0.26 | 0.31 | 0.17 | 0.41 | 0.45 | 0.39 | 0.33 | 0.68 | 0.62 | 0.40 | 0.27 | 0.51 | 0.41 |
| Social Studies | 0.74 | 0.50 | 0.41 | 0.28 | 0.55 | 0.44 | 0.35 | 0.66 | 0.49 | 0.42 | 0.24 | 0.26 | 0.29 | 0.19 | 0.48 | 0.47 | 0.42 | 0.37 | 0.72 | 0.64 | 0.36 | 0.29 | 0.49 | 0.42 |
| Humanities | 0.71 | 0.41 | 0.46 | 0.29 | 0.57 | 0.36 | 0.41 | 0.71 | 0.42 | 0.47 | 0.21 | 0.33 | 0.35 | 0.20 | 0.43 | 0.49 | 0.32 | 0.44 | 0.71 | 0.67 | 0.42 | 0.32 | 0.52 | 0.45 |

| Test | Sound Blending | Retrieval Fluency | Sound Awareness | Letter-Word Identification | Applied Problems | Spelling | Passage Comprehension | Calculation | Writing Samples | Word Attack | Oral Reading | Sentence Reading Fluency | Math Facts Fluency | Sentence Writing Fluency | Reading Recall | Number Matrices | Editing | Word Reading Fluency | Spelling of Sounds | Reading Vocabulary | Science | Social Studies | Humanities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sound Blending | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| Retrieval Fluency | 0.32 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| Sound Awareness | 0.51 | 0.37 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| Letter-Word Identification | 0.40 | 0.32 | 0.54 | 1.00 | | | | | | | | | | | | | | | | | | | |
| Applied Problems | 0.40 | 0.36 | 0.46 | 0.61 | 1.00 | | | | | | | | | | | | | | | | | | |
| Spelling | 0.39 | 0.31 | 0.48 | 0.81 | 0.57 | 1.00 | | | | | | | | | | | | | | | | | |
| Passage Comprehension | 0.46 | 0.38 | 0.58 | 0.72 | 0.63 | 0.62 | 1.00 | | | | | | | | | | | | | | | | |
| Calculation | 0.32 | 0.31 | 0.43 | 0.63 | 0.79 | 0.61 | 0.60 | 1.00 | | | | | | | | | | | | | | | |
| Writing Samples | 0.29 | 0.27 | 0.45 | 0.63 | 0.42 | 0.50 | 0.62 | 0.51 | 1.00 | | | | | | | | | | | | | | |
| Word Attack | 0.43 | 0.30 | 0.53 | 0.74 | 0.47 | 0.65 | 0.62 | 0.49 | 0.57 | 1.00 | | | | | | | | | | | | | |
| Oral Reading | 0.51 | 0.21 | 0.51 | 0.74 | 0.54 | 0.69 | 0.65 | 0.53 | 0.46 | 0.62 | 1.00 | | | | | | | | | | | | |
| Sentence Reading Fluency | 0.29 | 0.37 | 0.50 | 0.65 | 0.48 | 0.68 | 0.58 | 0.50 | 0.44 | 0.48 | 0.64 | 1.00 | | | | | | | | | | | |
| Math Facts Fluency | 0.26 | 0.33 | 0.47 | 0.57 | 0.58 | 0.61 | 0.44 | 0.66 | 0.42 | 0.39 | 0.52 | 0.65 | 1.00 | | | | | | | | | | |
| Sentence Writing Fluency | 0.22 | 0.30 | 0.44 | 0.61 | 0.46 | 0.60 | 0.52 | 0.52 | 0.50 | 0.47 | 0.56 | 0.72 | 0.61 | 1.00 | | | | | | | | | |
| Reading Recall | 0.17 | 0.28 | 0.41 | 0.54 | 0.42 | 0.43 | 0.53 | 0.51 | 0.48 | 0.41 | 0.53 | 0.48 | 0.44 | 0.52 | 1.00 | | | | | | | | |
| Number Matrices | 0.35 | 0.39 | 0.51 | 0.51 | 0.65 | 0.55 | 0.48 | 0.63 | 0.36 | 0.42 | 0.40 | 0.47 | 0.54 | 0.39 | 0.38 | 1.00 | | | | | | | |
| Editing | 0.39 | 0.39 | 0.55 | 0.72 | 0.65 | 0.74 | 0.66 | 0.62 | 0.46 | 0.56 | 0.69 | 0.59 | 0.50 | 0.57 | 0.47 | 0.60 | 1.00 | | | | | | |
| Word Reading Fluency | 0.18 | 0.41 | 0.36 | 0.52 | 0.41 | 0.57 | 0.46 | 0.44 | 0.34 | 0.37 | 0.54 | 0.77 | 0.62 | 0.69 | 0.43 | 0.37 | 0.52 | 1.00 | | | | | |
| Spelling of Sounds | 0.54 | 0.29 | 0.61 | 0.61 | 0.50 | 0.60 | 0.57 | 0.52 | 0.52 | 0.66 | 0.61 | 0.54 | 0.47 | 0.45 | 0.37 | 0.47 | 0.51 | 0.44 | 1.00 | | | | |
| Reading Vocabulary | 0.41 | 0.37 | 0.57 | 0.72 | 0.65 | 0.66 | 0.72 | 0.61 | 0.47 | 0.56 | 0.66 | 0.59 | 0.46 | 0.51 | 0.43 | 0.54 | 0.73 | 0.49 | 0.48 | 1.00 | | | |
| Science | 0.36 | 0.35 | 0.45 | 0.53 | 0.63 | 0.49 | 0.54 | 0.58 | 0.42 | 0.50 | 0.39 | 0.37 | 0.29 | 0.32 | 0.29 | 0.51 | 0.57 | 0.27 | 0.43 | 0.66 | 1.00 | | |
| Social Studies | 0.44 | 0.40 | 0.46 | 0.59 | 0.62 | 0.52 | 0.56 | 0.58 | 0.42 | 0.53 | 0.50 | 0.42 | 0.42 | 0.36 | 0.29 | 0.53 | 0.56 | 0.34 | 0.39 | 0.67 | 0.77 | 1.00 | |
| Humanities | 0.55 | 0.42 | 0.50 | 0.56 | 0.61 | 0.53 | 0.55 | 0.50 | 0.35 | 0.47 | 0.48 | 0.39 | 0.38 | 0.36 | 0.22 | 0.54 | 0.59 | 0.33 | 0.46 | 0.67 | 0.69 | 0.72 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

## *Table E-6.*

*Test Score Intercorrelations—*
*Ages 40 Through 90+ (n = 1,146)*

| Test | Oral Vocabulary | Number Series | Verbal Attention | Letter-Pattern Matching | Phonological Processing | Story Recall | Visualization | General Information | Concept Formation | Numbers Reversed | Number-Pattern Matching | Nonword Repetition | Visual-Auditory Learning | Picture Recognition | Analysis-Synthesis | Object-Number Sequencing | Pair Cancellation | Memory for Words | Picture Vocabulary | Oral Comprehension | Segmentation | Rapid Picture Naming | Sentence Repetition | Understanding Directions | Sound Blending | Retrieval Fluency | Sound Awareness | Letter-Word Identification | Applied Problems | Spelling | Passage Comprehension | Calculation | Writing Samples | Word Attack | Oral Reading | Sentence Reading Fluency | Math Facts Fluency | Sentence Writing Fluency | Reading Recall | Number Matrices | Editing | Word Reading Fluency | Spelling of Sounds | Reading Vocabulary | Science | Social Studies | Humanities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oral Vocabulary | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Number Series | 0.56 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Verbal Attention | 0.58 | 0.46 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Letter-Pattern Matching | 0.46 | 0.45 | 0.38 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Phonological Processing | 0.63 | 0.56 | 0.59 | 0.50 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Story Recall | 0.49 | 0.47 | 0.42 | 0.33 | 0.38 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Visualization | 0.44 | 0.44 | 0.35 | 0.36 | 0.48 | 0.43 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| General Information | 0.78 | 0.44 | 0.48 | 0.37 | 0.50 | 0.44 | 0.44 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Concept Formation | 0.50 | 0.51 | 0.38 | 0.33 | 0.52 | 0.42 | 0.53 | 0.43 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Numbers Reversed | 0.48 | 0.47 | 0.56 | 0.51 | 0.52 | 0.35 | 0.43 | 0.43 | 0.43 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Number-Pattern Matching | 0.39 | 0.51 | 0.40 | 0.63 | 0.45 | 0.36 | 0.36 | 0.27 | 0.31 | 0.42 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nonword Repetition | 0.47 | 0.27 | 0.53 | 0.25 | 0.43 | 0.35 | 0.39 | 0.39 | 0.37 | 0.33 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Visual-Auditory Learning | 0.42 | 0.30 | 0.33 | 0.39 | 0.48 | 0.42 | 0.50 | 0.35 | 0.53 | 0.44 | 0.25 | 0.30 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Picture Recognition | 0.27 | 0.18 | 0.21 | 0.35 | 0.28 | 0.35 | 0.46 | 0.29 | 0.31 | 0.30 | 0.28 | 0.29 | 0.40 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Analysis-Synthesis | 0.47 | 0.50 | 0.45 | 0.43 | 0.48 | 0.48 | 0.57 | 0.43 | 0.59 | 0.44 | 0.41 | 0.29 | 0.45 | 0.43 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Object-Number Sequencing | 0.52 | 0.43 | 0.64 | 0.53 | 0.61 | 0.49 | 0.50 | 0.45 | 0.51 | 0.55 | 0.45 | 0.52 | 0.45 | 0.41 | 0.52 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pair Cancellation | 0.35 | 0.34 | 0.37 | 0.60 | 0.44 | 0.31 | 0.34 | 0.27 | 0.36 | 0.35 | 0.55 | 0.24 | 0.26 | 0.22 | 0.39 | 0.45 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Memory for Words | 0.41 | 0.29 | 0.56 | 0.36 | 0.58 | 0.42 | 0.43 | 0.35 | 0.42 | 0.55 | 0.34 | 0.50 | 0.41 | 0.33 | 0.46 | 0.60 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Picture Vocabulary | 0.72 | 0.42 | 0.46 | 0.40 | 0.52 | 0.47 | 0.44 | 0.74 | 0.42 | 0.38 | 0.28 | 0.36 | 0.37 | 0.27 | 0.35 | 0.46 | 0.31 | 0.35 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oral Comprehension | 0.71 | 0.50 | 0.57 | 0.30 | 0.60 | 0.51 | 0.42 | 0.62 | 0.47 | 0.43 | 0.40 | 0.41 | 0.38 | 0.40 | 0.43 | 0.52 | 0.34 | 0.38 | 0.69 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Segmentation | 0.51 | 0.44 | 0.46 | 0.38 | 0.69 | 0.42 | 0.51 | 0.42 | 0.49 | 0.48 | 0.40 | 0.39 | 0.52 | 0.33 | 0.46 | 0.50 | 0.32 | 0.50 | 0.34 | 0.44 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rapid Picture Naming | 0.31 | 0.25 | 0.38 | 0.39 | 0.36 | 0.21 | 0.25 | 0.28 | 0.36 | 0.29 | 0.35 | 0.33 | 0.27 | 0.40 | 0.27 | 0.47 | 0.36 | 0.32 | 0.42 | 0.42 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sentence Repetition | 0.56 | 0.35 | 0.61 | 0.37 | 0.56 | 0.35 | 0.38 | 0.44 | 0.36 | 0.41 | 0.30 | 0.55 | 0.29 | 0.31 | 0.32 | 0.51 | 0.33 | 0.54 | 0.51 | 0.63 | 0.42 | 0.36 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| Understanding Directions | 0.49 | 0.49 | 0.50 | 0.40 | 0.49 | 0.48 | 0.48 | 0.41 | 0.52 | 0.38 | 0.32 | 0.48 | 0.44 | 0.38 | 0.44 | 0.51 | 0.35 | 0.45 | 0.49 | 0.54 | 0.43 | 0.42 | 0.58 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| Sound Blending | 0.49 | 0.32 | 0.40 | 0.37 | 0.62 | 0.36 | 0.43 | 0.43 | 0.46 | 0.42 | 0.27 | 0.46 | 0.52 | 0.32 | 0.48 | 0.50 | 0.31 | 0.56 | 0.42 | 0.46 | 0.53 | 0.27 | 0.36 | 0.45 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| Retrieval Fluency | 0.43 | 0.33 | 0.41 | 0.41 | 0.54 | 0.34 | 0.33 | 0.33 | 0.37 | 0.37 | 0.44 | 0.28 | 0.29 | 0.37 | 0.52 | 0.55 | 0.42 | 0.50 | 0.40 | 0.46 | 0.33 | 0.46 | 0.38 | 0.35 | 0.35 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| Sound Awareness | 0.55 | 0.55 | 0.54 | 0.45 | 0.72 | 0.46 | 0.48 | 0.48 | 0.48 | 0.47 | 0.40 | 0.48 | 0.45 | 0.35 | 0.43 | 0.52 | 0.37 | 0.49 | 0.48 | 0.55 | 0.60 | 0.34 | 0.55 | 0.54 | 0.59 | 0.39 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| Letter-Word Identification | 0.68 | 0.65 | 0.54 | 0.46 | 0.58 | 0.36 | 0.36 | 0.59 | 0.39 | 0.48 | 0.50 | 0.38 | 0.31 | 0.27 | 0.33 | 0.35 | 0.37 | 0.37 | 0.61 | 0.62 | 0.45 | 0.31 | 0.54 | 0.45 | 0.43 | 0.35 | 0.59 | 1.00 | | | | | | | | | | | | | | | | | | | |
| Applied Problems | 0.69 | 0.74 | 0.50 | 0.45 | 0.57 | 0.47 | 0.59 | 0.61 | 0.60 | 0.54 | 0.46 | 0.30 | 0.46 | 0.31 | 0.57 | 0.49 | 0.45 | 0.38 | 0.58 | 0.63 | 0.49 | 0.24 | 0.46 | 0.50 | 0.45 | 0.42 | 0.52 | 0.64 | 1.00 | | | | | | | | | | | | | | | | | | |
| Spelling | 0.65 | 0.60 | 0.61 | 0.47 | 0.60 | 0.38 | 0.39 | 0.58 | 0.38 | 0.49 | 0.50 | 0.49 | 0.34 | 0.27 | 0.38 | 0.44 | 0.41 | 0.43 | 0.55 | 0.61 | 0.43 | 0.27 | 0.59 | 0.43 | 0.45 | 0.39 | 0.58 | 0.84 | 0.64 | 1.00 | | | | | | | | | | | | | | | | | |
| Passage Comprehension | 0.73 | 0.66 | 0.53 | 0.49 | 0.63 | 0.45 | 0.47 | 0.67 | 0.49 | 0.50 | 0.48 | 0.37 | 0.40 | 0.28 | 0.39 | 0.46 | 0.33 | 0.39 | 0.63 | 0.67 | 0.59 | 0.33 | 0.56 | 0.54 | 0.48 | 0.40 | 0.63 | 0.76 | 0.66 | 0.69 | 1.00 | | | | | | | | | | | | | | | | |
| Calculation | 0.61 | 0.76 | 0.48 | 0.49 | 0.57 | 0.49 | 0.51 | 0.50 | 0.53 | 0.49 | 0.54 | 0.26 | 0.40 | 0.19 | 0.51 | 0.46 | 0.47 | 0.32 | 0.48 | 0.50 | 0.46 | 0.24 | 0.42 | 0.42 | 0.43 | 0.40 | 0.52 | 0.68 | 0.83 | 0.68 | 0.67 | 1.00 | | | | | | | | | | | | | | | |
| Writing Samples | 0.53 | 0.62 | 0.45 | 0.50 | 0.53 | 0.49 | 0.35 | 0.41 | 0.36 | 0.38 | 0.52 | 0.34 | 0.33 | 0.32 | 0.38 | 0.36 | 0.30 | 0.31 | 0.45 | 0.46 | 0.47 | 0.29 | 0.38 | 0.40 | 0.40 | 0.35 | 0.54 | 0.70 | 0.50 | 0.61 | 0.70 | 0.62 | 1.00 | | | | | | | | | | | | | | |
| Word Attack | 0.58 | 0.60 | 0.54 | 0.41 | 0.60 | 0.33 | 0.42 | 0.43 | 0.38 | 0.43 | 0.40 | 0.46 | 0.35 | 0.31 | 0.37 | 0.40 | 0.32 | 0.40 | 0.54 | 0.59 | 0.51 | 0.37 | 0.56 | 0.50 | 0.47 | 0.36 | 0.62 | 0.78 | 0.53 | 0.72 | 0.67 | 0.56 | 0.64 | 1.00 | | | | | | | | | | | | | |
| Oral Reading | 0.63 | 0.49 | 0.49 | 0.44 | 0.53 | 0.33 | 0.39 | 0.60 | 0.35 | 0.48 | 0.42 | 0.45 | 0.34 | 0.13 | 0.31 | 0.38 | 0.32 | 0.39 | 0.59 | 0.49 | 0.36 | 0.21 | 0.49 | 0.40 | 0.55 | 0.27 | 0.56 | 0.78 | 0.56 | 0.75 | 0.68 | 0.58 | 0.55 | 0.67 | 1.00 | | | | | | | | | | | | |
| Sentence Reading Fluency | 0.56 | 0.55 | 0.42 | 0.60 | 0.50 | 0.39 | 0.32 | 0.51 | 0.44 | 0.48 | 0.63 | 0.33 | 0.36 | 0.28 | 0.34 | 0.44 | 0.48 | 0.40 | 0.47 | 0.48 | 0.35 | 0.42 | 0.52 | 0.47 | 0.35 | 0.43 | 0.58 | 0.71 | 0.56 | 0.72 | 0.66 | 0.58 | 0.55 | 0.55 | 0.68 | 1.00 | | | | | | | | | | | |
| Math Facts Fluency | 0.50 | 0.60 | 0.43 | 0.57 | 0.45 | 0.37 | 0.33 | 0.46 | 0.34 | 0.40 | 0.56 | 0.26 | 0.27 | 0.29 | 0.35 | 0.42 | 0.46 | 0.25 | 0.37 | 0.42 | 0.27 | 0.36 | 0.38 | 0.41 | 0.32 | 0.40 | 0.52 | 0.60 | 0.60 | 0.65 | 0.52 | 0.70 | 0.51 | 0.44 | 0.55 | 0.71 | 1.00 | | | | | | | | | | |
| Sentence Writing Fluency | 0.46 | 0.54 | 0.48 | 0.56 | 0.51 | 0.31 | 0.35 | 0.34 | 0.34 | 0.49 | 0.62 | 0.35 | 0.34 | 0.26 | 0.33 | 0.42 | 0.47 | 0.29 | 0.31 | 0.42 | 0.33 | 0.32 | 0.47 | 0.41 | 0.28 | 0.36 | 0.51 | 0.65 | 0.52 | 0.67 | 0.59 | 0.59 | 0.58 | 0.53 | 0.62 | 0.76 | 0.66 | 1.00 | | | | | | | | | |
| Reading Recall | 0.44 | 0.58 | 0.38 | 0.37 | 0.46 | 0.35 | 0.32 | 0.29 | 0.47 | 0.32 | 0.35 | 0.24 | 0.29 | 0.27 | 0.30 | 0.33 | 0.15 | 0.20 | 0.42 | 0.38 | 0.30 | 0.30 | 0.34 | 0.38 | 0.26 | 0.36 | 0.46 | 0.62 | 0.49 | 0.54 | 0.62 | 0.60 | 0.60 | 0.52 | 0.58 | 0.56 | 0.48 | 0.58 | 1.00 | | | | | | | | |
| Number Matrices | 0.56 | 0.71 | 0.51 | 0.38 | 0.62 | 0.41 | 0.42 | 0.48 | 0.50 | 0.47 | 0.40 | 0.36 | 0.42 | 0.22 | 0.56 | 0.47 | 0.43 | 0.39 | 0.44 | 0.46 | 0.49 | 0.28 | 0.48 | 0.44 | 0.42 | 0.47 | 0.52 | 0.52 | 0.65 | 0.59 | 0.54 | 0.66 | 0.43 | 0.43 | 0.43 | 0.52 | 0.54 | 0.45 | 0.41 | 1.00 | | | | | | | |
| Editing | 0.69 | 0.60 | 0.64 | 0.47 | 0.64 | 0.42 | 0.44 | 0.58 | 0.35 | 0.60 | 0.52 | 0.43 | 0.25 | 0.14 | 0.41 | 0.49 | 0.37 | 0.47 | 0.62 | 0.63 | 0.45 | 0.25 | 0.57 | 0.48 | 0.42 | 0.43 | 0.61 | 0.76 | 0.64 | 0.79 | 0.71 | 0.64 | 0.56 | 0.64 | 0.74 | 0.67 | 0.54 | 0.66 | 0.56 | 0.61 | 1.00 | | | | | | |
| Word Reading Fluency | 0.45 | 0.48 | 0.38 | 0.69 | 0.50 | 0.29 | 0.34 | 0.39 | 0.37 | 0.36 | 0.68 | 0.26 | 0.34 | 0.22 | 0.33 | 0.46 | 0.49 | 0.36 | 0.47 | 0.41 | 0.27 | 0.43 | 0.42 | 0.42 | 0.27 | 0.50 | 0.44 | 0.57 | 0.49 | 0.61 | 0.53 | 0.52 | 0.45 | 0.46 | 0.57 | 0.79 | 0.66 | 0.72 | 0.49 | 0.45 | 0.59 | 1.00 | | | | | |
| Spelling of Sounds | 0.54 | 0.61 | 0.54 | 0.46 | 0.68 | 0.37 | 0.47 | 0.45 | 0.43 | 0.56 | 0.40 | 0.46 | 0.46 | 0.20 | 0.43 | 0.49 | 0.38 | 0.50 | 0.43 | 0.50 | 0.62 | 0.31 | 0.51 | 0.45 | 0.62 | 0.36 | 0.72 | 0.66 | 0.57 | 0.68 | 0.65 | 0.61 | 0.59 | 0.70 | 0.66 | 0.61 | 0.55 | 0.54 | 0.47 | 0.57 | 0.61 | 0.49 | 1.00 | | | | |
| Reading Vocabulary | 0.80 | 0.61 | 0.56 | 0.46 | 0.68 | 0.47 | 0.43 | 0.70 | 0.44 | 0.50 | 0.44 | 0.42 | 0.42 | 0.23 | 0.39 | 0.47 | 0.35 | 0.41 | 0.68 | 0.76 | 0.55 | 0.32 | 0.63 | 0.48 | 0.49 | 0.41 | 0.64 | 0.77 | 0.68 | 0.74 | 0.79 | 0.66 | 0.57 | 0.64 | 0.73 | 0.68 | 0.53 | 0.61 | 0.53 | 0.58 | 0.78 | 0.58 | 0.60 | 1.00 | | | |
| Science | 0.63 | 0.60 | 0.55 | 0.30 | 0.59 | 0.53 | 0.37 | 0.55 | 0.45 | 0.52 | 0.28 | 0.34 | 0.33 | 0.22 | 0.44 | 0.50 | 0.40 | 0.35 | 0.69 | 0.70 | 0.42 | 0.33 | 0.57 | 0.49 | 0.41 | 0.40 | 0.55 | 0.58 | 0.67 | 0.56 | 0.60 | 0.62 | 0.49 | 0.57 | 0.46 | 0.44 | 0.34 | 0.41 | 0.41 | 0.53 | 0.61 | 0.34 | 0.50 | 0.71 | 1.00 | | |
| Social Studies | 0.75 | 0.59 | 0.50 | 0.35 | 0.58 | 0.51 | 0.38 | 0.67 | 0.50 | 0.41 | 0.32 | 0.32 | 0.28 | 0.21 | 0.51 | 0.48 | 0.44 | 0.35 | 0.72 | 0.69 | 0.35 | 0.34 | 0.53 | 0.47 | 0.45 | 0.41 | 0.50 | 0.64 | 0.65 | 0.59 | 0.60 | 0.64 | 0.52 | 0.59 | 0.55 | 0.47 | 0.47 | 0.42 | 0.38 | 0.54 | 0.60 | 0.39 | 0.47 | 0.68 | 0.76 | 1.00 | |
| Humanities | 0.72 | 0.51 | 0.51 | 0.39 | 0.62 | 0.44 | 0.43 | 0.73 | 0.43 | 0.48 | 0.31 | 0.41 | 0.35 | 0.23 | 0.47 | 0.52 | 0.35 | 0.44 | 0.70 | 0.67 | 0.46 | 0.31 | 0.56 | 0.47 | 0.59 | 0.45 | 0.56 | 0.61 | 0.66 | 0.61 | 0.61 | 0.59 | 0.45 | 0.53 | 0.57 | 0.47 | 0.44 | 0.44 | 0.35 | 0.58 | 0.62 | 0.41 | 0.56 | 0.73 | 0.71 | 0.74 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

*Appendix F*

# Cluster Score Intercorrelations

***Table F-1.***
*Cluster Score Intercorrelations—*
*Ages 3 Through 5 (n = 435)*

| Cluster | Short-Term Working Memory | Auditory Processing | Long-Term Retrieval | Visual Processing | Auditory Memory Span | Number Facility | Oral Language | Broad Oral Language | Oral Expression | Listening Comprehension | Phonetic Coding | Speed of Lexical Access | Reading | Academic Knowledge | Brief Achievement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Short-Term Working Memory** | 1.00 | | | | | | | | | | | | | | |
| **Auditory Processing** | 0.62 | 1.00 | | | | | | | | | | | | | |
| **Long-Term Retrieval** | 0.48 | 0.46 | 1.00 | | | | | | | | | | | | |
| **Visual Processing** | 0.36 | 0.39 | 0.53 | 1.00 | | | | | | | | | | | |
| **Auditory Memory Span** | 0.52 | 0.63 | 0.40 | 0.41 | 1.00 | | | | | | | | | | |
| **Number Facility** | 0.74 | 0.52 | 0.43 | 0.40 | 0.29 | 1.00 | | | | | | | | | |
| **Oral Language** | 0.40 | 0.43 | 0.49 | 0.40 | 0.46 | 0.36 | 1.00 | | | | | | | | |
| **Broad Oral Language** | 0.44 | 0.49 | 0.52 | 0.47 | 0.52 | 0.39 | 0.96 | 1.00 | | | | | | | |
| **Oral Expression** | 0.39 | 0.55 | 0.37 | 0.41 | 0.79 | 0.24 | 0.77 | 0.79 | 1.00 | | | | | | |
| **Listening Comprehension** | 0.47 | 0.50 | 0.50 | 0.49 | 0.54 | 0.44 | 0.86 | 0.95 | 0.71 | 1.00 | | | | | |
| **Phonetic Coding** | 0.51 | 0.60 | 0.54 | 0.47 | 0.42 | 0.53 | 0.38 | 0.43 | 0.36 | 0.46 | 1.00 | | | | |
| **Speed of Lexical Access** | 0.39 | 0.44 | 0.29 | 0.30 | 0.42 | 0.47 | 0.50 | 0.53 | 0.44 | 0.51 | 0.34 | 1.00 | | | |
| **Reading** | 0.50 | 0.44 | 0.43 | 0.44 | 0.36 | 0.60 | 0.60 | 0.63 | 0.48 | 0.64 | 0.55 | 0.41 | 1.00 | | |
| **Academic Knowledge** | 0.50 | 0.50 | 0.51 | 0.29 | 0.47 | 0.36 | 0.71 | 0.71 | 0.63 | 0.62 | 0.42 | 0.47 | 0.46 | 1.00 | |
| **Brief Achievement** | 0.56 | 0.52 | 0.47 | 0.49 | 0.43 | 0.63 | 0.60 | 0.62 | 0.52 | 0.61 | 0.50 | 0.39 | 0.88 | 0.56 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

## Table F-2.

*Cluster Score Intercorrelations—Ages 6 Through 8 (n = 825)*

| Test | General Intellectual Ability | Brief Intellectual Ability | *Gf-Gc* Composite | Comprehension-Knowledge | Comprehension-Knowledge–Extended | Fluid Reasoning | Fluid Reasoning–Extended | Short-Term Working Memory | Short-Term Working Memory–Extended | Cognitive Processing Speed | Auditory Processing | Long-Term Retrieval | Visual Processing | Quantitative Reasoning | Auditory Memory Span | Number Facility | Perceptual Speed | Cognitive Efficiency | Cognitive Efficiency–Extended | Reading Aptitude A | Reading Aptitude B | Math Aptitude A | Math Aptitude B | Writing Aptitude A | Writing Aptitude B | Oral Language | Broad Oral Language | Oral Expression | Listening Comprehension | Phonetic Coding | Speed of Lexical Access | Vocabulary | Reading | Broad Reading | Basic Reading Skills | Reading Comprehension | Reading Comprehension–Extended | Reading Fluency | Reading Rate | Mathematics | Broad Mathematics | Math Calculation Skills | Math Problem Solving | Written Language | Broad Written Language | Basic Writing Skills | Written Expression | Academic Skills | Academic Applications | Academic Fluency | Academic Knowledge | Phoneme-Grapheme Knowledge | Brief Achievement | Broad Achievement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General Intellectual Ability | 1.00 |
| Brief Intellectual Ability | 0.93 | 1.00 |
| *Gf-Gc* Composite | 0.84 | 0.84 | 1.00 |
| Comprehension-Knowledge | 0.60 | 0.59 | 0.80 | 1.00 |
| Comprehension-Knowledge–Extended | 0.59 | 0.57 | 0.77 | 0.96 | 1.00 |
| Fluid Reasoning | 0.80 | 0.82 | 0.88 | 0.42 | 0.41 | 1.00 |
| Fluid Reasoning–Extended | 0.81 | 0.79 | 0.85 | 0.44 | 0.42 | 0.94 | 1.00 |
| Short-Term Working Memory | 0.72 | 0.76 | 0.56 | 0.40 | 0.38 | 0.54 | 0.58 | 1.00 |
| Short-Term Working Memory–Extended | 0.75 | 0.75 | 0.58 | 0.41 | 0.39 | 0.56 | 0.61 | 0.94 | 1.00 |
| Cognitive Processing Speed | 0.63 | 0.42 | 0.39 | 0.29 | 0.28 | 0.37 | 0.41 | 0.42 | 0.48 | 1.00 |
| Auditory Processing | 0.70 | 0.64 | 0.61 | 0.49 | 0.49 | 0.54 | 0.53 | 0.56 | 0.62 | 0.33 | 1.00 |
| Long-Term Retrieval | 0.58 | 0.47 | 0.51 | 0.38 | 0.40 | 0.47 | 0.54 | 0.40 | 0.46 | 0.28 | 0.48 | 1.00 |
| Visual Processing | 0.54 | 0.39 | 0.49 | 0.36 | 0.37 | 0.45 | 0.53 | 0.37 | 0.43 | 0.28 | 0.48 | 0.57 | 1.00 |
| Quantitative Reasoning | 0.82 | 0.81 | 0.77 | 0.39 | 0.36 | 0.85 | 0.95 | 0.57 | 0.59 | 0.42 | 0.46 | 0.49 | 0.48 | 1.00 |
| Auditory Memory Span | 0.53 | 0.50 | 0.47 | 0.42 | 0.44 | 0.38 | 0.40 | 0.52 | 0.57 | 0.24 | 0.65 | 0.42 | 0.44 | 0.34 | 1.00 |
| Number Facility | 0.72 | 0.63 | 0.53 | 0.30 | 0.27 | 0.56 | 0.58 | 0.72 | 0.72 | 0.69 | 0.43 | 0.35 | 0.39 | 0.60 | 0.33 | 1.00 |
| Perceptual Speed | 0.71 | 0.54 | 0.45 | 0.27 | 0.25 | 0.48 | 0.50 | 0.48 | 0.53 | 0.85 | 0.35 | 0.32 | 0.34 | 0.54 | 0.23 | 0.89 | 1.00 |
| Cognitive Efficiency | 0.74 | 0.56 | 0.51 | 0.36 | 0.33 | 0.50 | 0.54 | 0.72 | 0.72 | 0.80 | 0.40 | 0.38 | 0.40 | 0.55 | 0.32 | 0.82 | 0.82 | 1.00 |
| Cognitive Efficiency–Extended | 0.82 | 0.71 | 0.57 | 0.37 | 0.34 | 0.57 | 0.61 | 0.77 | 0.78 | 0.79 | 0.49 | 0.40 | 0.40 | 0.64 | 0.39 | 0.95 | 0.93 | 0.90 | 1.00 |
| Reading Aptitude A | 0.87 | 0.77 | 0.80 | 0.56 | 0.54 | 0.77 | 0.77 | 0.61 | 0.66 | 0.66 | 0.66 | 0.50 | 0.49 | 0.70 | 0.49 | 0.84 | 0.80 | 0.67 | 0.84 | 1.00 |
| Reading Aptitude B | 0.88 | 0.84 | 0.70 | 0.53 | 0.51 | 0.64 | 0.66 | 0.73 | 0.75 | 0.64 | 0.66 | 0.45 | 0.41 | 0.66 | 0.51 | 0.86 | 0.81 | 0.67 | 0.89 | 0.93 | 1.00 |
| Math Aptitude A | 0.87 | 0.78 | 0.78 | 0.54 | 0.53 | 0.75 | 0.75 | 0.56 | 0.61 | 0.79 | 0.58 | 0.47 | 0.52 | 0.74 | 0.44 | 0.71 | 0.72 | 0.67 | 0.76 | 0.84 | 0.80 | 1.00 |
| Math Aptitude B | 0.80 | 0.72 | 0.76 | 0.60 | 0.57 | 0.68 | 0.81 | 0.76 | 0.77 | 0.49 | 0.58 | 0.59 | 0.68 | 0.79 | 0.52 | 0.68 | 0.53 | 0.72 | 0.71 | 0.73 | 0.69 | 0.74 | 1.00 |
| Writing Aptitude A | 0.87 | 0.77 | 0.71 | 0.54 | 0.53 | 0.65 | 0.67 | 0.59 | 0.65 | 0.66 | 0.63 | 0.54 | 0.46 | 0.67 | 0.47 | 0.85 | 0.84 | 0.67 | 0.86 | 0.95 | 0.96 | 0.82 | 0.69 | 1.00 |
| Writing Aptitude B | 0.88 | 0.84 | 0.70 | 0.53 | 0.51 | 0.64 | 0.66 | 0.73 | 0.75 | 0.64 | 0.66 | 0.45 | 0.41 | 0.66 | 0.51 | 0.86 | 0.81 | 0.67 | 0.89 | 0.93 | 1.00 | 0.80 | 0.69 | 0.96 | 1.00 |
| Oral Language | 0.54 | 0.54 | 0.64 | 0.71 | 0.84 | 0.41 | 0.40 | 0.38 | 0.40 | 0.20 | 0.48 | 0.45 | 0.43 | 0.34 | 0.48 | 0.28 | 0.21 | 0.25 | 0.32 | 0.51 | 0.50 | 0.48 | 0.50 | 0.52 | 0.50 | 1.00 |
| Broad Oral Language | 0.62 | 0.63 | 0.69 | 0.68 | 0.79 | 0.51 | 0.51 | 0.47 | 0.50 | 0.26 | 0.56 | 0.51 | 0.50 | 0.44 | 0.55 | 0.34 | 0.27 | 0.32 | 0.39 | 0.57 | 0.56 | 0.56 | 0.58 | 0.56 | 0.56 | 0.94 | 1.00 |
| Oral Expression | 0.52 | 0.49 | 0.55 | 0.62 | 0.72 | 0.35 | 0.33 | 0.40 | 0.43 | 0.24 | 0.59 | 0.39 | 0.40 | 0.25 | 0.79 | 0.22 | 0.18 | 0.27 | 0.30 | 0.46 | 0.46 | 0.45 | 0.46 | 0.44 | 0.47 | 0.79 | 0.80 | 1.00 |
| Listening Comprehension | 0.64 | 0.66 | 0.66 | 0.56 | 0.62 | 0.56 | 0.56 | 0.53 | 0.56 | 0.26 | 0.57 | 0.52 | 0.54 | 0.51 | 0.56 | 0.41 | 0.29 | 0.33 | 0.44 | 0.59 | 0.59 | 0.57 | 0.60 | 0.57 | 0.59 | 0.82 | 0.94 | 0.69 | 1.00 |
| Phonetic Coding | 0.59 | 0.49 | 0.55 | 0.41 | 0.40 | 0.51 | 0.56 | 0.41 | 0.47 | 0.30 | 0.64 | 0.56 | 0.52 | 0.51 | 0.47 | 0.39 | 0.34 | 0.39 | 0.42 | 0.59 | 0.53 | 0.51 | 0.60 | 0.55 | 0.53 | 0.37 | 0.44 | 0.37 | 0.47 | 1.00 |
| Speed of Lexical Access | 0.46 | 0.41 | 0.40 | 0.34 | 0.40 | 0.34 | 0.36 | 0.42 | 0.48 | 0.43 | 0.41 | 0.28 | 0.32 | 0.30 | 0.39 | 0.44 | 0.41 | 0.39 | 0.48 | 0.52 | 0.52 | 0.47 | 0.41 | 0.50 | 0.52 | 0.47 | 0.53 | 0.41 | 0.51 | 0.28 | 1.00 |
| Vocabulary | 0.63 | 0.61 | 0.74 | 0.87 | 0.95 | 0.44 | 0.44 | 0.38 | 0.41 | 0.30 | 0.53 | 0.44 | 0.37 | 0.38 | 0.47 | 0.29 | 0.28 | 0.34 | 0.36 | 0.58 | 0.55 | 0.57 | 0.57 | 0.58 | 0.55 | 0.88 | 0.85 | 0.77 | 0.67 | 0.41 | 0.46 | 1.00 |
| Reading | 0.73 | 0.73 | 0.72 | 0.54 | 0.55 | 0.66 | 0.59 | 0.49 | 0.45 | 0.38 | 0.52 | 0.36 | 0.42 | 0.58 | 0.42 | 0.57 | 0.53 | 0.48 | 0.59 | 0.70 | 0.69 | 0.65 | 0.53 | 0.68 | 0.69 | 0.56 | 0.60 | 0.52 | 0.59 | 0.50 | 0.36 | 0.57 | 1.00 |
| Broad Reading | 0.73 | 0.68 | 0.70 | 0.52 | 0.51 | 0.65 | 0.59 | 0.49 | 0.47 | 0.50 | 0.49 | 0.37 | 0.41 | 0.56 | 0.43 | 0.65 | 0.63 | 0.56 | 0.67 | 0.75 | 0.72 | 0.69 | 0.54 | 0.73 | 0.72 | 0.50 | 0.54 | 0.50 | 0.54 | 0.44 | 0.41 | 0.52 | 0.94 | 1.00 |
| Basic Reading Skills | 0.70 | 0.72 | 0.66 | 0.46 | 0.48 | 0.64 | 0.57 | 0.49 | 0.44 | 0.32 | 0.55 | 0.37 | 0.42 | 0.57 | 0.44 | 0.51 | 0.45 | 0.43 | 0.54 | 0.64 | 0.65 | 0.61 | 0.51 | 0.62 | 0.65 | 0.54 | 0.58 | 0.51 | 0.58 | 0.49 | 0.37 | 0.53 | 0.94 | 0.87 | 1.00 |
| Reading Comprehension | 0.73 | 0.71 | 0.70 | 0.46 | 0.48 | 0.69 | 0.62 | 0.46 | 0.44 | 0.33 | 0.51 | 0.39 | 0.44 | 0.59 | 0.36 | 0.52 | 0.50 | 0.47 | 0.56 | 0.68 | 0.65 | 0.59 | 0.53 | 0.65 | 0.65 | 0.50 | 0.55 | 0.47 | 0.55 | 0.49 | 0.35 | 0.53 | 0.91 | 0.85 | 0.80 | 1.00 |
| Reading Comprehension–Extended | 0.77 | 0.74 | 0.74 | 0.56 | 0.58 | 0.69 | 0.62 | 0.48 | 0.46 | 0.35 | 0.56 | 0.43 | 0.44 | 0.60 | 0.43 | 0.53 | 0.50 | 0.48 | 0.57 | 0.71 | 0.69 | 0.64 | 0.57 | 0.70 | 0.69 | 0.59 | 0.63 | 0.56 | 0.61 | 0.52 | 0.37 | 0.62 | 0.92 | 0.88 | 0.82 | 0.97 | 1.00 |
| Reading Fluency | 0.66 | 0.59 | 0.62 | 0.47 | 0.46 | 0.57 | 0.52 | 0.47 | 0.46 | 0.52 | 0.48 | 0.35 | 0.37 | 0.49 | 0.42 | 0.65 | 0.63 | 0.57 | 0.66 | 0.71 | 0.67 | 0.65 | 0.52 | 0.69 | 0.67 | 0.41 | 0.46 | 0.46 | 0.45 | 0.37 | 0.37 | 0.45 | 0.80 | 0.94 | 0.76 | 0.74 | 0.78 | 1.00 |
| Reading Rate | 0.63 | 0.52 | 0.55 | 0.39 | 0.39 | 0.52 | 0.48 | 0.39 | 0.42 | 0.61 | 0.38 | 0.29 | 0.33 | 0.45 | 0.35 | 0.69 | 0.74 | 0.60 | 0.70 | 0.72 | 0.69 | 0.64 | 0.45 | 0.71 | 0.69 | 0.36 | 0.39 | 0.38 | 0.38 | 0.25 | 0.45 | 0.39 | 0.69 | 0.87 | 0.63 | 0.63 | 0.67 | 0.92 | 1.00 |
| Mathematics | 0.75 | 0.71 | 0.72 | 0.47 | 0.46 | 0.72 | 0.70 | 0.48 | 0.50 | 0.49 | 0.40 | 0.42 | 0.42 | 0.70 | 0.36 | 0.60 | 0.57 | 0.54 | 0.62 | 0.71 | 0.66 | 0.76 | 0.63 | 0.68 | 0.66 | 0.42 | 0.47 | 0.41 | 0.47 | 0.43 | 0.29 | 0.48 | 0.67 | 0.68 | 0.62 | 0.64 | 0.68 | 0.62 | 0.60 | 1.00 |
| Broad Mathematics | 0.76 | 0.71 | 0.69 | 0.45 | 0.43 | 0.69 | 0.66 | 0.50 | 0.52 | 0.56 | 0.39 | 0.39 | 0.41 | 0.67 | 0.34 | 0.66 | 0.66 | 0.60 | 0.69 | 0.72 | 0.70 | 0.76 | 0.60 | 0.72 | 0.70 | 0.39 | 0.44 | 0.39 | 0.45 | 0.38 | 0.34 | 0.44 | 0.68 | 0.73 | 0.63 | 0.63 | 0.67 | 0.69 | 0.69 | 0.94 | 1.00 |
| Math Calculation Skills | 0.73 | 0.66 | 0.62 | 0.40 | 0.37 | 0.63 | 0.59 | 0.48 | 0.50 | 0.58 | 0.36 | 0.34 | 0.34 | 0.61 | 0.30 | 0.67 | 0.69 | 0.61 | 0.70 | 0.70 | 0.69 | 0.71 | 0.53 | 0.71 | 0.69 | 0.31 | 0.36 | 0.33 | 0.38 | 0.33 | 0.35 | 0.38 | 0.65 | 0.72 | 0.60 | 0.61 | 0.64 | 0.68 | 0.71 | 0.87 | 0.98 | 1.00 |
| Math Problem Solving | 0.74 | 0.74 | 0.76 | 0.50 | 0.50 | 0.75 | 0.75 | 0.53 | 0.55 | 0.39 | 0.48 | 0.44 | 0.43 | 0.73 | 0.46 | 0.50 | 0.41 | 0.46 | 0.53 | 0.65 | 0.60 | 0.73 | 0.68 | 0.60 | 0.61 | 0.46 | 0.52 | 0.47 | 0.53 | 0.49 | 0.29 | 0.51 | 0.57 | 0.58 | 0.54 | 0.53 | 0.59 | 0.53 | 0.50 | 0.85 | 0.80 | 0.70 | 1.00 |
| Written Language | 0.74 | 0.72 | 0.63 | 0.42 | 0.41 | 0.63 | 0.59 | 0.51 | 0.48 | 0.39 | 0.54 | 0.44 | 0.42 | 0.62 | 0.41 | 0.60 | 0.57 | 0.49 | 0.63 | 0.67 | 0.70 | 0.62 | 0.53 | 0.70 | 0.70 | 0.44 | 0.48 | 0.42 | 0.50 | 0.47 | 0.30 | 0.44 | 0.86 | 0.83 | 0.85 | 0.77 | 0.79 | 0.74 | 0.66 | 0.66 | 0.69 | 0.67 | 0.56 | 1.00 |
| Broad Written Language | 0.75 | 0.72 | 0.62 | 0.39 | 0.38 | 0.63 | 0.59 | 0.54 | 0.52 | 0.45 | 0.55 | 0.43 | 0.42 | 0.62 | 0.40 | 0.66 | 0.63 | 0.55 | 0.69 | 0.70 | 0.74 | 0.65 | 0.54 | 0.73 | 0.74 | 0.41 | 0.46 | 0.41 | 0.49 | 0.44 | 0.33 | 0.41 | 0.86 | 0.87 | 0.84 | 0.79 | 0.81 | 0.79 | 0.73 | 0.67 | 0.72 | 0.72 | 0.56 | 0.98 | 1.00 |
| Basic Writing Skills | 0.73 | 0.73 | 0.65 | 0.50 | 0.49 | 0.58 | 0.55 | 0.59 | 0.55 | 0.41 | 0.55 | 0.34 | 0.38 | 0.57 | 0.47 | 0.60 | 0.54 | 0.52 | 0.64 | 0.67 | 0.72 | 0.65 | 0.58 | 0.68 | 0.72 | 0.50 | 0.53 | 0.51 | 0.53 | 0.42 | 0.29 | 0.51 | 0.82 | 0.84 | 0.81 | 0.72 | 0.78 | 0.79 | 0.72 | 0.69 | 0.72 | 0.69 | 0.65 | 0.86 | 0.87 | 1.00 |
| Written Expression | 0.70 | 0.66 | 0.54 | 0.30 | 0.30 | 0.59 | 0.56 | 0.49 | 0.47 | 0.42 | 0.49 | 0.42 | 0.40 | 0.60 | 0.31 | 0.63 | 0.61 | 0.52 | 0.65 | 0.66 | 0.69 | 0.59 | 0.50 | 0.70 | 0.69 | 0.34 | 0.40 | 0.32 | 0.44 | 0.41 | 0.32 | 0.34 | 0.79 | 0.79 | 0.76 | 0.76 | 0.76 | 0.71 | 0.66 | 0.60 | 0.64 | 0.65 | 0.46 | 0.92 | 0.95 | 0.72 | 1.00 |
| Academic Skills | 0.77 | 0.75 | 0.71 | 0.50 | 0.49 | 0.68 | 0.63 | 0.53 | 0.51 | 0.47 | 0.52 | 0.39 | 0.40 | 0.63 | 0.44 | 0.64 | 0.61 | 0.54 | 0.67 | 0.74 | 0.74 | 0.72 | 0.57 | 0.73 | 0.74 | 0.48 | 0.52 | 0.49 | 0.52 | 0.45 | 0.34 | 0.52 | 0.90 | 0.89 | 0.89 | 0.78 | 0.83 | 0.81 | 0.74 | 0.84 | 0.85 | 0.83 | 0.70 | 0.89 | 0.90 | 0.90 | 0.77 | 1.00 |
| Academic Applications | 0.79 | 0.77 | 0.75 | 0.51 | 0.51 | 0.74 | 0.70 | 0.51 | 0.49 | 0.39 | 0.52 | 0.48 | 0.50 | 0.70 | 0.40 | 0.60 | 0.57 | 0.52 | 0.63 | 0.73 | 0.71 | 0.70 | 0.62 | 0.73 | 0.71 | 0.54 | 0.59 | 0.47 | 0.60 | 0.54 | 0.34 | 0.55 | 0.90 | 0.84 | 0.82 | 0.88 | 0.88 | 0.71 | 0.63 | 0.78 | 0.76 | 0.69 | 0.68 | 0.90 | 0.89 | 0.75 | 0.88 | 0.84 | 1.00 |
| Academic Fluency | 0.70 | 0.61 | 0.60 | 0.41 | 0.38 | 0.58 | 0.54 | 0.50 | 0.50 | 0.61 | 0.42 | 0.33 | 0.38 | 0.54 | 0.36 | 0.72 | 0.73 | 0.64 | 0.74 | 0.73 | 0.72 | 0.69 | 0.51 | 0.73 | 0.72 | 0.33 | 0.39 | 0.38 | 0.42 | 0.30 | 0.41 | 0.37 | 0.74 | 0.89 | 0.69 | 0.68 | 0.71 | 0.92 | 0.93 | 0.69 | 0.83 | 0.85 | 0.58 | 0.74 | 0.82 | 0.77 | 0.75 | 0.82 | 0.70 | 1.00 |
| Academic Knowledge | 0.60 | 0.61 | 0.67 | 0.66 | 0.72 | 0.49 | 0.52 | 0.46 | 0.49 | 0.27 | 0.46 | 0.43 | 0.28 | 0.50 | 0.50 | 0.29 | 0.20 | 0.33 | 0.34 | 0.48 | 0.47 | 0.56 | 0.58 | 0.49 | 0.47 | 0.72 | 0.72 | 0.67 | 0.63 | 0.39 | 0.42 | 0.75 | 0.48 | 0.44 | 0.50 | 0.41 | 0.52 | 0.37 | 0.31 | 0.55 | 0.48 | 0.42 | 0.57 | 0.47 | 0.45 | 0.49 | 0.39 | 0.53 | 0.52 | 0.35 | 1.00 |
| Phoneme-Grapheme Knowledge | 0.69 | 0.68 | 0.62 | 0.37 | 0.39 | 0.65 | 0.60 | 0.50 | 0.47 | 0.29 | 0.60 | 0.44 | 0.44 | 0.59 | 0.46 | 0.44 | 0.37 | 0.41 | 0.48 | 0.58 | 0.57 | 0.59 | 0.54 | 0.55 | 0.57 | 0.46 | 0.53 | 0.47 | 0.55 | 0.59 | 0.34 | 0.45 | 0.80 | 0.75 | 0.90 | 0.72 | 0.72 | 0.67 | 0.53 | 0.56 | 0.55 | 0.52 | 0.53 | 0.79 | 0.77 | 0.71 | 0.71 | 0.76 | 0.76 | 0.59 | 0.46 | 1.00 |
| Brief Achievement | 0.77 | 0.77 | 0.74 | 0.54 | 0.54 | 0.69 | 0.64 | 0.55 | 0.52 | 0.43 | 0.53 | 0.40 | 0.46 | 0.64 | 0.47 | 0.60 | 0.55 | 0.52 | 0.63 | 0.72 | 0.72 | 0.71 | 0.60 | 0.70 | 0.72 | 0.55 | 0.58 | 0.53 | 0.59 | 0.47 | 0.33 | 0.56 | 0.91 | 0.90 | 0.90 | 0.77 | 0.82 | 0.81 | 0.72 | 0.81 | 0.81 | 0.75 | 0.74 | 0.88 | 0.88 | 0.91 | 0.74 | 0.97 | 0.86 | 0.79 | 0.55 | 0.77 | 1.00 |
| Broad Achievement | 0.81 | 0.76 | 0.73 | 0.50 | 0.49 | 0.71 | 0.66 | 0.55 | 0.54 | 0.55 | 0.52 | 0.43 | 0.45 | 0.66 | 0.43 | 0.71 | 0.70 | 0.62 | 0.74 | 0.79 | 0.78 | 0.76 | 0.61 | 0.79 | 0.78 | 0.48 | 0.53 | 0.48 | 0.54 | 0.46 | 0.40 | 0.51 | 0.91 | 0.95 | 0.86 | 0.83 | 0.86 | 0.89 | 0.84 | 0.83 | 0.88 | 0.86 | 0.70 | 0.90 | 0.93 | 0.87 | 0.85 | 0.96 | 0.90 | 0.92 | 0.50 | 0.75 | 0.94 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

**Table F-3.**

*Cluster Score Intercorrelations—Ages 9 Through 13 (n = 1,572)*

| Test | General Intellectual Ability | Brief Intellectual Ability | *Gf-Gc* Composite | Comprehension-Knowledge | Comprehension-Knowledge–Extended | Fluid Reasoning | Fluid Reasoning–Extended | Short-Term Working Memory | Short-Term Working Memory–Extended | Cognitive Processing Speed | Auditory Processing | Long-Term Retrieval | Visual Processing | Quantitative Reasoning | Auditory Memory Span | Number Facility | Perceptual Speed | Cognitive Efficiency | Cognitive Efficiency–Extended | Reading Aptitude A | Reading Aptitude B | Math Aptitude A | Math Aptitude B | Writing Aptitude A | Writing Aptitude B | Oral Language | Broad Oral Language | Oral Expression | Listening Comprehension | Phonetic Coding | Speed of Lexical Access | Vocabulary | Reading | Broad Reading | Basic Reading Skills | Reading Comprehension | Reading Comprehension–Extended | Reading Fluency | Reading Rate | Mathematics | Broad Mathematics | Math Calculation Skills | Math Problem Solving | Written Language | Broad Written Language | Basic Writing Skills | Written Expression | Academic Skills | Academic Applications | Academic Fluency | Academic Knowledge | Phoneme-Grapheme Knowledge | Brief Achievement | Broad Achievement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General Intellectual Ability | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Brief Intellectual Ability | 0.93 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Gf-Gc* Composite | 0.85 | 0.85 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Comprehension-Knowledge | 0.65 | 0.66 | 0.83 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Comprehension-Knowledge–Extended | 0.66 | 0.66 | 0.81 | 0.97 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fluid Reasoning | 0.79 | 0.79 | 0.87 | 0.46 | 0.46 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fluid Reasoning–Extended | 0.79 | 0.76 | 0.85 | 0.48 | 0.47 | 0.94 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Short-Term Working Memory | 0.72 | 0.75 | 0.57 | 0.45 | 0.44 | 0.51 | 0.53 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Short-Term Working Memory–Extended | 0.75 | 0.74 | 0.59 | 0.47 | 0.47 | 0.54 | 0.57 | 0.94 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cognitive Processing Speed | 0.60 | 0.41 | 0.40 | 0.28 | 0.29 | 0.39 | 0.42 | 0.38 | 0.44 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Auditory Processing | 0.67 | 0.60 | 0.57 | 0.48 | 0.48 | 0.50 | 0.47 | 0.52 | 0.59 | 0.31 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Long-Term Retrieval | 0.55 | 0.43 | 0.49 | 0.37 | 0.39 | 0.47 | 0.52 | 0.38 | 0.44 | 0.25 | 0.40 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Visual Processing | 0.50 | 0.34 | 0.43 | 0.35 | 0.36 | 0.38 | 0.46 | 0.34 | 0.40 | 0.30 | 0.39 | 0.49 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Quantitative Reasoning | 0.80 | 0.78 | 0.76 | 0.44 | 0.43 | 0.84 | 0.94 | 0.52 | 0.54 | 0.42 | 0.41 | 0.47 | 0.44 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Auditory Memory Span | 0.57 | 0.53 | 0.46 | 0.41 | 0.43 | 0.38 | 0.40 | 0.55 | 0.59 | 0.24 | 0.66 | 0.37 | 0.36 | 0.35 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Number Facility | 0.69 | 0.59 | 0.52 | 0.32 | 0.32 | 0.55 | 0.56 | 0.70 | 0.69 | 0.66 | 0.37 | 0.34 | 0.39 | 0.57 | 0.34 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Perceptual Speed | 0.67 | 0.50 | 0.44 | 0.27 | 0.27 | 0.46 | 0.48 | 0.43 | 0.48 | 0.85 | 0.30 | 0.29 | 0.34 | 0.52 | 0.25 | 0.86 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cognitive Efficiency | 0.71 | 0.54 | 0.51 | 0.37 | 0.37 | 0.49 | 0.51 | 0.71 | 0.71 | 0.78 | 0.36 | 0.35 | 0.38 | 0.52 | 0.35 | 0.80 | 0.80 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cognitive Efficiency–Extended | 0.80 | 0.69 | 0.57 | 0.40 | 0.39 | 0.56 | 0.58 | 0.76 | 0.77 | 0.78 | 0.45 | 0.38 | 0.40 | 0.61 | 0.42 | 0.93 | 0.91 | 0.90 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reading Aptitude A | 0.85 | 0.76 | 0.81 | 0.59 | 0.58 | 0.79 | 0.78 | 0.57 | 0.63 | 0.63 | 0.61 | 0.49 | 0.45 | 0.70 | 0.49 | 0.80 | 0.76 | 0.63 | 0.81 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reading Aptitude B | 0.88 | 0.84 | 0.71 | 0.58 | 0.58 | 0.63 | 0.64 | 0.70 | 0.73 | 0.62 | 0.63 | 0.43 | 0.39 | 0.65 | 0.55 | 0.82 | 0.77 | 0.64 | 0.87 | 0.92 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Math Aptitude A | 0.86 | 0.77 | 0.77 | 0.56 | 0.57 | 0.74 | 0.74 | 0.53 | 0.58 | 0.78 | 0.53 | 0.43 | 0.52 | 0.74 | 0.41 | 0.68 | 0.69 | 0.64 | 0.74 | 0.82 | 0.78 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Math Aptitude B | 0.80 | 0.72 | 0.77 | 0.64 | 0.62 | 0.68 | 0.81 | 0.74 | 0.74 | 0.45 | 0.52 | 0.56 | 0.65 | 0.80 | 0.51 | 0.66 | 0.49 | 0.68 | 0.68 | 0.73 | 0.68 | 0.74 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Writing Aptitude A | 0.86 | 0.75 | 0.72 | 0.58 | 0.58 | 0.64 | 0.66 | 0.56 | 0.61 | 0.65 | 0.58 | 0.53 | 0.44 | 0.66 | 0.48 | 0.83 | 0.81 | 0.63 | 0.84 | 0.94 | 0.95 | 0.80 | 0.68 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Writing Aptitude B | 0.88 | 0.84 | 0.71 | 0.58 | 0.58 | 0.63 | 0.64 | 0.70 | 0.73 | 0.62 | 0.63 | 0.43 | 0.39 | 0.65 | 0.55 | 0.82 | 0.77 | 0.64 | 0.87 | 0.92 | 1.00 | 0.78 | 0.68 | 0.95 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oral Language | 0.60 | 0.60 | 0.68 | 0.75 | 0.86 | 0.43 | 0.43 | 0.43 | 0.46 | 0.24 | 0.45 | 0.43 | 0.40 | 0.39 | 0.47 | 0.34 | 0.25 | 0.29 | 0.37 | 0.56 | 0.56 | 0.52 | 0.55 | 0.58 | 0.56 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Broad Oral Language | 0.68 | 0.67 | 0.72 | 0.71 | 0.81 | 0.53 | 0.52 | 0.49 | 0.53 | 0.29 | 0.53 | 0.49 | 0.46 | 0.48 | 0.54 | 0.38 | 0.30 | 0.35 | 0.44 | 0.60 | 0.60 | 0.59 | 0.60 | 0.61 | 0.60 | 0.94 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oral Expression | 0.61 | 0.59 | 0.59 | 0.63 | 0.72 | 0.40 | 0.38 | 0.47 | 0.50 | 0.29 | 0.60 | 0.35 | 0.36 | 0.33 | 0.81 | 0.29 | 0.25 | 0.34 | 0.39 | 0.51 | 0.55 | 0.50 | 0.50 | 0.51 | 0.55 | 0.78 | 0.79 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Listening Comprehension | 0.66 | 0.65 | 0.65 | 0.58 | 0.63 | 0.54 | 0.54 | 0.50 | 0.53 | 0.28 | 0.53 | 0.50 | 0.49 | 0.50 | 0.54 | 0.40 | 0.32 | 0.34 | 0.45 | 0.59 | 0.59 | 0.57 | 0.58 | 0.59 | 0.59 | 0.80 | 0.94 | 0.69 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Phonetic Coding | 0.48 | 0.38 | 0.42 | 0.32 | 0.31 | 0.39 | 0.44 | 0.35 | 0.39 | 0.20 | 0.56 | 0.45 | 0.37 | 0.39 | 0.40 | 0.30 | 0.22 | 0.27 | 0.32 | 0.50 | 0.45 | 0.38 | 0.48 | 0.45 | 0.45 | 0.31 | 0.36 | 0.28 | 0.38 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| Speed of Lexical Access | 0.47 | 0.42 | 0.41 | 0.37 | 0.43 | 0.34 | 0.37 | 0.37 | 0.44 | 0.43 | 0.39 | 0.26 | 0.36 | 0.33 | 0.40 | 0.41 | 0.40 | 0.37 | 0.46 | 0.51 | 0.52 | 0.47 | 0.41 | 0.50 | 0.52 | 0.50 | 0.53 | 0.44 | 0.49 | 0.21 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| Vocabulary | 0.68 | 0.68 | 0.78 | 0.88 | 0.96 | 0.48 | 0.48 | 0.44 | 0.47 | 0.31 | 0.49 | 0.41 | 0.34 | 0.44 | 0.47 | 0.33 | 0.29 | 0.37 | 0.41 | 0.61 | 0.60 | 0.60 | 0.62 | 0.61 | 0.60 | 0.90 | 0.85 | 0.77 | 0.66 | 0.32 | 0.47 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| Reading | 0.72 | 0.73 | 0.71 | 0.62 | 0.63 | 0.60 | 0.54 | 0.49 | 0.45 | 0.37 | 0.49 | 0.31 | 0.33 | 0.55 | 0.43 | 0.54 | 0.49 | 0.45 | 0.57 | 0.67 | 0.69 | 0.64 | 0.53 | 0.68 | 0.69 | 0.62 | 0.63 | 0.57 | 0.59 | 0.37 | 0.37 | 0.63 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| Broad Reading | 0.73 | 0.70 | 0.72 | 0.61 | 0.60 | 0.61 | 0.55 | 0.49 | 0.48 | 0.52 | 0.48 | 0.36 | 0.34 | 0.54 | 0.44 | 0.64 | 0.63 | 0.56 | 0.67 | 0.74 | 0.73 | 0.69 | 0.54 | 0.74 | 0.73 | 0.56 | 0.59 | 0.55 | 0.57 | 0.30 | 0.44 | 0.59 | 0.92 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| Basic Reading Skills | 0.69 | 0.71 | 0.63 | 0.51 | 0.54 | 0.56 | 0.51 | 0.50 | 0.45 | 0.35 | 0.52 | 0.27 | 0.32 | 0.53 | 0.44 | 0.50 | 0.43 | 0.43 | 0.54 | 0.60 | 0.65 | 0.60 | 0.51 | 0.60 | 0.65 | 0.55 | 0.58 | 0.55 | 0.55 | 0.36 | 0.36 | 0.57 | 0.91 | 0.84 | 1.00 | | | | | | | | | | | | | | | | | | | |
| Reading Comprehension | 0.70 | 0.69 | 0.69 | 0.53 | 0.54 | 0.64 | 0.58 | 0.44 | 0.43 | 0.32 | 0.46 | 0.36 | 0.34 | 0.56 | 0.39 | 0.49 | 0.46 | 0.43 | 0.53 | 0.65 | 0.63 | 0.57 | 0.51 | 0.63 | 0.63 | 0.53 | 0.56 | 0.51 | 0.54 | 0.35 | 0.36 | 0.56 | 0.88 | 0.82 | 0.72 | 1.00 | | | | | | | | | | | | | | | | | | |
| Reading Comprehension–Extended | 0.75 | 0.73 | 0.74 | 0.63 | 0.65 | 0.64 | 0.59 | 0.47 | 0.46 | 0.34 | 0.52 | 0.40 | 0.34 | 0.58 | 0.45 | 0.50 | 0.46 | 0.45 | 0.54 | 0.68 | 0.68 | 0.61 | 0.56 | 0.69 | 0.68 | 0.63 | 0.65 | 0.59 | 0.60 | 0.40 | 0.39 | 0.66 | 0.90 | 0.85 | 0.76 | 0.96 | 1.00 | | | | | | | | | | | | | | | | | |
| Reading Fluency | 0.65 | 0.59 | 0.63 | 0.56 | 0.54 | 0.53 | 0.49 | 0.46 | 0.46 | 0.53 | 0.45 | 0.34 | 0.29 | 0.47 | 0.40 | 0.62 | 0.62 | 0.57 | 0.65 | 0.68 | 0.66 | 0.62 | 0.51 | 0.67 | 0.66 | 0.45 | 0.49 | 0.48 | 0.45 | 0.24 | 0.39 | 0.51 | 0.74 | 0.92 | 0.70 | 0.68 | 0.73 | 1.00 | | | | | | | | | | | | | | | | |
| Reading Rate | 0.64 | 0.54 | 0.58 | 0.46 | 0.46 | 0.53 | 0.48 | 0.40 | 0.43 | 0.64 | 0.38 | 0.31 | 0.27 | 0.46 | 0.36 | 0.67 | 0.74 | 0.61 | 0.71 | 0.72 | 0.68 | 0.64 | 0.45 | 0.71 | 0.68 | 0.40 | 0.45 | 0.43 | 0.42 | 0.15 | 0.48 | 0.45 | 0.63 | 0.86 | 0.59 | 0.59 | 0.64 | 0.90 | 1.00 | | | | | | | | | | | | | | | |
| Mathematics | 0.77 | 0.74 | 0.76 | 0.52 | 0.52 | 0.75 | 0.73 | 0.50 | 0.51 | 0.49 | 0.38 | 0.42 | 0.39 | 0.73 | 0.36 | 0.60 | 0.55 | 0.53 | 0.62 | 0.71 | 0.66 | 0.77 | 0.67 | 0.68 | 0.66 | 0.47 | 0.52 | 0.44 | 0.50 | 0.32 | 0.33 | 0.53 | 0.68 | 0.69 | 0.61 | 0.64 | 0.68 | 0.61 | 0.58 | 1.00 | | | | | | | | | | | | | | |
| Broad Mathematics | 0.78 | 0.73 | 0.73 | 0.53 | 0.52 | 0.71 | 0.67 | 0.53 | 0.54 | 0.57 | 0.39 | 0.37 | 0.39 | 0.68 | 0.35 | 0.65 | 0.63 | 0.61 | 0.69 | 0.72 | 0.70 | 0.77 | 0.63 | 0.71 | 0.70 | 0.45 | 0.51 | 0.44 | 0.50 | 0.27 | 0.39 | 0.51 | 0.68 | 0.74 | 0.62 | 0.63 | 0.66 | 0.70 | 0.69 | 0.94 | 1.00 | | | | | | | | | | | | | |
| Math Calculation Skills | 0.73 | 0.68 | 0.65 | 0.47 | 0.46 | 0.63 | 0.59 | 0.49 | 0.50 | 0.59 | 0.36 | 0.33 | 0.33 | 0.61 | 0.31 | 0.64 | 0.65 | 0.61 | 0.69 | 0.67 | 0.67 | 0.72 | 0.55 | 0.69 | 0.67 | 0.37 | 0.43 | 0.40 | 0.42 | 0.22 | 0.38 | 0.44 | 0.64 | 0.73 | 0.59 | 0.60 | 0.62 | 0.70 | 0.70 | 0.86 | 0.97 | 1.00 | | | | | | | | | | | | |
| Math Problem Solving | 0.76 | 0.76 | 0.77 | 0.54 | 0.55 | 0.77 | 0.76 | 0.52 | 0.53 | 0.42 | 0.46 | 0.42 | 0.39 | 0.76 | 0.43 | 0.51 | 0.43 | 0.47 | 0.54 | 0.67 | 0.63 | 0.74 | 0.68 | 0.62 | 0.63 | 0.51 | 0.56 | 0.52 | 0.52 | 0.37 | 0.38 | 0.56 | 0.59 | 0.61 | 0.53 | 0.56 | 0.62 | 0.55 | 0.53 | 0.85 | 0.81 | 0.71 | 1.00 | | | | | | | | | | | |
| Written Language | 0.73 | 0.71 | 0.63 | 0.49 | 0.50 | 0.59 | 0.55 | 0.50 | 0.46 | 0.43 | 0.51 | 0.37 | 0.33 | 0.58 | 0.41 | 0.58 | 0.56 | 0.49 | 0.63 | 0.66 | 0.71 | 0.62 | 0.51 | 0.70 | 0.71 | 0.50 | 0.52 | 0.49 | 0.49 | 0.34 | 0.33 | 0.52 | 0.84 | 0.82 | 0.82 | 0.74 | 0.76 | 0.70 | 0.65 | 0.66 | 0.69 | 0.67 | 0.58 | 1.00 | | | | | | | | | | |
| Broad Written Language | 0.75 | 0.72 | 0.63 | 0.48 | 0.48 | 0.60 | 0.56 | 0.53 | 0.50 | 0.49 | 0.52 | 0.38 | 0.35 | 0.59 | 0.41 | 0.65 | 0.63 | 0.55 | 0.69 | 0.70 | 0.74 | 0.66 | 0.54 | 0.74 | 0.74 | 0.47 | 0.50 | 0.48 | 0.49 | 0.32 | 0.35 | 0.49 | 0.84 | 0.86 | 0.81 | 0.75 | 0.77 | 0.76 | 0.73 | 0.68 | 0.73 | 0.73 | 0.60 | 0.97 | 1.00 | | | | | | | | | |
| Basic Writing Skills | 0.74 | 0.74 | 0.67 | 0.59 | 0.60 | 0.56 | 0.52 | 0.60 | 0.57 | 0.42 | 0.55 | 0.30 | 0.29 | 0.55 | 0.49 | 0.60 | 0.51 | 0.52 | 0.64 | 0.67 | 0.73 | 0.64 | 0.58 | 0.69 | 0.73 | 0.58 | 0.59 | 0.58 | 0.55 | 0.32 | 0.33 | 0.61 | 0.81 | 0.83 | 0.80 | 0.69 | 0.76 | 0.76 | 0.69 | 0.68 | 0.71 | 0.68 | 0.67 | 0.87 | 0.87 | 1.00 | | | | | | | | |
| Written Expression | 0.67 | 0.62 | 0.53 | 0.34 | 0.34 | 0.55 | 0.52 | 0.44 | 0.41 | 0.46 | 0.43 | 0.38 | 0.33 | 0.56 | 0.31 | 0.62 | 0.62 | 0.51 | 0.65 | 0.64 | 0.67 | 0.59 | 0.47 | 0.69 | 0.67 | 0.35 | 0.40 | 0.35 | 0.41 | 0.27 | 0.33 | 0.36 | 0.74 | 0.76 | 0.69 | 0.70 | 0.70 | 0.66 | 0.64 | 0.60 | 0.64 | 0.65 | 0.48 | 0.88 | 0.93 | 0.66 | 1.00 | | | | | | | |
| Academic Skills | 0.77 | 0.77 | 0.72 | 0.57 | 0.58 | 0.66 | 0.61 | 0.55 | 0.52 | 0.48 | 0.50 | 0.35 | 0.33 | 0.62 | 0.44 | 0.61 | 0.57 | 0.53 | 0.66 | 0.71 | 0.74 | 0.71 | 0.58 | 0.72 | 0.74 | 0.54 | 0.56 | 0.54 | 0.53 | 0.33 | 0.36 | 0.59 | 0.90 | 0.88 | 0.88 | 0.75 | 0.80 | 0.77 | 0.69 | 0.83 | 0.84 | 0.82 | 0.71 | 0.89 | 0.90 | 0.91 | 0.73 | 1.00 | | | | | | |
| Academic Applications | 0.79 | 0.77 | 0.76 | 0.58 | 0.59 | 0.72 | 0.68 | 0.49 | 0.48 | 0.42 | 0.47 | 0.44 | 0.42 | 0.69 | 0.40 | 0.60 | 0.55 | 0.50 | 0.62 | 0.73 | 0.71 | 0.71 | 0.63 | 0.74 | 0.71 | 0.59 | 0.62 | 0.51 | 0.60 | 0.41 | 0.37 | 0.60 | 0.88 | 0.83 | 0.76 | 0.86 | 0.86 | 0.67 | 0.61 | 0.81 | 0.77 | 0.69 | 0.71 | 0.86 | 0.85 | 0.73 | 0.84 | 0.82 | 1.00 | | | | | |
| Academic Fluency | 0.69 | 0.62 | 0.62 | 0.49 | 0.47 | 0.56 | 0.52 | 0.48 | 0.50 | 0.63 | 0.41 | 0.33 | 0.33 | 0.52 | 0.36 | 0.69 | 0.71 | 0.64 | 0.73 | 0.70 | 0.70 | 0.68 | 0.51 | 0.71 | 0.70 | 0.39 | 0.45 | 0.43 | 0.46 | 0.18 | 0.45 | 0.44 | 0.68 | 0.88 | 0.63 | 0.63 | 0.66 | 0.91 | 0.91 | 0.68 | 0.84 | 0.86 | 0.60 | 0.70 | 0.80 | 0.73 | 0.72 | 0.77 | 0.67 | 1.00 | | | | |
| Academic Knowledge | 0.66 | 0.67 | 0.71 | 0.70 | 0.76 | 0.53 | 0.56 | 0.49 | 0.52 | 0.31 | 0.45 | 0.40 | 0.28 | 0.56 | 0.48 | 0.36 | 0.25 | 0.37 | 0.40 | 0.54 | 0.54 | 0.60 | 0.62 | 0.55 | 0.54 | 0.77 | 0.76 | 0.69 | 0.65 | 0.34 | 0.45 | 0.78 | 0.57 | 0.53 | 0.55 | 0.48 | 0.60 | 0.44 | 0.40 | 0.60 | 0.55 | 0.47 | 0.61 | 0.54 | 0.53 | 0.59 | 0.43 | 0.60 | 0.60 | 0.42 | 1.00 | | | |
| Phoneme-Grapheme Knowledge | 0.66 | 0.65 | 0.56 | 0.39 | 0.41 | 0.56 | 0.51 | 0.50 | 0.47 | 0.30 | 0.58 | 0.31 | 0.31 | 0.53 | 0.47 | 0.42 | 0.34 | 0.42 | 0.47 | 0.52 | 0.56 | 0.55 | 0.51 | 0.50 | 0.56 | 0.42 | 0.48 | 0.49 | 0.48 | 0.51 | 0.30 | 0.44 | 0.72 | 0.68 | 0.86 | 0.60 | 0.62 | 0.61 | 0.50 | 0.52 | 0.53 | 0.51 | 0.48 | 0.71 | 0.69 | 0.68 | 0.58 | 0.71 | 0.65 | 0.54 | 0.47 | 1.00 | | |
| Brief Achievement | 0.78 | 0.79 | 0.76 | 0.63 | 0.63 | 0.67 | 0.63 | 0.57 | 0.54 | 0.45 | 0.52 | 0.35 | 0.38 | 0.64 | 0.46 | 0.60 | 0.53 | 0.52 | 0.64 | 0.72 | 0.73 | 0.72 | 0.63 | 0.70 | 0.73 | 0.62 | 0.63 | 0.58 | 0.59 | 0.35 | 0.37 | 0.64 | 0.90 | 0.88 | 0.89 | 0.74 | 0.79 | 0.77 | 0.69 | 0.82 | 0.82 | 0.75 | 0.75 | 0.88 | 0.87 | 0.91 | 0.70 | 0.97 | 0.85 | 0.75 | 0.64 | 0.71 | 1.00 | |
| Broad Achievement | 0.81 | 0.77 | 0.76 | 0.59 | 0.59 | 0.69 | 0.64 | 0.55 | 0.55 | 0.57 | 0.50 | 0.40 | 0.39 | 0.65 | 0.43 | 0.70 | 0.68 | 0.62 | 0.74 | 0.78 | 0.78 | 0.76 | 0.62 | 0.79 | 0.78 | 0.54 | 0.58 | 0.54 | 0.57 | 0.32 | 0.43 | 0.58 | 0.88 | 0.95 | 0.82 | 0.80 | 0.83 | 0.87 | 0.83 | 0.83 | 0.89 | 0.88 | 0.73 | 0.89 | 0.92 | 0.86 | 0.83 | 0.94 | 0.88 | 0.91 | 0.58 | 0.68 | 0.93 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

## *Table F-4.*

*Cluster Score Intercorrelations—Ages 14 Through 19 (n = 1,685)*

| Test | General Intellectual Ability | Brief Intellectual Ability | *Gf-Gc* Composite | Comprehension-Knowledge | Comprehension-Knowledge–Extended | Fluid Reasoning | Fluid Reasoning–Extended | Short-Term Working Memory | Short-Term Working Memory–Extended | Cognitive Processing Speed | Auditory Processing | Long-Term Retrieval | Visual Processing | Quantitative Reasoning | Auditory Memory Span | Number Facility | Perceptual Speed | Cognitive Efficiency | Cognitive Efficiency–Extended | Reading Aptitude A | Reading Aptitude B | Math Aptitude A | Math Aptitude B | Writing Aptitude A | Writing Aptitude B | Oral Language | Broad Oral Language | Oral Expression | Listening Comprehension | Phonetic Coding | Speed of Lexical Access | Vocabulary | Reading | Broad Reading | Basic Reading Skills | Reading Comprehension | Reading Comprehension–Extended | Reading Fluency | Reading Rate | Mathematics | Broad Mathematics | Math Calculation Skills | Math Problem Solving | Written Language | Broad Written Language | Basic Writing Skills | Written Expression | Academic Skills | Academic Applications | Academic Fluency | Academic Knowledge | Phoneme-Grapheme Knowledge | Brief Achievement | Broad Achievement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **General Intellectual Ability** | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Brief Intellectual Ability** | 0.94 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***Gf-Gc* Composite** | 0.88 | 0.88 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Comprehension-Knowledge** | 0.73 | 0.73 | 0.85 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Comprehension-Knowledge–Extended** | 0.73 | 0.72 | 0.84 | 0.97 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Fluid Reasoning** | 0.81 | 0.80 | 0.89 | 0.52 | 0.52 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Fluid Reasoning–Extended** | 0.81 | 0.78 | 0.86 | 0.53 | 0.53 | 0.94 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Short-Term Working Memory** | 0.75 | 0.77 | 0.60 | 0.51 | 0.51 | 0.53 | 0.55 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Short-Term Working Memory–Extended** | 0.79 | 0.78 | 0.64 | 0.53 | 0.54 | 0.58 | 0.61 | 0.95 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Cognitive Processing Speed** | 0.64 | 0.47 | 0.46 | 0.38 | 0.38 | 0.42 | 0.46 | 0.45 | 0.51 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Auditory Processing** | 0.70 | 0.63 | 0.60 | 0.53 | 0.54 | 0.52 | 0.50 | 0.57 | 0.62 | 0.39 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Long-Term Retrieval** | 0.59 | 0.48 | 0.55 | 0.45 | 0.47 | 0.51 | 0.55 | 0.41 | 0.48 | 0.34 | 0.43 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Visual Processing** | 0.50 | 0.35 | 0.43 | 0.35 | 0.37 | 0.40 | 0.49 | 0.35 | 0.42 | 0.31 | 0.39 | 0.50 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Quantitative Reasoning** | 0.81 | 0.79 | 0.78 | 0.50 | 0.49 | 0.85 | 0.95 | 0.55 | 0.59 | 0.45 | 0.45 | 0.48 | 0.47 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Auditory Memory Span** | 0.61 | 0.57 | 0.49 | 0.44 | 0.47 | 0.41 | 0.43 | 0.60 | 0.64 | 0.34 | 0.67 | 0.39 | 0.41 | 0.39 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Number Facility** | 0.71 | 0.64 | 0.56 | 0.42 | 0.41 | 0.55 | 0.57 | 0.77 | 0.75 | 0.66 | 0.45 | 0.36 | 0.38 | 0.58 | 0.42 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Perceptual Speed** | 0.68 | 0.53 | 0.47 | 0.35 | 0.35 | 0.47 | 0.50 | 0.48 | 0.55 | 0.85 | 0.38 | 0.34 | 0.34 | 0.52 | 0.34 | 0.83 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Cognitive Efficiency** | 0.75 | 0.59 | 0.56 | 0.45 | 0.45 | 0.53 | 0.55 | 0.76 | 0.77 | 0.78 | 0.46 | 0.43 | 0.41 | 0.55 | 0.45 | 0.82 | 0.81 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Cognitive Efficiency–Extended** | 0.82 | 0.73 | 0.61 | 0.49 | 0.49 | 0.57 | 0.60 | 0.81 | 0.83 | 0.79 | 0.53 | 0.42 | 0.40 | 0.61 | 0.52 | 0.93 | 0.90 | 0.91 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Reading Aptitude A** | 0.88 | 0.80 | 0.85 | 0.68 | 0.68 | 0.80 | 0.79 | 0.62 | 0.68 | 0.65 | 0.67 | 0.53 | 0.43 | 0.71 | 0.54 | 0.79 | 0.74 | 0.66 | 0.80 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Reading Aptitude B** | 0.89 | 0.86 | 0.75 | 0.67 | 0.67 | 0.63 | 0.64 | 0.75 | 0.78 | 0.64 | 0.68 | 0.45 | 0.36 | 0.64 | 0.60 | 0.82 | 0.75 | 0.67 | 0.87 | 0.92 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Math Aptitude A** | 0.88 | 0.81 | 0.82 | 0.65 | 0.65 | 0.77 | 0.77 | 0.60 | 0.64 | 0.79 | 0.58 | 0.50 | 0.49 | 0.76 | 0.48 | 0.70 | 0.69 | 0.68 | 0.75 | 0.85 | 0.80 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Math Aptitude B** | 0.84 | 0.76 | 0.80 | 0.68 | 0.68 | 0.72 | 0.83 | 0.77 | 0.79 | 0.52 | 0.58 | 0.59 | 0.65 | 0.82 | 0.55 | 0.72 | 0.54 | 0.74 | 0.74 | 0.77 | 0.73 | 0.79 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Writing Aptitude A** | 0.88 | 0.80 | 0.77 | 0.68 | 0.68 | 0.67 | 0.68 | 0.63 | 0.68 | 0.66 | 0.65 | 0.56 | 0.43 | 0.67 | 0.54 | 0.82 | 0.79 | 0.67 | 0.84 | 0.94 | 0.95 | 0.83 | 0.74 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Writing Aptitude B** | 0.89 | 0.86 | 0.75 | 0.67 | 0.67 | 0.63 | 0.64 | 0.75 | 0.78 | 0.64 | 0.68 | 0.45 | 0.36 | 0.64 | 0.60 | 0.82 | 0.76 | 0.67 | 0.87 | 0.92 | 1.00 | 0.80 | 0.73 | 0.95 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Oral Language** | 0.68 | 0.66 | 0.72 | 0.78 | 0.87 | 0.50 | 0.50 | 0.51 | 0.53 | 0.32 | 0.53 | 0.49 | 0.40 | 0.46 | 0.53 | 0.43 | 0.32 | 0.39 | 0.46 | 0.65 | 0.65 | 0.60 | 0.62 | 0.66 | 0.65 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Broad Oral Language** | 0.74 | 0.73 | 0.75 | 0.73 | 0.82 | 0.59 | 0.59 | 0.56 | 0.60 | 0.38 | 0.60 | 0.55 | 0.47 | 0.55 | 0.60 | 0.46 | 0.37 | 0.45 | 0.52 | 0.68 | 0.68 | 0.66 | 0.67 | 0.69 | 0.68 | 0.94 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Oral Expression** | 0.66 | 0.62 | 0.61 | 0.64 | 0.72 | 0.44 | 0.43 | 0.52 | 0.56 | 0.36 | 0.64 | 0.41 | 0.39 | 0.39 | 0.83 | 0.37 | 0.33 | 0.42 | 0.48 | 0.59 | 0.62 | 0.55 | 0.55 | 0.59 | 0.62 | 0.79 | 0.81 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Listening Comprehension** | 0.71 | 0.70 | 0.68 | 0.60 | 0.64 | 0.59 | 0.60 | 0.56 | 0.60 | 0.36 | 0.59 | 0.53 | 0.49 | 0.56 | 0.60 | 0.46 | 0.36 | 0.42 | 0.52 | 0.65 | 0.65 | 0.63 | 0.63 | 0.66 | 0.65 | 0.81 | 0.94 | 0.71 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Phonetic Coding** | 0.59 | 0.49 | 0.54 | 0.45 | 0.45 | 0.49 | 0.53 | 0.45 | 0.50 | 0.36 | 0.63 | 0.51 | 0.42 | 0.47 | 0.45 | 0.42 | 0.35 | 0.43 | 0.45 | 0.61 | 0.55 | 0.53 | 0.59 | 0.57 | 0.55 | 0.44 | 0.48 | 0.39 | 0.49 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| **Speed of Lexical Access** | 0.46 | 0.39 | 0.40 | 0.35 | 0.40 | 0.35 | 0.38 | 0.39 | 0.47 | 0.45 | 0.42 | 0.28 | 0.39 | 0.34 | 0.43 | 0.42 | 0.43 | 0.41 | 0.47 | 0.51 | 0.50 | 0.47 | 0.43 | 0.49 | 0.50 | 0.47 | 0.52 | 0.43 | 0.49 | 0.32 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| **Vocabulary** | 0.76 | 0.74 | 0.82 | 0.90 | 0.97 | 0.55 | 0.55 | 0.52 | 0.55 | 0.40 | 0.57 | 0.50 | 0.36 | 0.50 | 0.51 | 0.43 | 0.37 | 0.46 | 0.50 | 0.71 | 0.69 | 0.68 | 0.68 | 0.71 | 0.69 | 0.91 | 0.86 | 0.78 | 0.69 | 0.45 | 0.44 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| **Reading** | 0.76 | 0.76 | 0.75 | 0.68 | 0.70 | 0.63 | 0.57 | 0.54 | 0.52 | 0.42 | 0.53 | 0.38 | 0.35 | 0.57 | 0.48 | 0.57 | 0.51 | 0.51 | 0.60 | 0.72 | 0.72 | 0.68 | 0.60 | 0.72 | 0.72 | 0.68 | 0.69 | 0.62 | 0.64 | 0.52 | 0.33 | 0.71 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| **Broad Reading** | 0.75 | 0.72 | 0.74 | 0.67 | 0.67 | 0.63 | 0.58 | 0.53 | 0.54 | 0.55 | 0.51 | 0.41 | 0.35 | 0.56 | 0.49 | 0.64 | 0.62 | 0.59 | 0.67 | 0.76 | 0.74 | 0.72 | 0.60 | 0.76 | 0.74 | 0.63 | 0.66 | 0.61 | 0.61 | 0.45 | 0.40 | 0.67 | 0.93 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| **Basic Reading Skills** | 0.70 | 0.71 | 0.66 | 0.58 | 0.60 | 0.57 | 0.52 | 0.53 | 0.49 | 0.38 | 0.56 | 0.32 | 0.34 | 0.54 | 0.49 | 0.51 | 0.44 | 0.47 | 0.55 | 0.64 | 0.66 | 0.63 | 0.56 | 0.64 | 0.66 | 0.62 | 0.65 | 0.60 | 0.60 | 0.50 | 0.33 | 0.64 | 0.92 | 0.84 | 1.00 | | | | | | | | | | | | | | | | | | | |
| **Reading Comprehension** | 0.73 | 0.71 | 0.72 | 0.58 | 0.60 | 0.68 | 0.62 | 0.49 | 0.50 | 0.37 | 0.47 | 0.44 | 0.39 | 0.59 | 0.43 | 0.52 | 0.49 | 0.50 | 0.57 | 0.69 | 0.66 | 0.62 | 0.59 | 0.67 | 0.66 | 0.60 | 0.63 | 0.56 | 0.59 | 0.48 | 0.34 | 0.63 | 0.89 | 0.85 | 0.74 | 1.00 | | | | | | | | | | | | | | | | | | |
| **Reading Comprehension–Extended** | 0.78 | 0.76 | 0.78 | 0.69 | 0.71 | 0.68 | 0.63 | 0.53 | 0.53 | 0.39 | 0.53 | 0.47 | 0.39 | 0.61 | 0.49 | 0.54 | 0.49 | 0.51 | 0.58 | 0.74 | 0.71 | 0.67 | 0.64 | 0.73 | 0.71 | 0.70 | 0.71 | 0.64 | 0.65 | 0.51 | 0.36 | 0.73 | 0.91 | 0.88 | 0.78 | 0.96 | 1.00 | | | | | | | | | | | | | | | | | |
| **Reading Fluency** | 0.66 | 0.60 | 0.65 | 0.60 | 0.60 | 0.54 | 0.51 | 0.48 | 0.50 | 0.56 | 0.46 | 0.38 | 0.29 | 0.47 | 0.44 | 0.61 | 0.61 | 0.58 | 0.64 | 0.69 | 0.66 | 0.66 | 0.55 | 0.69 | 0.66 | 0.52 | 0.55 | 0.54 | 0.48 | 0.36 | 0.35 | 0.59 | 0.75 | 0.92 | 0.69 | 0.71 | 0.76 | 1.00 | | | | | | | | | | | | | | | | |
| **Reading Rate** | 0.63 | 0.54 | 0.58 | 0.50 | 0.51 | 0.51 | 0.48 | 0.40 | 0.46 | 0.64 | 0.38 | 0.32 | 0.25 | 0.44 | 0.39 | 0.62 | 0.72 | 0.60 | 0.68 | 0.69 | 0.66 | 0.64 | 0.47 | 0.68 | 0.66 | 0.46 | 0.49 | 0.47 | 0.43 | 0.24 | 0.45 | 0.51 | 0.63 | 0.84 | 0.55 | 0.59 | 0.64 | 0.90 | 1.00 | | | | | | | | | | | | | | | |
| **Mathematics** | 0.80 | 0.78 | 0.80 | 0.62 | 0.62 | 0.76 | 0.74 | 0.56 | 0.58 | 0.52 | 0.46 | 0.47 | 0.40 | 0.74 | 0.42 | 0.62 | 0.55 | 0.56 | 0.64 | 0.75 | 0.70 | 0.80 | 0.72 | 0.73 | 0.70 | 0.56 | 0.60 | 0.50 | 0.57 | 0.47 | 0.31 | 0.63 | 0.69 | 0.69 | 0.62 | 0.67 | 0.71 | 0.62 | 0.57 | 1.00 | | | | | | | | | | | | | | |
| **Broad Mathematics** | 0.80 | 0.76 | 0.76 | 0.60 | 0.59 | 0.72 | 0.70 | 0.55 | 0.59 | 0.57 | 0.44 | 0.43 | 0.40 | 0.70 | 0.39 | 0.65 | 0.61 | 0.61 | 0.68 | 0.74 | 0.71 | 0.79 | 0.68 | 0.74 | 0.71 | 0.52 | 0.57 | 0.48 | 0.55 | 0.41 | 0.36 | 0.59 | 0.67 | 0.72 | 0.61 | 0.64 | 0.68 | 0.68 | 0.66 | 0.95 | 1.00 | | | | | | | | | | | | | |
| **Math Calculation Skills** | 0.75 | 0.71 | 0.69 | 0.54 | 0.52 | 0.66 | 0.63 | 0.51 | 0.55 | 0.58 | 0.40 | 0.38 | 0.34 | 0.64 | 0.35 | 0.64 | 0.63 | 0.59 | 0.67 | 0.70 | 0.69 | 0.75 | 0.61 | 0.71 | 0.69 | 0.44 | 0.50 | 0.43 | 0.48 | 0.35 | 0.35 | 0.52 | 0.63 | 0.69 | 0.57 | 0.60 | 0.64 | 0.67 | 0.66 | 0.89 | 0.98 | 1.00 | | | | | | | | | | | | |
| **Math Problem Solving** | 0.80 | 0.80 | 0.81 | 0.63 | 0.64 | 0.77 | 0.77 | 0.58 | 0.60 | 0.46 | 0.53 | 0.47 | 0.39 | 0.77 | 0.47 | 0.55 | 0.45 | 0.52 | 0.58 | 0.72 | 0.68 | 0.78 | 0.73 | 0.68 | 0.68 | 0.60 | 0.63 | 0.56 | 0.58 | 0.49 | 0.34 | 0.65 | 0.63 | 0.64 | 0.56 | 0.59 | 0.66 | 0.57 | 0.53 | 0.89 | 0.85 | 0.76 | 1.00 | | | | | | | | | | | |
| **Written Language** | 0.76 | 0.73 | 0.68 | 0.59 | 0.60 | 0.60 | 0.58 | 0.55 | 0.54 | 0.46 | 0.56 | 0.43 | 0.37 | 0.59 | 0.48 | 0.60 | 0.57 | 0.54 | 0.65 | 0.70 | 0.73 | 0.66 | 0.60 | 0.74 | 0.73 | 0.59 | 0.61 | 0.56 | 0.56 | 0.49 | 0.30 | 0.62 | 0.85 | 0.83 | 0.82 | 0.76 | 0.79 | 0.71 | 0.63 | 0.68 | 0.69 | 0.66 | 0.63 | 1.00 | | | | | | | | | | |
| **Broad Written Language** | 0.77 | 0.73 | 0.68 | 0.57 | 0.58 | 0.61 | 0.59 | 0.57 | 0.56 | 0.52 | 0.57 | 0.43 | 0.38 | 0.60 | 0.48 | 0.65 | 0.63 | 0.59 | 0.70 | 0.73 | 0.76 | 0.70 | 0.61 | 0.76 | 0.76 | 0.56 | 0.59 | 0.55 | 0.57 | 0.47 | 0.32 | 0.60 | 0.84 | 0.86 | 0.81 | 0.77 | 0.80 | 0.77 | 0.70 | 0.70 | 0.73 | 0.71 | 0.64 | 0.98 | 1.00 | | | | | | | | | |
| **Basic Writing Skills** | 0.76 | 0.75 | 0.69 | 0.65 | 0.67 | 0.55 | 0.53 | 0.63 | 0.61 | 0.45 | 0.60 | 0.33 | 0.31 | 0.55 | 0.53 | 0.62 | 0.52 | 0.56 | 0.66 | 0.69 | 0.76 | 0.67 | 0.64 | 0.73 | 0.76 | 0.65 | 0.65 | 0.63 | 0.59 | 0.44 | 0.29 | 0.68 | 0.82 | 0.82 | 0.79 | 0.69 | 0.77 | 0.75 | 0.67 | 0.70 | 0.71 | 0.67 | 0.70 | 0.87 | 0.88 | 1.00 | | | | | | | | |
| **Written Expression** | 0.70 | 0.64 | 0.58 | 0.44 | 0.45 | 0.57 | 0.56 | 0.49 | 0.49 | 0.49 | 0.47 | 0.44 | 0.37 | 0.58 | 0.38 | 0.62 | 0.63 | 0.56 | 0.66 | 0.66 | 0.67 | 0.63 | 0.55 | 0.71 | 0.68 | 0.45 | 0.50 | 0.43 | 0.49 | 0.42 | 0.30 | 0.48 | 0.75 | 0.76 | 0.69 | 0.74 | 0.73 | 0.67 | 0.62 | 0.62 | 0.64 | 0.63 | 0.53 | 0.88 | 0.92 | 0.67 | 1.00 | | | | | | | |
| **Academic Skills** | 0.80 | 0.79 | 0.77 | 0.66 | 0.67 | 0.68 | 0.64 | 0.59 | 0.57 | 0.50 | 0.56 | 0.40 | 0.35 | 0.64 | 0.49 | 0.63 | 0.57 | 0.56 | 0.67 | 0.76 | 0.77 | 0.76 | 0.65 | 0.76 | 0.77 | 0.63 | 0.65 | 0.60 | 0.60 | 0.48 | 0.32 | 0.68 | 0.90 | 0.88 | 0.88 | 0.76 | 0.82 | 0.76 | 0.67 | 0.85 | 0.84 | 0.82 | 0.76 | 0.89 | 0.90 | 0.91 | 0.74 | 1.00 | | | | | | |
| **Academic Applications** | 0.84 | 0.81 | 0.82 | 0.67 | 0.69 | 0.75 | 0.72 | 0.57 | 0.58 | 0.48 | 0.53 | 0.52 | 0.46 | 0.71 | 0.48 | 0.63 | 0.57 | 0.58 | 0.66 | 0.78 | 0.75 | 0.77 | 0.71 | 0.78 | 0.75 | 0.67 | 0.70 | 0.58 | 0.66 | 0.57 | 0.34 | 0.70 | 0.88 | 0.84 | 0.77 | 0.87 | 0.89 | 0.69 | 0.60 | 0.84 | 0.80 | 0.72 | 0.77 | 0.87 | 0.86 | 0.75 | 0.84 | 0.85 | 1.00 | | | | | |
| **Academic Fluency** | 0.70 | 0.62 | 0.63 | 0.53 | 0.52 | 0.57 | 0.53 | 0.49 | 0.53 | 0.64 | 0.42 | 0.36 | 0.33 | 0.52 | 0.40 | 0.67 | 0.71 | 0.64 | 0.71 | 0.70 | 0.69 | 0.70 | 0.55 | 0.72 | 0.69 | 0.45 | 0.50 | 0.47 | 0.49 | 0.29 | 0.42 | 0.51 | 0.67 | 0.87 | 0.61 | 0.64 | 0.68 | 0.90 | 0.91 | 0.68 | 0.81 | 0.84 | 0.62 | 0.69 | 0.78 | 0.71 | 0.71 | 0.76 | 0.68 | 1.00 | | | | |
| **Academic Knowledge** | 0.74 | 0.74 | 0.77 | 0.75 | 0.80 | 0.61 | 0.63 | 0.57 | 0.60 | 0.39 | 0.53 | 0.46 | 0.32 | 0.62 | 0.54 | 0.47 | 0.33 | 0.46 | 0.50 | 0.66 | 0.65 | 0.69 | 0.70 | 0.66 | 0.65 | 0.81 | 0.80 | 0.71 | 0.70 | 0.47 | 0.43 | 0.82 | 0.64 | 0.61 | 0.62 | 0.55 | 0.66 | 0.52 | 0.45 | 0.69 | 0.63 | 0.56 | 0.70 | 0.62 | 0.61 | 0.66 | 0.51 | 0.69 | 0.69 | 0.49 | 1.00 | | | |
| **Phoneme-Grapheme Knowledge** | 0.70 | 0.68 | 0.62 | 0.48 | 0.50 | 0.59 | 0.56 | 0.55 | 0.53 | 0.39 | 0.62 | 0.39 | 0.35 | 0.56 | 0.51 | 0.48 | 0.40 | 0.48 | 0.53 | 0.61 | 0.62 | 0.63 | 0.59 | 0.59 | 0.62 | 0.52 | 0.58 | 0.55 | 0.57 | 0.62 | 0.34 | 0.54 | 0.76 | 0.71 | 0.88 | 0.65 | 0.67 | 0.62 | 0.49 | 0.58 | 0.56 | 0.53 | 0.55 | 0.74 | 0.72 | 0.69 | 0.63 | 0.75 | 0.71 | 0.54 | 0.55 | 1.00 | | |
| **Brief Achievement** | 0.81 | 0.80 | 0.79 | 0.70 | 0.71 | 0.68 | 0.64 | 0.60 | 0.59 | 0.48 | 0.57 | 0.40 | 0.39 | 0.64 | 0.52 | 0.61 | 0.53 | 0.56 | 0.65 | 0.75 | 0.76 | 0.76 | 0.68 | 0.74 | 0.76 | 0.69 | 0.70 | 0.63 | 0.64 | 0.50 | 0.33 | 0.72 | 0.90 | 0.88 | 0.88 | 0.75 | 0.82 | 0.77 | 0.67 | 0.83 | 0.82 | 0.75 | 0.79 | 0.88 | 0.89 | 0.91 | 0.71 | 0.97 | 0.86 | 0.74 | 0.72 | 0.75 | 1.00 | |
| **Broad Achievement** | 0.84 | 0.80 | 0.80 | 0.68 | 0.68 | 0.72 | 0.68 | 0.60 | 0.61 | 0.60 | 0.54 | 0.46 | 0.41 | 0.67 | 0.49 | 0.70 | 0.67 | 0.65 | 0.74 | 0.81 | 0.80 | 0.81 | 0.69 | 0.82 | 0.80 | 0.63 | 0.66 | 0.60 | 0.63 | 0.48 | 0.40 | 0.68 | 0.89 | 0.94 | 0.81 | 0.82 | 0.86 | 0.87 | 0.80 | 0.86 | 0.89 | 0.87 | 0.78 | 0.89 | 0.92 | 0.86 | 0.82 | 0.95 | 0.90 | 0.90 | 0.67 | 0.72 | 0.94 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

# Table F-5.

*Cluster Score Intercorrelations—Ages 20 Through 39 (n = 1,251)*

| Test | General Intellectual Ability | Brief Intellectual Ability | *Gf-Gc* Composite | Comprehension-Knowledge | Comprehension-Knowledge–Extended | Fluid Reasoning | Fluid Reasoning–Extended | Short-Term Working Memory | Short-Term Working Memory–Extended | Cognitive Processing Speed | Auditory Processing | Long-Term Retrieval | Visual Processing | Quantitative Reasoning | Auditory Memory Span | Number Facility | Perceptual Speed | Cognitive Efficiency | Cognitive Efficiency–Extended | Reading Aptitude A | Reading Aptitude B | Math Aptitude A | Math Aptitude B | Writing Aptitude A | Writing Aptitude B | Oral Language | Broad Oral Language | Oral Expression | Listening Comprehension | Phonetic Coding | Speed of Lexical Access | Vocabulary | Reading | Broad Reading | Basic Reading Skills | Reading Comprehension | Reading Comprehension–Extended | Reading Fluency | Reading Rate | Mathematics | Broad Mathematics | Math Calculation Skills | Math Problem Solving | Written Language | Broad Written Language | Basic Writing Skills | Written Expression | Academic Skills | Academic Applications | Academic Fluency | Academic Knowledge | Phoneme-Grapheme Knowledge | Brief Achievement | Broad Achievement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General Intellectual Ability | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Brief Intellectual Ability | 0.93 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Gf-Gc* Composite | 0.88 | 0.88 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Comprehension-Knowledge | 0.73 | 0.73 | 0.87 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Comprehension-Knowledge–Extended | 0.74 | 0.72 | 0.86 | 0.97 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fluid Reasoning | 0.81 | 0.81 | 0.89 | 0.54 | 0.55 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fluid Reasoning–Extended | 0.82 | 0.79 | 0.87 | 0.57 | 0.56 | 0.94 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Short-Term Working Memory | 0.74 | 0.77 | 0.62 | 0.55 | 0.54 | 0.55 | 0.58 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Short-Term Working Memory–Extended | 0.78 | 0.78 | 0.66 | 0.57 | 0.58 | 0.59 | 0.63 | 0.95 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cognitive Processing Speed | 0.66 | 0.45 | 0.45 | 0.36 | 0.39 | 0.43 | 0.48 | 0.43 | 0.49 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Auditory Processing | 0.71 | 0.62 | 0.61 | 0.57 | 0.58 | 0.51 | 0.49 | 0.56 | 0.63 | 0.41 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Long-Term Retrieval | 0.62 | 0.50 | 0.57 | 0.50 | 0.52 | 0.51 | 0.56 | 0.43 | 0.48 | 0.35 | 0.47 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Visual Processing | 0.58 | 0.43 | 0.51 | 0.41 | 0.43 | 0.48 | 0.57 | 0.43 | 0.48 | 0.38 | 0.45 | 0.56 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Quantitative Reasoning | 0.81 | 0.81 | 0.78 | 0.51 | 0.50 | 0.85 | 0.95 | 0.56 | 0.59 | 0.47 | 0.42 | 0.49 | 0.52 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Auditory Memory Span | 0.65 | 0.59 | 0.54 | 0.52 | 0.55 | 0.43 | 0.45 | 0.63 | 0.67 | 0.38 | 0.68 | 0.44 | 0.46 | 0.39 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Number Facility | 0.73 | 0.64 | 0.57 | 0.43 | 0.43 | 0.57 | 0.61 | 0.78 | 0.77 | 0.65 | 0.47 | 0.42 | 0.46 | 0.61 | 0.47 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Perceptual Speed | 0.68 | 0.50 | 0.45 | 0.32 | 0.33 | 0.46 | 0.51 | 0.46 | 0.51 | 0.85 | 0.38 | 0.36 | 0.40 | 0.53 | 0.35 | 0.81 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cognitive Efficiency | 0.76 | 0.60 | 0.56 | 0.46 | 0.47 | 0.54 | 0.57 | 0.76 | 0.76 | 0.78 | 0.46 | 0.43 | 0.46 | 0.57 | 0.49 | 0.84 | 0.81 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cognitive Efficiency–Extended | 0.83 | 0.72 | 0.61 | 0.49 | 0.50 | 0.58 | 0.63 | 0.81 | 0.82 | 0.78 | 0.53 | 0.46 | 0.48 | 0.63 | 0.55 | 0.93 | 0.89 | 0.92 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reading Aptitude A | 0.89 | 0.79 | 0.86 | 0.70 | 0.71 | 0.81 | 0.81 | 0.64 | 0.69 | 0.65 | 0.69 | 0.58 | 0.55 | 0.72 | 0.59 | 0.78 | 0.72 | 0.68 | 0.79 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reading Aptitude B | 0.91 | 0.86 | 0.76 | 0.69 | 0.69 | 0.65 | 0.68 | 0.76 | 0.79 | 0.64 | 0.70 | 0.52 | 0.48 | 0.66 | 0.65 | 0.81 | 0.73 | 0.69 | 0.87 | 0.92 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Math Aptitude A | 0.89 | 0.80 | 0.81 | 0.64 | 0.66 | 0.78 | 0.79 | 0.59 | 0.64 | 0.79 | 0.59 | 0.53 | 0.58 | 0.77 | 0.52 | 0.70 | 0.67 | 0.67 | 0.74 | 0.85 | 0.81 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Math Aptitude B | 0.86 | 0.78 | 0.82 | 0.71 | 0.71 | 0.73 | 0.84 | 0.80 | 0.81 | 0.53 | 0.58 | 0.62 | 0.69 | 0.81 | 0.59 | 0.75 | 0.54 | 0.75 | 0.76 | 0.81 | 0.77 | 0.80 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Writing Aptitude A | 0.90 | 0.79 | 0.78 | 0.70 | 0.70 | 0.67 | 0.70 | 0.62 | 0.67 | 0.66 | 0.68 | 0.63 | 0.52 | 0.68 | 0.58 | 0.80 | 0.77 | 0.67 | 0.82 | 0.94 | 0.95 | 0.83 | 0.76 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Writing Aptitude B | 0.91 | 0.86 | 0.76 | 0.69 | 0.69 | 0.65 | 0.68 | 0.76 | 0.79 | 0.64 | 0.70 | 0.52 | 0.48 | 0.67 | 0.65 | 0.81 | 0.73 | 0.69 | 0.87 | 0.92 | 1.00 | 0.81 | 0.77 | 0.95 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oral Language | 0.69 | 0.66 | 0.75 | 0.81 | 0.89 | 0.52 | 0.53 | 0.52 | 0.56 | 0.36 | 0.57 | 0.54 | 0.49 | 0.46 | 0.58 | 0.43 | 0.31 | 0.42 | 0.47 | 0.68 | 0.67 | 0.63 | 0.65 | 0.68 | 0.67 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Broad Oral Language | 0.76 | 0.72 | 0.77 | 0.77 | 0.85 | 0.60 | 0.60 | 0.57 | 0.62 | 0.43 | 0.64 | 0.59 | 0.54 | 0.53 | 0.65 | 0.48 | 0.38 | 0.48 | 0.54 | 0.72 | 0.71 | 0.69 | 0.69 | 0.72 | 0.71 | 0.94 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oral Expression | 0.67 | 0.62 | 0.64 | 0.68 | 0.76 | 0.46 | 0.45 | 0.53 | 0.57 | 0.42 | 0.65 | 0.45 | 0.45 | 0.38 | 0.83 | 0.40 | 0.34 | 0.45 | 0.50 | 0.62 | 0.65 | 0.60 | 0.58 | 0.61 | 0.65 | 0.82 | 0.84 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Listening Comprehension | 0.73 | 0.70 | 0.71 | 0.66 | 0.70 | 0.60 | 0.60 | 0.56 | 0.61 | 0.40 | 0.64 | 0.57 | 0.55 | 0.54 | 0.64 | 0.48 | 0.38 | 0.45 | 0.54 | 0.70 | 0.69 | 0.66 | 0.66 | 0.69 | 0.70 | 0.83 | 0.95 | 0.74 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Phonetic Coding | 0.63 | 0.52 | 0.59 | 0.55 | 0.55 | 0.50 | 0.55 | 0.50 | 0.55 | 0.36 | 0.66 | 0.54 | 0.47 | 0.48 | 0.52 | 0.46 | 0.35 | 0.45 | 0.48 | 0.65 | 0.61 | 0.54 | 0.64 | 0.62 | 0.61 | 0.55 | 0.59 | 0.46 | 0.57 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| Speed of Lexical Access | 0.47 | 0.39 | 0.39 | 0.35 | 0.41 | 0.34 | 0.38 | 0.39 | 0.47 | 0.48 | 0.43 | 0.29 | 0.38 | 0.33 | 0.44 | 0.44 | 0.45 | 0.41 | 0.49 | 0.53 | 0.53 | 0.48 | 0.42 | 0.51 | 0.53 | 0.48 | 0.51 | 0.44 | 0.49 | 0.36 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| Vocabulary | 0.77 | 0.74 | 0.83 | 0.91 | 0.97 | 0.56 | 0.57 | 0.55 | 0.58 | 0.42 | 0.59 | 0.55 | 0.43 | 0.51 | 0.57 | 0.44 | 0.37 | 0.49 | 0.52 | 0.73 | 0.72 | 0.69 | 0.71 | 0.73 | 0.72 | 0.92 | 0.88 | 0.80 | 0.73 | 0.56 | 0.45 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| Reading | 0.78 | 0.77 | 0.77 | 0.69 | 0.70 | 0.66 | 0.62 | 0.56 | 0.55 | 0.46 | 0.57 | 0.43 | 0.42 | 0.61 | 0.54 | 0.59 | 0.52 | 0.55 | 0.63 | 0.74 | 0.74 | 0.71 | 0.64 | 0.73 | 0.74 | 0.68 | 0.70 | 0.64 | 0.66 | 0.56 | 0.36 | 0.71 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| Broad Reading | 0.77 | 0.72 | 0.74 | 0.66 | 0.67 | 0.65 | 0.61 | 0.54 | 0.55 | 0.57 | 0.55 | 0.44 | 0.40 | 0.58 | 0.55 | 0.64 | 0.64 | 0.62 | 0.69 | 0.77 | 0.75 | 0.72 | 0.62 | 0.76 | 0.75 | 0.62 | 0.66 | 0.64 | 0.63 | 0.49 | 0.44 | 0.67 | 0.92 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| Basic Reading Skills | 0.73 | 0.73 | 0.68 | 0.58 | 0.60 | 0.61 | 0.57 | 0.55 | 0.52 | 0.44 | 0.59 | 0.37 | 0.41 | 0.58 | 0.53 | 0.55 | 0.48 | 0.52 | 0.59 | 0.66 | 0.69 | 0.67 | 0.59 | 0.66 | 0.69 | 0.61 | 0.64 | 0.60 | 0.60 | 0.52 | 0.38 | 0.63 | 0.92 | 0.85 | 1.00 | | | | | | | | | | | | | | | | | | | |
| Reading Comprehension | 0.75 | 0.72 | 0.74 | 0.61 | 0.62 | 0.70 | 0.65 | 0.50 | 0.50 | 0.39 | 0.50 | 0.47 | 0.44 | 0.62 | 0.45 | 0.52 | 0.48 | 0.51 | 0.57 | 0.71 | 0.67 | 0.64 | 0.62 | 0.68 | 0.67 | 0.61 | 0.64 | 0.57 | 0.61 | 0.51 | 0.34 | 0.65 | 0.89 | 0.84 | 0.74 | 1.00 | | | | | | | | | | | | | | | | | | |
| Reading Comprehension–Extended | 0.80 | 0.76 | 0.80 | 0.71 | 0.72 | 0.69 | 0.66 | 0.52 | 0.53 | 0.42 | 0.56 | 0.50 | 0.43 | 0.63 | 0.52 | 0.54 | 0.49 | 0.53 | 0.59 | 0.76 | 0.73 | 0.69 | 0.66 | 0.75 | 0.73 | 0.71 | 0.72 | 0.65 | 0.67 | 0.55 | 0.36 | 0.74 | 0.92 | 0.87 | 0.78 | 0.96 | 1.00 | | | | | | | | | | | | | | | | | |
| Reading Fluency | 0.67 | 0.59 | 0.64 | 0.58 | 0.58 | 0.55 | 0.52 | 0.47 | 0.49 | 0.58 | 0.51 | 0.40 | 0.33 | 0.48 | 0.50 | 0.60 | 0.63 | 0.60 | 0.65 | 0.69 | 0.66 | 0.64 | 0.55 | 0.68 | 0.66 | 0.51 | 0.55 | 0.58 | 0.51 | 0.41 | 0.39 | 0.58 | 0.76 | 0.93 | 0.72 | 0.70 | 0.74 | 1.00 | | | | | | | | | | | | | | | | |
| Reading Rate | 0.62 | 0.50 | 0.54 | 0.45 | 0.47 | 0.50 | 0.47 | 0.38 | 0.43 | 0.66 | 0.41 | 0.34 | 0.30 | 0.44 | 0.44 | 0.61 | 0.73 | 0.61 | 0.67 | 0.68 | 0.64 | 0.61 | 0.46 | 0.67 | 0.64 | 0.42 | 0.47 | 0.50 | 0.43 | 0.27 | 0.48 | 0.48 | 0.63 | 0.85 | 0.59 | 0.59 | 0.63 | 0.91 | 1.00 | | | | | | | | | | | | | | | |
| Mathematics | 0.79 | 0.77 | 0.79 | 0.61 | 0.62 | 0.77 | 0.76 | 0.53 | 0.55 | 0.49 | 0.44 | 0.47 | 0.44 | 0.75 | 0.44 | 0.58 | 0.49 | 0.54 | 0.60 | 0.72 | 0.68 | 0.80 | 0.71 | 0.70 | 0.68 | 0.57 | 0.60 | 0.53 | 0.56 | 0.46 | 0.27 | 0.63 | 0.70 | 0.68 | 0.64 | 0.67 | 0.72 | 0.59 | 0.52 | 1.00 | | | | | | | | | | | | | | |
| Broad Mathematics | 0.79 | 0.76 | 0.76 | 0.59 | 0.59 | 0.74 | 0.72 | 0.54 | 0.56 | 0.55 | 0.45 | 0.43 | 0.43 | 0.72 | 0.44 | 0.61 | 0.57 | 0.58 | 0.65 | 0.73 | 0.70 | 0.79 | 0.67 | 0.71 | 0.70 | 0.53 | 0.58 | 0.53 | 0.55 | 0.41 | 0.34 | 0.60 | 0.70 | 0.73 | 0.65 | 0.66 | 0.70 | 0.67 | 0.63 | 0.95 | 1.00 | | | | | | | | | | | | | |
| Math Calculation Skills | 0.74 | 0.70 | 0.68 | 0.51 | 0.51 | 0.68 | 0.64 | 0.49 | 0.51 | 0.56 | 0.42 | 0.37 | 0.37 | 0.65 | 0.40 | 0.59 | 0.60 | 0.57 | 0.64 | 0.68 | 0.67 | 0.73 | 0.58 | 0.68 | 0.67 | 0.44 | 0.50 | 0.48 | 0.49 | 0.35 | 0.35 | 0.52 | 0.66 | 0.71 | 0.63 | 0.62 | 0.65 | 0.67 | 0.65 | 0.87 | 0.97 | 1.00 | | | | | | | | | | | | |
| Math Problem Solving | 0.81 | 0.81 | 0.82 | 0.64 | 0.66 | 0.79 | 0.79 | 0.58 | 0.59 | 0.47 | 0.51 | 0.49 | 0.47 | 0.79 | 0.51 | 0.55 | 0.43 | 0.53 | 0.58 | 0.73 | 0.69 | 0.80 | 0.74 | 0.68 | 0.69 | 0.62 | 0.65 | 0.60 | 0.60 | 0.49 | 0.34 | 0.67 | 0.66 | 0.66 | 0.61 | 0.62 | 0.69 | 0.57 | 0.51 | 0.89 | 0.86 | 0.76 | 1.00 | | | | | | | | | | | |
| Written Language | 0.74 | 0.72 | 0.66 | 0.57 | 0.57 | 0.59 | 0.56 | 0.54 | 0.52 | 0.46 | 0.58 | 0.44 | 0.38 | 0.58 | 0.50 | 0.58 | 0.56 | 0.54 | 0.64 | 0.67 | 0.72 | 0.64 | 0.57 | 0.72 | 0.72 | 0.54 | 0.57 | 0.55 | 0.54 | 0.49 | 0.32 | 0.58 | 0.84 | 0.83 | 0.84 | 0.73 | 0.76 | 0.73 | 0.64 | 0.65 | 0.69 | 0.69 | 0.61 | 1.00 | | | | | | | | | | |
| Broad Written Language | 0.76 | 0.72 | 0.65 | 0.54 | 0.55 | 0.60 | 0.58 | 0.56 | 0.55 | 0.53 | 0.58 | 0.44 | 0.40 | 0.59 | 0.50 | 0.63 | 0.63 | 0.60 | 0.69 | 0.70 | 0.74 | 0.67 | 0.58 | 0.74 | 0.74 | 0.52 | 0.56 | 0.55 | 0.55 | 0.46 | 0.35 | 0.56 | 0.84 | 0.87 | 0.84 | 0.74 | 0.78 | 0.79 | 0.72 | 0.67 | 0.72 | 0.72 | 0.62 | 0.98 | 1.00 | | | | | | | | | |
| Basic Writing Skills | 0.76 | 0.74 | 0.69 | 0.65 | 0.66 | 0.56 | 0.55 | 0.63 | 0.62 | 0.48 | 0.61 | 0.37 | 0.35 | 0.56 | 0.58 | 0.61 | 0.52 | 0.58 | 0.66 | 0.69 | 0.75 | 0.68 | 0.65 | 0.72 | 0.76 | 0.62 | 0.64 | 0.64 | 0.59 | 0.48 | 0.31 | 0.67 | 0.82 | 0.83 | 0.81 | 0.69 | 0.76 | 0.77 | 0.67 | 0.70 | 0.72 | 0.69 | 0.70 | 0.86 | 0.87 | 1.00 | | | | | | | | |
| Written Expression | 0.68 | 0.63 | 0.55 | 0.41 | 0.41 | 0.56 | 0.54 | 0.47 | 0.46 | 0.48 | 0.48 | 0.43 | 0.38 | 0.57 | 0.38 | 0.60 | 0.61 | 0.55 | 0.64 | 0.62 | 0.65 | 0.60 | 0.51 | 0.68 | 0.66 | 0.41 | 0.47 | 0.42 | 0.47 | 0.39 | 0.33 | 0.44 | 0.74 | 0.76 | 0.72 | 0.71 | 0.71 | 0.67 | 0.63 | 0.58 | 0.62 | 0.63 | 0.51 | 0.87 | 0.92 | 0.64 | 1.00 | | | | | | | |
| Academic Skills | 0.80 | 0.78 | 0.75 | 0.64 | 0.64 | 0.68 | 0.65 | 0.58 | 0.57 | 0.53 | 0.56 | 0.42 | 0.39 | 0.65 | 0.53 | 0.62 | 0.56 | 0.58 | 0.66 | 0.74 | 0.75 | 0.76 | 0.65 | 0.74 | 0.75 | 0.60 | 0.62 | 0.61 | 0.58 | 0.49 | 0.33 | 0.65 | 0.89 | 0.87 | 0.89 | 0.75 | 0.81 | 0.77 | 0.67 | 0.84 | 0.86 | 0.84 | 0.76 | 0.89 | 0.89 | 0.91 | 0.72 | 1.00 | | | | | | |
| Academic Applications | 0.85 | 0.83 | 0.83 | 0.69 | 0.70 | 0.76 | 0.74 | 0.58 | 0.58 | 0.47 | 0.55 | 0.53 | 0.49 | 0.74 | 0.51 | 0.61 | 0.54 | 0.57 | 0.65 | 0.77 | 0.75 | 0.77 | 0.72 | 0.78 | 0.75 | 0.68 | 0.71 | 0.61 | 0.67 | 0.58 | 0.35 | 0.72 | 0.90 | 0.83 | 0.78 | 0.88 | 0.89 | 0.68 | 0.57 | 0.84 | 0.80 | 0.73 | 0.79 | 0.84 | 0.83 | 0.74 | 0.81 | 0.83 | 1.00 | | | | | |
| Academic Fluency | 0.69 | 0.61 | 0.61 | 0.50 | 0.50 | 0.58 | 0.54 | 0.47 | 0.50 | 0.64 | 0.46 | 0.37 | 0.37 | 0.53 | 0.46 | 0.64 | 0.71 | 0.64 | 0.70 | 0.69 | 0.68 | 0.68 | 0.53 | 0.70 | 0.68 | 0.44 | 0.51 | 0.52 | 0.50 | 0.32 | 0.45 | 0.49 | 0.69 | 0.88 | 0.66 | 0.64 | 0.67 | 0.91 | 0.92 | 0.64 | 0.79 | 0.83 | 0.62 | 0.72 | 0.80 | 0.73 | 0.72 | 0.77 | 0.66 | 1.00 | | | | |
| Academic Knowledge | 0.73 | 0.73 | 0.77 | 0.77 | 0.81 | 0.59 | 0.62 | 0.58 | 0.61 | 0.41 | 0.53 | 0.47 | 0.36 | 0.60 | 0.57 | 0.46 | 0.30 | 0.46 | 0.49 | 0.65 | 0.65 | 0.70 | 0.70 | 0.66 | 0.65 | 0.81 | 0.79 | 0.73 | 0.69 | 0.53 | 0.42 | 0.83 | 0.66 | 0.61 | 0.63 | 0.55 | 0.67 | 0.50 | 0.41 | 0.69 | 0.63 | 0.55 | 0.70 | 0.59 | 0.57 | 0.64 | 0.47 | 0.68 | 0.69 | 0.46 | 1.00 | | | |
| Phoneme-Grapheme Knowledge | 0.71 | 0.68 | 0.62 | 0.49 | 0.52 | 0.60 | 0.57 | 0.55 | 0.54 | 0.42 | 0.64 | 0.42 | 0.42 | 0.57 | 0.53 | 0.51 | 0.43 | 0.52 | 0.56 | 0.62 | 0.64 | 0.64 | 0.60 | 0.61 | 0.64 | 0.54 | 0.58 | 0.55 | 0.56 | 0.63 | 0.39 | 0.55 | 0.76 | 0.73 | 0.88 | 0.65 | 0.67 | 0.65 | 0.53 | 0.57 | 0.58 | 0.56 | 0.56 | 0.75 | 0.74 | 0.69 | 0.64 | 0.75 | 0.71 | 0.58 | 0.56 | 1.00 | | |
| Brief Achievement | 0.81 | 0.80 | 0.79 | 0.69 | 0.70 | 0.70 | 0.67 | 0.60 | 0.59 | 0.51 | 0.58 | 0.43 | 0.45 | 0.67 | 0.56 | 0.61 | 0.54 | 0.58 | 0.66 | 0.75 | 0.76 | 0.76 | 0.69 | 0.74 | 0.76 | 0.67 | 0.68 | 0.65 | 0.63 | 0.52 | 0.33 | 0.71 | 0.91 | 0.88 | 0.89 | 0.75 | 0.82 | 0.77 | 0.67 | 0.83 | 0.84 | 0.78 | 0.81 | 0.88 | 0.87 | 0.92 | 0.69 | 0.97 | 0.86 | 0.75 | 0.71 | 0.75 | 1.00 | |
| Broad Achievement | 0.84 | 0.80 | 0.79 | 0.66 | 0.66 | 0.73 | 0.69 | 0.59 | 0.60 | 0.60 | 0.57 | 0.47 | 0.45 | 0.69 | 0.54 | 0.68 | 0.66 | 0.65 | 0.73 | 0.80 | 0.79 | 0.80 | 0.68 | 0.80 | 0.79 | 0.61 | 0.66 | 0.63 | 0.63 | 0.49 | 0.41 | 0.67 | 0.90 | 0.94 | 0.84 | 0.81 | 0.85 | 0.87 | 0.80 | 0.84 | 0.90 | 0.88 | 0.78 | 0.89 | 0.92 | 0.87 | 0.81 | 0.95 | 0.89 | 0.90 | 0.66 | 0.74 | 0.94 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

## *Table F-6.*

*Cluster Score Intercorrelations—*
*Ages 40 Through 90+ (n = 1,146)*

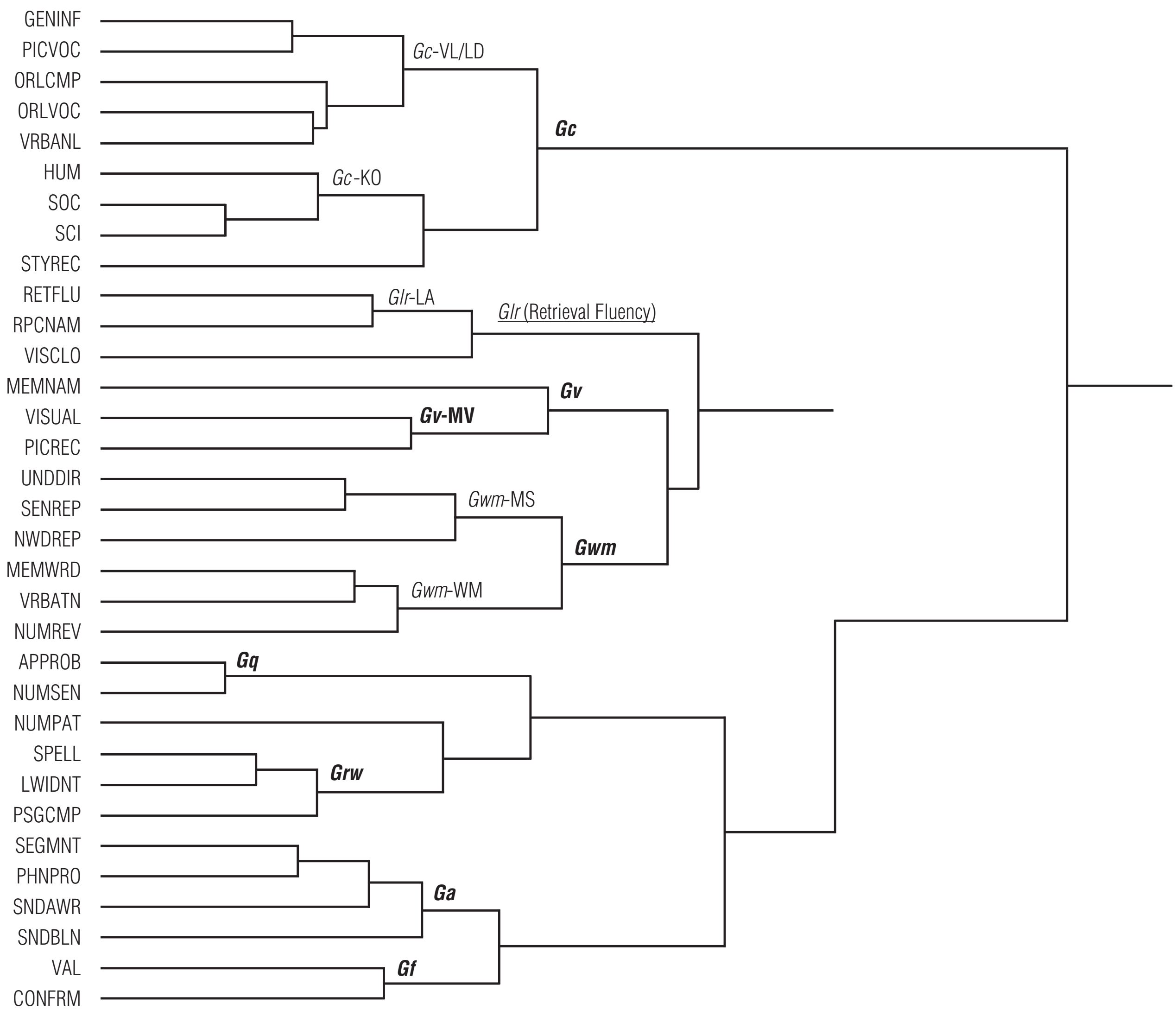
| Test | General Intellectual Ability | Brief Intellectual Ability | *Gf-Gc* Composite | Comprehension-Knowledge | Comprehension-Knowledge–Extended | Fluid Reasoning | Fluid Reasoning–Extended | Short-Term Working Memory | Short-Term Working Memory–Extended | Cognitive Processing Speed | Auditory Processing | Long-Term Retrieval | Visual Processing | Quantitative Reasoning | Auditory Memory Span | Number Facility | Perceptual Speed | Cognitive Efficiency | Cognitive Efficiency–Extended | Reading Aptitude A | Reading Aptitude B | Math Aptitude A | Math Aptitude B | Writing Aptitude A | Writing Aptitude B | Oral Language | Broad Oral Language | Oral Expression | Listening Comprehension | Phonetic Coding | Speed of Lexical Access | Vocabulary | Reading | Broad Reading | Basic Reading Skills | Reading Comprehension | Reading Comprehension–Extended | Reading Fluency | Reading Rate | Mathematics | Broad Mathematics | Math Calculation Skills | Math Problem Solving | Written Language | Broad Written Language | Basic Writing Skills | Written Expression | Academic Skills | Academic Applications | Academic Fluency | Academic Knowledge | Phoneme-Grapheme Knowledge | Brief Achievement | Broad Achievement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General Intellectual Ability | 1.00 |
| Brief Intellectual Ability | 0.94 | 1.00 |
| *Gf-Gc* Composite | 0.89 | 0.89 | 1.00 |
| Comprehension-Knowledge | 0.77 | 0.78 | 0.88 | 1.00 |
| Comprehension-Knowledge–Extended | 0.77 | 0.77 | 0.87 | 0.98 | 1.00 |
| Fluid Reasoning | 0.81 | 0.81 | 0.89 | 0.58 | 0.58 | 1.00 |
| Fluid Reasoning–Extended | 0.82 | 0.79 | 0.87 | 0.59 | 0.58 | 0.95 | 1.00 |
| Short-Term Working Memory | 0.78 | 0.78 | 0.64 | 0.57 | 0.57 | 0.57 | 0.60 | 1.00 |
| Short-Term Working Memory–Extended | 0.82 | 0.79 | 0.67 | 0.60 | 0.60 | 0.60 | 0.64 | 0.96 | 1.00 |
| Cognitive Processing Speed | 0.69 | 0.52 | 0.50 | 0.42 | 0.43 | 0.47 | 0.51 | 0.51 | 0.56 | 1.00 |
| Auditory Processing | 0.77 | 0.70 | 0.66 | 0.61 | 0.61 | 0.57 | 0.58 | 0.64 | 0.70 | 0.46 | 1.00 |
| Long-Term Retrieval | 0.66 | 0.55 | 0.61 | 0.51 | 0.53 | 0.57 | 0.62 | 0.51 | 0.57 | 0.42 | 0.52 | 1.00 |
| Visual Processing | 0.59 | 0.44 | 0.52 | 0.45 | 0.46 | 0.49 | 0.58 | 0.43 | 0.50 | 0.41 | 0.50 | 0.59 | 1.00 |
| Quantitative Reasoning | 0.82 | 0.81 | 0.81 | 0.57 | 0.56 | 0.87 | 0.96 | 0.59 | 0.62 | 0.51 | 0.53 | 0.56 | 0.55 | 1.00 |
| Auditory Memory Span | 0.68 | 0.62 | 0.55 | 0.52 | 0.54 | 0.46 | 0.50 | 0.68 | 0.72 | 0.41 | 0.73 | 0.48 | 0.48 | 0.46 | 1.00 |
| Number Facility | 0.74 | 0.66 | 0.59 | 0.48 | 0.47 | 0.58 | 0.61 | 0.80 | 0.78 | 0.67 | 0.53 | 0.47 | 0.47 | 0.62 | 0.53 | 1.00 |
| Perceptual Speed | 0.73 | 0.57 | 0.52 | 0.43 | 0.43 | 0.51 | 0.54 | 0.54 | 0.59 | 0.85 | 0.46 | 0.43 | 0.43 | 0.57 | 0.43 | 0.85 | 1.00 |
| Cognitive Efficiency | 0.78 | 0.63 | 0.60 | 0.52 | 0.52 | 0.55 | 0.58 | 0.79 | 0.79 | 0.80 | 0.53 | 0.52 | 0.48 | 0.59 | 0.54 | 0.85 | 0.84 | 1.00 |
| Cognitive Efficiency–Extended | 0.85 | 0.75 | 0.65 | 0.55 | 0.55 | 0.60 | 0.64 | 0.84 | 0.85 | 0.80 | 0.61 | 0.53 | 0.49 | 0.66 | 0.61 | 0.94 | 0.91 | 0.93 | 1.00 |
| Reading Aptitude A | 0.90 | 0.82 | 0.86 | 0.72 | 0.71 | 0.82 | 0.82 | 0.68 | 0.73 | 0.67 | 0.74 | 0.62 | 0.55 | 0.76 | 0.63 | 0.81 | 0.77 | 0.71 | 0.83 | 1.00 |
| Reading Aptitude B | 0.92 | 0.88 | 0.78 | 0.72 | 0.71 | 0.68 | 0.70 | 0.78 | 0.81 | 0.67 | 0.76 | 0.55 | 0.48 | 0.70 | 0.68 | 0.83 | 0.78 | 0.72 | 0.89 | 0.93 | 1.00 |
| Math Aptitude A | 0.90 | 0.83 | 0.83 | 0.69 | 0.69 | 0.79 | 0.80 | 0.64 | 0.68 | 0.81 | 0.64 | 0.58 | 0.59 | 0.80 | 0.54 | 0.71 | 0.71 | 0.70 | 0.77 | 0.86 | 0.82 | 1.00 |
| Math Aptitude B | 0.87 | 0.80 | 0.83 | 0.73 | 0.72 | 0.74 | 0.85 | 0.81 | 0.83 | 0.57 | 0.66 | 0.67 | 0.70 | 0.84 | 0.64 | 0.76 | 0.60 | 0.78 | 0.79 | 0.82 | 0.79 | 0.81 | 1.00 |
| Writing Aptitude A | 0.91 | 0.83 | 0.80 | 0.72 | 0.72 | 0.70 | 0.72 | 0.68 | 0.72 | 0.69 | 0.72 | 0.63 | 0.53 | 0.72 | 0.62 | 0.83 | 0.82 | 0.72 | 0.86 | 0.95 | 0.96 | 0.84 | 0.79 | 1.00 |
| Writing Aptitude B | 0.92 | 0.88 | 0.78 | 0.72 | 0.71 | 0.68 | 0.70 | 0.78 | 0.81 | 0.67 | 0.76 | 0.55 | 0.49 | 0.70 | 0.68 | 0.83 | 0.78 | 0.72 | 0.89 | 0.93 | 1.00 | 0.82 | 0.79 | 0.96 | 1.00 |
| Oral Language | 0.73 | 0.72 | 0.76 | 0.80 | 0.89 | 0.56 | 0.56 | 0.55 | 0.59 | 0.41 | 0.59 | 0.53 | 0.48 | 0.52 | 0.57 | 0.47 | 0.41 | 0.46 | 0.53 | 0.69 | 0.70 | 0.66 | 0.66 | 0.70 | 0.70 | 1.00 |
| Broad Oral Language | 0.77 | 0.75 | 0.79 | 0.78 | 0.85 | 0.63 | 0.63 | 0.59 | 0.64 | 0.46 | 0.65 | 0.59 | 0.54 | 0.59 | 0.64 | 0.51 | 0.45 | 0.51 | 0.58 | 0.73 | 0.72 | 0.70 | 0.70 | 0.73 | 0.72 | 0.95 | 1.00 |
| Oral Expression | 0.72 | 0.69 | 0.68 | 0.71 | 0.78 | 0.50 | 0.50 | 0.60 | 0.63 | 0.45 | 0.68 | 0.47 | 0.46 | 0.47 | 0.82 | 0.46 | 0.42 | 0.50 | 0.56 | 0.65 | 0.69 | 0.63 | 0.63 | 0.66 | 0.69 | 0.85 | 0.86 | 1.00 |
| Listening Comprehension | 0.75 | 0.74 | 0.74 | 0.67 | 0.71 | 0.65 | 0.65 | 0.60 | 0.64 | 0.44 | 0.66 | 0.59 | 0.56 | 0.61 | 0.66 | 0.52 | 0.44 | 0.49 | 0.58 | 0.72 | 0.71 | 0.69 | 0.68 | 0.71 | 0.71 | 0.85 | 0.95 | 0.78 | 1.00 |
| Phonetic Coding | 0.70 | 0.59 | 0.62 | 0.55 | 0.54 | 0.56 | 0.61 | 0.57 | 0.62 | 0.44 | 0.72 | 0.63 | 0.53 | 0.56 | 0.60 | 0.53 | 0.45 | 0.54 | 0.57 | 0.70 | 0.67 | 0.60 | 0.69 | 0.67 | 0.67 | 0.51 | 0.57 | 0.50 | 0.58 | 1.00 |
| Speed of Lexical Access | 0.53 | 0.46 | 0.46 | 0.39 | 0.44 | 0.42 | 0.46 | 0.45 | 0.54 | 0.50 | 0.50 | 0.36 | 0.45 | 0.42 | 0.49 | 0.48 | 0.49 | 0.47 | 0.54 | 0.57 | 0.56 | 0.51 | 0.49 | 0.54 | 0.56 | 0.53 | 0.56 | 0.51 | 0.54 | 0.38 | 1.00 |
| Vocabulary | 0.79 | 0.78 | 0.84 | 0.92 | 0.97 | 0.59 | 0.58 | 0.57 | 0.60 | 0.45 | 0.62 | 0.54 | 0.45 | 0.55 | 0.56 | 0.48 | 0.45 | 0.52 | 0.57 | 0.73 | 0.73 | 0.71 | 0.71 | 0.74 | 0.74 | 0.92 | 0.89 | 0.82 | 0.74 | 0.54 | 0.47 | 1.00 |
| Reading | 0.80 | 0.80 | 0.79 | 0.74 | 0.75 | 0.67 | 0.62 | 0.61 | 0.59 | 0.49 | 0.61 | 0.47 | 0.42 | 0.62 | 0.56 | 0.61 | 0.56 | 0.58 | 0.66 | 0.75 | 0.77 | 0.72 | 0.66 | 0.76 | 0.77 | 0.73 | 0.74 | 0.70 | 0.69 | 0.59 | 0.41 | 0.76 | 1.00 |
| Broad Reading | 0.79 | 0.77 | 0.77 | 0.71 | 0.71 | 0.67 | 0.62 | 0.60 | 0.60 | 0.58 | 0.59 | 0.49 | 0.42 | 0.62 | 0.58 | 0.68 | 0.66 | 0.64 | 0.72 | 0.78 | 0.78 | 0.74 | 0.65 | 0.79 | 0.78 | 0.68 | 0.70 | 0.69 | 0.67 | 0.54 | 0.48 | 0.71 | 0.94 | 1.00 |
| Basic Reading Skills | 0.75 | 0.76 | 0.70 | 0.64 | 0.66 | 0.62 | 0.58 | 0.58 | 0.56 | 0.46 | 0.62 | 0.42 | 0.41 | 0.60 | 0.56 | 0.57 | 0.52 | 0.54 | 0.62 | 0.69 | 0.72 | 0.68 | 0.61 | 0.70 | 0.72 | 0.68 | 0.69 | 0.68 | 0.65 | 0.56 | 0.41 | 0.69 | 0.93 | 0.88 | 1.00 |
| Reading Comprehension | 0.77 | 0.76 | 0.77 | 0.66 | 0.68 | 0.71 | 0.65 | 0.56 | 0.57 | 0.43 | 0.56 | 0.49 | 0.44 | 0.63 | 0.50 | 0.56 | 0.53 | 0.56 | 0.62 | 0.73 | 0.71 | 0.67 | 0.63 | 0.72 | 0.71 | 0.67 | 0.69 | 0.64 | 0.66 | 0.56 | 0.43 | 0.70 | 0.91 | 0.87 | 0.78 | 1.00 |
| Reading Comprehension–Extended | 0.82 | 0.81 | 0.82 | 0.75 | 0.76 | 0.71 | 0.66 | 0.61 | 0.61 | 0.46 | 0.63 | 0.53 | 0.44 | 0.64 | 0.57 | 0.60 | 0.55 | 0.59 | 0.65 | 0.78 | 0.77 | 0.72 | 0.69 | 0.78 | 0.77 | 0.75 | 0.76 | 0.72 | 0.72 | 0.60 | 0.44 | 0.78 | 0.93 | 0.90 | 0.82 | 0.97 | 1.00 |
| Reading Fluency | 0.71 | 0.67 | 0.68 | 0.64 | 0.64 | 0.58 | 0.55 | 0.56 | 0.57 | 0.58 | 0.56 | 0.46 | 0.36 | 0.54 | 0.55 | 0.66 | 0.65 | 0.63 | 0.69 | 0.72 | 0.72 | 0.68 | 0.60 | 0.73 | 0.72 | 0.59 | 0.61 | 0.63 | 0.58 | 0.48 | 0.44 | 0.64 | 0.81 | 0.94 | 0.77 | 0.75 | 0.80 | 1.00 |
| Reading Rate | 0.68 | 0.60 | 0.61 | 0.53 | 0.54 | 0.56 | 0.54 | 0.49 | 0.52 | 0.66 | 0.49 | 0.43 | 0.36 | 0.52 | 0.51 | 0.68 | 0.76 | 0.66 | 0.73 | 0.73 | 0.71 | 0.67 | 0.54 | 0.73 | 0.71 | 0.52 | 0.57 | 0.56 | 0.54 | 0.38 | 0.53 | 0.55 | 0.70 | 0.87 | 0.65 | 0.66 | 0.70 | 0.91 | 1.00 |
| Mathematics | 0.80 | 0.80 | 0.82 | 0.65 | 0.65 | 0.79 | 0.78 | 0.59 | 0.60 | 0.55 | 0.50 | 0.55 | 0.48 | 0.78 | 0.47 | 0.62 | 0.56 | 0.59 | 0.65 | 0.76 | 0.72 | 0.82 | 0.74 | 0.74 | 0.72 | 0.61 | 0.64 | 0.57 | 0.61 | 0.54 | 0.36 | 0.66 | 0.74 | 0.72 | 0.68 | 0.71 | 0.75 | 0.64 | 0.59 | 1.00 |
| Broad Mathematics | 0.81 | 0.79 | 0.79 | 0.65 | 0.63 | 0.76 | 0.74 | 0.59 | 0.60 | 0.60 | 0.51 | 0.52 | 0.47 | 0.75 | 0.46 | 0.65 | 0.63 | 0.63 | 0.69 | 0.76 | 0.74 | 0.82 | 0.71 | 0.75 | 0.74 | 0.59 | 0.62 | 0.56 | 0.60 | 0.50 | 0.42 | 0.63 | 0.74 | 0.77 | 0.68 | 0.70 | 0.74 | 0.72 | 0.70 | 0.95 | 1.00 |
| Math Calculation Skills | 0.76 | 0.74 | 0.72 | 0.58 | 0.57 | 0.69 | 0.67 | 0.54 | 0.56 | 0.60 | 0.48 | 0.47 | 0.41 | 0.69 | 0.42 | 0.64 | 0.65 | 0.61 | 0.68 | 0.72 | 0.71 | 0.77 | 0.63 | 0.73 | 0.71 | 0.52 | 0.55 | 0.51 | 0.54 | 0.45 | 0.42 | 0.57 | 0.71 | 0.76 | 0.66 | 0.68 | 0.70 | 0.72 | 0.71 | 0.89 | 0.98 | 1.00 |
| Math Problem Solving | 0.82 | 0.82 | 0.83 | 0.67 | 0.67 | 0.81 | 0.81 | 0.62 | 0.64 | 0.52 | 0.58 | 0.57 | 0.49 | 0.81 | 0.53 | 0.60 | 0.51 | 0.57 | 0.63 | 0.76 | 0.72 | 0.82 | 0.77 | 0.73 | 0.73 | 0.62 | 0.66 | 0.61 | 0.64 | 0.58 | 0.41 | 0.67 | 0.68 | 0.69 | 0.62 | 0.65 | 0.71 | 0.62 | 0.58 | 0.90 | 0.86 | 0.77 | 1.00 |
| Written Language | 0.79 | 0.78 | 0.71 | 0.64 | 0.65 | 0.63 | 0.61 | 0.61 | 0.60 | 0.53 | 0.65 | 0.49 | 0.43 | 0.64 | 0.55 | 0.63 | 0.61 | 0.60 | 0.69 | 0.73 | 0.77 | 0.70 | 0.64 | 0.76 | 0.77 | 0.63 | 0.64 | 0.64 | 0.61 | 0.56 | 0.40 | 0.66 | 0.88 | 0.87 | 0.87 | 0.79 | 0.82 | 0.79 | 0.70 | 0.72 | 0.75 | 0.74 | 0.67 | 1.00 |
| Broad Written Language | 0.80 | 0.77 | 0.70 | 0.61 | 0.61 | 0.64 | 0.62 | 0.63 | 0.62 | 0.57 | 0.65 | 0.49 | 0.44 | 0.64 | 0.55 | 0.67 | 0.66 | 0.63 | 0.73 | 0.75 | 0.79 | 0.72 | 0.64 | 0.78 | 0.79 | 0.60 | 0.63 | 0.63 | 0.61 | 0.53 | 0.42 | 0.63 | 0.87 | 0.89 | 0.86 | 0.80 | 0.83 | 0.83 | 0.76 | 0.73 | 0.77 | 0.77 | 0.67 | 0.98 | 1.00 |
| Basic Writing Skills | 0.79 | 0.79 | 0.72 | 0.69 | 0.70 | 0.59 | 0.58 | 0.68 | 0.67 | 0.51 | 0.67 | 0.42 | 0.38 | 0.60 | 0.62 | 0.65 | 0.57 | 0.61 | 0.70 | 0.73 | 0.79 | 0.71 | 0.68 | 0.76 | 0.79 | 0.69 | 0.69 | 0.70 | 0.65 | 0.53 | 0.38 | 0.71 | 0.85 | 0.86 | 0.85 | 0.75 | 0.81 | 0.82 | 0.72 | 0.72 | 0.74 | 0.72 | 0.72 | 0.90 | 0.90 | 1.00 |
| Written Expression | 0.74 | 0.70 | 0.63 | 0.51 | 0.51 | 0.61 | 0.58 | 0.56 | 0.55 | 0.55 | 0.56 | 0.48 | 0.42 | 0.61 | 0.45 | 0.65 | 0.67 | 0.61 | 0.70 | 0.70 | 0.72 | 0.67 | 0.58 | 0.74 | 0.73 | 0.50 | 0.54 | 0.52 | 0.54 | 0.49 | 0.41 | 0.53 | 0.79 | 0.81 | 0.76 | 0.77 | 0.77 | 0.74 | 0.71 | 0.66 | 0.70 | 0.71 | 0.58 | 0.90 | 0.94 | 0.73 | 1.00 |
| Academic Skills | 0.82 | 0.82 | 0.78 | 0.70 | 0.70 | 0.70 | 0.67 | 0.63 | 0.62 | 0.55 | 0.61 | 0.49 | 0.42 | 0.68 | 0.56 | 0.65 | 0.60 | 0.60 | 0.69 | 0.77 | 0.78 | 0.78 | 0.69 | 0.77 | 0.78 | 0.67 | 0.68 | 0.67 | 0.64 | 0.55 | 0.39 | 0.71 | 0.92 | 0.90 | 0.91 | 0.80 | 0.85 | 0.81 | 0.72 | 0.86 | 0.87 | 0.85 | 0.78 | 0.92 | 0.92 | 0.92 | 0.79 | 1.00 |
| Academic Applications | 0.86 | 0.85 | 0.85 | 0.74 | 0.74 | 0.77 | 0.75 | 0.63 | 0.63 | 0.54 | 0.61 | 0.58 | 0.52 | 0.75 | 0.54 | 0.65 | 0.61 | 0.63 | 0.70 | 0.81 | 0.79 | 0.80 | 0.75 | 0.81 | 0.79 | 0.72 | 0.74 | 0.67 | 0.71 | 0.63 | 0.43 | 0.75 | 0.91 | 0.87 | 0.81 | 0.90 | 0.91 | 0.74 | 0.66 | 0.86 | 0.84 | 0.78 | 0.80 | 0.88 | 0.87 | 0.78 | 0.85 | 0.87 | 1.00 |
| Academic Fluency | 0.72 | 0.67 | 0.66 | 0.57 | 0.56 | 0.61 | 0.58 | 0.55 | 0.56 | 0.65 | 0.51 | 0.45 | 0.39 | 0.58 | 0.49 | 0.69 | 0.72 | 0.66 | 0.73 | 0.73 | 0.72 | 0.71 | 0.58 | 0.74 | 0.73 | 0.51 | 0.56 | 0.55 | 0.56 | 0.41 | 0.50 | 0.55 | 0.74 | 0.90 | 0.69 | 0.70 | 0.73 | 0.92 | 0.93 | 0.69 | 0.82 | 0.85 | 0.65 | 0.77 | 0.83 | 0.77 | 0.78 | 0.80 | 0.73 | 1.00 |
| Academic Knowledge | 0.77 | 0.78 | 0.80 | 0.78 | 0.82 | 0.65 | 0.66 | 0.61 | 0.64 | 0.46 | 0.60 | 0.50 | 0.40 | 0.66 | 0.58 | 0.49 | 0.39 | 0.51 | 0.55 | 0.69 | 0.69 | 0.73 | 0.72 | 0.70 | 0.70 | 0.83 | 0.82 | 0.77 | 0.74 | 0.56 | 0.45 | 0.83 | 0.71 | 0.66 | 0.69 | 0.63 | 0.73 | 0.58 | 0.49 | 0.73 | 0.68 | 0.61 | 0.73 | 0.66 | 0.65 | 0.69 | 0.56 | 0.73 | 0.74 | 0.53 | 1.00 |
| Phoneme-Grapheme Knowledge | 0.76 | 0.74 | 0.67 | 0.56 | 0.58 | 0.63 | 0.62 | 0.62 | 0.62 | 0.47 | 0.69 | 0.48 | 0.44 | 0.63 | 0.61 | 0.56 | 0.49 | 0.56 | 0.62 | 0.68 | 0.70 | 0.68 | 0.65 | 0.67 | 0.70 | 0.61 | 0.64 | 0.64 | 0.64 | 0.68 | 0.43 | 0.61 | 0.80 | 0.77 | 0.89 | 0.71 | 0.74 | 0.71 | 0.60 | 0.64 | 0.65 | 0.63 | 0.62 | 0.80 | 0.79 | 0.76 | 0.71 | 0.80 | 0.76 | 0.64 | 0.64 | 1.00 |
| Brief Achievement | 0.82 | 0.83 | 0.81 | 0.73 | 0.74 | 0.71 | 0.68 | 0.65 | 0.63 | 0.54 | 0.63 | 0.49 | 0.46 | 0.69 | 0.58 | 0.64 | 0.58 | 0.60 | 0.69 | 0.77 | 0.79 | 0.78 | 0.71 | 0.77 | 0.79 | 0.72 | 0.73 | 0.70 | 0.68 | 0.57 | 0.40 | 0.75 | 0.92 | 0.90 | 0.91 | 0.79 | 0.85 | 0.82 | 0.72 | 0.85 | 0.85 | 0.80 | 0.80 | 0.91 | 0.90 | 0.93 | 0.76 | 0.98 | 0.88 | 0.78 | 0.75 | 0.80 | 1.00 |
| Broad Achievement | 0.85 | 0.83 | 0.81 | 0.71 | 0.71 | 0.74 | 0.70 | 0.65 | 0.65 | 0.62 | 0.62 | 0.53 | 0.47 | 0.71 | 0.57 | 0.72 | 0.70 | 0.68 | 0.76 | 0.82 | 0.82 | 0.81 | 0.71 | 0.83 | 0.82 | 0.67 | 0.70 | 0.67 | 0.68 | 0.56 | 0.47 | 0.71 | 0.91 | 0.96 | 0.86 | 0.85 | 0.89 | 0.90 | 0.84 | 0.85 | 0.90 | 0.89 | 0.79 | 0.92 | 0.94 | 0.89 | 0.86 | 0.96 | 0.92 | 0.92 | 0.71 | 0.79 | 0.95 | 1.00 |

*Note.* A listwise deletion of missing data option was used to calculate the correlation matrix.

# *Appendix G*

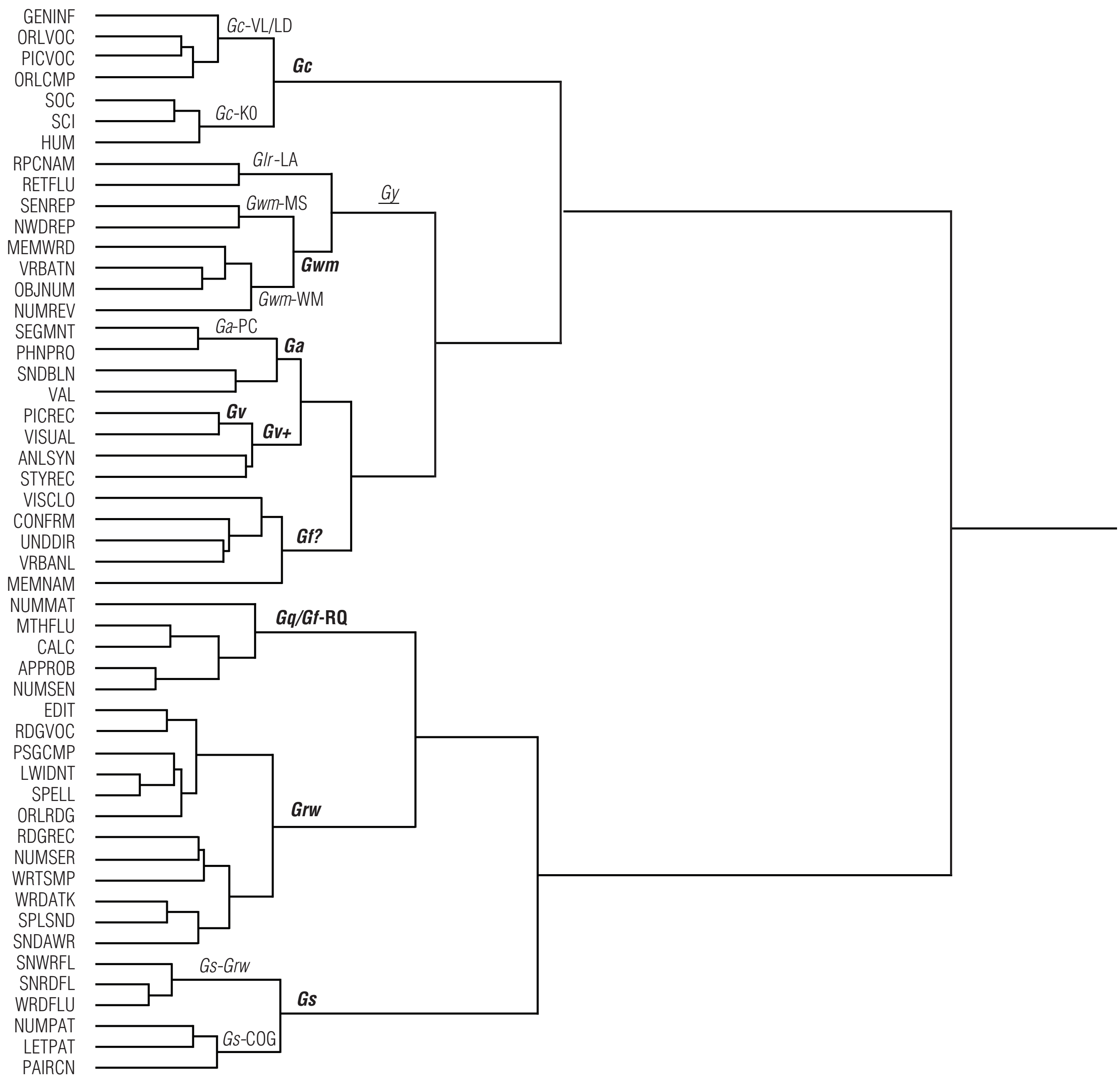
# Ward's Cluster Analysis Solutions

***Figure G-1.***
*Ward's cluster analysis of ages 3 through 5 model-development sample A (n = 209).*



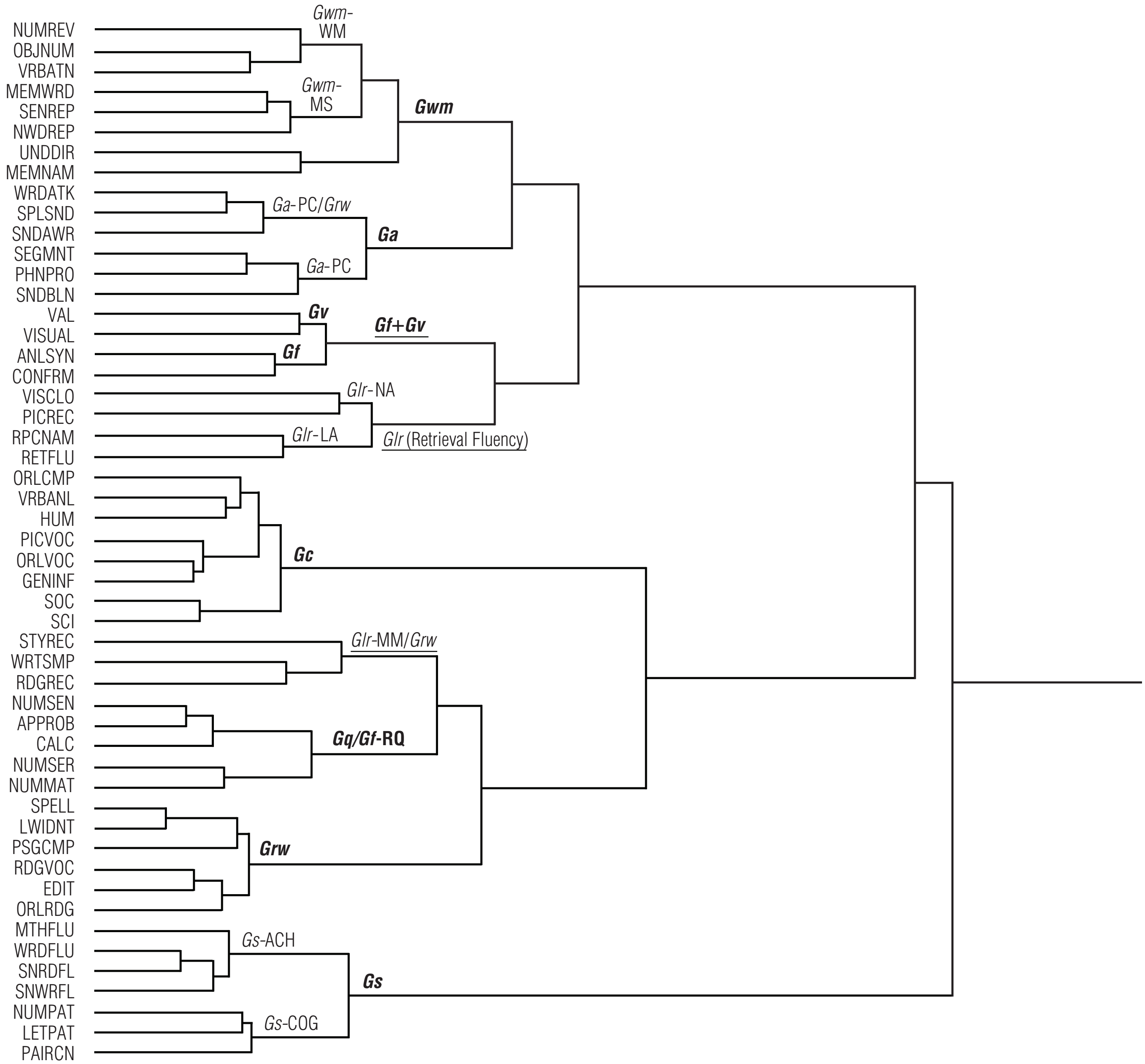

*Note.* Bold font = Broad or general CHC abilities; underlined text = Possible intermediate level stratum dimensions

***Figure G-2.***
*Ward's cluster analysis of ages 6 through 8 model-development sample A (*n *= 412).*



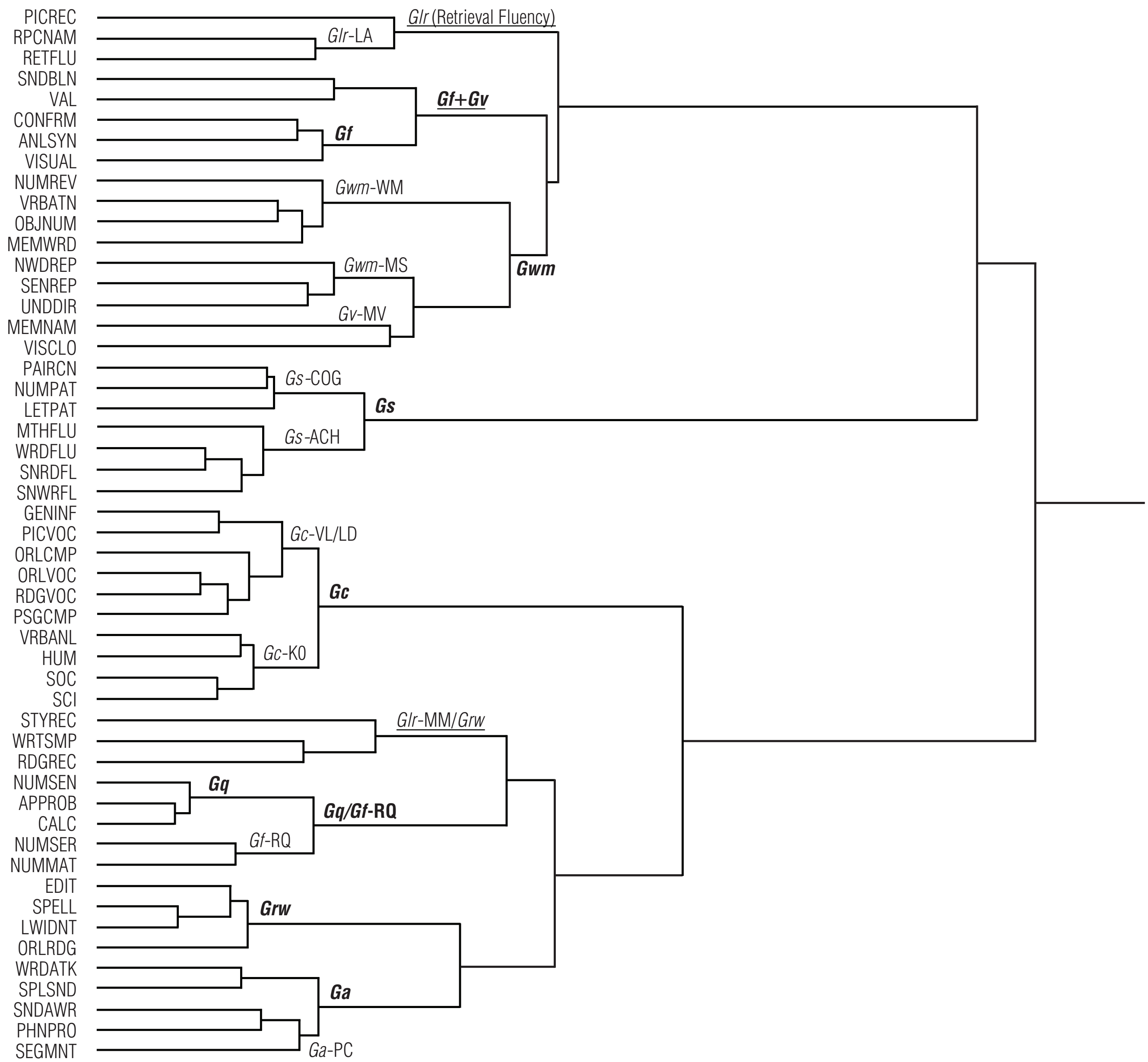

*Note.* Bold font = Broad or general CHC abilities. Underlined font = Possible intermediate level stratum dimensions

***Figure G-3.***
*Ward's cluster analysis of ages 9 through 13 model-development sample A (n = 785).*



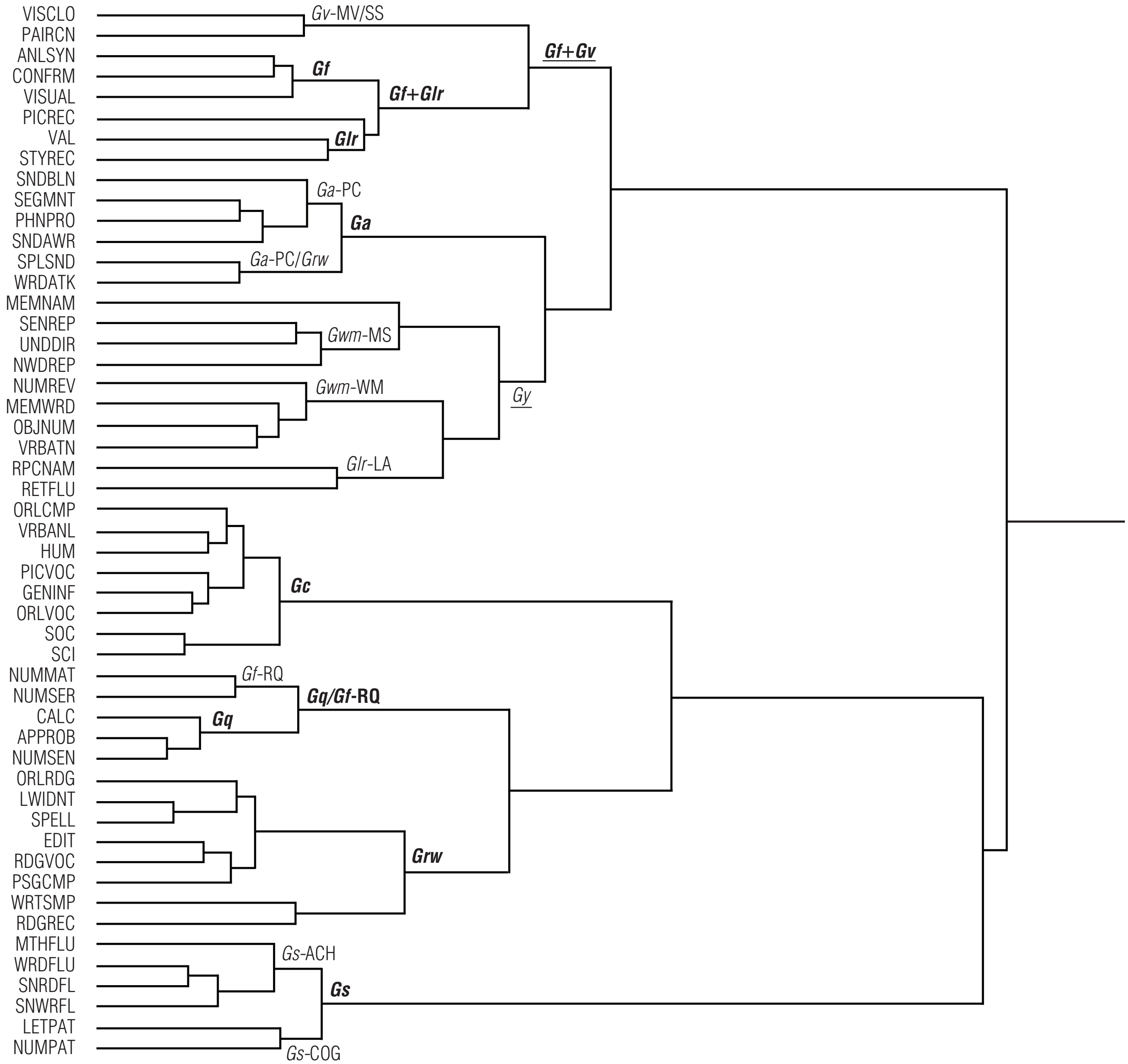

*Note.* Bold font = Broad or general CHC abilities. Underlined font = Possible intermediate level stratum dimensions

**_Figure G-4._**
*Ward's cluster analysis of ages 14 through 19 model-development sample A (*n *= 842).*



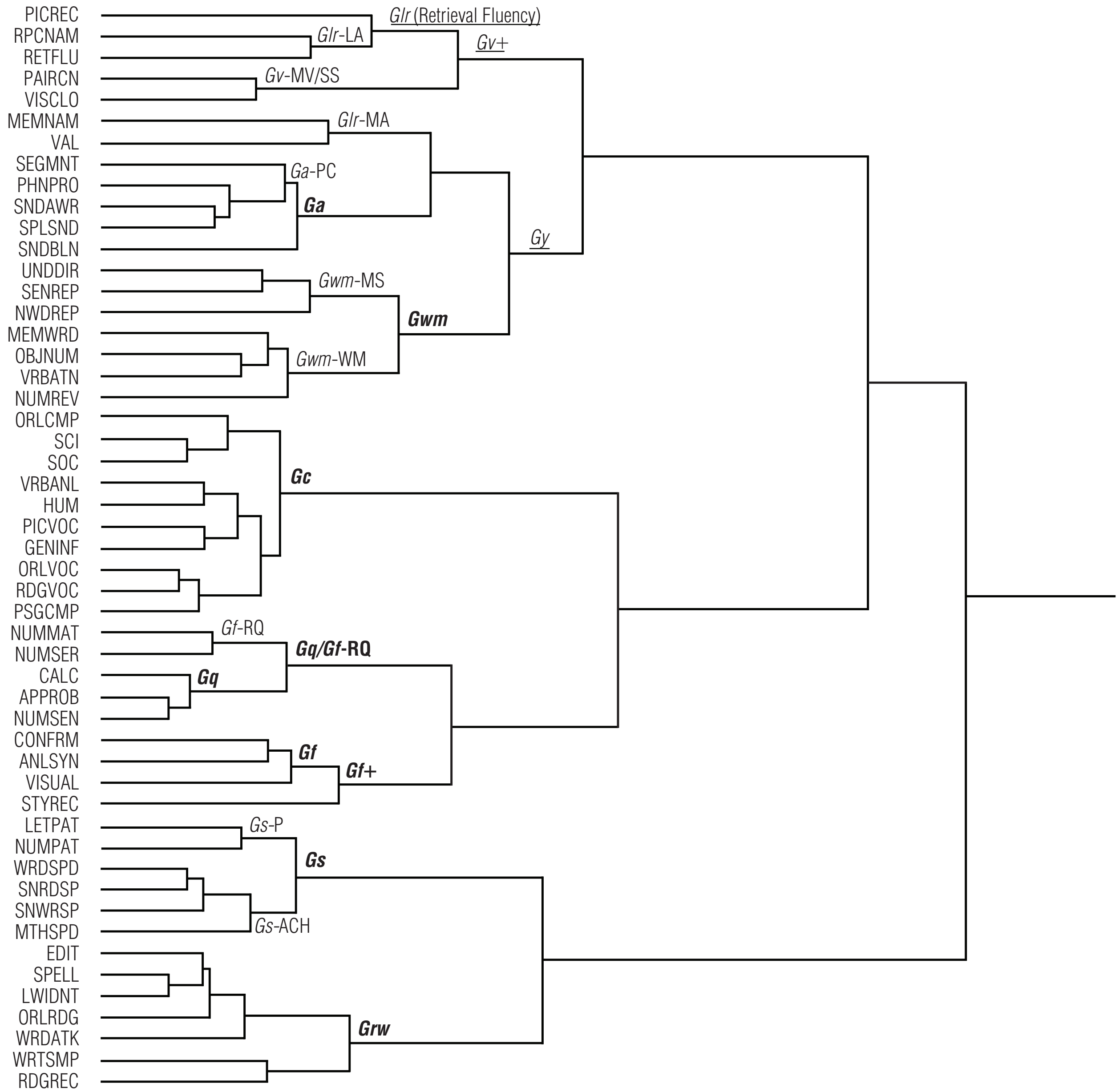

*Note*. Bold font = Broad or general CHC abilities. Underlined font = Possible intermediate level stratum dimensions

***Figure G-5.***
*Ward's cluster analysis of ages 20 through 39 model-development sample A (n = 625).*




*Note*. Bold font = Broad or general CHC abilities. Underlined font = Possible intermediate level stratum dimensions

***Figure G-6.***
*Ward's cluster analysis of ages 40 through 90+ model-development sample A (*n *= 571).*




*Note*. Bold font = Broad or general CHC abilities. Underlined font = Possible intermediate level stratum dimensions

*Appendix H*

# Exploratory Principal Component Analysis Solutions

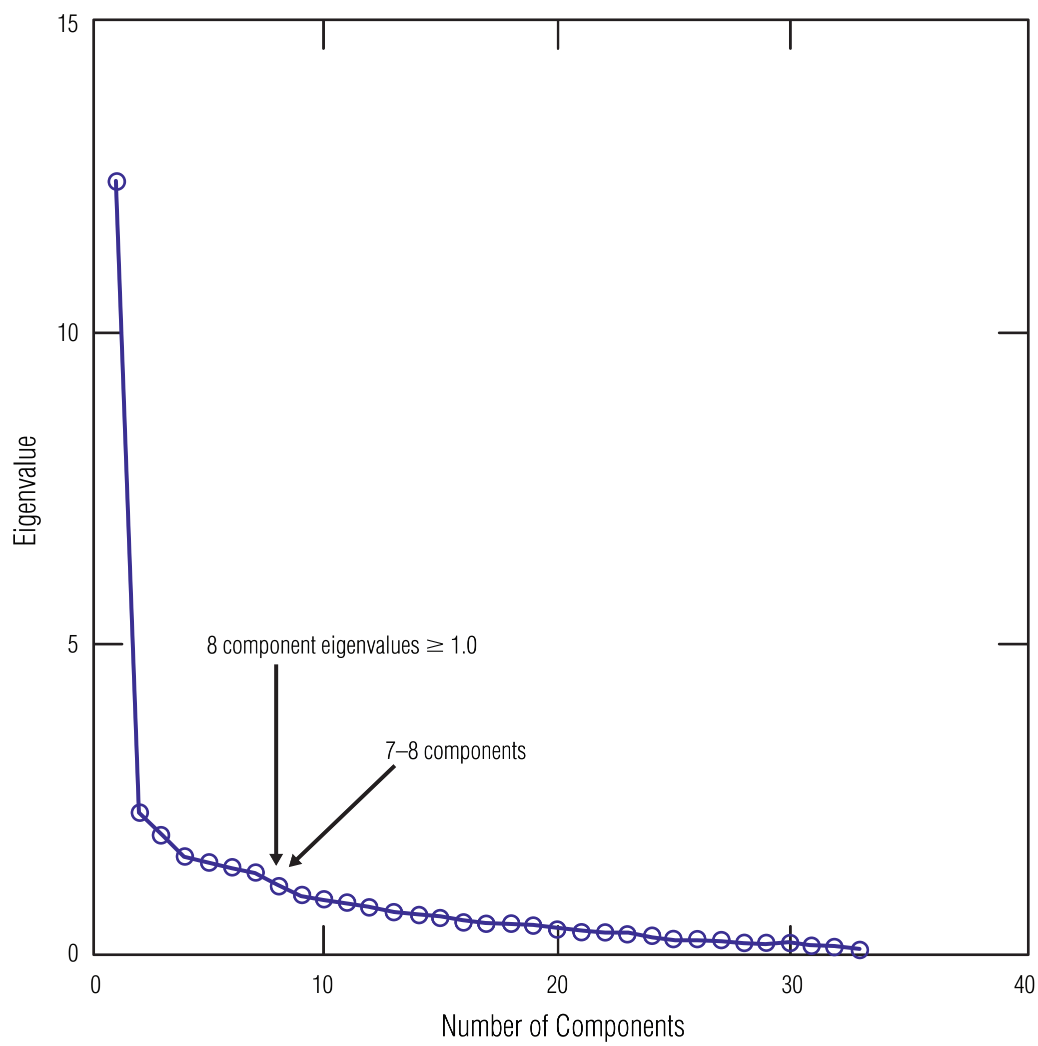



***Figure H-1.***
*Scree plot (eigenvalues/ latent roots) of ages 3 through 5 model-development sample A.*

***Table H-1a.***
*Seven-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 3 Through 5 Model-Development Sample A*

| | Seven Varimax Rotated Components | | | | | | |
|---|---|---|---|---|---|---|---|
| **Tests** | ***Grw*** | ***Gc*** | ***Glr*-LA** | ***Gwm*** | **?** | ***Ga+Gf*** | ***Gq+*** |
| PSGCMP | 0.80 | | | | | | |
| SPELL | 0.65 | | | | | | |
| LWIDNT | 0.63 | | | | | | |
| NUMPAT | 0.54 | | | | | | *0.43* |
| PICVOC | | 0.83 | | | | | |
| HUM | | 0.76 | | | | | |
| GENINF | | 0.73 | | | | | |
| SOC | | 0.67 | | | | | |
| ORLVOC | | 0.59 | | | | | |
| ORLCMP | *0.41* | 0.58 | | | | | |
| SCI | | 0.56 | | | | | 0.55 |
| VRBANL | | 0.54 | | | | | |
| RPCNAM | | | 0.79 | | | | |
| VISCLO | | | 0.59 | | | | |
| RETFLU | | | 0.58 | | | | |
| MEMWRD | | | | 0.74 | | | |
| NWDREP | | | | 0.68 | | | |
| VRBATN | | | | 0.65 | | | |
| SENREP | | | | 0.57 | | | |
| MEMNAM | | | | | 0.75 | | |
| VISUAL | | | | | 0.61 | | |
| PHNPRO | | | | | | 0.73 | |
| SEGMNT | | | | | | 0.68 | |
| VAL | | | | | | 0.65 | |
| SNDBLN | | | | | | 0.65 | |
| CONFRM | | | | | | 0.62 | |
| STYREC | | | | | | | 0.65 |
| NUMSEN | | | | | | | 0.57 |
| NUMREV | | | | *0.43* | | *0.43* | 0.51 |
| APPROB | | | | | *0.41* | | 0.48 |
| SNDAWR | | | | | | *0.41* | |
| PICREC | | | | 0.37 | | 0.38 | |
| UNDDIR | | | | | *0.41* | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤ .40; other loadings of < .40 were removed for readability purposes. ? = uninterpretable component.

***Table H-1b.***

*Eight-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 3 Through 5 Model-Development Sample A*

| | **Eight Varimax Rotated Components** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Grw*** | ***Gc*** | ***Glr*-LA** | ***Gwm*** | **?** | ***Ga+Gf*** | ***Gq+*** | ***Gv*** |
| PSGCMP | 0.75 | | | | | *0.40* | | |
| LWIDNT | 0.71 | | | | | | | |
| SPELL | 0.70 | | | | | | | |
| NUMPAT | 0.59 | | | | | | | |
| PICVOC | | 0.84 | | | | | | |
| HUM | | 0.78 | | | | | | |
| GENINF | | 0.73 | | | | | | |
| SOC | | 0.69 | | | | | | |
| SCI | | 0.61 | | | | | 0.50 | |
| ORLVOC | | 0.61 | | | | | | |
| ORLCMP | | 0.58 | | | | | | |
| VRBANL | | 0.55 | | | | *0.41* | | |
| RPCNAM | | | 0.78 | | | | | |
| RETFLU | | | 0.59 | | | | | |
| VISCLO | | | 0.58 | | | | | |
| MEMWRD | | | | 0.74 | | | | |
| NWDREP | | | | 0.68 | | | | |
| VRBATN | | | | 0.64 | | | | |
| SENREP | | | | 0.59 | | | | |
| MEMNAM | | | | | 0.81 | | | |
| PHNPRO | | | | | | 0.71 | | |
| SEGMNT | | | | | | 0.69 | | |
| VAL | | | | | | 0.67 | | |
| SNDBLN | | | | | | 0.66 | | |
| CONFRM | | | | | | 0.63 | | |
| NUMSEN | | | | | | | 0.57 | |
| NUMREV | | | | *0.42* | | | 0.53 | |
| VISUAL | | | | | | | | 0.75 |
| PICREC | | | | | | | | 0.63 |
| STYREC | | | | | | | 0.45 | 0.56 |
| SNDAWR | | | | | | *0.44* | | |
| UNDDIR | <u>0.34</u> | <u>0.38</u> | | | | | | |
| APPROB | *0.43* | | | | | | 0.47 | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤ .40; other loadings of < .40 were removed for readability purposes. ? = uninterpretable component.

***Table H-1c.***
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 3 Through 5 Model-Development Sample A*

| | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Grw*** | ***Gc*** | ***Glr*-LA** | ***Gwm*-MS** | **?** | ***Ga+ Grw*** | ***Gwm*-WM** | ***Gv*** | **?** |
| LWIDNT | 0.73 | | | | | | | | |
| SPELL | 0.71 | | | | | | | | |
| PSGCMP | 0.68 | | | | | *0.42* | | | |
| NUMPAT | 0.66 | | | | | | | | |
| APPROB | 0.53 | | | | | | | | |
| PICVOC | | 0.82 | | | | | | | |
| GENINF | | 0.77 | | | | | | | |
| HUM | | 0.74 | | | | | | | |
| ORLVOC | | 0.61 | | | | | | | |
| SOC | | 0.60 | | | | | | | 0.58 |
| ORLCMP | | 0.56 | | | | | | | |
| VRBANL | | 0.56 | | | | | | | |
| SCI | | 0.50 | | | | | | | 0.67 |
| RPCNAM | | | 0.79 | | | | | | |
| RETFLU | | | 0.70 | | | | | | |
| SENREP | | | | 0.74 | | | | | |
| NWDREP | | | | 0.73 | | | | | |
| MEMNAM | | | | | 0.82 | | | | |
| PHNPRO | | | | | | 0.72 | | | |
| SEGMNT | | | | | | 0.72 | | | |
| CONFRM | | | | | | 0.66 | | | |
| SNDBLN | | | | | | 0.65 | | | |
| VAL | | | | | | 0.61 | | | |
| MEMWRD | | | | | | | 0.70 | | |
| VRBATN | | | | | | | 0.64 | | |
| NUMREV | | | | | | | 0.59 | | |
| VISUAL | | | | | | | | 0.77 | |
| PICREC | | | *0.41* | | | | | 0.65 | |
| STYREC | | | | | | | | *0.44* | 0.65 |
| VISCLO | | | *0.42* | | | | | | 0.54 |
| NUMSEN | 0.46 | | | | | | | | *0.44* |
| SNDAWR | | | | | | *0.43* | | | |
| UNDDIR | | | | *0.43* | | | | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; loadings of < .40 were removed for readability purposes. ? = uninterpretable component.

**_Figure H-2._**
*Scree plot (eigenvalues/ latent roots) of ages 6 through 8 model-development sample A.*

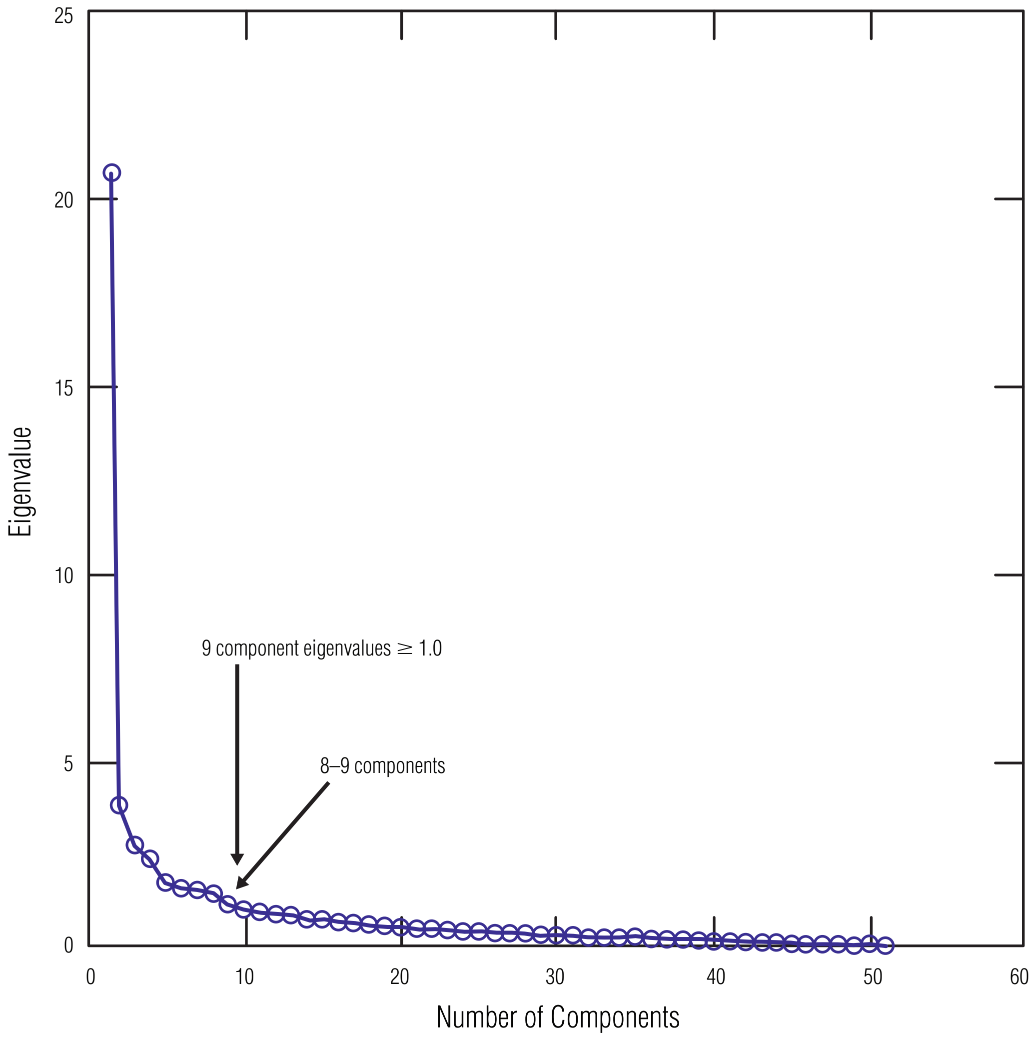



**_Table H-2a._**
*Eight-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 6 Through 8 Model-Development Sample A*

| | Eight Varimax Rotated Components | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Grw*** | ***Gc*** | ***Gs*** | ***Gv+ Gf+ Ga*** | ***Gq*** | ***Gwm*** | ***Glr*-MM** | ***Gv*-MV/ MM** |
| LWIDNT | 0.84 | | | | | | | |
| PSGCMP | 0.77 | | | | | | | |
| ORLRDG | 0.77 | | | | | | | |
| SPELL | 0.76 | | | | | | | |
| RDGREC | 0.73 | | | | | | | |
| SNWRFL | 0.71 | | *0.43* | | | | | |
| EDIT | 0.70 | | | | | | | |
| WRDATK | 0.70 | | | | | | | |
| WRTSMP | 0.70 | | | | | | *0.44* | |
| SNRDFL | 0.69 | | 0.51 | | | | | |
| SPLSND | 0.63 | | | | | | | |
| RDGVOC | 0.63 | 0.54 | | | | | | |
| NUMSER | 0.59 | | | | 0.57 | | | |

***Table H-2a.*** *(cont.)*
*Eight-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 6 Through 8 Model-Development Sample A*

| | Eight Varimax Rotated Components | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Grw*** | ***Gc*** | ***Gs*** | ***Gv+ Gf+Ga*** | ***Gq*** | ***Gwm*** | ***Glr*-MM** | ***Gv*-MV/ MM** |
| WRDFLU | 0.58 | | 0.65 | | | | | |
| MTHFLU | 0.54 | | 0.52 | | | | | |
| SNDAWR | 0.54 | | | *0.44* | | | | |
| PICVOC | | 0.84 | | | | | | |
| ORLVOC | | 0.73 | | | | | | |
| SOC | | 0.72 | | | | | | |
| GENINF | | 0.72 | | | | | | |
| HUM | | 0.66 | | | | | | |
| ORLCMP | | 0.64 | | | | | | |
| SCI | | 0.61 | | | | | | |
| VRBANL | | 0.52 | | *0.41* | | | | |
| PAIRCN | | | 0.78 | | | | | |
| LETPAT | | | 0.75 | | | | | |
| NUMPAT | 0.45 | | 0.68 | | | | | |
| VISUAL | | | | 0.69 | | | | |
| VAL | | | | 0.69 | | | | |
| PICREC | | | | 0.65 | | | | |
| SNDBLN | | | | 0.59 | | | | |
| SEGMNT | | | | 0.57 | | | | |
| ANLSYN | | | | 0.51 | | | | |
| NUMMAT | | | | | 0.64 | | | |
| CALC | 0.50 | | | | 0.63 | | | |
| APPROB | | | | | 0.59 | | | |
| MEMWRD | | | | | | 0.71 | | |
| VRBATN | | | | | | 0.70 | | |
| OBJNUM | | | *0.41* | | | 0.64 | | |
| NWDREP | | | | | | 0.61 | | |
| MEMNAM | | | | | | | | 0.71 |
| VISCLO | | | | | | | | 0.62 |
| UNDDIR | | | | | | | | *0.44* |
| RPCNAM | | | 0.48 | | | | | |
| SENREP | | 0.49 | | | | *0.40* | | |
| CONFRM | | | | 0.48 | | | | |
| STYREC | | | | 0.45 | | | *0.42* | |
| PHNPRO | 0.35 | 0.34 | | | | 0.36 | | |
| NUMREV | | | | | | *0.41* | | |
| RETFLU | | *0.42* | | | | | | |
| NUMSEN | | | | | 0.48 | | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤ .40; other loadings of < .40 were removed for readability purposes.

**Table H-2b.**
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 6 Through 8 Model-Development Sample A*

| | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Grw*** | ***Gc*** | ***Gs*** | ***Gv+Gf*** | ***Gq*** | ***Gwm*** | ***Glr*-MM** | ***Gv*-MV/ MM** | ***Ga*** |
| LWIDNT | 0.84 | | | | | | | | |
| ORLRDG | 0.77 | | | | | | | | |
| SPELL | 0.77 | | | | | | | | |
| PSGCMP | 0.77 | | | | | | | | |
| SNWRFL | 0.73 | | | | | | | | |
| RDGREC | 0.73 | | | | | | | | |
| SNRDFL | 0.72 | | 0.45 | | | | | | |
| EDIT | 0.71 | | | | | | | | |
| WRTSMP | 0.68 | | | | | | 0.46 | | |
| WRDATK | 0.68 | | | | | | | | |
| RDGVOC | 0.63 | 0.54 | | | | | | | |
| WRDFLU | 0.63 | | 0.59 | | | | | | |
| SPLSND | 0.61 | | | | | | | | *0.42* |
| NUMSER | 0.58 | | | | 0.58 | | | | |
| MTHFLU | 0.58 | | 0.45 | | *0.42* | | | | |
| SNDAWR | 0.52 | | | | | | | | 0.46 |
| CALC | 0.51 | | | | 0.64 | | | | |
| PICVOC | | 0.83 | | | | | | | |
| ORLVOC | | 0.73 | | | | | | | |
| SOC | | 0.73 | | | | | | | |
| GENINF | | 0.71 | | | | | | | |
| HUM | | 0.67 | | | | | | | |
| ORLCMP | | 0.63 | | | | | | | |
| SCI | | 0.62 | | | | | <u>0.38</u> | | |
| VRBANL | | 0.51 | | | | | | | |
| PAIRCN | | | 0.83 | | | | | | |
| LETPAT | | | 0.75 | | | | | | |
| NUMPAT | 0.48 | | 0.64 | | | | | | |
| PICREC | | | | 0.75 | | | | | |
| VISUAL | | | | 0.66 | | | | | |
| VAL | | | | 0.58 | | | | | |
| APPROB | *0.41* | | | | 0.64 | | | | |
| NUMMAT | | | | | 0.62 | | | | |
| NUMSEN | | | | | 0.51 | | | | |
| VRBATN | | | | | | 0.72 | | | |
| MEMWRD | | | | | | 0.70 | | | |
| OBJNUM | | | | | | 0.66 | | | |
| NWDREP | | | | | | 0.58 | | | |
| MEMNAM | | | | | | | | 0.75 | |
| VISCLO | | | | | | | | 0.57 | |
| SNDBLN | | | | | | | | | 0.63 |
| SEGMNT | | | | | | | | | 0.61 |

**Table H-2b.** *(cont.)*
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 6 Through 8 Model-Development Sample A*

| | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Grw*** | ***Gc*** | ***Gs*** | ***Gv+Gf*** | ***Gq*** | ***Gwm*** | ***Glr*-MM** | ***Gv*-MV/ MM** | ***Ga*** |
| PHNPRO | | | | | | | | | 0.58 |
| ANLSYN | | | | 0.45 | | | | | |
| CONFRM | | | | *0.42* | | | | | |
| STYREC | | | | *0.43* | | | <u>0.36</u> | | |
| RPCNAM | | | 0.48 | | | | | | |
| RETFLU | | *0.42* | | | | | | | |
| SENREP | | 0.49 | | | | | | | |
| NUMREV | | | | | | *0.43* | | | |
| UNDDIR | | | | | | | | 0.46 | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤ .40; other loadings of < .40 were removed for readability purposes.

**Table H-2c.**
*Ten-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 6 Through 8 Model-Development Sample A*

| | Ten Varimax Rotated Components | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Grw*** | ***Gc*** | ***Gs*** | ***Gv*** | ***Gq*** | ***Gwm*** | ***Glr*-MM** | ***Gv*-MV/ MA** | ***Ga*** | ***Glr*-LA** |
| LWIDNT | 0.84 | | | | | | | | | |
| PSGCMP | 0.77 | | | | | | | | | |
| ORLRDG | 0.77 | | | | | | | | | |
| SPELL | 0.77 | | | | | | | | | |
| RDGREC | 0.73 | | | | | | | | | |
| SNWRFL | 0.72 | | *0.44* | | | | | | | |
| SNRDFL | 0.71 | | 0.46 | | | | | | | |
| EDIT | 0.71 | | | | | | | | | |
| WRDATK | 0.68 | | | | | | | | | |
| WRTSMP | 0.68 | | | | | | 0.51 | | | |
| RDGVOC | 0.63 | 0.55 | | | | | | | | |
| WRDFLU | 0.62 | | 0.59 | | | | | | | |
| SPLSND | 0.61 | | | | | | | | *0.40* | |
| NUMSER | 0.58 | | | | 0.59 | | | | | |
| MTHFLU | 0.57 | | 0.51 | | | | | | | |
| SNDAWR | 0.52 | | | | | | | | *0.43* | |
| CALC | 0.50 | | | | 0.61 | | | | | |
| PICVOC | | 0.81 | | | | | | | | |
| GENINF | | 0.75 | | | | | | | | |
| ORLVOC | | 0.72 | | | | | | | | |
| SOC | | 0.70 | | | | | *0.41* | | | |
| HUM | | 0.70 | | | | | | | | |
| SCI | | 0.60 | | | | | 0.51 | | | |
| ORLCMP | | 0.59 | | | | | | | | |
| VRBANL | | 0.52 | | | | | | | | |
| PAIRCN | | | 0.81 | | | | | | | |
| LETPAT | | | 0.78 | | | | | | | |

***Table H-2c.*** *(cont.)*
*Ten-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 6 Through 8 Model-Development Sample A*

| | Ten Varimax Rotated Components | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Grw*** | ***Gc*** | ***Gs*** | ***Gv*** | ***Gq*** | ***Gwm*** | ***Glr*-MM** | ***Gv*-MV/ MA** | ***Ga*** | ***Glr*-LA** |
| NUMPAT | 0.48 | | 0.63 | | | | | | | |
| PICREC | | | | 0.76 | | | | | | |
| VISUAL | | | | 0.65 | | | | | | |
| VAL | | | | 0.59 | | | | | | |
| NUMMAT | | | | | 0.64 | | | | | |
| APPROB | *0.41* | | | | 0.64 | | | | | |
| MEMWRD | | | | | | 0.71 | | | | |
| VRBATN | | | | | | 0.70 | | | | |
| OBJNUM | | | | | | 0.66 | | | | |
| NWDREP | | | | | | 0.58 | | | | |
| MEMNAM | | | | | | | | 0.75 | | |
| VISCLO | | | | | | | | 0.59 | | |
| SEGMNT | | | | | | | | | 0.64 | |
| PHNPRO | | | | | | | | | 0.59 | |
| SNDBLN | | | | | | | | | 0.57 | |
| RPCNAM | | | | | | | | | | 0.60 |
| RETFLU | | | | | | | | | | 0.50 |
| CONFRM | | | | | 0.50 | | | | | |
| UNDDIR | | | | | | | | 0.45 | | |
| NUMREV | | | | | | 0.47 | | | | |
| ANLSYN | | | | *0.44* | | | | | | |
| SENREP | | 0.49 | | | | | | | | |
| STYREC | | | | *0.44* | | | 0.48 | | | |
| NUMSEN | | | | | 0.48 | | | | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; loadings of < .40 were removed for readability purposes.

***Figure H-3.***
*Scree plot (eigenvalues/ latent roots) of ages 9 through 13 model-development sample A.*

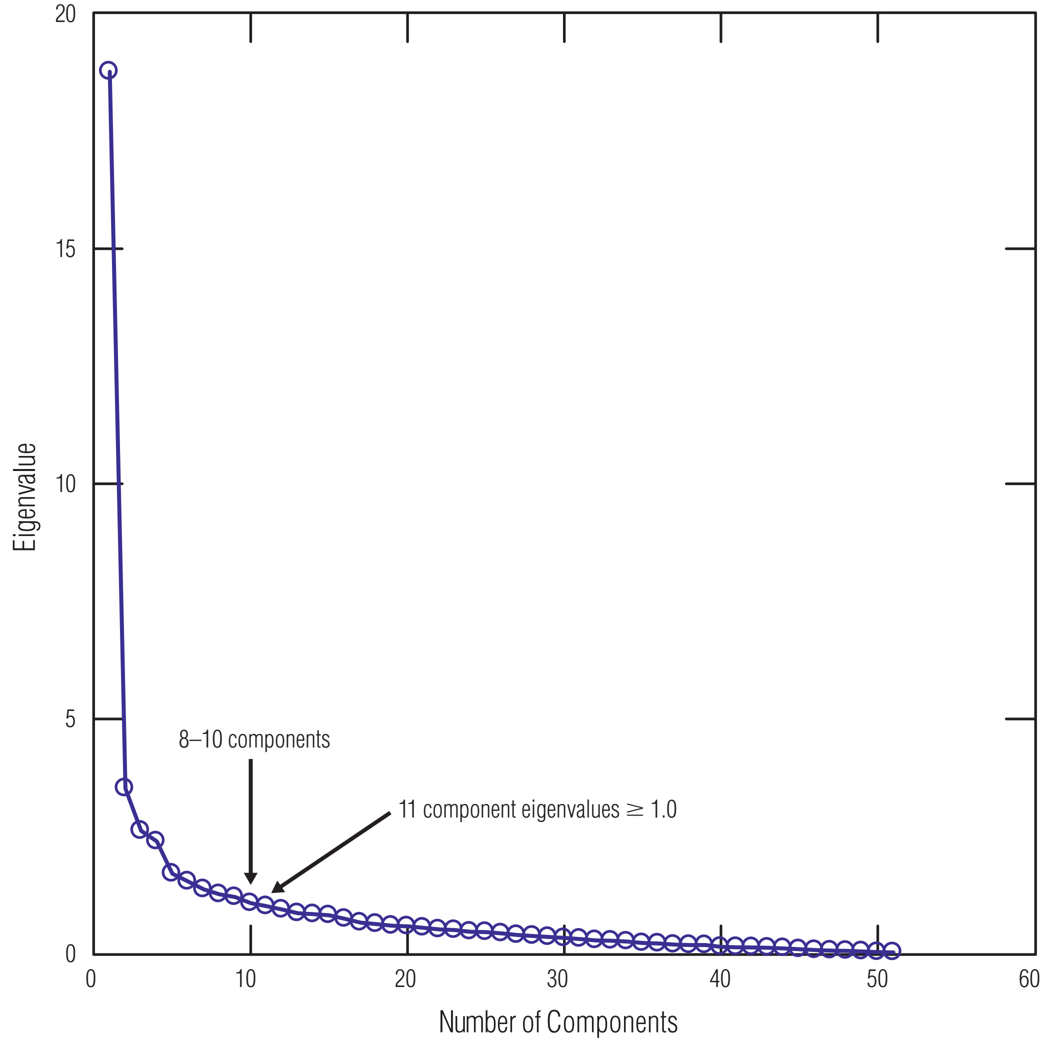



***Table H-3a.***
*Eight-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 9 Through 13 Model-Development Sample A*

| | **Eight Varimax Rotated Components** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gs*** | ***Gv*+ *Gf*+ *Ga*** | ***Grw*** | ***Glr*-(Ret Flu)** | ***Gq*+ *Gf*** | ***Gwm*** | ***Gv*-MV/ MA** |
| PICVOC | 0.82 | | | | | | | |
| GENINF | 0.80 | | | | | | | |
| ORLVOC | 0.75 | | | | | | | |
| SOC | 0.73 | | | | | | | |
| HUM | 0.71 | | | | | | | |
| ORLCMP | 0.68 | | | | | | | |
| RDGVOC | 0.67 | | | 0.47 | | | | |
| SCI | 0.61 | | | | | *0.43* | | |
| VRBANL | 0.59 | | 0.48 | | | | | |
| WRDFLU | | 0.79 | | | | | | |
| LETPAT | | 0.77 | | | | | | |
| SNRDFL | | 0.74 | | | | | | |
| NUMPAT | | 0.72 | | | | | | |

***Table H-3a.*** *(cont.)*
*Eight-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 9 Through 13 Model-Development Sample A*

| | Eight Varimax Rotated Components | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gs*** | ***Gv*+ *Gf*+*Ga*** | ***Grw*** | ***Glr*-(Ret Flu)** | ***Gq*+*Gf*** | ***Gwm*** | ***Gv*-MV/ MA** |
| MTHFLU | | 0.70 | | | | | | |
| SNWRFL | | 0.66 | | *0.44* | | | | |
| PAIRCN | | 0.65 | | | | | | |
| VAL | | | 0.70 | | | | | |
| VISUAL | | | 0.66 | | | | | |
| SNDBLN | | | 0.59 | | | | | |
| SEGMNT | | | 0.51 | | | | | |
| WRDATK | | | | 0.69 | | | | |
| LWIDNT | *0.42* | | | 0.68 | | | | |
| WRTSMP | | | | 0.68 | | | | |
| PSGCMP | *0.44* | | | 0.64 | | | | |
| RDGREC | | | | 0.61 | | | | |
| SPELL | *0.41* | *0.42* | | 0.57 | | | | |
| SPLSND | | | | 0.54 | | | | |
| ORLRDG | *0.44* | | | 0.51 | | | | |
| PICREC | | | | | 0.61 | | | |
| RPCNAM | | | | | 0.52 | | | |
| NUMSER | | | | 0.49 | | 0.63 | | |
| CALC | | *0.44* | | | | 0.58 | | |
| APPROB | 0.45 | | | | | 0.54 | | |
| ANLSYN | | | *0.44* | | | 0.53 | | |
| NUMMAT | | | | | | 0.50 | | |
| MEMWRD | | | | | | | 0.71 | |
| VRBATN | | | | | | | 0.65 | |
| OBJNUM | | | | | | | 0.61 | |
| NWDREP | | | | | | | 0.56 | |
| SENREP | | | | | | | 0.55 | |
| PHNPRO | | | | | | | 0.52 | |
| VISCLO | | | | | | | | 0.68 |
| MEMNAM | | | | | | | | 0.61 |
| UNDDIR | | | | | | | <u>0.39</u> | |
| SNDAWR | | | | 0.50 | | | | |
| NUMSEN | 0.45 | | | | | *0.41* | | |
| CONFRM | | | 0.48 | | | | | |
| STYREC | | | | | 0.48 | | | |
| RETFLU | | | | | *0.41* | | | |
| EDIT | 0.49 | | | 0.49 | | | | |
| NUMREV | | <u>0.34</u> | | | | | <u>0.37</u> | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤ .40; other loadings of < .40 were removed for readability purposes.

**Table H-3b.**
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 9 Through 13 Model-Development Sample A*

| | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Tests | *Gc* | *Gs* | *Gv+Gf* | *Grw* | *Glr*-MM | *Gq+Gf* | *Gwm* | *Gv*-MV/ MA | *Ga* |
| PICVOC | 0.83 | | | | | | | | |
| GENINF | 0.80 | | | | | | | | |
| ORLVOC | 0.76 | | | | | | | | |
| SOC | 0.74 | | | | | | | | |
| HUM | 0.73 | | | | | | | | |
| ORLCMP | 0.70 | | | | | | | | |
| RDGVOC | 0.67 | | | *0.44* | | | | | |
| SCI | 0.62 | | | | | | | | |
| VRBANL | 0.59 | | | | | | | | |
| WRDFLU | | 0.79 | | | | | | | |
| LETPAT | | 0.78 | | | | | | | |
| NUMPAT | | 0.74 | | | | | | | |
| SNRDFL | | 0.71 | | *0.40* | | | | | |
| PAIRCN | | 0.68 | | | | | | *0.43* | |
| MTHFLU | | 0.66 | | | | | | | |
| SNWRFL | | 0.64 | | 0.45 | | | | | |
| PICREC | | | 0.65 | | | | | | |
| VISUAL | | | 0.65 | | | | | | |
| VAL | | | 0.59 | | | | | | |
| WRTSMP | | | | 0.68 | 0.35 | | | | |
| LWIDNT | *0.43* | | | 0.67 | | | | | |
| WRDATK | | | | 0.67 | | | | | |
| RDGREC | | | | 0.65 | | | | | |
| PSGCMP | *0.44* | | | 0.63 | | | | | |
| SPELL | *0.41* | *0.41* | | 0.55 | | | | | |
| NUMSER | | | | 0.51 | | 0.64 | | | |
| RETFLU | | | | | 0.51 | | | | |
| CALC | | *0.40* | | | | 0.60 | | | |
| APPROB | *0.44* | | | | | 0.59 | | | |
| ANLSYN | | | *0.41* | | | 0.55 | | | |
| NUMMAT | | | | | | 0.52 | | | |
| VRBATN | | | | | | | 0.65 | | |
| NWDREP | | | | | | | 0.62 | | |
| OBJNUM | | | | | | | 0.60 | | |
| SENREP | | | | | | | 0.60 | | |
| MEMWRD | | | | | | | 0.60 | | *0.42* |
| UNDDIR | | | | | | | 0.54 | | |
| VISCLO | | | | | | | | 0.75 | |
| SEGMNT | | | | | | | | | 0.72 |
| SNDBLN | | | | | | | | | 0.69 |
| PHNPRO | | | | | | | | | 0.64 |
| SPLSND | | | | 0.47 | | | | | 0.54 |

**Table H-3b.** *(cont.)*
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 9 Through 13 Model-Development Sample A*

| Tests | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***Gc*** | ***Gs*** | ***Gv+Gf*** | ***Grw*** | ***Glr*-MM** | ***Gq+Gf*** | ***Gwm*** | ***Gv*-MV/ MA** | ***Ga*** |
| SNDAWR | | | | 0.45 | | | | | *0.43* |
| NUMREV | | | | | | <u>0.38</u> | <u>0.33</u> | | |
| ORLRDG | *0.42* | | | 0.47 | | | | | |
| CONFRM | | | *0.44* | | | *0.44* | | | |
| EDIT | 0.49 | | | 0.47 | | | | | |
| NUMSEN | 0.45 | | | | | *0.44* | | | |
| RPCNAM | | | | | | | *0.41* | | |
| MEMNAM | | | | | | | | 0.47 | |
| STYREC | | | *0.41* | | <u>0.38</u> | | | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤ .40; other loadings of < .40 were removed for readability purposes.

**Table H-3c.**
*Ten-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 9 Through 13 Model-Development Sample A*

| Tests | Ten Varimax Rotated Components | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***Gc*** | ***Gs*** | ***Gv*** | ***Grw*** | ***Gwm*** | ***Gq+Gf*** | **?** | ***Gv*-MV/ SS** | ***Ga*** | ***Glr*-LA** |
| PICVOC | 0.83 | | | | | | | | | |
| GENINF | 0.80 | | | | | | | | | |
| ORLVOC | 0.77 | | | | | | | | | |
| SOC | 0.75 | | | | | | | | | |
| HUM | 0.74 | | | | | | | | | |
| ORLCMP | 0.70 | | | | | | | | | |
| RDGVOC | 0.68 | | | | | | | | | |
| SCI | 0.63 | | | | | | | | | |
| VRBANL | 0.60 | | | | | | | | | |
| EDIT | 0.51 | | | 0.45 | | | | | | |
| WRDFLU | | 0.80 | | | | | | | | |
| LETPAT | | 0.77 | | | | | | | | |
| SNRDFL | | 0.75 | | | | | | | | |
| NUMPAT | | 0.73 | | | | | | | | |
| MTHFLU | | 0.69 | | | | | | | | |
| SNWRFL | | 0.67 | | *0.40* | | | | | | |
| PAIRCN | | 0.64 | | | | | | 0.52 | | |
| PICREC | | | 0.73 | | | | | | | |
| VISUAL | | | 0.59 | | | | | | | |
| WRTSMP | | | | 0.74 | | | | | | |
| WRDATK | | | | 0.66 | | | | | | |
| LWIDNT | 0.45 | | | 0.66 | | | | | | |
| RDGREC | | | | 0.59 | | | | | | |
| PSGCMP | 0.45 | | | 0.57 | | | | | | |
| SPELL | *0.43* | 0.45 | | 0.52 | | | | | | |
| NUMSER | | | | 0.50 | | 0.62 | | | | |
| VRBATN | | | | | 0.70 | | | | | |

***Table H-3c.*** *(cont.)*
*Ten-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 9 Through 13 Model-Development Sample A*

| | **Ten Varimax Rotated Components** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gs*** | ***Gv*** | ***Grw*** | ***Gwm*** | ***Gq+Gf*** | **?** | ***Gv*-MV/ SS** | ***Ga*** | ***Glr*-LA** |
| MEMWRD | | | | | 0.66 | | | | | |
| OBJNUM | | | | | 0.65 | | | | | |
| SENREP | | | | | 0.55 | | | | | |
| NWDREP | | | | | 0.54 | | | | | |
| NUMMAT | | | | | | 0.59 | | | | |
| ANLSYN | | | | | | 0.58 | | | | |
| CALC | | *0.43* | | | | 0.56 | | | | |
| CONFRM | | | | | | 0.56 | | | | |
| APPROB | 0.47 | | | | | 0.55 | | | | |
| MEMNAM | | | | | | | 0.71 | | | |
| VISCLO | | | | | | | | 0.73 | | |
| SEGMNT | | | | | | | | | 0.76 | |
| SNDBLN | | | | | | | | | 0.69 | |
| PHNPRO | | | | | | | | | 0.64 | |
| RPCNAM | | | | | | | | | | 0.60 |
| RETFLU | | | | | | | | | | 0.51 |
| NUMREV | | | | | 0.50 | | | | | |
| ORLRDG | *0.44* | *0.41* | | | | | | | | |
| SPLSND | | | | 0.46 | | | | | 0.49 | |
| UNDDIR | | | | | *0.41* | | *0.42* | | | |
| STYREC | | | *0.44* | | | | | | | |
| NUMSEN | 0.47 | | | | | | | | | |
| SNDAWR | | | | *0.41* | | | | | 0.45 | |
| VAL | | | 0.45 | | | | | | 0.48 | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; loadings of < .40 were removed for readability purposes.

***Figure H-4.***
*Scree plot (eigenvalues/ latent roots) of ages 14 through 19 model-development sample A.*

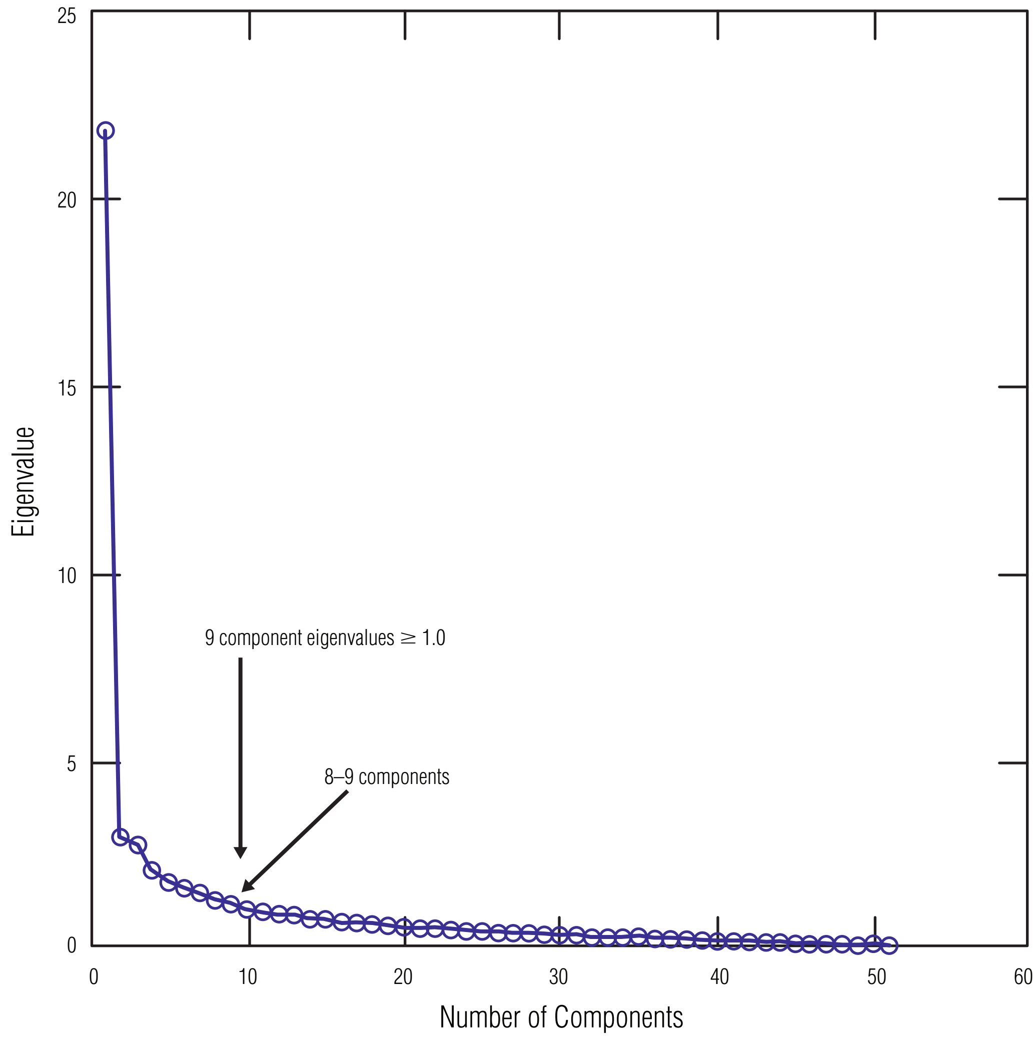



***Table H-4a.***
*Eight-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 14 Through 19 Model-Development Sample A*

| | Eight Varimax Rotated Components | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gq+Gf*** | ***Gs*** | ***Glr*-MA/ MV** | ***Gwm*** | ***Grw*** | ***Glr*-LA** | ***Ga+Gv*** |
| PICVOC | 0.81 | | | | | | | |
| GENINF | 0.78 | | | | | | | |
| SOC | 0.74 | | | | | | | |
| ORLCMP | 0.73 | | | | | | | |
| ORLVOC | 0.73 | | | | | | | |
| HUM | 0.72 | | | | | | | |
| RDGVOC | 0.71 | | | | | 0.46 | | |
| SCI | 0.64 | | | | | | | |
| VRBANL | 0.62 | | | | | | | |
| EDIT | 0.51 | | | | | 0.48 | | |
| STYREC | | 0.60 | | | | | | |
| ANLSYN | | 0.60 | | | | | | |
| NUMSER | | 0.60 | | | | 0.49 | | |

**Table H-4a.** *(cont.)*
*Eight-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 14 Through 19 Model-Development Sample A*

| | Eight Varimax Rotated Components | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gq+Gf*** | ***Gs*** | ***Glr*-MA/ MV** | ***Gwm*** | ***Grw*** | ***Glr*-LA** | ***Ga+Gv*** |
| CALC | | 0.53 | 0.45 | | | | | |
| APPROB | 0.49 | 0.51 | | | | | | |
| WRDFLU | | | 0.80 | | | | | |
| NUMPAT | | | 0.73 | | | | | |
| PAIRCN | | | 0.71 | *0.40* | | | | |
| LETPAT | | | 0.71 | | | | | |
| SNWRFL | | | 0.68 | | | *0.41* | | |
| MTHFLU | | | 0.67 | | | | | |
| SNWRFL | | | 0.62 | | | 0.48 | | |
| VISCLO | | | | 0.71 | | | | |
| MEMNAM | | | | 0.61 | | | | |
| MEMWRD | | | | | 0.69 | | | |
| VRBATN | | | | | 0.67 | | | |
| NWDREP | | | | | 0.58 | | | |
| SENREP | *0.42* | | | | 0.53 | | | |
| OBJNUM | | | *0.40* | | 0.53 | | | |
| WRTSMP | | | | | | 0.70 | | |
| LWIDNT | 0.47 | | | | | 0.68 | | |
| RDGREC | | | | | | 0.67 | | |
| PSGCMP | 0.47 | | | | | 0.62 | | |
| WRDATK | | | | | | 0.61 | | |
| ORLRDG | *0.42* | | | | | 0.55 | | |
| SPELL | 0.46 | | | | | 0.55 | | |
| PICREC | | | | | | | 0.78 | |
| RPCNAM | | | | | | | 0.51 | |
| SNDBLN | | | | | | | | 0.73 |
| VAL | | | | | | | | 0.63 |
| SEGMNT | | | | | | | | 0.60 |
| SPLSND | | | | | | 0.46 | | 0.54 |
| PHNPRO | 0.45 | | | | | | | 0.45 |
| VISUAL | | | | | | | | *0.43* |
| SNDAWR | | | | | | 0.45 | | |
| CONFRM | | 0.49 | | | | | | |
| NUMREV | | | 0.31 | | 0.36 | | | 0.30 |
| NUMMAT | | 0.45 | | | | | | |
| NUMSEN | 0.48 | *0.41* | | | | | | |
| RETFLU | | | *0.40* | | | | | |
| UNDDIR | | | | 0.46 | | | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤ .40; other loadings of < .40 were removed for readability purposes.

***Table H-4b.***
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 14 Through 19 Model-Development Sample A*

| | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gq+Gf*** | ***Gs*** | **?** | ***Gwm*** | ***Glr*-LA** | ***Gv*-MV/ SS** | ***Ga+Gv*** | ***Grw+ Ga*** |
| PICVOC | 0.82 | | | | | | | | |
| GENINF | 0.78 | | | | | | | | |
| SOC | 0.74 | | | | | | | | |
| ORLCMP | 0.74 | | | | | | | | |
| ORLVOC | 0.74 | | | | | | | | |
| RDGVOC | 0.73 | | | | | | | | |
| HUM | 0.72 | | | | | | | | |
| SCI | 0.64 | | | | | | | | |
| VRBANL | 0.63 | | | | | | | | |
| EDIT | 0.52 | | | | | | | | *0.42* |
| NUMSER | | 0.62 | | | | | | | 0.46 |
| ANLSYN | | 0.60 | | | | | | | |
| STYREC | | 0.59 | | | | | | | |
| CALC | | 0.55 | 0.47 | | | | | | |
| APPROB | 0.50 | 0.53 | | | | | | | |
| CONFRM | | 0.51 | | | | | | | |
| WRDFLU | | | 0.83 | | | | | | |
| SNRDFL | | | 0.73 | | | | | | |
| MTHFLU | | | 0.71 | | | | | | |
| LETPAT | | | 0.70 | | | | | | |
| SNWRFL | | | 0.68 | | | | | | |
| NUMPAT | | | 0.68 | | | | | | |
| PAIRCN | | | 0.57 | | | | 0.65 | | |
| MEMNAM | | | | 0.75 | | | | | |
| MEMWRD | | | | | 0.71 | | | | |
| VRBATN | | | | | 0.66 | | | | |
| OBJNUM | | | | | 0.56 | | | | |
| NWDREP | | | | | 0.55 | | | | |
| SENREP | *0.43* | | | | 0.51 | | | | |
| PICREC | | | | | | 0.79 | | | |
| VISCLO | | | | | | | 0.68 | | |
| SNDBLN | | | | | | | | 0.72 | |
| VAL | | | | | | | | 0.61 | |
| SEGMNT | | | | | | | | 0.57 | *0.42* |
| SPLSND | | | | | | | | 0.52 | 0.51 |
| WRTSMP | | | | | | | | | 0.74 |
| LWIDNT | 0.49 | | | | | | | | 0.65 |
| WRDATK | | | | | | | | | 0.65 |
| PSGCMP | 0.49 | | | | | | | | 0.60 |
| RDGREC | | | | | | | | | 0.53 |
| SPELL | 0.48 | | 0.45 | | | | | | 0.50 |
| SNDAWR | | | | | | | | | 0.45 |

***Table H-4b.*** *(cont.)*
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 14 Through 19 Model-Development Sample A*

| | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gq+Gf*** | ***Gs*** | **?** | ***Gwm*** | ***Glr*-LA** | ***Gv*-MV/ SS** | ***Ga+Gv*** | ***Grw+ Ga*** |
| ORLRDG | 0.45 | | *0.43* | | | | | | *0.43* |
| NUMSEN | 0.48 | *0.43* | | | | | | | |
| PHNPRO | 0.45 | | | | *0.41* | | | *0.43* | |
| UNDDIR | | | | 0.47 | | | | | |
| NUMMAT | | 0.47 | | | | | | | |
| NUMREV | | 0.30 | 0.31 | | 0.38 | | | | |
| VISUAL | | *0.41* | | | | | | *0.40* | |
| RPCNAM | | | | | | 0.49 | | | |
| RETFLU | | | | | *0.42* | | | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤ .40; other loadings of < .40 were removed for readability purposes. ? = uninterpretable component.

***Table H-4c.***
*Ten-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 14 Through 19 Model-Development Sample A*

| | Ten Varimax Rotated Components | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gq+Gf*** | ***Gs*** | ***Ga+Gv*** | ***Gwm*** | ***Gv*** | ***Gv*-MV/ SS** | ***Grw+ Ga*** | **?** | ***Glr*-LA** |
| PICVOC | 0.82 | | | | | | | | | |
| GENINF | 0.81 | | | | | | | | | |
| ORLVOC | 0.74 | | | | | | | | | |
| SOC | 0.74 | | | | | | | | | |
| ORLCMP | 0.73 | | | | | | | | | |
| RDGVOC | 0.72 | | | | | | | | | |
| HUM | 0.72 | | | | | | | | | |
| SCI | 0.64 | | | | | | | | | |
| VRBANL | 0.63 | | | | | | | | | |
| EDIT | 0.53 | | | | | | | *0.40* | | |
| NUMSER | | 0.67 | | | | | | *0.43* | | |
| CALC | | 0.59 | 0.47 | | | | | | | |
| NUMMAT | | 0.58 | | | | | | | | |
| ANLSYN | | 0.55 | | | | | | | | |
| APPROB | 0.50 | 0.55 | | | | | | | | |
| WRDFLU | | | 0.81 | | | | | | | |
| SNRDFL | | | 0.73 | | | | | | | |
| LETPAT | | | 0.71 | | | | | | | |
| MTHFLU | | | 0.71 | | | | | | | |
| SNWRSP | | | 0.69 | | | | | | | |
| NUMPAT | | | 0.69 | | | | | | | |
| PAIRCN | | | 0.57 | | | | 0.64 | | | |
| SNDBLN | | | | 0.72 | | | | | | |
| VAL | | | | 0.60 | | | | | | |
| SEGMNT | | | | 0.58 | | | | *0.43* | | |
| SPLSND | | | | 0.52 | | | | 0.51 | | |
| VRBATN | | | | | 0.69 | | | | | |

***Table H-4c.*** *(cont.)*
*Ten-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 14 Through 19 Model-Development Sample A*

| | Ten Varimax Rotated Components | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gq*+*Gf*** | ***Gs*** | ***Ga*+*Gv*** | ***Gwm*** | ***Gv*** | ***Gv*-MV/ SS** | ***Grw*+ *Ga*** | **?** | ***Glr*-LA** |
| MEMWRD | | | | | 0.67 | | | | | |
| NWDREP | | | | | 0.58 | | | | | |
| OBJNUM | | | | | 0.54 | | | | | |
| PICREC | | | | | | 0.74 | | | | |
| STYREC | | | | | | 0.60 | | | | |
| VISCLO | | | | | | | 0.69 | | | |
| WRTSMP | | | | | | | | 0.70 | | |
| WRDATK | | | | | | | | 0.67 | | |
| LWIDNT | 0.49 | | | | | | | 0.64 | | |
| PSGCMP | 0.50 | | | | | | | 0.58 | | |
| RDGREC | | | | | | | | 0.56 | | |
| MEMNAM | | | | | | | | | 0.73 | |
| RETFLU | | | | | | | | | | 0.69 |
| RPCNAM | | | | | | | | | | 0.61 |
| PHNPRO | *0.41* | | | *0.44* | | | | | | |
| SENREP | *0.42* | | | | 0.45 | | | | | |
| CONFRM | | 0.50 | | | | | | | | |
| ORLRDG | 0.47 | | 0.47 | | | | | | | |
| UNDDIR | | | | | | | | | 0.47 | |
| SNDAWR | | | | | | | | 0.45 | | |
| NUMREV | | | | | *0.43* | | | | | |
| NUMSEN | 0.47 | 0.45 | | | | | | | | |
| VISUAL | | | | *0.41* | | *0.42* | | | | |
| SPELL | 0.48 | | 0.47 | | | | | 0.48 | | |

*Note*. Regular font = loading of ≥ .45; italic font = loading of .40 to .44; loadings of < .40 were removed for readability purposes.
? = uninterpretable component.

**Figure H-5.**
*Scree plot (eigenvalues/ latent roots) of ages 20 through 39 model-development sample A.*

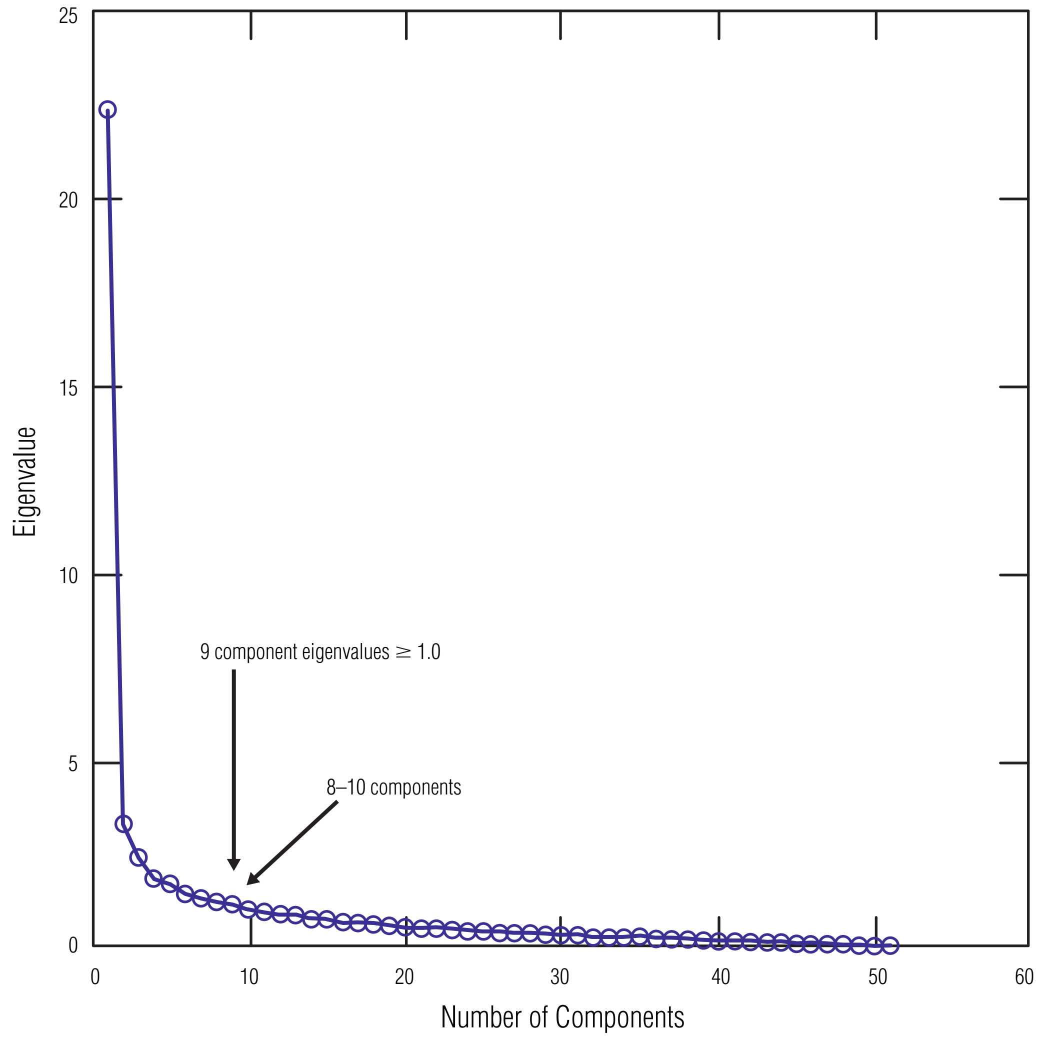



**Table H-5a.**
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 20 Through 39 Model-Development Sample A*

| | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gs*+ *Grw*** | ***Gwm*** | ***Gq*+*Gf*** | ***Grw*** | ***Glr*-MV/ SS** | ***Gv*+*Gf*** | ***Ga*** | ***Glr*-LA** |
| GENINF | 0.79 | | | | | | | | |
| PICVOC | 0.79 | | | | | | | | |
| SOC | 0.76 | | | | | | | | |
| ORLVOC | 0.76 | | | | | | | | |
| HUM | 0.75 | | | | | | | | |
| ORLCMP | 0.74 | | | | | | | | |
| RDGVOC | 0.74 | | | | | | | | |
| SCI | 0.70 | | | | | | | | |
| VRBANL | 0.68 | | | | | | | | |
| EDIT | 0.57 | *0.42* | | | | | | | |
| PSGCMP | 0.56 | | | | *0.41* | | | | |
| APPROB | 0.56 | | | 0.62 | | | | | |
| NUMSEN | 0.53 | | | 0.55 | | | | | |

***Table H-5a.*** *(cont.)*
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 20 Through 39 Model-Development Sample A*

| Tests | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***Gc*** | ***Gs+ Grw*** | ***Gwm*** | ***Gq+Gf*** | ***Grw*** | ***Glr*-MV/ SS** | ***Gv+Gf*** | ***Ga*** | ***Glr*-LA** |
| LWIDNT | 0.53 | 0.50 | | | *0.41* | | | | |
| WRDFLU | | 0.86 | | | | | | | |
| SNRDFL | | 0.81 | | | | | | | |
| SNWRFL | | 0.77 | | | | | | | |
| LETPAT | | 0.70 | | | | | | | |
| MTHFLU | | 0.67 | | | | | | | |
| NUMPAT | | 0.61 | | | | | | | |
| ORLRDG | 0.45 | 0.59 | | | | | | | |
| SPELL | 0.46 | 0.58 | | | | | | | |
| NWDREP | | | 0.67 | | | | | | |
| VRBATN | | | 0.66 | | | | | | |
| SENREP | *0.43* | | 0.62 | | | | | | |
| MEMWRD | | | 0.59 | | | | | *0.43* | |
| OBJNUM | | | 0.52 | | | | | | |
| NUMSER | | | | 0.65 | 0.45 | | | | |
| CALC | *0.40* | *0.41* | | 0.64 | | | | | |
| ANLSYN | | | | 0.53 | | | 0.45 | | |
| NUMMAT | | | | 0.53 | | | | | |
| WRTSMP | | | | | 0.73 | | | | |
| VISCLO | | | | | | 0.73 | | | |
| MEMNAM | | | | | | 0.59 | | | |
| PICREC | | | | | | | 0.69 | | |
| VAL | | | | | | | 0.59 | *0.42* | |
| STYREC | | | | | | | 0.56 | | |
| SEGMNT | | | | | | | | 0.67 | |
| SNDBLN | | | | | | | | 0.65 | |
| SPLSND | | | | | | | | 0.61 | |
| PHNPRO | *0.44* | | | | | | | 0.55 | |
| RPCNAM | | | | | | | | | 0.66 |
| RETFLU | | | | | | | | | 0.61 |
| PAIRCN | | *0.41* | | | | *0.43* | | | *0.43* |
| UNDDIR | | | 0.50 | | | | | | |
| RDGREC | | 0.49 | | | 0.48 | | | | |
| SNDAWR | | | | | | | | *0.44* | |
| NUMREV | | | 0.35 | 0.37 | | | | | |
| CONFRM | | | | *0.41* | | | *0.44* | | |
| WRDATK | | | | | 0.48 | | | | |
| VISUAL | | | | | | | 0.49 | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤ .40; other loadings of < .40 were removed for readability purposes. Eight-component solution not reported because it failed to converge (see explanation in Chapter 5 section regarding multicollinearity issues).

***Table H-5b.***
*Ten-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 20 Through 39 Model-Development Sample A*

| | Ten Varimax Rotated Components | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gs+ Grw*** | ***Gwm*** | ***Gq+Gf*** | ***Grw*** | ***Gv*-MV/ SS** | ***Gv+Gf*** | ***Ga*** | ***Glr*-LA** | **?** |
| GENINF | 0.80 | | | | | | | | | |
| PICVOC | 0.79 | | | | | | | | | |
| SOC | 0.76 | | | | | | | | | |
| HUM | 0.76 | | | | | | | | | |
| ORLVOC | 0.76 | | | | | | | | | |
| ORLCMP | 0.74 | | | | | | | | | |
| RDGVOC | 0.74 | | | | | | | | | |
| SCI | 0.71 | | | | | | | | | |
| VRBANL | 0.69 | | | | | | | | | |
| EDIT | 0.57 | *0.42* | | | | | | | | |
| APPROB | 0.57 | | | 0.61 | | | | | | |
| PSGCMP | 0.57 | | | | *0.41* | | | | | |
| NUMSEN | 0.54 | | | 0.52 | | | | | | |
| LWIDNT | 0.54 | 0.48 | | | *0.43* | | | | | |
| WRDFLU | | 0.86 | | | | | | | | |
| SNRDFL | | 0.80 | | | | | | | | |
| SNWRFL | | 0.76 | | | | | | | | |
| LETPAT | | 0.71 | | | | | | | | |
| MTHFLU | | 0.67 | | | | | | | | |
| NUMPAT | | 0.65 | | | | | | | | |
| SPELL | 0.47 | 0.57 | | | | | | | | |
| ORLRDG | 0.46 | 0.56 | | | | | | | | |
| NWDREP | | | 0.72 | | | | | | | |
| SENREP | *0.43* | | 0.66 | | | | | | | |
| VRBATN | | | 0.62 | | | | | | | |
| MEMWRD | | | 0.52 | | | | | *0.43* | | |
| NUMSER | | | | 0.67 | 0.48 | | | | | |
| CALC | *0.41* | *0.41* | | 0.61 | | | | | | |
| ANLSYN | | | | 0.55 | | | *0.43* | | | |
| NUMMAT | | | | 0.53 | | | | | | |
| WRTSMP | | | | | 0.72 | | | | | |
| RDGREC | | 0.45 | | | 0.53 | | | | | |
| WRDATK | | | | | 0.51 | | | | | |
| VISCLO | | | | | | 0.70 | | | | |
| PAIRCN | | 0.46 | | | | 0.64 | | | | |
| PICREC | | | | | | | 0.66 | | | |
| VAL | | | | | | | 0.63 | | | |
| STYREC | | | | | | | 0.54 | | | |
| VISUAL | | | | | | | 0.53 | | | |
| SEGMNT | | | | | | | | 0.70 | | |
| SNDBLN | | | | | | | | 0.62 | | |
| SPLSND | | | | | | | | 0.60 | | |

**Table H-5b.** *(cont.)*
*Ten-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 20 Through 39 Model-Development Sample A*

| Tests | Ten Varimax Rotated Components | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***Gc*** | ***Gs*+ *Grw*** | ***Gwm*** | ***Gq*+*Gf*** | ***Grw*** | ***Gv*-MV/ SS** | ***Gv*+*Gf*** | ***Ga*** | ***Glr*-LA** | **?** |
| PHNPRO | *0.44* | | | | | | | 0.58 | | |
| RPCNAM | | | | | | | | | 0.76 | |
| RETFLU | | | | | | | | | 0.59 | |
| MEMNAM | | | | | | | | | | 0.66 |
| NUMREV | | | | 0.46 | | | | | | |
| UNDDIR | | | 0.48 | | | | | | | |
| CONFRM | | | | *0.42* | | | 0.46 | | | |
| OBJNUM | | | 0.46 | | | | | | | |
| SNDAWR | | | | | | | | 0.46 | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; loadings of < .40 were removed for readability purposes.
? = uninterpretable component.

**Figure H-6.**
*Scree plot (eigenvalues/ latent roots) of ages 40 through 90+ model-development sample A.*

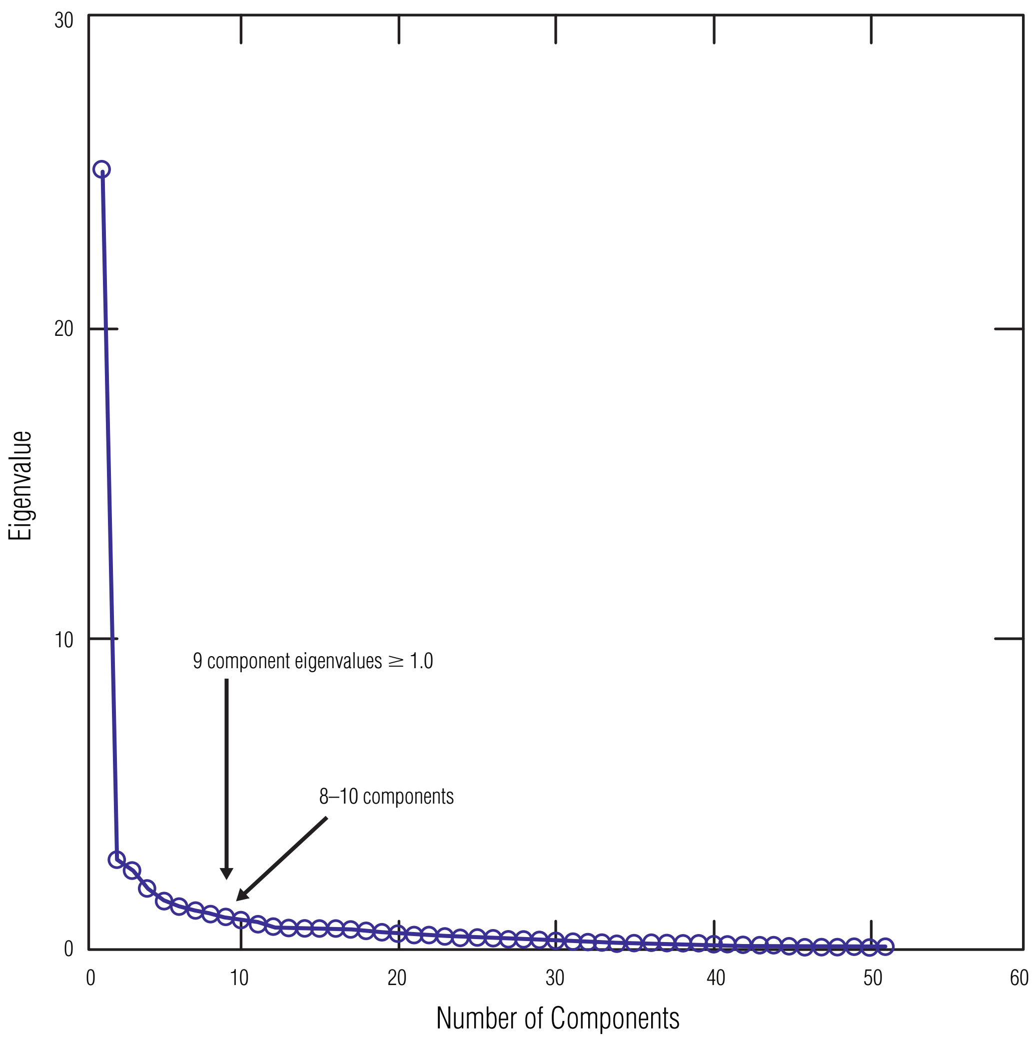


***Table H-6a.***
*Eight-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 40 Through 90+ Model-Development Sample A*

| | **Eight Varimax Rotated Components** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gwm*** | ***Gs*** | ***Gq+Gf*** | ***Glr*-LA** | ***Gv*-MV/ SS** | ***Gv+Ga*** | ***Grw*** |
| GENINF | 0.81 | | | | | | | |
| PICVOC | 0.80 | | | | | | | |
| ORLVOC | 0.74 | | | | | | | |
| HUM | 0.73 | | | | | | | |
| SOC | 0.73 | | | | | | | |
| ORLCMP | 0.69 | | | | | | | |
| RDGVOC | 0.69 | | | | | | | |
| SCI | 0.66 | | | *0.43* | | | | |
| VRBANL | 0.64 | | | | | | | |
| PSGCMP | 0.55 | | | | | | | 0.52 |
| NUMSEN | 0.52 | | | 0.47 | | | | |
| ORLRDG | 0.51 | | 0.46 | | | | | 0.45 |
| APPROB | 0.51 | | | 0.59 | | | | |
| EDIT | 0.51 | *0.42* | *0.42* | | | | | *0.41* |
| LWIDNT | 0.51 | | | | | | | 0.63 |
| MEMWRD | | 0.76 | | | | | | |
| VRBATN | | 0.67 | | | | | | |
| OBJNUM | | 0.60 | | | | | | |
| NUMREV | | 0.54 | | | | | | |
| NWDREP | | 0.52 | | | | | | |
| RETFLU | | 0.50 | | | | | | |
| SENREP | 0.47 | 0.50 | | | | | | |
| WRDFLU | | | 0.80 | | | | | |
| NUMPAT | | | 0.74 | | | | | |
| LETPAT | | | 0.73 | | | | | |
| SNRDFL | | | 0.72 | | | | | |
| SNWRFL | | | 0.70 | | | | | |
| MTHFLU | | | 0.68 | | | | | |
| PAIRCN | | | 0.54 | | | 0.46 | | |
| CALC | | | | 0.61 | | | | |
| NUMSER | | | | 0.58 | | | | 0.51 |
| ANLSYN | | | | 0.58 | | | | |
| NUMMAT | | | | 0.54 | | | | |
| PICREC | | | | | 0.69 | | *0.42* | |
| RPCNAM | | | | | 0.57 | | | |
| VISCLO | | | | | | 0.68 | | |
| MEMNAM | | | | | | 0.61 | | |
| VAL | | | | | | | 0.74 | |
| SNDBLN | | | | | | | 0.60 | |
| SEGMNT | | | | | | | 0.60 | |
| VISUAL | | | | | | | 0.55 | |
| RDGREC | | | | | | | | 0.67 |

***Table H-6a.*** *(cont.)*
*Eight-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 40 Through 90+ Model-Development Sample A*

| | **Eight Varimax Rotated Components** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Gwm*** | ***Gs*** | ***Gq+Gf*** | ***Glr*-LA** | ***Gv*-MV/ SS** | ***Gv+Ga*** | ***Grw*** |
| WRDATK | | | | | | | | 0.66 |
| WRTSMP | | | | | | | | 0.64 |
| SPLSND | | | | | | | | 0.53 |
| SPELL | 0.45 | | *0.44* | | | | | 0.52 |
| SNDAWR | | | | | | | | *0.42* |
| PHNPRO | | 0.47 | | | | | | |
| UNDDIR | <u>0.36</u> | | | | | <u>0.34</u> | | |
| CONFRM | | | | 0.49 | | | *0.41* | |
| STYREC | <u>0.35</u> | | | <u>0.38</u> | | | <u>0.36</u> | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; underlined font = tests with no salient single loading or tests that help define a factor but are ≤ .40; other loadings of < .40 were removed for readability purposes.

***Table H-6b.***
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 40 Through 90+ Model-Development Sample A*

| | **Nine Varimax Rotated Components** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Ga*** | ***Gs+ Grw*** | ***Gq+Gf*** | ***Gwm*** | **?** | ***Glr*-LA** | ***Grw*** | ***Gv*-MV/ SS** |
| PICVOC | 0.81 | | | | | | | | |
| GENINF | 0.80 | | | | | | | | |
| ORLVOC | 0.75 | | | | | | | | |
| HUM | 0.74 | | | | | | | | |
| SOC | 0.74 | | | | | | | | |
| ORLCMP | 0.71 | | | | | | | | |
| RDGVOC | 0.70 | | | | | | | | |
| SCI | 0.67 | | | | | | | | |
| VRBANL | 0.65 | | | | | | | | |
| PSGCMP | 0.57 | | | | | | | *0.44* | |
| NUMSEN | 0.53 | | | 0.46 | | | | | |
| LWIDNT | 0.53 | | 0.47 | | | | | 0.57 | |
| EDIT | 0.52 | | 0.46 | | | | | | |
| ORLRDG | 0.51 | | 0.52 | | | | | | |
| APPROB | 0.51 | | | 0.64 | | | | | |
| SEGMNT | | 0.68 | | | | | | | |
| SNDBLN | | 0.63 | | | | | | | |
| VAL | | 0.55 | | | | | | | |
| WRDFLU | | | 0.81 | | | | | | |
| SNRDFL | | | 0.75 | | | | | | |
| NUMPAT | | | 0.74 | | | | | | |
| SNWRFL | | | 0.72 | | | | | | |
| LETPAT | | | 0.71 | | | | | | |
| MTHFLU | | | 0.70 | | | | | | |
| CALC | | | *0.42* | 0.64 | | | | | |
| NUMSER | | | | 0.62 | | | | 0.45 | |
| ANLSYN | | | | 0.61 | | | | | |

**Table H-6b.** *(cont.)*
*Nine-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 40 Through 90+ Model-Development Sample A*

| | Nine Varimax Rotated Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Ga*** | ***Gs*+*Grw*** | ***Gq*+*Gf*** | ***Gwm*** | **?** | ***Glr*-LA** | ***Grw*** | ***Gv*-MV/SS** |
| CONFRM | | | | 0.60 | | | | | |
| NUMMAT | | | | 0.57 | | | | | |
| MEMWRD | | | | | 0.75 | | | | |
| VRBATN | | | | | 0.66 | | | | |
| OBJNUM | | | | | 0.62 | | | | |
| RETFLU | | | | | 0.57 | | | | |
| NUMREV | | | | | 0.53 | | | | |
| MEMNAM | | | | | | 0.75 | | | |
| PICREC | | | | | | | 0.75 | | |
| WRDATK | | | | | | | | 0.65 | |
| WRTSMP | | | | | | | | 0.62 | |
| RDGREC | | | *0.41* | | | | | 0.57 | |
| VISCLO | | | | | | | | | 0.72 |
| PAIRCN | | | 0.48 | | | | | | 0.70 |
| RPCNAM | | | | | | | 0.50 | | |
| PHNPRO | | *0.41* | | | *0.43* | | | | |
| SNDAWR | | | | | | | | | |
| SENREP | 0.48 | | | | 0.50 | | | | |
| UNDDIR | | | | | | | | | |
| SPLSND | | 0.45 | | | | | | 0.49 | |
| VISUAL | | *0.41* | | | | | | | |
| SPELL | 0.47 | | 0.50 | | | | | *0.44* | |
| STYREC | | | | | | | | | |
| NWDREP | | | | | 0.49 | | | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; loadings of < .40 were removed for readability purposes.
? = uninterpretable component.

**Table H-6c.**
*Ten-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 40 Through 90+ Model-Development Sample A*

| | Ten Varimax Rotated Components | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Ga*** | ***Gs*+*Grw*** | ***Gq*+*Gf*** | ***Glr*-LA** | ***Glr*-MA** | ***Gv*** | ***Grw*** | ***Gv*-MV/SS** | ***Gwm*** |
| PICVOC | 0.82 | | | | | | | | | |
| GENINF | 0.80 | | | | | | | | | |
| HUM | 0.75 | | | | | | | | | |
| ORLVOC | 0.75 | | | | | | | | | |
| SOC | 0.74 | | | | | | | | | |
| ORLCMP | 0.71 | | | | | | | | | |
| RDGVOC | 0.71 | | | | | | | | | |
| SCI | 0.67 | | | | | | | | | |
| VRBANL | 0.65 | | | | | | | | | |
| PSGCMP | 0.58 | | | | | | | *0.41* | | |
| NUMSEN | 0.53 | | | 0.45 | | | | | | |
| LWIDNT | 0.53 | | 0.48 | | | | | 0.54 | | |

***Table H-6c.*** *(cont.)*
*Ten-Component Varimax Rotated Exploratory Principle Component Analysis Solution of Ages 40 Through 90+ Model-Development Sample A*

| | Ten Varimax Rotated Components | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tests** | ***Gc*** | ***Ga*** | ***Gs*+ *Grw*** | ***Gq*+*Gf*** | ***Glr*-LA** | ***Glr*-MA** | ***Gv*** | ***Grw*** | ***Gv*-MV/ SS** | ***Gwm*** |
| APPROB | 0.51 | | | 0.64 | | | | | | |
| ORLRDG | 0.51 | | 0.53 | | | | | | | |
| EDIT | 0.50 | | 0.48 | | | | | | | *0.44* |
| SEGMNT | | 0.70 | | | | | | | | |
| SNDBLN | | 0.66 | | | | | | | | |
| PHNPRO | | 0.55 | | | | | | | | |
| SPLSND | | 0.51 | | | | | | *0.43* | | |
| VAL | | 0.50 | | | | *0.41* | *0.41* | | | |
| WRDFLU | | | 0.80 | | | | | | | |
| SNRDFL | | | 0.75 | | | | | | | |
| NUMPAT | | | 0.74 | | | | | | | |
| SNWRFL | | | 0.73 | | | | | | | |
| LETPAT | | | 0.71 | | | | | | | |
| MTHFLU | | | 0.71 | | | | | | | |
| SPELL | 0.45 | | 0.52 | | | | | *0.41* | | |
| CALC | | | *0.43* | 0.64 | | | | | | |
| NUMSER | | | | 0.61 | | | | *0.44* | | |
| ANLSYN | | | | 0.61 | | | | | | |
| NUMMAT | | | | 0.59 | | | | | | |
| CONFRM | | | | 0.56 | | | | | | |
| RPCNAM | | | | | 0.72 | | | | | |
| RETFLU | | | | | 0.61 | | | | | |
| MEMNAM | | | | | | 0.74 | | | | |
| PICREC | | | | | | | 0.74 | | | |
| WRDATK | | | | | | | | 0.63 | | |
| WRTSMP | | | | | | | | 0.60 | | |
| RDGREC | | | *0.41* | | | | | 0.59 | | |
| VISCLO | | | | | | | | | 0.72 | |
| PAIRCN | | | 0.47 | | | | | | 0.72 | |
| MEMWRD | | | | | | | | | | 0.70 |
| VRBATN | | | | | | | | | | 0.68 |
| NWDREP | | | | | | | | | | 0.63 |
| SENREP | 0.46 | | | | | | | | | 0.56 |
| OBJNUM | | | | | | | | | | 0.54 |
| NUMREV | | | | | | | | | | 0.48 |
| UNDDIR | | | | | | | | | | |
| SNDAWR | | *0.43* | | | | | | | | |
| VISUAL | | | | | | | 0.48 | | | |
| STYREC | | | | | | | 0.49 | | | |

*Note.* Regular font = loading of ≥ .45; italic font = loading of .40 to .44; loadings of < .40 were removed for readability purposes.

Appendix I

# WJ IV MDS Final Exploratory Solutions

***Figure I-1.***
*MDS (Guttman Radex) of WJ IV ages 3 through 5 model-development sample A (n = 209).*

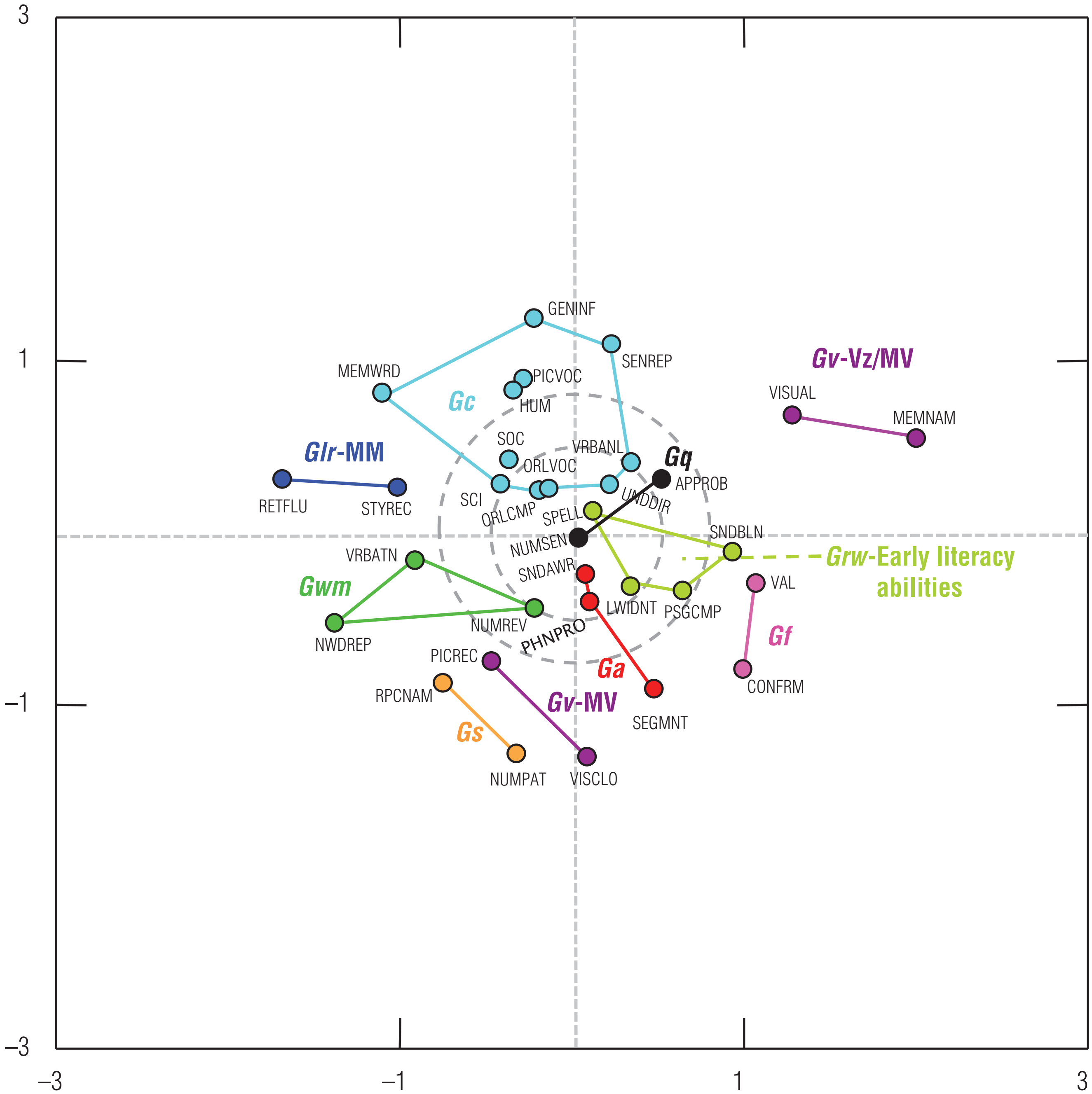


***Figure I-2.***
*MDS (Guttman Radex) of WJ IV ages 6 through 8 model-development sample A (n = 412).*

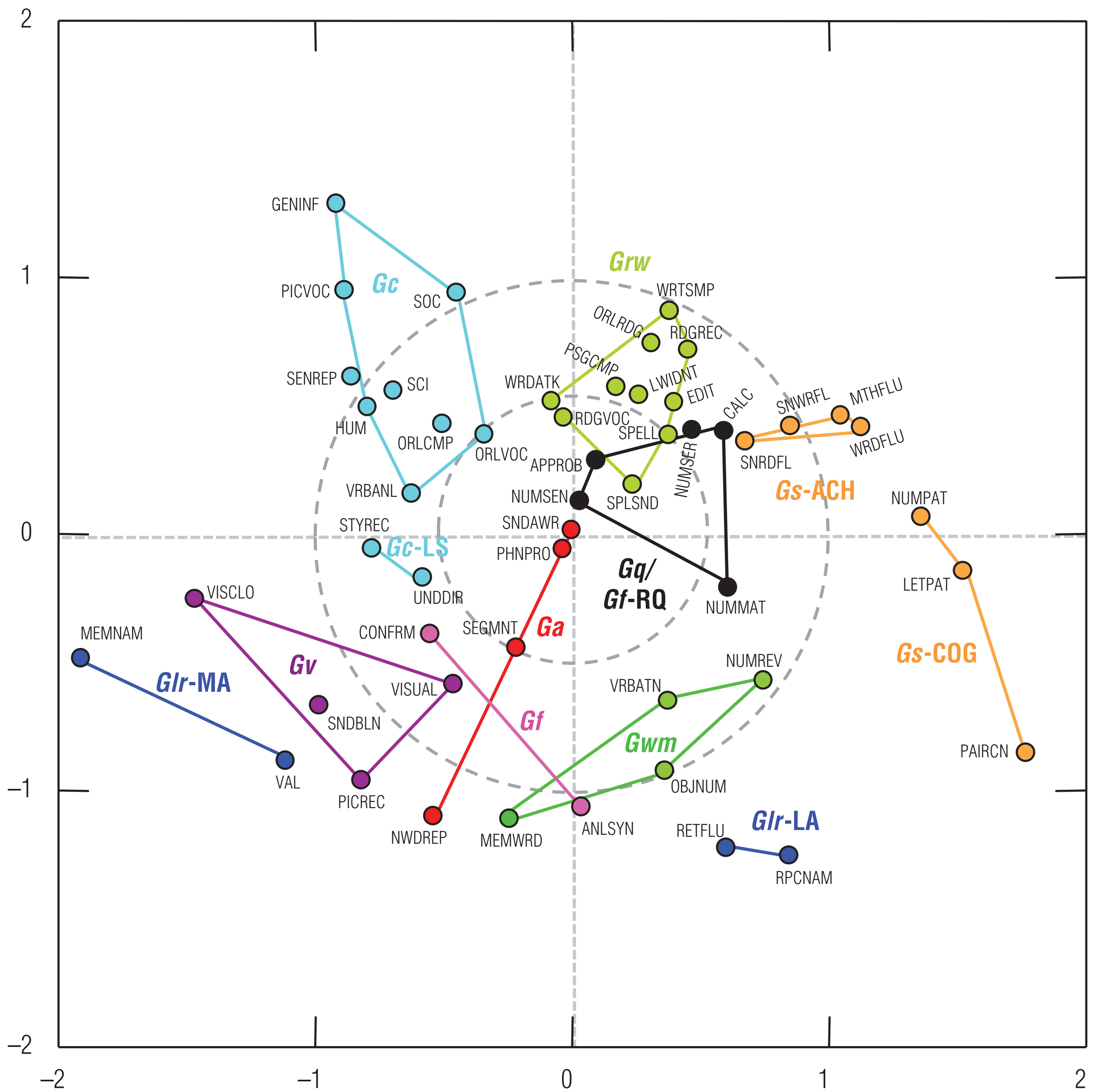


***Figure I-3.***
*MDS (Guttman Radex) of*
*WJ IV ages 9 through 13 model-development sample A (*n *= 785).*

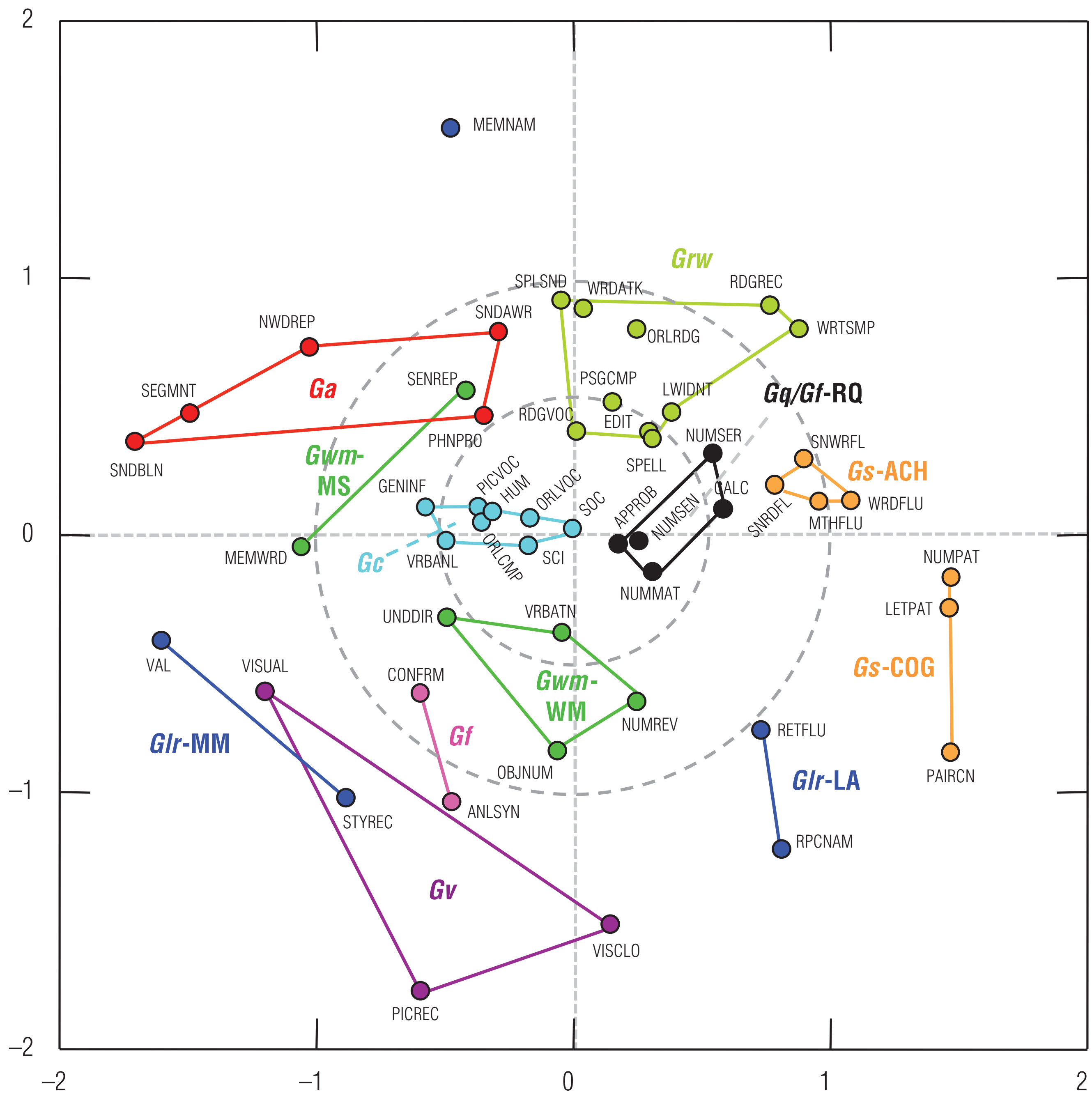


***Figure I-4.***
*MDS (Guttman Radex) of WJ IV ages 14 through 19 model-development sample A (n = 842).*

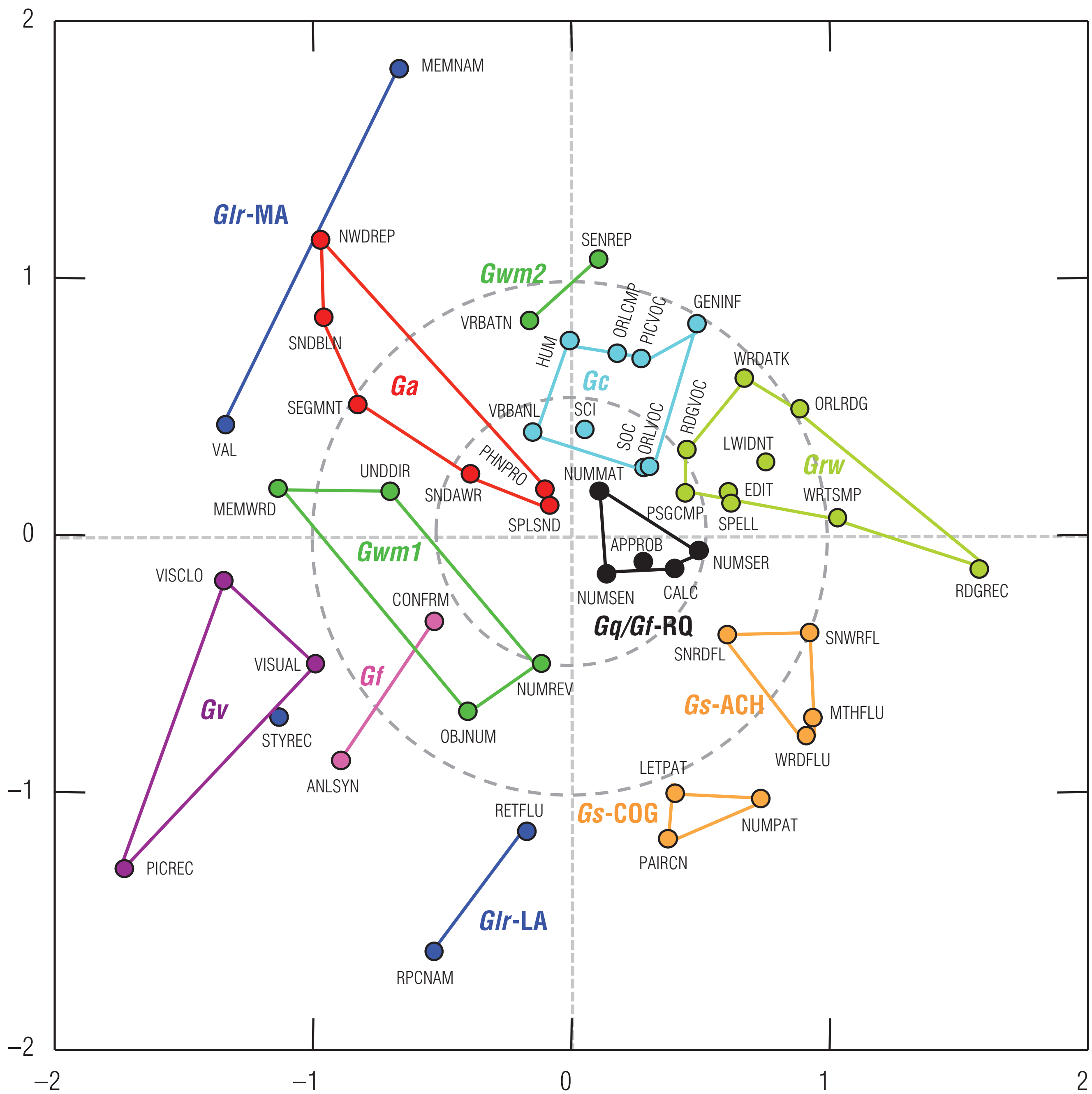


***Figure I-5.***
*MDS (Guttman Radex) of WJ IV ages 20 through 39 model-development sample A (n = 625).*

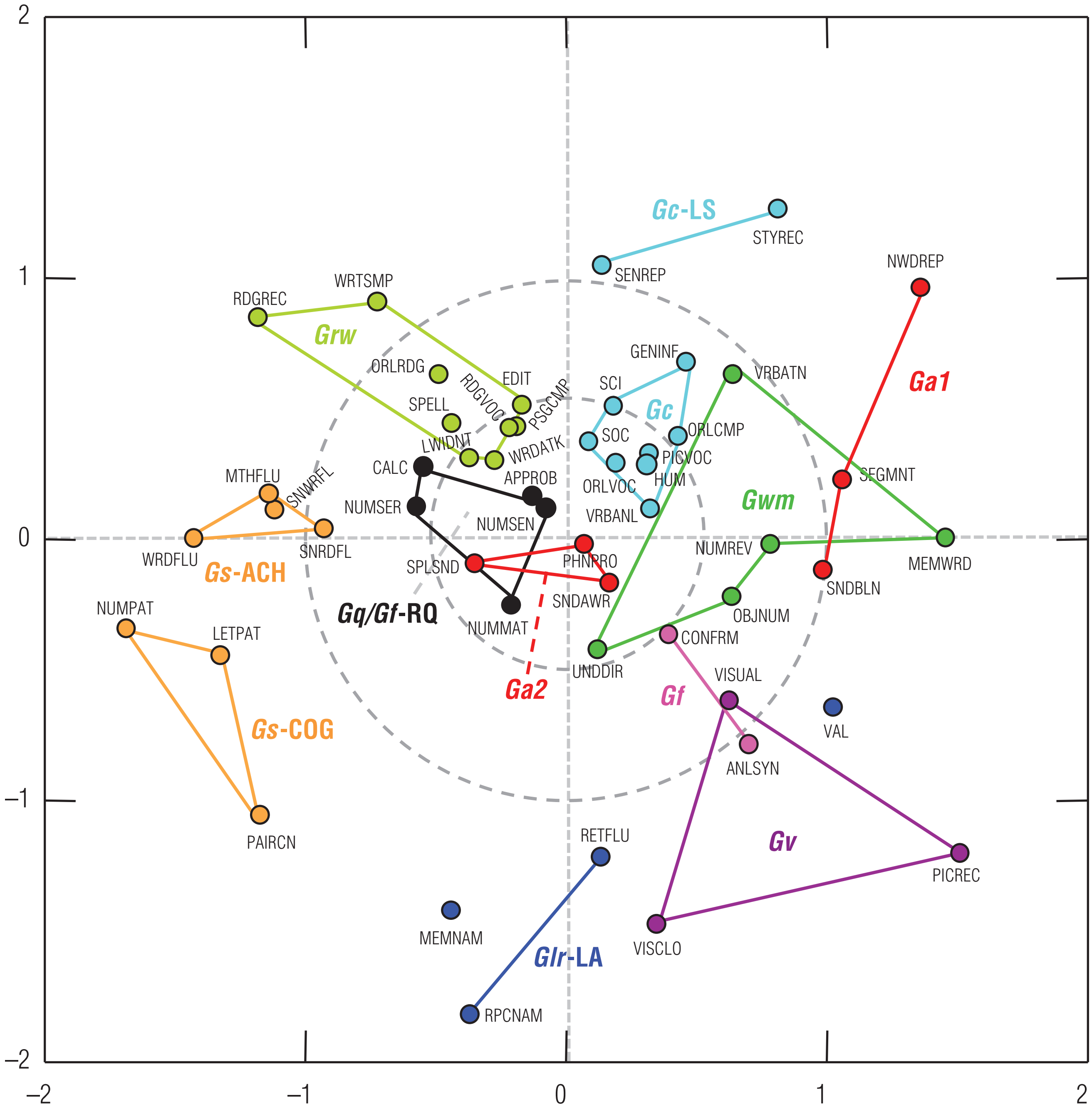


***Figure I-6.***
*MDS (Guttman Radex) of WJ IV ages 40 through 90+ model-development sample A (n = 571).*

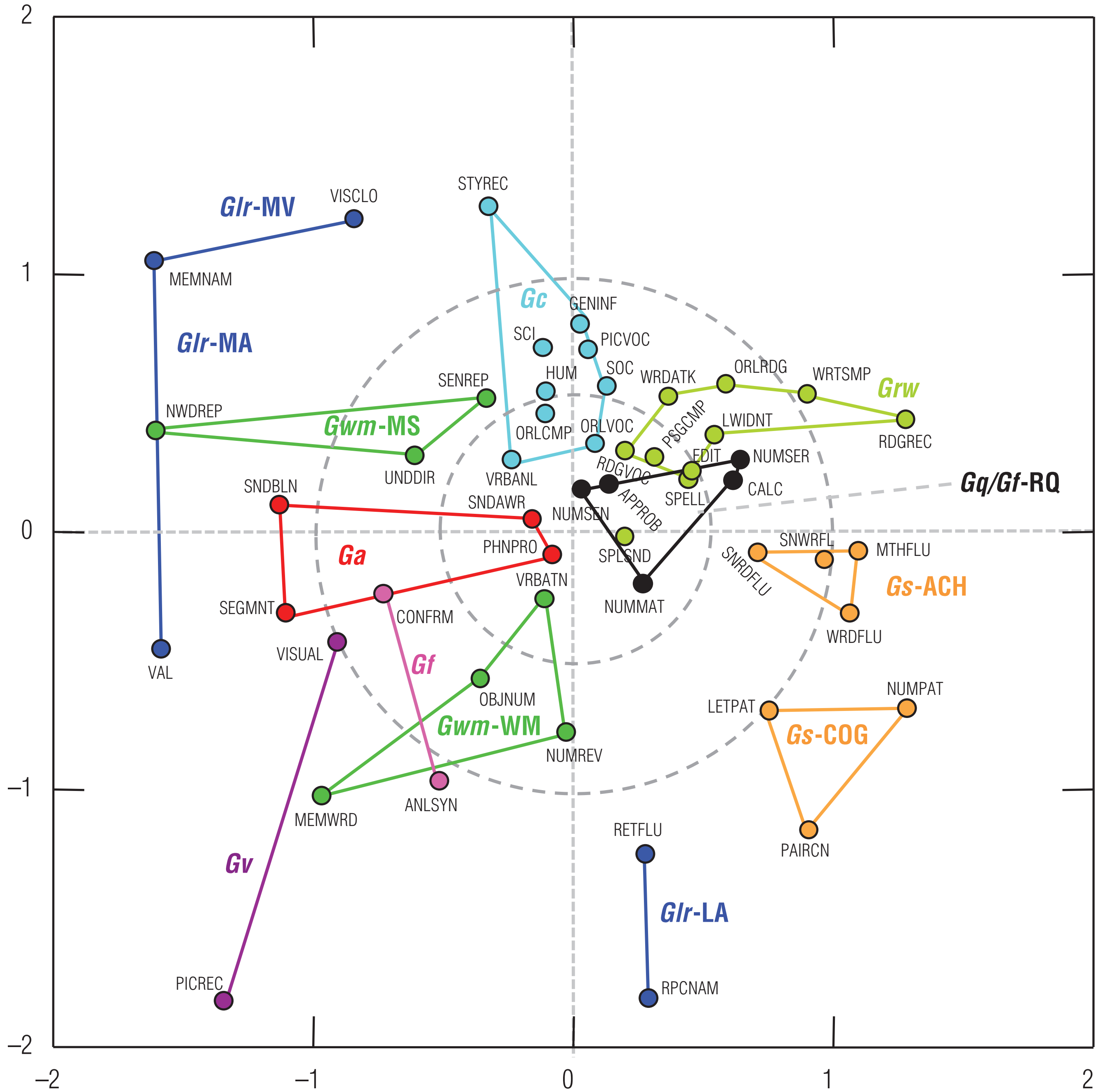


***Figure I-7.***
*MDS (Guttman Radex) content validity interpretation of WJ IV ages 6 through 8 model-development sample A (n = 412).*

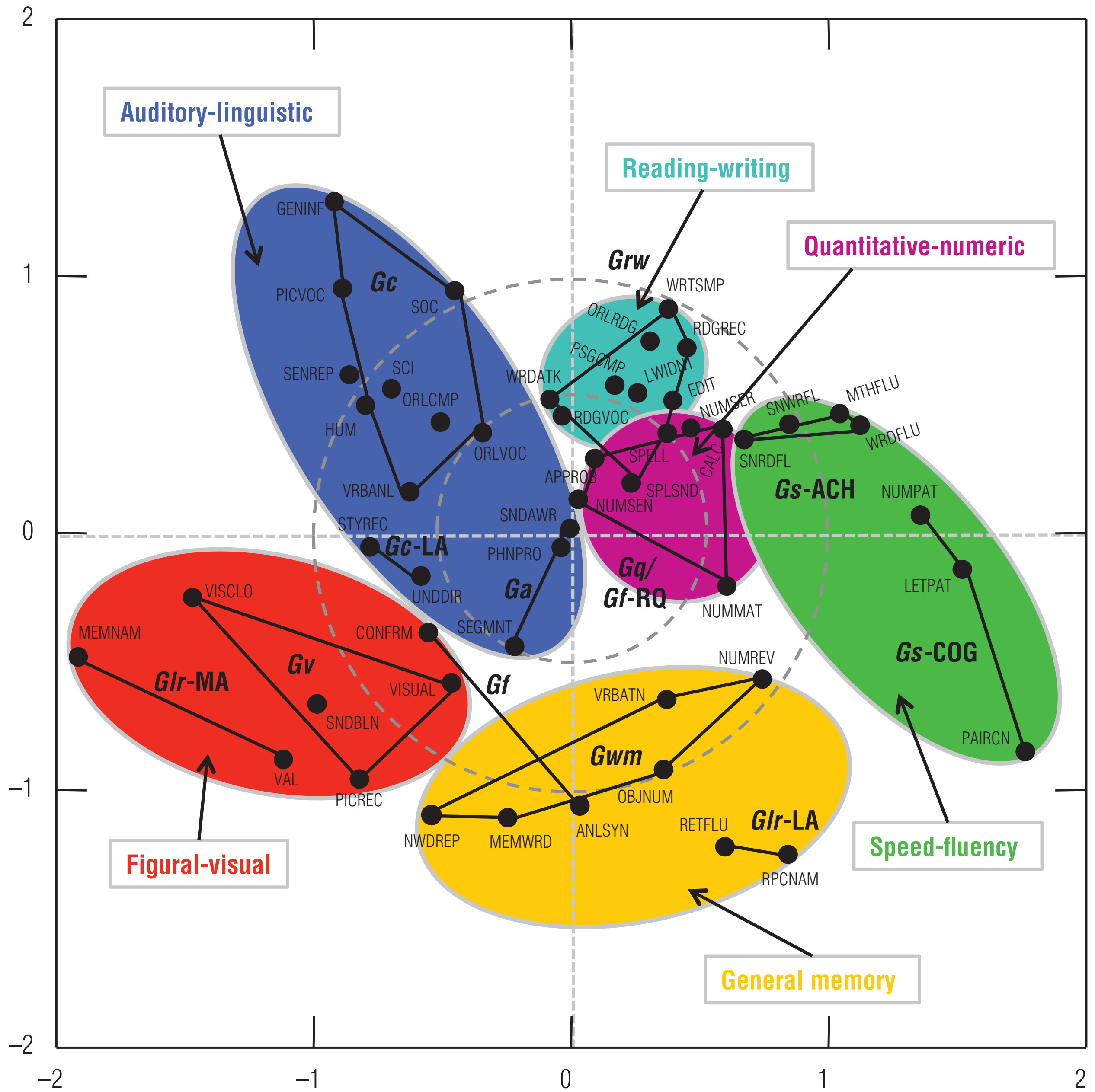


***Figure I-8.***
*MDS (Guttman Radex) content validity interpretation of WJ IV ages 9 through 13 model-development sample A (n = 785).*

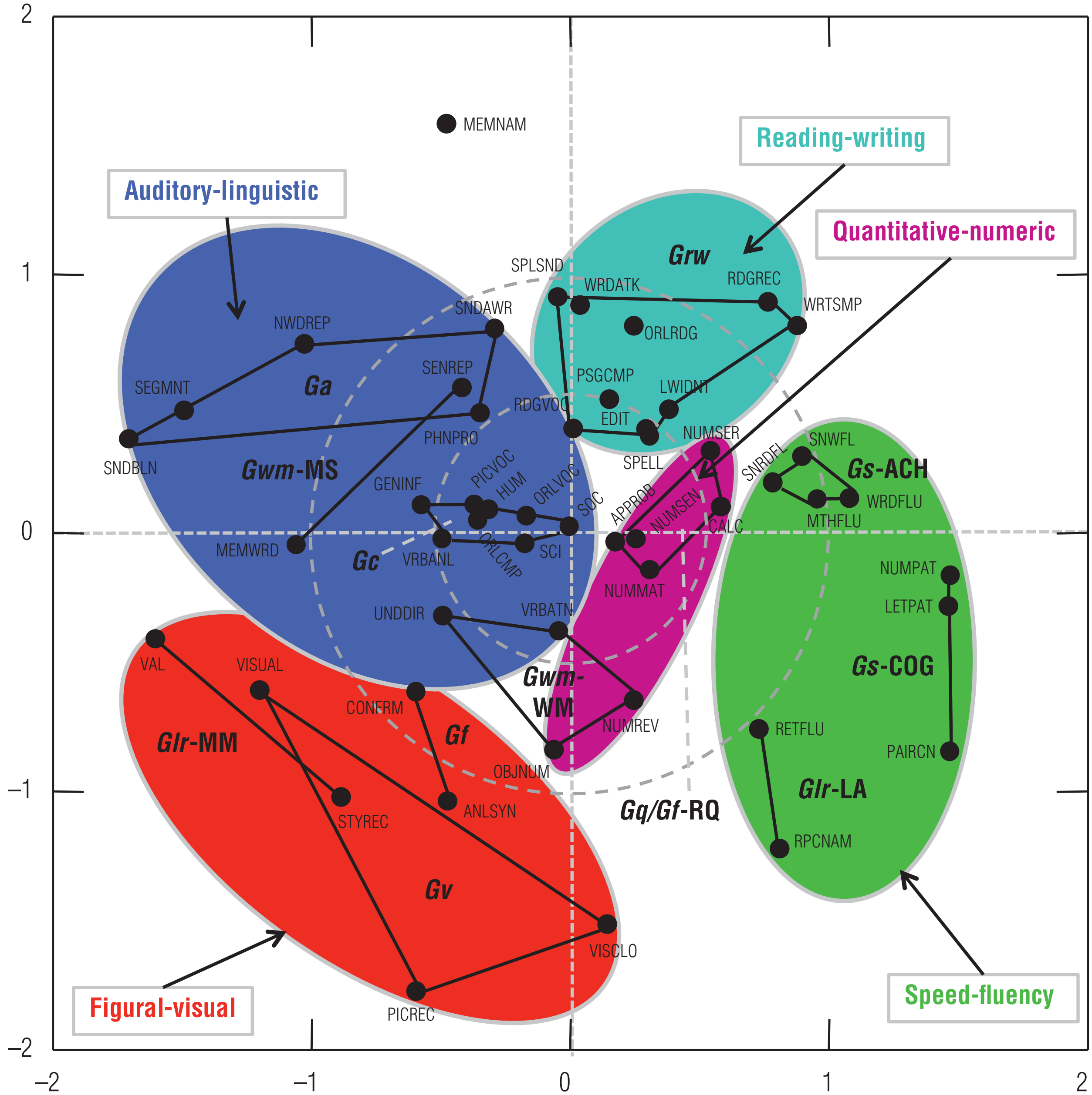


***Figure I-9.***
*MDS (Guttman Radex) content validity interpretation of WJ IV ages 14 through 19 model-development sample A (*n *= 842).*

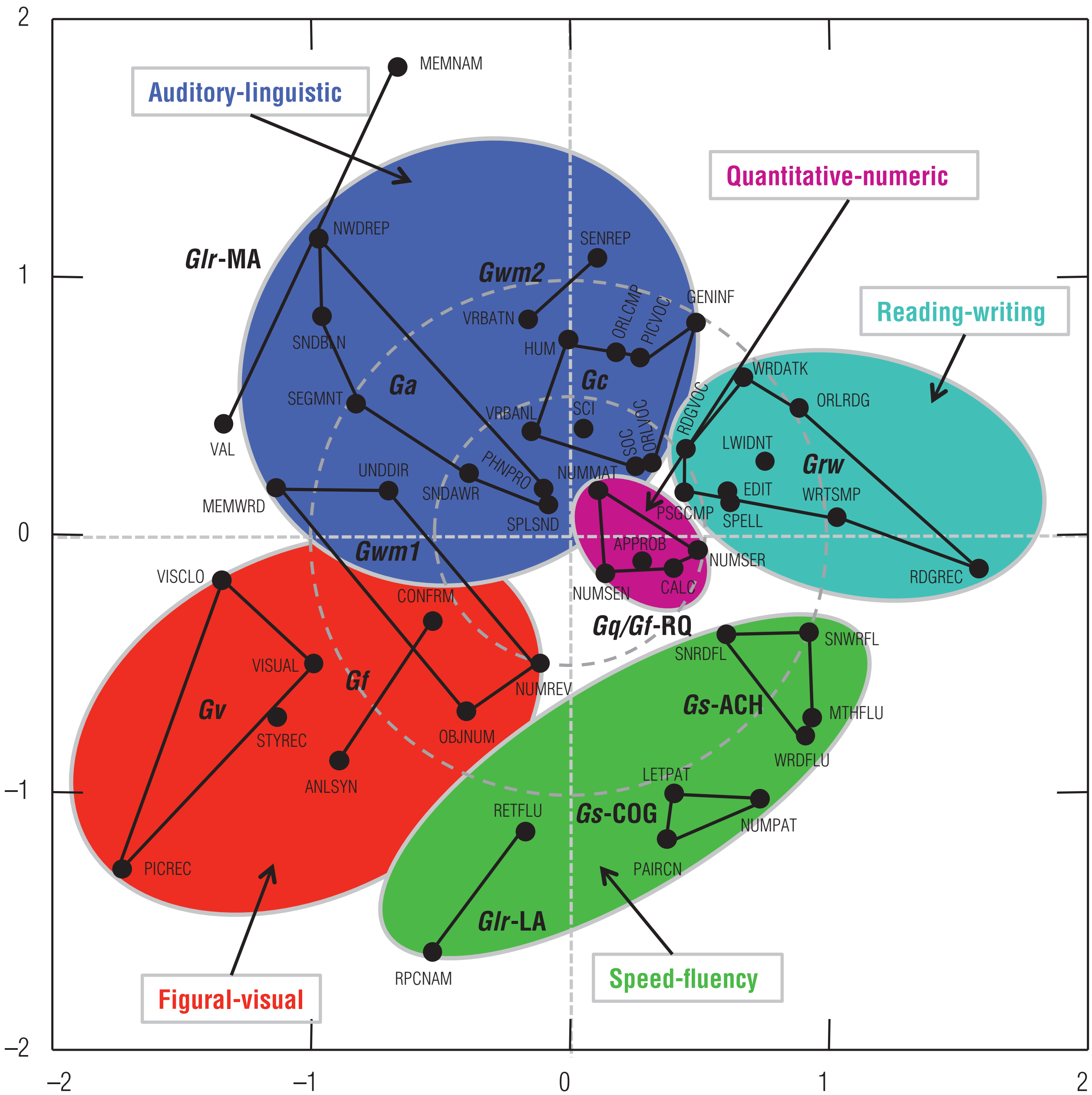


***Figure I-10.***
*MDS (Guttman Radex) content validity interpretation of WJ IV ages 20 through 39 model-development sample A (n = 625).*

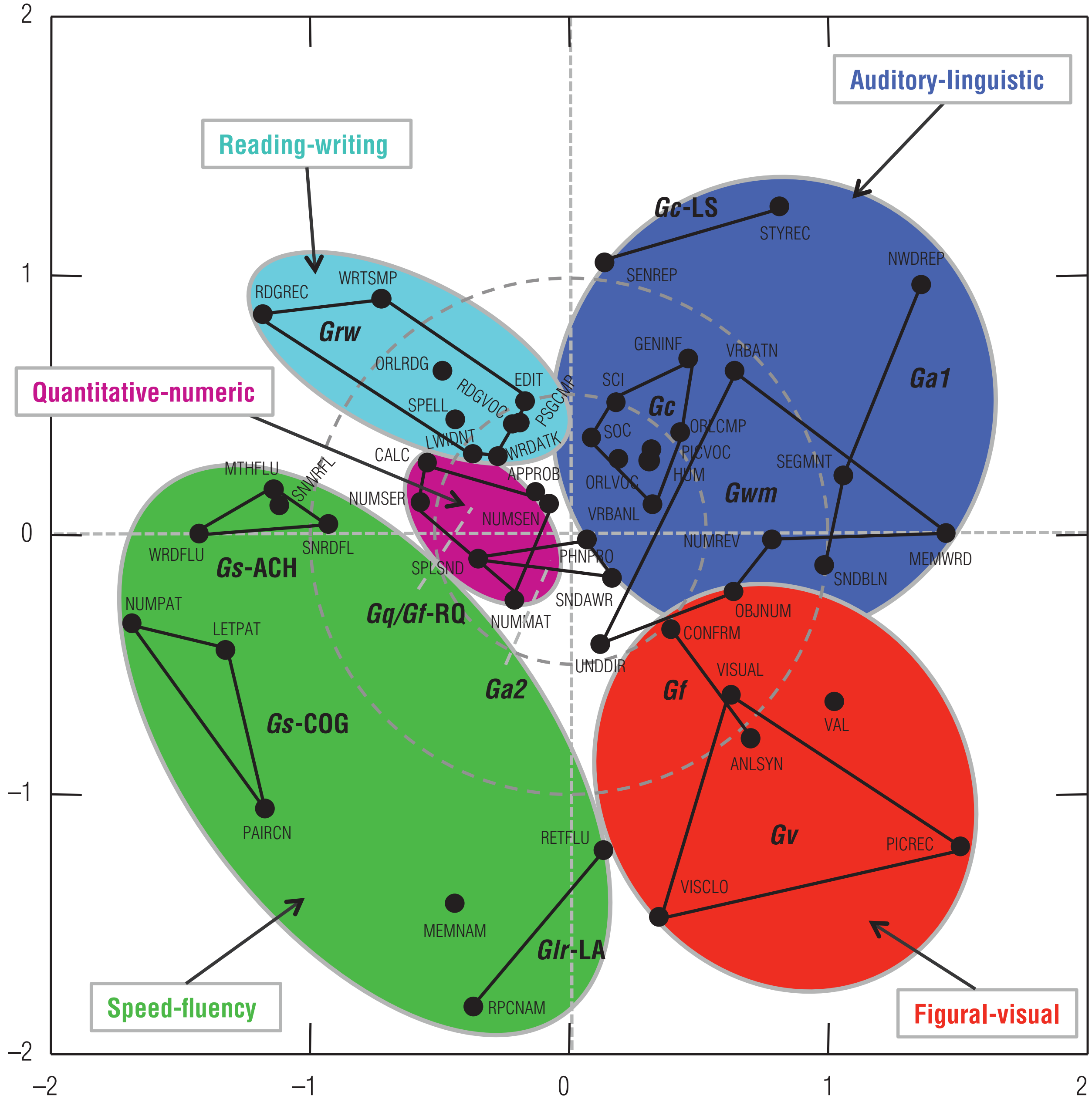
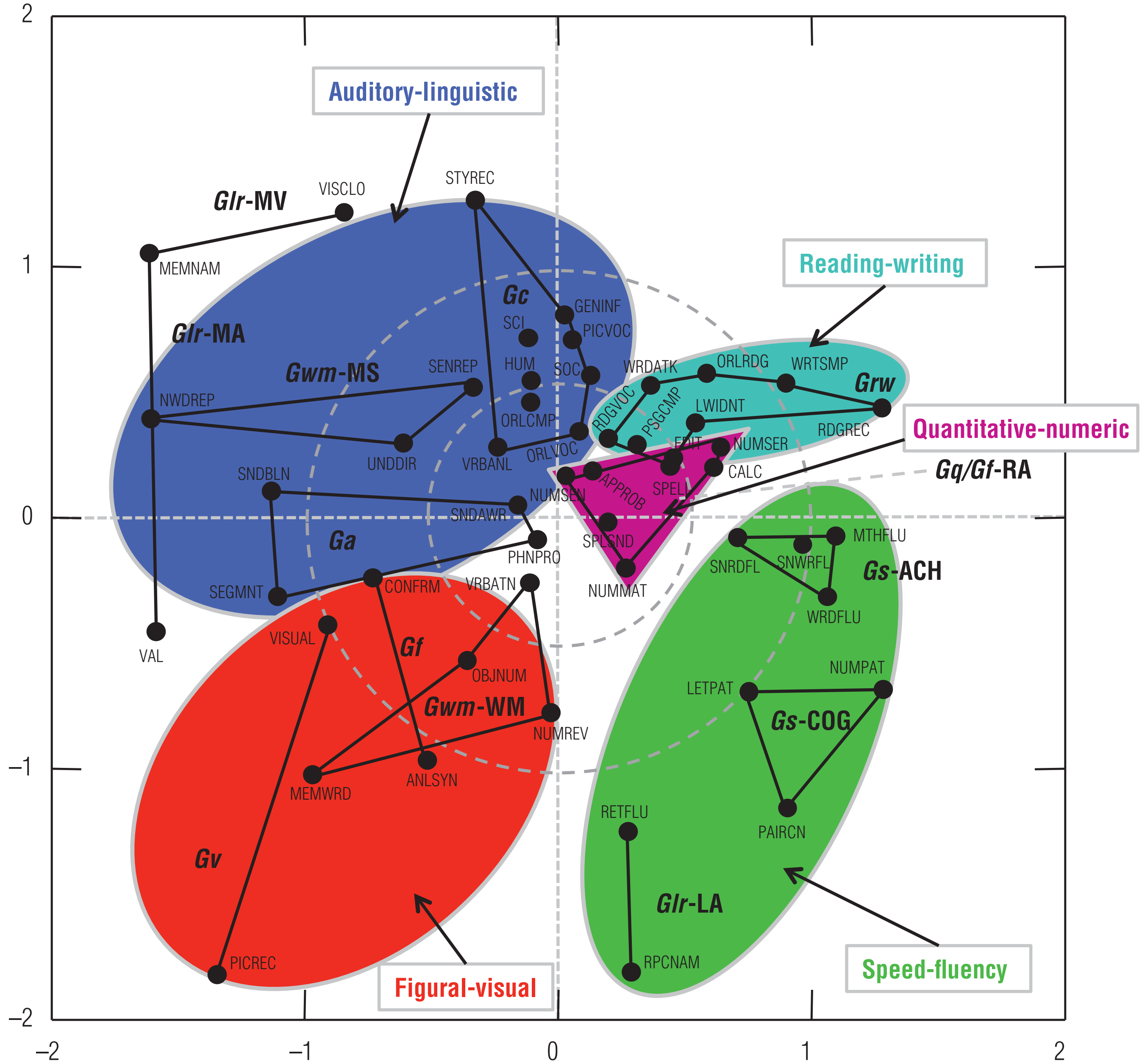


***Figure I-11.***
*MDS (Guttman Radex) content validity interpretation of WJ IV ages 40 through 90+ model-development sample A (n = 571).*



Appendix J

# Comparison of WJ IV CHC Broad Factor ML and SFLS Parameter Estimates

***Table J-1.***
*Comparison of ML and SFLS Parameter Estimates for WJ IV CHC Broad 9-Factor (Top Down; Model 3) Model-Development Sample for Ages 9 Through 13 (*n *= 785)*

| Latent Factors/Tests | ML | SFLS | Difference |
|---|---|---|---|
| ***g*** | | | |
| *Glr* | 0.92 | *1.00* | –0.08 |
| *Gf* | 0.91 | 0.88 | 0.03 |
| *Gq* | 0.88 | 0.86 | 0.02 |
| *Gc* | 0.79 | 0.78 | 0.01 |
| *Grw* | 0.78 | 0.78 | 0.00 |
| *Gwm* | 0.76 | 0.79 | –0.03 |
| *Gv* | 0.72 | 0.70 | 0.03 |
| *Ga* | 0.56 | 0.58 | –0.02 |
| *Gs* | 0.52 | 0.48 | 0.04 |
| ***Gc*** | | | |
| ORLVOC | 0.86 | 0.89 | –0.02 |
| PICVOC | 0.82 | 0.78 | 0.04 |
| SOC | 0.80 | 0.80 | 0.00 |
| HUM | 0.78 | 0.79 | –0.02 |
| GENINF | 0.77 | 0.72 | 0.05 |
| ORLCMP | 0.76 | 0.79 | –0.03 |
| SCI | 0.74 | 0.77 | –0.04 |
| VRBANL | 0.55 | 0.52 | 0.03 |
| RDGVOC | 0.51 | 0.50 | 0.01 |
| PSGCMP | 0.30 | 0.29 | 0.02 |
| PHNPRO | 0.30 | 0.27 | 0.03 |
| SENREP | 0.24 | 0.23 | 0.01 |

***Table J-1.*** *(cont.)*
*Comparison of ML and SFLS Parameter Estimates for WJ IV CHC Broad 9-Factor (Top Down; Model 3) Model-Development Sample for Ages 9 Through 13 (n = 785)*

| Latent Factors/Tests | ML | SFLS | Difference |
|---|---|---|---|
| ***Gf*** | | | |
| NUMSER | 0.77 | 0.78 | –0.01 |
| NUMMAT | 0.73 | 0.72 | 0.01 |
| CONFRM | 0.61 | 0.63 | –0.02 |
| ANLSYN | 0.58 | 0.56 | 0.02 |
| VRBANL | 0.28 | 0.31 | –0.03 |
| ***Gwm*** | | | |
| VRBATN | 0.77 | 0.76 | 0.01 |
| OBJNUM | 0.68 | 0.68 | 0.01 |
| UNDDIR | 0.64 | 0.74 | –0.09 |
| MEMWRD | 0.54 | 0.44 | 0.10 |
| SENREP | 0.51 | 0.52 | –0.01 |
| NWDREP | 0.50 | 0.42 | 0.07 |
| NUMREV | 0.36 | 0.32 | 0.04 |
| ***Gs*** | | | |
| NUMPAT | 0.78 | 0.85 | –0.07 |
| LETPAT | 0.73 | 0.80 | –0.07 |
| WRDFLU | 0.69 | 0.63 | 0.06 |
| PAIRCN | 0.58 | 0.58 | 0.00 |
| SNRDFL | 0.54 | 0.53 | 0.02 |
| MTHFLU | 0.52 | 0.56 | –0.03 |
| SNWRFL | 0.49 | 0.49 | 0.00 |
| RPCNAM | 0.30 | 0.23 | 0.07 |
| RETFLU | 0.17 | 0.14 | 0.03 |
| CALC | 0.21 | 0.29 | –0.08 |
| ***Ga*** | | | |
| SEGMNT | 0.73 | 0.70 | 0.02 |
| SNDBLN | 0.62 | 0.64 | –0.03 |
| PHNPRO | 0.60 | 0.67 | –0.07 |
| SNDAWR | 0.51 | 0.51 | 0.00 |
| SPLSND | 0.48 | 0.46 | 0.02 |
| MEMWRD | 0.25 | 0.29 | –0.04 |
| WRDATK | 0.23 | 0.24 | –0.01 |
| NWDREP | 0.19 | 0.24 | –0.05 |
| ***Glr*** | | | |
| STYREC | 0.51 | 0.47 | 0.05 |
| RETFLU | 0.44 | 0.45 | 0.00 |
| VAL | 0.42 | 0.41 | 0.01 |
| MEMNAM | 0.41 | 0.43 | –0.02 |
| RPCNAM | 0.27 | 0.29 | –0.03 |
| WRTSMP | 0.23 | 0.12 | 0.11 |
| RDGREC | 0.23 | 0.10 | 0.13 |

***Table J-1.*** *(cont.)*
*Comparison of ML and SFLS Parameter Estimates for WJ IV CHC Broad 9-Factor (Top Down; Model 3) Model-Development Sample for Ages 9 Through 13 (n = 785)*

| Latent Factors/Tests | ML | SFLS | Difference |
|---|---|---|---|
| ***Gv*** | | | |
| VISUAL | 0.63 | 0.68 | –0.04 |
| VISCLO | 0.59 | 0.60 | –0.01 |
| PICREC | 0.49 | 0.50 | –0.01 |
| PAIRCN | 0.20 | 0.13 | 0.06 |
| ***Grw*** | | | |
| LWIDNT | 0.88 | 0.89 | –0.01 |
| SPELL | 0.87 | 0.91 | –0.04 |
| EDIT | 0.81 | 0.88 | –0.07 |
| ORLRDG | 0.76 | 0.78 | –0.02 |
| WRDATK | 0.61 | 0.57 | 0.05 |
| PSGCMP | 0.54 | 0.56 | –0.02 |
| SNRDFL | 0.46 | 0.46 | 0.01 |
| SNWRFL | 0.45 | 0.43 | 0.02 |
| RDGVOC | 0.43 | 0.42 | 0.01 |
| RDGREC | 0.42 | 0.52 | –0.10 |
| SPLSND | 0.42 | 0.39 | 0.03 |
| WRTSMP | 0.41 | 0.49 | –0.08 |
| WRDFLU | 0.27 | 0.29 | –0.02 |
| SNDAWR | 0.33 | 0.34 | –0.01 |
| ***Gq*** | | | |
| APPROB | 0.90 | 0.90 | 0.00 |
| NUMSEN | 0.82 | 0.87 | –0.05 |
| CALC | 0.70 | 0.63 | 0.07 |
| MTHFLU | 0.40 | 0.38 | 0.02 |
| NUMREV | 0.26 | 0.31 | –0.05 |
| | **Grand median =** | | 0.00 |

*Note.* ML = maximum likelihood; SFLS = scale-free least squares. Italic font = Heywood case constrained/fixed to 1.0. Cell values are rounded to two decimal places.

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