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Educational Interventions and Accommodations Related to the *Woodcock-Johnson III Tests of Cognitive Abilities* and the *Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities*

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This bulletin relates the Woodcock-Johnson III Tests of Cognitive Abilities (WJ III® COG) *and the* Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities *(DS) to educational interventions and accommodations. The Cattell-Horn-Carroll (CHC) broad and narrow abilities and descriptions of the cognitive processes required for performance on each test provide the theoretical and conceptual bases for suggested links between the WJ III COG and DS and a number of evidence-based instructional interventions. Research discussed in this bulletin suggests that the CHC abilities (and, by inference, their constituent cognitive processes) are related to specific academic abilities. Consequently, educational interventions or accommodations that address related cognitive limitations may be foundational to improved performance in academic areas where learning difficulties are manifested.*

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Educational Interventions and Accommodations Related to the *Woodcock-Johnson III Tests of Cognitive Abilities* and the *Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities*

The *Woodcock-Johnson III Tests of Cognitive Abilities* (WJ III COG) (Woodcock, McGrew, & Mather, 2001, 2007) and the *Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities* (DS) (Woodcock, McGrew, Mather, & Schrank, 2003, 2007) include 31 tests for measuring general intellectual ability, broad and narrow cognitive abilities, and aspects of executive functioning. The WJ III COG includes 20 tests. The DS provides 11 additional tests.

Each of the WJ III COG and DS tests provide norm-referenced measures of one or more narrow, or specific, psychometrically defined cognitive abilities as informed by the independent research efforts of Horn (1965, 1988, 1989, 1991), Horn and Stankov (1982), Cattell (1941, 1943, 1950), Carroll (1987, 1990, 1993, 2003), and Woodcock (1998). This body of research has been interpreted conjointly as CHC theory (McGrew, 2005).

The WJ III COG and DS measure seven broad CHC abilities: Comprehension-Knowledge (*Gc*), Long-Term Retrieval (*Glr*), Visual-Spatial Thinking (*Gv*), Auditory Processing (*Ga*), Fluid Reasoning (*Gf*), Processing Speed (*Gs*), and Short-Term Memory (*Gsm*). These seven broad abilities are differentially related to reading, math, and writing achievement (Evans, Floyd, McGrew, & Leforgee, 2002; Floyd, Evans, & McGrew, 2003; Floyd, McGrew, & Evans, 2008).

Each of the WJ III COG and DS tests can also be interpreted as measuring one or more cognitive processes (McGrew, Schrank, & Woodcock, 2007; Schrank, 2006). The cognitive processes required for performance on each of the tests can provide cues to interventions that may enhance performance on similar educational tasks. "An implication, borne out in research, is that student performance should improve when teachers structure instruction and academic work to cue effective processing" (Wong, Harris, Graham, & Butler, 2003, p. 392).

CHC Abilities, Constituent Cognitive Processes, and Related Educational Interventions and Accommodations

Although it is generally accepted that an identified weakness in a particular cognitive ability is useful for describing why a student is struggling in one academic area but not another, the relationship between the identified weakness, the cognitive processes required for academic performance in the affected domain, and instructional interventions is not as widely understood. As the focus of professional practice shifts from determining service eligibility to assessing basic psychological processes that inform appropriate instruction, a need exists for providing a link between cognitive assessment and evidence-based educational interventions. Research has shown that the CHC broad and narrow abilities differentially predict performance on academic tasks (Evans, et al., 2002; Floyd, et al., 2003; Floyd, et al., 2008). This bulletin describes some differential implications for planning appropriate interventions and/or selection of accommodations based on an assessment of the CHC broad and narrow abilities as identified by the WJ III COG and DS.

The purpose of this bulletin is to describe how information gleaned from performance on the WJ III COG and DS can be useful for developing instructional interventions or accommodations, particularly when limited proficiency is identified in a broad or narrow ability and/or associated with a specific cognitive process. To provide an organizational schema that relates WJ III COG and DS test performance to evidence-based interventions, this bulletin outlines the broad factors and narrow abilities defined by CHC theory and provides brief descriptions of the cognitive processes required for performance in each of the tests. Suggested interventions or accommodations that are conceptually related to the narrow abilities and cognitive processes are included (see Table 1). As examples, some interventions are described in this bulletin. References to research evidence for each suggested intervention are provided for further information.

Table 1.
Organizational Schema Relating WJ III COG and Diagnostic Supplement Tests, CHC Broad Factors and Narrow Abilities, Cognitive Processes, and Related Educational Interventions

Test	Primary Broad CHC Factors ***Narrow CHC Abilities***	Cognitive Process(es)	Related Educational Interventions
Test 1: Verbal Comprehension	Comprehension-Knowledge (*Gc*) *Lexical knowledge* *Language development*	Object recognition and reidentification; semantic activation, access, and matching; verbal analogical reasoning	Creating a vocabulary-rich learning environment, particularly reading aloud to a young child and discussing new words; text talks; directed vocabulary thinking activities; explicit teaching of specific words; semantic feature analysis; semantic maps; use of computer technology to develop word knowledge; association of key words to prior knowledge; reading for a variety of purposes; independent word-learning strategies
Test 2: Visual-Auditory Learning	Long-Term Retrieval (*Glr*) *Associative memory*	Paired-associative encoding via directed spotlight attention; storage and retrieval	Active, successful learning experiences; rehearsal; overlearning; organizational strategies; mnemonics; illustrate or visualize content
Test 3: Spatial Relations	Visual-Spatial Thinking (*Gv*) *Visualization* *Spatial relations*	Visual feature detection; manipulation of visual images in space; matching	Multisensory teaching techniques; private speech
Test 4: Sound Blending	Auditory Processing (*Ga*) *Phonetic coding*	Synthesis of acoustic, phonological elements in immediate awareness; matching the sequence of elements to stored lexical entries; lexical activation and access	Early exposure to language sounds; promoting phonological awareness; direct instruction in sound blending; practice blending sounds into words

Table 1, continued

Organizational Schema Relating WJ III COG and Diagnostic Supplement Tests, CHC Broad Factors and Narrow Abilities, Cognitive Processes, and Related Educational Interventions

Test 5: Concept Formation	Fluid Reasoning (*Gf*) *Induction*	Rule-based categorization; rule switching; induction/ inference	Categorize using real objects; develop skills in drawing conclusions; hands-on problem-solving tasks; make meaningful associations; concrete examples of grouping objects
Test 6: Visual Matching	Processing Speed (*Gs*) *Perceptual speed*	Speeded visual perception and matching	Emphasize speediness; build cognitive speed via repetition, speed drills; use of technology
Test 7: Numbers Reversed	Short-Term Memory (*Gsm*) *Working memory*	Span of apprehension and recoding in working memory	Chunking strategies; rehearsal; mnemonics
Test 8: Incomplete Words	Auditory Processing (*Ga*) *Phonetic coding*	Analysis of a sequence of acoustic, phonological elements in immediate awareness; activation of a stored representation of the word from an incomplete set of phonological features	Promote phonological awareness; read aloud; games that focus on sounds and words
Test 9: Auditory Working Memory	Short-Term Memory (*Gsm*) *Working memory*	Recoding of acoustic, verbalizable stimuli held in immediate awareness	Rehearsal; mnemonics; active learning
Test 10: Visual-Auditory Learning–Delayed	Long-Term Retrieval (*Glr*) *Associative memory*	Retrieval and reidentification; associative encoding (for relearning)	Active, successful learning experiences; rehearsal; overlearning; organizational strategies; mnemonics; illustrate or visualize content
Test 11: General Information	Comprehension-Knowledge (*Gc*) *General (verbal) information*	Semantic activation and access to declarative generic knowledge	Text talks; semantic maps
Test 12: Retrieval Fluency	Long-Term Retrieval (*Glr*) *Ideational fluency* *Naming facility*	Recognition, fluent retrieval, and oral production of examples of a semantic category	Oral elaboration
Test 13: Picture Recognition	Visual-Spatial Thinking (*Gv*) *Visual memory*	Formation of iconic memories and matching of visual stimuli to stored representations	Activities designed to discriminate/match visual features and recall visual information
Test 14: Auditory Attention	Auditory Processing (*Ga*) *Speech-sound discrimination* *Resistance to auditory-stimulus distortion*	Selective auditory attention	Reduce distracting noise; modifications to listening environment
Test 15: Analysis-Synthesis	Fluid Reasoning (*Gf*) *General sequential reasoning* *Quantitative reasoning*	Algorithmic reasoning; deduction	Deductive reasoning using concrete objects; hands-on problem solving tasks; metacognitive strategies
Test 16: Decision Speed	Processing Speed (*Gs*) *Semantic processing speed*	Object recognition and speeded symbolic/semantic comparisons	Emphasize speediness; build cognitive speed via repetition
Test 17: Memory for Words	Short-Term Memory (*Gsm*) *Auditory memory span*	Formation of echoic memories and verbalizable span of echoic store	Mnemonics; rehearsal; provide visual cues
Test 18: Rapid Picture Naming	Processing Speed (*Gs*) *Naming facility*	Speed/fluency of retrieval and oral production of recognized objects	Increase fluency through self-competition

Table 1, continued

Organizational Schema Relating WJ III COG and Diagnostic Supplement Tests, CHC Broad Factors and Narrow Abilities, Cognitive Processes, and Related Educational Interventions

Test 19: Planning	Visual-Spatial Thinking (*Gv*) and Fluid Reasoning (*Gf*) *Spatial scanning* *General sequential reasoning*	Means-end analysis	Use of puzzles, pegboards, dot-to-dot drawings; multisensory teaching techniques; private speech
Test 20: Pair Cancellation	Processing Speed (*Gs*) *Attention and concentration*	Controlled, focal attention; vigilance	Speed drills; repetition
Test 21: Memory for Names	Long-Term Retrieval (*Glr*) *Associative memory*	Associative encoding via directed spotlight attention, storage, and retrieval	Active, successful learning experiences; rehearsal; overlearning; organizational strategies; mnemonics; illustrate or visualize content
Test 22: Visual Closure	Visual-Spatial Thinking (*Gv*) *Closure speed*	Object identification from a limited set of component geons	Accommodations to enhance visual stimuli (e.g., enlarge, use color overlays)
Test 23: Sound Patterns–Voice	Auditory Processing (*Ga*) *Sound discrimination*	Prelexical, perceptual analysis of auditory waveform patterns	Auditory training; enhancements/modifications to listening environment
Test 24: Number Series	Fluid Reasoning (*Gf*) *Mathematics knowledge* *Quantitative reasoning*	Representation and manipulation of points on a mental number line; identifying and applying an underlying rule/principle to complete a numerical sequence	Develop number sense; count by increments; manipulatives
Test 25: Number Matrices	Fluid Reasoning (*Gf*) *Quantitative reasoning*	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	Seriation; patterns; explicit instruction in number reasoning skills
Test 26: Cross Out	Processing Speed (*Gs*) *Perceptual speed*	Speeded visual matching	Emphasize speediness; build cognitive speed via repetition
Test 27: Memory for Sentences	Short-Term Memory (*Gsm*) *Auditory memory span* *Listening ability*	Formation of echoic memories aided by a semantic, meaning-based code	Associate new information with prior knowledge; rehearsal
Test 28: Block Rotation	Visual-Spatial Thinking (*Gv*) *Visualization* *Spatial relations*	Visual matching using visual-spatial manipulation	Use of puzzles, pegboards, dot-to-dot drawings; multisensory teaching techniques; private speech
Test 29: Sound Patterns–Music	Auditory Processing (*Ga*) *Sound discrimination* *Musical discrimination and judgment*	Prelexical, perceptual analysis of auditory waveform patterns	Auditory training; enhancements/modifications to listening environment
Test 30: Memory for Names–Delayed	Long-Term Retrieval (*Glr*) *Associative memory*	Reidentification	Interventions/accommodations to help recall previously learned information
Test 31: Bilingual Verbal Comprehension–English/Spanish	Comprehension-Knowledge (*Gc*) *Lexical knowledge* *Language development*	Object reidentification; semantic activation, access, and matching; verbal analogical reasoning	See Test 1: Verbal Comprehension

Comprehension-Knowledge (*Gc*)

The CHC broad ability, Comprehension-Knowledge (*Gc*), is sometimes referred to as acculturation knowledge, crystallized intelligence, or verbal abilities. It is typically viewed as a store of acquired knowledge that includes both declarative and procedural knowledge. For children and adolescents, Comprehension-Knowledge (*Gc*) is moderately to strongly related to reading (Evans, et al., 2002), mathematics (Floyd, et al., 2003), and writing (Floyd, et al., 2008) achievement. Oral language ability, an aspect of *Gc*, serves as the foundation for, and is positively related to, subsequent success in reading and writing (Glazer, 1989; Stanovich, 1986; Strickland & Feeley, 1991; Wiig & Semel, 1984). Research indicates significant relationships among level of oral vocabulary (Baumann & Kame'enui, 1991), background knowledge (Anderson & Pearson, 1984), and reading ability.

Two of the tests that compose the *Gc* cluster are Verbal Comprehension and General Information. The Verbal Comprehension test comprises four subtests: Picture Vocabulary, Synonyms, Antonyms, and Verbal Analogies. They measure the CHC narrow abilities of lexical knowledge (i.e., vocabulary knowledge) and language development (i.e., general development of spoken language skills that do not require reading ability). In contrast, the General Information test measures the CHC narrow ability of general (verbal) information.

The cognitive processing involved in lexical knowledge may be illustrated best in the Synonyms and Antonyms tasks, wherein an auditory form of a stimulus word is connected to a concept via semantic access. The Synonyms and Antonyms subtests are primarily language development tasks because the stimulus material involves no printed words (lexical retrieval cannot be accessed via reading). Both narrow abilities (lexical knowledge and language development) are measured in the Picture Vocabulary subtest. The Verbal Analogies subtest comprises cognitively complex tasks that require induction of the structure for the first part of each analogy and then mapping (or projecting) that structure onto the second part.

For young children, suggested interventions that encourage the development of knowledge and language abilities include creating a language- and experience-rich environment (Gunn, Simmons, Kame'enui, 1995; Hart & Risley, 2003), frequent exposure and practice with words (Gunn, et al., 1995; Hart & Risley, 2003), reading aloud to the child (Adams, 1990), and text talks (Beck & McKeown, 2001).

For example, when creating a language- and experience-rich environment, the child should be provided with early exposure to language and word knowledge. Opportunities for role playing; sharing time; and hands-on activities with new, interesting vocabulary help young children acquire new vocabulary and incorporate it into their daily language. Frequent exposure and practice are essential for children to learn new words well enough to recall them, to know their meaning, and to use them. At home, parents should engage the child in talk about what is happening during the day. They might describe and label things, as well as name objects and actions, as they interact each day with their child. Parents should ask lots of questions; answer the child's "why" questions; and take trips to the library, museum, zoo, and/or provide other opportunities for exposure to knowledge.

Text talks are teacher-led discussions that engage the child in a dialog about a story that was read and the vocabulary that was used. The teacher makes connections between new words and words and experiences already in the child's repertoire. The teacher models new words by paraphrasing using known words.

For older children and adolescents, interventions include increased time spent reading (Cunningham & Stanovich, 1991; Herman, Anderson, Pearson, & Nagy, 1987), reading for different purposes (Anderson, 1996; National Reading Panel, 2000; Stahl, 1999), intentional, explicit word instruction (Beck, McKeown, & Kucan, 2002; Graves, Juel, & Graves, 2004; National Reading Panel, 2000), direct instruction in morphology (Anglin, 1993; Baumann, Edwards, Boland, Olejnik, & Kame'enui, 2003; Baumann, Kame'enui, & Ash, 2003; Blachowicz & Fisher, 2000; Carlisle, 2004; Graves, 2000; National Reading Panel, 2000), development of word consciousness (Anderson & Nagy, 1992; Graves & Watts-Taffe, 2002; Nagy & Scott, 2000), and use of related computer programs (Davidson, Elcock, & Noyes, 1996).

Vocabulary-building interventions for older children and adults include semantic feature analysis (Anders & Bos, 1986; Pittelman, Heimlich, Berglund, & French, 1991) and semantic maps (Johnson & Pearson, 1984; Sinatra, Berg, & Dunn, 1985). Both methods provide a visual representation of the information to be studied. Semantic maps, for example, involve brainstorming words and phrases that are associated with a major concept being studied. Then the individual identifies which words/phrases go together in some way. These groups of related words/phrases are then labeled and form supporting details for the major concept.

Long-Term Retrieval (*Glr*)

The CHC broad ability Long-Term Retrieval (*Glr*) involves the cognitive processes of acquiring, storing, and retrieving information. *Glr* reflects the efficiency with which information is initially stored and later retrieved. Long-Term Retrieval (*Glr*) is related to reading achievement during the elementary school years (Evans, et al., 2002), to mathematics achievement during the same period (Floyd, et al., 2003), and to writing achievement in the early elementary school years (Floyd, et al., 2008). Naming facility, often referred to as rapid automatic naming (RAN), is a narrow ability subsumed by *Glr*. RAN has been found to predict reading achievement (Scarborough, 1998).

Two tests that compose the *Glr* cluster are Visual-Auditory Learning and Retrieval Fluency. Visual-Auditory Learning measures associative memory or paired-associate learning, and Retrieval Fluency measures ideational fluency and naming facility. In Visual-Auditory Learning, the initial task requires associating the visual rebus symbol with a verbal label. The controlled-learning format of this test uses *directed spotlight attention* (Gazzaniga, Ivry, & Mangun, 1998)—the mental, attention-focusing process that prepares the examinee to encode the stimulus. The retrieval phase requires the examinee to match a rebus presentation with its stored representation; this process is called *identification*. The directed-spotlight attention mechanism provides a cue to the intervention known as *active learning* (Marzano, Pickering, & Pollock, 2001). Active learning is required for the creation of meaning-based codes that are subsequently used to relate new information or task requirements to previously acquired knowledge.

The Retrieval Fluency test requires fluent retrieval and oral production of examples of a semantic category. This task does not include the encoding and storage processes but rather measures the rate or automaticity of retrieval. Oral elaboration (Wolf, Bowers, & Biddle, 2000; Wolfe, 2001) may be an effective intervention for limited performance or nonautomatic oral production of names in a semantic category.

Additional *Glr* tests are included in Table 1. For example, Memory for Names also measures associative memory. The educational interventions for limited proficiency on Memory for Names are similar to those for Visual-Auditory Learning.

Interventions for limitations in encoding, storing, and retrieving information include active learning (Marzano, et al., 2001), rehearsal, overlearning, elaboration (Squire & Schacter, 2003), mnemonics (Wolfe, 2001), visual representation (Greenleaf & Wells-Papanek, 2005), and organizational strategies. Varying the learning tasks, incorporating emotions and novelty, and fostering creativity are ways to promote active learning. Rehearsal is a critical factor in learning. Memories consolidate across time, so some individuals may benefit from shorter sessions at repeated intervals rather than one long session. For students with limitations, dividing learning into three, 50-minute sessions with 10-minute breaks in between sessions may be preferable to a single, three-hour study period. Recitation is one method of rehearsal. The individual reviews his or her notes on the information, covers the notes, and then recites aloud the material to be learned. This oral recitation technique incorporates more senses than just thinking about the notes and leads to better recall. Overlearning improves storage and recall. It occurs when the individual continues to review and rehearse information he or she already knows. Even one additional review can significantly increase recall.

Visual-Spatial Thinking (*Gv*)

Visual-spatial thinking (*Gv*) involves visual perception (the process of extracting features from visual stimuli) and includes the processes involved in generating, storing, retrieving, and transforming visual images. While the ability to make sense of visual information is important to school success, the research has not shown a meaningful connection between achievement and the visual processing tasks found on most intelligence tests (Evans, et al., 2002; Floyd, et al., 2003; Floyd, et al., 2008). In clarifying the relationship between visual processing and reading, Berninger (1990) points out that these visual perceptual abilities should not be confused with the orthographic code-processing abilities important during reading. In addition, a few research studies have indicated a relationship between visual processing and higher-level math achievement, such as geometry or calculus (Hegarty & Kozhevnikov, 1999).

Spatial Relations and Picture Recognition are two of the tests that create the *Gv* cluster. Spatial Relations measures the ability to use visualization (the skill to apprehend spatial forms or shapes, often by rotating or manipulating them in the imagination of the "mind's eye"). Picture Recognition is a visual memory task.

Individuals with limited performance in one or more of the visual-spatial thinking abilities may benefit from interventions designed to develop skills in discriminating visual features, mentally manipulating visual images, matching, and recalling visual information (Greenleaf & Wells-Papanek, 2005). Students may benefit from multisensory teaching techniques that make use of multiple sensory pathways to introduce and practice the information to be learned (Williams, Richman, & Yarbrough, 1992). For example, tactile/kinesthetic activities may enhance learning by incorporating multiple senses into the instructional process. For students in grades 3 and above, cognitive-behavioral interventions (such as using private speech to initiate, direct, or maintain a behavior) (Meichenbaum, 1977) may be applied to visual-spatial tasks.

In certain instances, accommodations that compensate for limitations in visual processing may be necessary. Some example accommodations include enlarging print materials, reducing the amount of visual information the student sees at one time, providing tools to support visual tracking, reading directions aloud, making use of color coding, using a tape recorder or a note buddy to reduce the need to take notes, providing extended time or shortening assignments, and using colored lenses or overlays to enhance visual perception. It may be helpful to provide repeated exposures to printed visuals, isolate visual information that is presented (e.g., exposing only certain visual information on a page), or use auditory modalities to compensate for limitations in visual memory.

Table 1 identifies and outlines the cognitive processing requirements and related educational interventions for the other WJ III COG and DS *Gv* tests—Planning, Visual Closure, and Block Rotation.

Auditory Processing (*Ga*)

Auditory Processing (*Ga*) is a broad CHC ability that involves auditory perception (the process of extracting features from auditory stimuli) and includes a wide range of abilities that are needed to discriminate, analyze, synthesize, comprehend, and manipulate sounds. Auditory Processing is related to reading achievement in the elementary school years (Evans, et al., 2002). In particular, phonological awareness, an aspect of auditory processing, is an important prerequisite to reading competence (Adams, 1990).

Two of the tests that compose the *Ga* cluster are Sound Blending and Auditory Attention. Sound Blending is a measure of phonetic coding, and Auditory Attention measures speech-sound discrimination and resistance to auditory-stimulus distortion.

For young children, possible interventions include early exposure to sounds, music, rhythms, and language (Glazer, 1989; Strickland, 1991), reading aloud to the child (Adams, 1990; Anderson, Hiebert, Scott, & Wilkinson, 1985), providing opportunities that encourage exploration and manipulation of sounds, words, and language (Adams, 1990), and daily practice with language (Bridge, Winograd, & Haley, 1983).

For example, a young child can be taken on a “sound walk” around the house or classroom. Introduce Tommy Clock, who says, /t/-/t/-/t/; listen to the clock as it ticks. Find Furry Kitty who bites her lip and says, /f/-/f/-/f/ or Sammy Snake who says, /s/-/s/-/s/. Playing with sounds in this way will lay a foundation and get the child ready for phonics. Focus the child’s attention on the sounds that occur in the environment. The instructional objective is to get the child to imitate the sounds after they are modeled by the adult.

For school-aged children and some adolescents with limited phonemic awareness, interventions include explicit, systematic instruction in phonics (National Reading Panel, 2000), use of decodable texts for daily practice (Meyer & Felton, 1999), and books on tape to increase exposure to the sounds of language (Carbo, 1989). For example, books on tape provide opportunities to hear correct word pronunciation and prosody. This exposure will help the student develop phonological awareness as well as make the connection between sounds and printed words.

In addition, it may be beneficial to structure the student’s learning environment to reduce distracting noise and increase his or her ability to selectively attend to relevant auditory stimuli (Bellis, 2003). Accommodations could include maintaining a low noise level in the classroom or seating the student close to the primary channels of auditory information (Zentall, 1983).

Table 1 identifies and outlines the cognitive processing requirements and related educational interventions/accommodations for the other WJ III COG and DS *Ga* tests—Incomplete Words, Sound Patterns–Voice, and Sound Patterns–Music.

Fluid Reasoning (*Gf*)

Reasoning is a complex, hierarchical cognitive function that can rely on many other cognitive processes, depending on the nature and requirements of the task. Inductive and deductive reasoning are the hallmarks of this broad CHC ability. Reasoning also often relies on emergent properties; that is, those functions that cannot be predicted based on simple interactions between other functions. Nevertheless, certain narrow abilities have been identified by CHC theory based on different types of reasoning processes. Fluid Reasoning (*Gf*) is related to mathematics achievement (Floyd, et al., 2003), reading comprehension (Evans, et al., 2002), and writing ability (Floyd, et al., 2008; McGrew & Knopik, 1993).

Concept Formation (a measure of induction or inference) and Analysis-Synthesis (a measure of general sequential reasoning or deductive reasoning) are two tests that compose the *Gf* cluster. The Concept Formation task requires rule application and frequent switching from one rule to another. Analysis-Synthesis requires drawing correct conclusions from stated conditions or premises, often from a series of sequential steps. Because of its use of specific solution keys that, if followed correctly, furnish the correct answer to each test item, Analysis-Synthesis can also be described as a measure of algorithmic reasoning. In CHC theory, algorithmic reasoning is an aspect of quantitative reasoning.

Interventions that are designed to develop skills in categorization and drawing conclusions, that involve connecting new concepts to prior knowledge, that use teacher demonstrations and guided practice, and provide feedback on performance may positively influence the development of reasoning abilities (Klauer, Willmes, & Phye, 2002). Repeated opportunities to sort and classify objects are important in developing reasoning skills (Quinn, 2004). Hands-on problem-solving tasks provide opportunities to be actively engaged in learning. These tasks need to be demonstrated by a teacher using a think-aloud procedure to model the steps involved in solving the problem.

For young children, there are a variety of games designed to help develop early-reasoning skills such as matching, finding similarities and differences, and categorizing. Use of games is a fun way to actively engage a child in learning these important skills. For example, play, "I'm thinking of something _______," wherein an object is described in terms of some concept or attribute, and the child must identify the object based on questions he or she asks. Introduce the child to deductive reasoning using concrete objects, and engage him or her in the learning process. Provide repetition and review. Ask the child to verbalize what he or she has learned.

For older children and adults, interventions include cooperative learning groups and reciprocal teaching (Palincsar & Brown, 1984), graphic organizers (Marzano, et al., 2001), and metacognitive strategies (Manning & Payne, 1996; Pressley, 1990). Cooperative learning groups and reciprocal teaching are effective ways to actively engage an individual in learning and to develop reasoning skills. Use of graphic organizers, such as Venn diagrams or concept maps, can help organize the information conceptually, linking new information to known information. Teaching metacognitive strategies and then providing opportunities to practice the strategies is important in developing higher-level reasoning skills. The individual is taught to think about the task, set goals, use self-talk, monitor progress, and then reward him- or herself when the task is accomplished. These metacognitive strategies help the individual to be aware of, monitor, and control his or her learning. Some specific strategies that might be incorporated include teaching the individual to compare new concepts to previously learned concepts or to use analogies, metaphors, or similes when approaching a task (Greenleaf, 2005).

Two additional *Gf* tests are included in the WJ III COG and DS. The Number Series test measures the ability to identify and apply an analog or rule to complete a numerical sequence. The mental representations (or "number sense") that constitute this ability form the basis for the ability to learn symbols for numbers and perform simple calculations (Dehaene, 1997, 2000). Number Matrices requires a foundation in mathematics knowledge (i.e., access to the category-specific verbal and visual codes, such as knowledge of the number line). However, in Number Matrices, the verbal and/or visual codes are transcoded into analogical representations between sets of numbers. The solution to each item is obtained by mapping the relationship implied from the first part of the item onto the latter part of the item, thereby completing the analogy. Related interventions involve explicit instruction in seriation and number reasoning skills (High/Scope Educational Research Foundation, 2003; Kroesbergen & Van Luit, 2003).

Processing Speed (*Gs*)

Efficiency of cognitive processing is based partly on the speed of mental activity. For many years, cognitive speediness, or mental quickness, has been considered an important aspect of intelligence (Nettelbeck, 1994; Vernon, 1983). "In the face of limited processing resources, the speed of processing is critical because it determines in part how rapidly limited resources can be reallocated to other cognitive tasks" (Kail, 1991, p. 152). Processing Speed (*Gs*) is related to reading (Evans, et al., 2002), mathematics (Floyd, et al., 2003), and writing achievement (Floyd, et al., 2008; McGrew & Knopik, 1993).

Two of the tests that compose the *Gs* cluster are Visual Matching and Decision Speed. Visual Matching is a perceptual speed measure, and Decision Speed measures speed of semantic processing (i.e., the speed of mental manipulation of stimulus content). Perceptual speed involves making comparisons based on rapid visual searches. Decision speed of semantic processing (i.e., the speed of mental manipulation of stimulus content) requires making symbolic comparisons of concepts. In contrast to decision making based on physical comparisons, the semantic or acquired knowledge (rather than perceptual information) needed for the Decision Speed test influences the decision-making process. (Rapid Picture Naming and Pair Cancellation are also measures of processing speed.)

There is some evidence that perceptual speed, as measured in Visual Matching or Cross Out (another *Gs* test), is related to the orthographic processing required for reading. The rapid processing of visual symbols resembles the perceptual demands of reading. Research has confirmed the link between perceptual speed and reading (McGrew, 1993; McGrew, Flanagan, Keith, & Vanderwood, 1997).

Cognitive speediness can sometimes be positively influenced by repetitive practice, speed drills, and use of computer games that require an individual to quickly make decisions (Mahncke, Bronstone, & Merzenich, 2006; Tallal, et al., 1996). For example, repetition is an important factor in building speed. Repeated and extensive practice may enable a student to perform the same tasks in a more automatic fashion to increase speeded performance. Speed drills focus performance on quickly completing a task. When a student's performance on familiar tasks is timed and progress monitored, speed may increase. For example, the student might be asked to count aloud, or say the letters of the alphabet, as quickly as he or she can for 10 seconds. The number of numerals or letters named is recorded. The speed drill is repeated at regular intervals, recording the number of items named each time.

Processing speed (*Gs*) is a well-researched cognitive process that has implications for the provision of educational accommodations (Geary & Brown, 1990; Hayes, Hynd, & Wisenbaker, 1986; Kail, 1990, 1991, 2003; Kail, Hall, & Caskey, 1999; Ofiesh, 2000; Shaywitz, 2003; Wolff, Michel, Ovrut, & Drake, 1990). Accommodations that compensate for limitations in processing or perceptual speed include providing extended time, reducing the quantity of work required (breaking large assignments into two or more component assignments), eliminating or limiting copying activities, and increasing wait times both after questions are asked and after responses are given.

Short-Term Memory (*Gsm*)

Short-Term Memory (*Gsm*) is the ability to apprehend and maintain awareness of elements of information in the immediate situation (the last minute or so). It is a limited-capacity system that includes the narrow abilities of memory span and working memory. Short-Term Memory is related to reading (Evans, et al., 2002), mathematics (Floyd, et al., 2003), and writing achievement (Floyd, et al., 2008).

Numbers Reversed, a measure of working memory, and Memory for Words, a measure of memory span, are two tests in the *Gsm* cluster. Numbers Reversed requires the ability to temporarily store and orally recode presented information (a subprocess of working memory). In this test, the individual is required to repeat a series of digits backward. Memory for Words measures the span of verbal (auditory) store by requiring the individual to repeat a series of unrelated words. Memory for Sentences (another *Gsm* test) also measures the span of verbal memory, but in this test, memory is aided by context (i.e., semantic, meaning-based code).

Interventions for limitations in short-term memory include making meaningful connections between prior knowledge and new learning, rehearsal (Squire & Schacter, 2003), using mnemonics (Wolfe, 2001), and teaching chunking strategies (Hardiman, 2003).

Students with limitations in short-term memory may benefit from learning to use mnemonics to aid recall (Wolfe, 2001). Mnemonics are strategies that provide cognitive cues to enhance the encoding and recall of new information. They can be especially helpful in learning rules, patterns, and word lists. For example, the rhyme, "*i* before *e* except after *c*," is a mnemonic that is helpful in spelling.

Chunking strategies may be helpful in making more efficient use of available short-term memory by recoding the information (Hardiman, 2003). Chunking strategies enable a person to group related items into units, making the information more manageable for understanding, storage, and recall. A common example of the chunking strategy is apparent when learning a telephone number. It is much more difficult to remember 7 to 10 separate numbers than it is to learn two or three groups of numbers. For example, for most adults, it may be difficult to recall 4-6-3-9-7-1-3-5-2-8; however, most adults may find it manageable to recall this same string, in chunks, as 463-971-3528.

Finally, accommodations may be needed to compensate for limitations in short-term memory or working memory, such as keeping oral directions short and simple, asking the student to paraphrase directions to ensure understanding, and providing visual cues for directions or steps to be followed.

Summary

This bulletin describes how an understanding of the CHC broad and narrow abilities and cognitive processes is useful for developing educational interventions or accommodations. The 31 tests included in the WJ III COG and DS provide measures of seven broad abilities and several narrow abilities as defined by CHC theory. Performance on each test requires different forms of cognitive processing. The CHC abilities and constituent cognitive processes are related differentially to the development of reading, math, and writing abilities. These relationships help link cognitive assessment to instructional interventions by utilizing knowledge of the student's differentiated cognitive proficiencies to structure, augment, and individualize instructional interventions and/or suggest accommodations to an educational plan.

One criterion used by the courts in appraising the merits of an educational evaluation is whether it aided the development of the student's individual educational plan (Etscheidt, 2003). In regular and special education, the primary purpose of diagnostic assessment is to inform instruction. The WJ III COG and DS offer a strong theoretical, conceptual, and research-based foundation for linking assessment to instruction. WJ III COG and DS provide professionals with a core set of measures needed to conduct a comprehensive educational evaluation that not only helps explain why a student may or may not have responded to prior instruction, but also provides a framework for developing and implementing evidence-based, individualized educational interventions or accommodations.

References

Adams, M. J. (1990). *Beginning to read: Thinking and learning about print.* Cambridge, MA: MIT Press.

Anders, P., & Bos, C. (1986). Semantic feature analysis: An interactive strategy for vocabulary development and text comprehension. *Journal of Reading*, *9*(7), 610–616.

Anderson, R. C. (1996). Research foundations to support wide reading. In V. Greaney (Ed.), *Promoting reading in developing countries* (pp. 55–77). Newark, DE: International Reading Association.

Anderson, R. C., Hiebert, E. H., Scott, J. A., & Wilkinson, I. A. G. (1985). *Becoming a nation of readers: The report of the Commission on Reading*. Washington, DC: The National Institute of Education.

Anderson, R. C., & Nagy, W. E. (1992). The vocabulary conundrum. *American Educator*, *16*, 14–18, 44–47.

Anderson, R. C., & Pearson, P. D. (1984). A schema-theoretic view of basic processes in reading. In P. D. Pearson, R. Barr, M. L. Kamil, & P. Mosenthal (Eds.), *Handbook of reading research* (Vol. 1, pp. 255–291). White Plains, NY: Longman.

Anglin, J. M. (1993). Vocabulary development: A morphological analysis. *Monographs of the Society for Research in Child Development*, *58*(10, Serial No. 238).

Baumann, J. F., Edwards, E. C., Boland, E. M., Olejnik, S., & Kame'enui, E. J. (2003). Vocabulary tricks: Effects of instruction in morphology and context on fifth-grade students' ability to derive and infer word meanings. *American Educational Research Journal*, *40*(2), 447–494.

Baumann, J. F., & Kame'enui, E. J. (1991). Research on vocabulary instruction: Ode to Voltaire. In J. Flood, J. M. Jensen, D. Lapp, & J. R. Squire (Eds.), *Handbook of research on teaching the English language arts* (pp. 604–632). New York: Macmillan.

Baumann, J. F., Kame'enui, E. J., & Ash, G. E. (2003). Research on vocabulary instruction: Voltaire redux. In J. Flood, D. Lapp, J. R. Squire, & J. M. Jensen (Eds.), *Handbook on research on teaching the English language arts* (2nd ed., pp. 752–785). Mahwah, NJ: Erlbaum.

Beck, I. L., & McKeown, M. G. (2001). Text talk: Capturing the benefits of read-aloud experiences for young children. *The Reading Teacher*, *55*, 10–20.

Beck, I. L., McKeown, M. G., & Kucan, L. (2002). *Bringing words to life: Robust vocabulary instruction*. New York: Guilford.

Bellis, T. J. (2003). *Assessment and management of central auditory processing disorders in the educational setting from science to practice.* Clifton Park, NY: Thomson.

Berninger, V. W. (1990). Multiple orthographic codes: Key to alternative instructional methodologies for developing the orthographic phonological connections underlying word identification. *School Psychology Review*, *19*(4), 518–533.

Blachowicz, C., & Fisher, P. (2000). Vocabulary instruction. In M. L. Kamil, P. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research*: *Vol. 3* (pp. 503–523). Mahwah, NJ: Erlbaum.

Bridge, C. A., Winograd, P. N., & Haley, D. (1983). Using predictable materials vs. preprimers to teach beginning sight words. *The Reading Teacher*, *36*(9), 884–891.

Carbo, M. (1989). *How to record books for maximum reading gains.* Roslyn Heights, NY: National Reading Styles Institute.

Carlisle, J. F. (2004). Morphological processes influencing literacy learning. In C. A. Stone, E. R. Silliman, B. J. Ehren, & K. Apel (Eds.), *Handbook on language and literacy: Development and disorders* (pp. 318–339). New York: Guilford.

Carroll, J. B. (1987). New perspectives in the analysis of abilities. In R. R. Ronning, J. A. Glover, J. C. Conoley, & J. C. Witt (Eds.), *The influence of cognitive psychology on testing* (pp. 267–284). Mahwah, NJ: Erlbaum.

Carroll, J. B. (1990). Estimating item and ability parameters in homogeneous tests with the person characteristic function. *Applied Psychological Measurement*, *14*(2), 109–125.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytic studies*. New York: Cambridge University Press.

Carroll, J. B. (2003). The higher-stratum structure of cognitive abilities: Current evidence supports g and about ten broad factors. In H. Nyborg (Ed.), *The scientific study of general intelligence: Tribute to Arthur R. Jensen* (pp. 5–22). New York: Pergamon.

Cattell, R. B. (1941). Some theoretical issues in adult intelligence testing. *Psychological Bulletin*, *38*, 592.

Cattell, R. B. (1943). The measurement of adult intelligence. *Psychological Bulletin*, *40*, 153–193.

Cattell, R. B. (1950). *Personality: A systematic theoretical and factoral study.* New York: McGraw-Hill.

Cunningham, A. E., & Stanovich, K. E. (1991). Tracking the unique effects of print. *Journal of Educational Psychology*, *83*, 264–274.

Davidson, J., Elcock, J., & Noyes, P. (1996). A preliminary study of the effect of computer-assisted practice on reading attainment. *Journal of Research in Reading*, *19*(2), 102–110.

Dehaene, S. (1997). *The number sense*. New York: Oxford University Press.

Dehaene, S. (2000). Cerebral bases of number processing and calculation. In M. S. Gazzaniga (Ed.), *The new cognitive neurosciences* (2nd ed., pp. 987–998). Cambridge, Mass: MIT Press.

Etscheidt, S. (2003). Ascertaining the adequacy, scope, and utility of district evaluations. *Exceptional Children, 69,* 227–247.

Evans, J. J., Floyd, R. G., McGrew, K. S., & Leforgee, M. H. (2002). The relations between measures of Cattell-Horn-Carroll (CHC) cognitive abilities and reading achievement during childhood and adolescence. *School Psychology Review*, *31*(2), 246–262.

Floyd, R. G., Evans, J. J., & McGrew, K. S. (2003). Relations between measures of Cattell-Horn-Carroll (CHC) cognitive abilities and mathematics achievement across the school-age years. *Psychology in the Schools, 40*(2), 155–171.

Floyd, R. G., McGrew, K. S., & Evans, J. J. (2008). The relative contribution of the Cattell-Horn-Carroll cognitive abilities in explaining writing achievement during childhood and adolescence. *Psychology in the Schools*, *45,* 132–144.

Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (1998). *Cognitive neuroscience: The biology of the mind.* New York: Norton.

Geary, D. D., & Brown, S. C. (1990). Cognitive addition: Strategy choice and speed-of-processing differences in gifted, normal, and mathematically disabled children. *Developmental Psychology, 27*, 398–406.

Glazer, S. M. (1989). Oral language and literacy. In D. S. Strickland & L. M. Morrow (Eds.), *Emerging literacy: Young children learn to read and write* (pp. 16–26). Newark, DE: International Reading Association.

Graves, M. F. (2000). A vocabulary program to complement and bolster a middle-grade comprehension program. In B. M. Taylor, M. F. Graves, & P. van den Broek (Eds.), *Reading for meaning: Fostering comprehension in the middle grades* (pp. 116–135). New York: Teachers College Press.

Graves, M. F., Juel, C., & Graves, B. B. (2004). *Teaching reading in the 21st century* (3rd ed.). Boston: Allyn & Bacon.

Graves, M. F., & Watts-Taffe, S. (2002). The role of word consciousness in a research-based vocabulary program. In A. Farstrup & S. J. Samuels (Eds.), *What research has* *to say about reading instruction* (pp. 140–165). Newark, DE: International Reading Association.

Greenleaf, R. K. (2005). *Brain based teaching*. Newfield, ME: Greenleaf & Papanek Publications.

Greenleaf, R. K., & Wells-Papanek, D. (2005). *Memory, recall, the brain & learning*. Newfield, ME: Greenleaf & Papanek Publications.

Gunn, B. K., Simmons, D. C., & Kame'enui, E. J. (1995). *Emergent literacy: A synthesis of the research*. Eugene, OR: The National Center to Improve the Tools of Educators.

Hardiman, M. M. (2003). *Connecting brain research with effective teaching*. Lanham, MD: Rowman & Littlefield Education.

Hart, B., & Risley, T. R. (2003). The early catastrophe: The 30 million word gap by age 3. *American Educator*, 22, 4–9.

Hayes, F. B., Hynd, G. W., & Wisenbaker, J. (1986). Learning disabled and normal college students' performance on reaction time and speeded classification tasks. *Journal of Educational Psychology*, *78*, 39–43.

Hegarty, M., & Kozhevnikov, M. (1999). Types of visual-spatial representations and mathematical problem-solving. *Journal of Educational Psychology, 91*(4), 684–689.

Herman, P. A., Anderson, R. C., Pearson, P. D., & Nagy, W. E. (1987). Incidental acquisition of word meanings from expositions with varied text features. *Reading Research Quarterly*, *23*, 263–284.

High/Scope Educational Research Foundation. (2003). *Classification, seriation, and number.* Ypsilanti, MI: High/Scope Press.

Horn, J. L. (1965). *Fluid and crystallized intelligence.* Unpublished doctoral dissertation, University of Illinois, Urbana–Champaign.

Horn, J. L. (1988). Thinking about human abilities. In J. R. Nesselroade & R. B. Cattell (Eds.), *Handbook of multivariate psychology* (2nd ed., pp. 645–865). New York: Academic Press.

Horn, J. L. (1989). Models for intelligence. In R. Linn (Ed.), *Intelligence: Measurement, theory and public policy* (pp. 29–73). Urbana, IL: University of Illinois Press.

Horn, J. L. (1991). Measurement of intellectual capabilities: A review of theory. In K. S. McGrew, J. K. Werder, & R. W. Woodcock, *WJ-R technical manual* (pp. 197–232). Rolling Meadows, IL: Riverside Publishing.

Horn, J. L., & Stankov, L. (1982). Auditory and visual factors of intelligence. *Intelligence*, *6*, 165–185.

Johnson, D. D., & Pearson, P. D. (1984). *Teaching reading vocabulary.* New York: Holt, Rinehart and Winston.

Kail, R. (1990). More evidence for a common, central constraint on speed of processing. In J. Enns (Ed.), *Advances in psychology: Vol. 69. The development of attention: Research & theory* (pp. 159–173). Amsterdam: Elsevier.

Kail, R. (1991). Development of processing speed in childhood and adolescence. *Advances in Child Development and Behavior, 23,* 151–184.

Kail, R. (2003). Information processing and memory. In M. Bornstein & L. Davidson (Eds.), *Well being: Positive development across the lifespan* (pp. 269–279). Mahwah, NJ: Erlbaum.

Kail, R., Hall, L. K., & Caskey, B. J. (1999). Processing speed, exposure to print, and naming speed. *Applied Psycholinguistics*, *20*, 303–314.

Klauer, K. J., Willmes, K., & Phye, G. D. (2002). Inducing inductive reasoning: Does it transfer to fluid intelligence? *Contemporary Educational Psychology, 27*, 1–25.

Kroesbergen, E. H., & Van Luit, J. E. H. (2003). Mathematical interventions for children with special educational needs. *Remedial and Special Education*, *24*, 97–114.

Mahncke, H. W., Bronstone, A., & Merzenich, M. M. (2006). Brain plasticity and functional losses in the aged: Scientific bases for a novel intervention. *Progress in Brain Research*, *157*, 81–109.

Manning, B., & Payne, B. (1996). *Self-talk for teachers and students: Metacognitive strategies for personal and classroom use*. Boston: Allyn & Bacon.

Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001). *Classroom instruction that works.* Alexandria, VA: Association for Supervision and Curriculum Development.

McGrew, K. S. (1993). The relationship between the WJ-R *Gf-Gc* cognitive clusters and reading achievement across the lifespan. *Journal of Psychoeducational Assessment* (Monograph Series: WJ-R Monograph), 39–53.

McGrew, K. S. (2005). The Cattell-Horn-Carroll theory of cognitive abilities: Past, present, and future. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (2nd ed., pp. 136–182). New York: Guilford.

McGrew, K. S., Flanagan, D. P., Keith, T. Z., & Vanderwood, M. (1997). Beyond *g*: The impact of *Gf-Gc* specific cognitive abilities research on the future use and interpretation of intelligence tests in the schools. *School Psychology Review, 26,* 177–189.

McGrew, K. S., & Knopik, S. N. (1993). The relationship between the WJ-R *Gf-Gc* cognitive clusters and writing achievement across the life-span. *School Psychology Review, 22*(4), 687–695.

McGrew, K. S., Schrank, F. A., & Woodcock, R. W. (2007). Technical Manual. *Woodcock-Johnson III Normative Update*. Rolling Meadows, IL: Riverside Publishing.

Meichenbaum, D. H. (1977). *Cognitive-behavior modification: An integrative approach.* New York: Plenum Press.

Meyer, M. S., & Felton, R. H. (1999). Repeated reading to enhance fluency: Old approaches and new directions. *Annals of Dyslexia*, *49*, 283–306.

Nagy, W. E., & Scott, J. A. (2000). Vocabulary processes. In M. L. Kamil, P. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research: Vol. 3* (pp. 269–284). Mahwah, NJ: Erlbaum.

National Reading Panel. (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction.* Washington, DC: National Institute of Child Health and Human Development.

Nettelbeck, T. (1994). Speediness. In R. J. Sternberg (Ed.), *Encyclopedia of human intelligence* (pp. 1014–1019). New York: Macmillan.

Ofiesh, N. S. (2000). Using processing speed tests to predict the benefit of extended test time for university students with learning disabilities. *Journal of Postsecondary Education and Disability*, *14*, 39–56.

Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, *2*, 117–175.

Pittelman, S. D., Heimlich, J. E., Berglund, R. L., & French, M. P. (1991). *Semantic feature analysis: Classroom applications.* Newark, DE: International Reading Association.

Pressley, M. (1990). *Cognitive strategy instruction that really improves children's academic performance.* College Park, MD: University of Maryland, College of Education.

Quinn, P. C. (2004). Development of subordinate-level categorization in 3- to 7-month-old infants. *Child Development*, *75*(3), 886–899.

Scarborough, H. S. (1998). Predicting the future achievement of second graders with reading disabilities: Contributions of phonemic awareness, verbal memory, rapid naming, and IQ. *Annals of Dyslexia, 48*, 115–136.

Schrank, F. A. (2006). *Specification of the cognitive processes involved in the performance on the Woodcock-Johnson III* (Assessment Service Bulletin No. 7). Rolling Meadows, IL: Riverside Publishing.

Shaywitz, S. (2003). *Overcoming dyslexia: A new and complete science-based program for overcoming reading problems at any level*. New York: Alfred Knopf.

Sinatra, R. C., Berg, D., & Dunn, R. (1985). Semantic mapping improves reading comprehension of learning-disabled students. *Teaching Exceptional Children*, *17*(4), 310–314.

Squire, L. R., & Schacter, D. L. (2003). *Neuropsychology of memory* (3rd ed.). New York: Guilford.

Stahl, S. A. (1999). *Vocabulary development.* Cambridge, MA: Brookline Books.

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly*, *21*, 360–407.

Strickland, D. S. (1991). Emerging literacy: How young children learn to read. In B. Persky & L. H. Golubchick (Eds.), *Early childhood education* (2nd ed., pp. 337–344). Lanham, MD: University Press of America.

Strickland, D. S., & Feeley, J. T. (1991). Development in the early school years. In J. Flood, J. M. Jensen, D. Lapp, & J. R. Squire (Eds.), *Handbook of research on teaching the English language arts* (pp. 529–535). New York: Macmillan.

Tallal, P., Miller, S. L., Bedi, G., Byma, G., Wang, X., Nagarajan, S. S., Schreiner, C., Jenkins, W. M., & Merzenich, M. M. (1996). Language comprehension in language-learning impaired children improved with acoustically modified speech. *Science*, *5*(271), 81–84.

Vernon, P. A. (1983). Speed of information processing and general intelligence. *Intelligence, 7,* 53–70.

Wiig, E. H., & Semel, E. M. (1984). *Language assessment and intervention for the learning disabled* (2nd ed.). Columbus, OH: Charles E. Merrill.

Williams, J. K., Richman, L. C., & Yarbrough, D. B. (1992). Comparison of visual-spatial performance strategy training in children with Turner syndrome and learning disabilities. *Journal of Learning Disabilities*, *25*, 658–664.

Wolf, M., Bowers, P. G., & Biddle, K. (2000). Naming-speed processes, timing, and reading: A conceptual review. *Journal of Learning Disabilities, 33*(4), 387–407.

Wolfe, P. (2001). *Brain matters*. Alexandria, VA: Association for Supervision and Curriculum Development.

Wolff, P. H., Michel, G. F., Ovrut, M., & Drake, C. (1990). Rate and timing precision of motor coordination in developmental dyslexia. *Developmental Psychology*, *26*, 349–359.

Wong, B. Y. L., Harris, K. R., Graham, S., & Butler, D. L. (2003). Cognitive strategy instruction research in learning disabilities. In H. L. Swanson, K. R. Harris, & S. Graham (Eds.), *Handbook of Learning Disabilities* (pp. 383–402). New York: Guilford.

Woodcock, R. W. (1998). Extending *Gf-Gc* theory into practice. In J. J. McArdle & R. W. Woodcock (Eds.), *Human cognitive abilities in theory and practice* (pp. 137–156). Mahwah, NJ: Erlbaum.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001, 2007). *Woodcock Johnson III Tests of Cognitive Abilities*. Rolling Meadows, IL: Riverside Publishing.

Woodcock, R. W., McGrew, K. S., Mather, N., & Schrank, F. A. (2003, 2007). *Woodcock Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities.* Rolling Meadows, IL: Riverside Publishing.

Zentall, S. S. (1983). Learning environments: A review of physical and temporal factors. *Exceptional Education Quarterly*, *4*(2), 10–15.

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