

# Areas of Processing Deficit and Their Link to Areas of Academic Achievement

## Phonological Processing Model

Wagner, R.K., Torgesen, J.K., & Rashotte, C.A. (1999). Comprehensive Test of Phonological Processing. Austin, TX: PRO-ED; Wagner, R.K., Torgesen, J.K., & Rashotte, C.A. (1994). Development of reading-related phonological processing abilities: New evidence of bi-directional causality from a latent variable longitudinal study. *Developmental Psychology*, 30, 73-87; Wagner, R.K., & Torgesen, J.K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin*, 101, 192-212.

### Overview

The past decade has witnessed a profound advancement in the understanding of phonological processing – the kind of auditory processing that is most strongly related to mastery of written language (reading and writing), and is clearly implicated as the most common cause of reading disabilities. Phonological awareness, phonological memory, and rapid naming represent three correlated, yet distinct kinds of phonological processing abilities. Deficits in phonological awareness, phonological memory, and/or rapid naming are common in children with reading disabilities. These deficits appear to be the root of many decoding difficulties faced by individuals with reading disabilities.

### Definition of Phonological Core Deficit

Phonological core deficits entail difficulties making use of phonological information when processing written or oral language. The major components of phonological deficits involve phonemic awareness (one's understanding of and access to the sound structure of language), sound-symbol relationships, and storage and retrieval of phonological information in memory.

### Three Kind of Phonological Processing

**Phonological Awareness:** Phonological awareness refers to an individual's awareness of and access to the sound structure of his/her oral language. This awareness proceeds from word length phonological units in compound words (e.g., cowboy), to syllables within words, to onset-rimes units within syllables to individual phonemes within rimes, and finally to individual phonemes within consonant clusters.

**Phonological Memory:** Phonological memory refers to coding information phonologically for temporary storage in working memory. A deficient phonological memory does not appear to impair either reading or listening to a noticeable extent, provided the words involved are already in the individual's vocabulary. However, phonological memory impairments can constrain the ability to learn new written or spoken vocabulary.

**Rapid Naming:** Rapid naming of objects, colors, digits, or letters requires efficient retrieval of phonological information from long-term memory. The efficiency with which individuals are able to retrieve phonological codes associated with individual phonemes, word segments, or entire words should influence the degree to which phonological information is useful in decoding printed words. Measures of rapid naming require speed and processing of visual as well as phonological information. The skills involved

include efficient retrieval of phonological information from long-term memory and executing a sequence of operations quickly and repeatedly.

**Double Deficit Hypothesis:** It has been hypothesized that individuals who have double deficits – that is, deficits in both rapid naming and phonological awareness – appear to have greater difficulties learning to read than do individuals with deficits in either rapid naming or phonological awareness alone.

### **Link to Achievement**

**Reading:** Deficits in phonological awareness are viewed as the hallmark of basic word reading disabilities. It is, however, the most responsive to intervention of the phonological processing skill areas. Phonological awareness skills should proceed from sensitivity to same verses, different or phonological segments, to an ability to identify and count phonological segments, to an ability to manipulate phonological segments.

Storage of phonological information during reading involves creating a sound-based representation of written words in working memory. Deficits in storage of phonological information result in faulty representations in memory, which lead to inaccurate application of sound rules during reading tasks. A deficit in phonological memory does not inevitably lead to poor reading of familiar material, but is more likely to impair decoding of new words, particularly words that are long enough to decode bit by bit as a means of storing intermediate sounds. A deficit in phonological memory may impair reading comprehension for more complex sentences.

Naming facility or “rapid automatic naming” is very important to reading achievement. Retrieval of phonological information from long-term memory refers to how the child remembers pronunciations of letters, word segments, or entire words. Reading disabled children may have difficulty in this area, which leads to slow and inaccurate recall of phonological codes from memory. Efficient retrieval of phonological information and execution of sequences of operations are required when readers attempt to decode unfamiliar words. Deficits in this area often result in difficulties with reading fluency.

**Math:** Some literature suggests that phonological deficits may be related to math disabilities. Phonological processing problems have been associated with difficulties memorizing basic math facts. The research, however, is not conclusive.

**Written Expression:** Phonological awareness provides students with an important tool for understanding the link between written and spoken language. Phonological memory impairments can constrain the ability to learn new written vocabulary.

**Oral Language:** Phonological memory impairments can constrain the ability to learn new oral vocabulary. It is likely to impair listening comprehension for complex sentences.

# Carroll-Horn –Cattell (CHC) Theory of Cognitive Processing

The following information was adapted from:

Flanagan, D. P., Ortiz, S. O., Alfonso, V. C. & Mascolo (2002). *The Achievement Test Desk Reference: Comprehensive Assessment and Learning Disabilities*. Boston: Allyn & Bacon.  
Flanagan, D. P., & Ortiz, S. O. (2001). *Essentials of the cross battery approach*. New York: Wiley.. Flanagan, D. P., McGrew, K.S. & Ortiz, S. O. (2000). *The Weschler intelligence scale s and Gf-Gc theory: A contemporary approach to interpretation*. Boston: Allyn & Bacon.

## Fluid Reasoning

### Technical Definition

Fluid reasoning is the ability to use and engage in various mental operations when faced with a relatively novel task that cannot be performed automatically. It includes the ability to discover the underlying characteristic that governs a problem or set of materials, the ability to start with stated rules, premises, or conditions, and engage in one or more steps to reach a solution to a problem. It also affects the ability to reason inductively and deductively with concepts involving mathematical relations and properties.

### User Friendly Description

Fluid Reasoning refers to a type of thinking that an individual may use when faced with a relatively new task that cannot be performed automatically. This type of thinking includes such things as forming and recognizing concepts (e.g., how are a dog, cat, and cow alike?), identifying and perceiving relationships (e.g., *sun is to morning as moon is to night*), drawing inferences (e.g., after reading a story, answer the question), and reorganizing or transforming information. Overall, this ability can be thought of as a problem-solving type of intelligence.

### Link to Achievement

**Reading:** Fluid reasoning or reasoning abilities have been shown to play a moderate role in reading. For example, the ability to reach general conclusions from specific information is important for reading comprehension.

**Math:** Fluid reasoning is related to mathematical activities at all ages. For example, figuring out how to set up math problems by using information in a word problem is important for math reasoning.

**Written Expression:** Fluid Reasoning skills are related to basic writing skills primarily in the elementary school years and are consistently related to written expression at all ages.

## **Crystallized Intelligence** (Comprehension Knowledge or Verbal Comprehension)

### **Technical Definition**

Crystallized intelligence is the breadth and depth of a person's acquired knowledge of a culture and the effective application of this knowledge. It includes general language development or the understanding of words, sentences, and paragraphs (not requiring reading) in spoken native language, the extent of vocabulary that can be understood in terms of correct word meanings, the ability to listen to and comprehend oral communication, the range of general concepts, and the range of cultural knowledge (e.g., music, art).

### **User Friendly Description**

Crystallized abilities refer to a person's knowledge base (or general fund of information) that has been accumulated over time. It involves knowledge of one's culture, as well as verbal or language-based knowledge that has been developed during general life experiences and formal schooling.

### **Link to Achievement**

**Reading:** Crystallized abilities, especially one's language development, vocabulary knowledge, and the ability to listen are important for reading. This ability is related to reading comprehension in particular. Low crystallized abilities may hamper an individual's ability to comprehend written text due to a lack of vocabulary knowledge, basic concepts, and general life experiences that are needed to understand the text.

**Math:** Crystallized abilities, including language development, vocabulary knowledge, and listening abilities are important to math achievement at all ages. These abilities become increasingly more important with age. Low crystallized abilities may hamper an individual's ability to comprehend word problems due to a lack of vocabulary knowledge. They may hamper one's ability to learn basic math processes, such as long division, due to impairments in one's ability to listen to and follow sequential directions.

**Written Expression:** Crystallized abilities, such as language development, vocabulary knowledge, and general information are important to writing achievement primarily after age seven (7). These abilities become increasingly more important with age.

**Oral Language:** Crystallized abilities, especially one's language development, vocabulary knowledge, and the ability to listen are important for both listening comprehension and oral expression. Low crystallized abilities may hamper an individual's ability to comprehend oral communications due to a lack of vocabulary knowledge, basic concepts, and general life experiences that are needed to understand the information being presented.

## Visual Processing

### **Technical Definition**

Visual Processing is the ability to generate, perceive, analyze, synthesize, manipulate, transform, and think with visual patterns and stimuli. It includes the ability to perceive and manipulate visual patterns rapidly or to maintain orientation with respect to objects in space; the ability to manipulate objects or visual patterns mentally and to “see” how they would appear under altered conditions; the ability to combine disconnected, vague, or partially obscured visual stimuli or patterns quickly into a meaningful whole, without knowing in advance what the pattern is. It also includes the ability to survey a spatial field or pattern accurately and quickly, and identify a path through the visual field or pattern; the ability to form and store mental representations or images of visual stimulus and then recognize or recall it later; the ability to identify a visual pattern embedded in a complex visual array, when knowing in advance what the pattern is; and the ability to identify a pictorial or visual pattern when parts of the pattern are presented rapidly in order.

### **User Friendly Description**

Visual processing is an individual’s ability to think about visual patterns and visual stimuli (e.g., What is the shortest route from your house to school?). This type of cognitive processing ability also involves the ability to generate, perceive, analyze, synthesize, manipulate, and transform visual patterns and stimuli (e.g., Draw a picture of how this shape would look if I turned it upside-down.). Additionally, examples of this type of ability include putting puzzles together, completing a maze, and interpreting graphs or charts.

### **Link to Achievement**

**Math:** Visual Processing may be important for tasks that require abstract reasoning or mathematical skills.

## Short-Term Memory

### **Technical Definition**

Short-term memory is the ability to apprehend and hold information in immediate awareness and then use it within a few seconds. Working memory, a subcomponent of short-term memory, includes the ability to attend to and immediately recall temporally ordered elements in corrected order after a single presentation, as well as the ability to store temporarily and perform a set of cognitive operations on information that requires divided attention.

### **User Friendly Description**

Short-term memory is the ability to hold information in one’s mind and then use it within a few seconds. A component of short-term memory is working memory. Working memory relates to an individual’s ability to attend to verbally- or visually-presented information, to process information in memory, and then to formulate a response. Difficulties with working memory may make the processing of complex information more time-consuming, draining a student’s mental energies more quickly and perhaps result in more frequent errors on a variety of tasks.

### **Link to Achievement**

**Reading:** Short-term memory is important to reading achievement. Reading comprehension, involving long reading passages, may be affected by skills specifically related to working memory. Basic word reading may be impacted by deficits in short-term memory because it may interfere with acquiring letter and word identification skills.

**Math:** Short-term memory is important to math computation skills. For example, deficits in short-term memory may impact one's ability to remember a sequence of orally presented steps required to solve long math problems (i.e., first multiply, then add, then subtract).

**Written Expression:** Short-term memory is important to writing. Memory span is especially important to spelling skills, where working memory has shown relations with advanced writing skills (e.g., written expression).

**Oral Language:** A student with short-term memory deficits may have problems following oral directions because they are unable to retain the information long enough to be acted upon. A student with short-term memory deficits also may have problems with oral expression because of difficulties with word-find or being unable to retain information long enough to verbally express it.

## **Long-Term Retrieval**

### **Technical Definition**

Long-term retrieval is the ability to store information (e.g., concepts, ideas, items or names) in long-term memory and to retrieve it later fluently through association. It includes the ability to recall part of a previously learned unrelated pair of items when the other part is presented (i.e., paired-associative learning); the ability to produce rapidly a series of ideas, words, or phrases related to specific conditions or objects; the ability to draw or sketch several examples or elaborations rapidly when given a starting visual stimulus; and the ability to produce names for concepts rapidly. It also includes the ability to recall as many unrelated items as possible in any order after a large collection of items is presented; and the ability to recall a set of items where there is a meaningful relationship between items or the items create a meaningful connected discourse.

### **User Friendly Description**

Long-term retrieval refers to an individual's ability to take and store a variety of information (e.g., ideas, names, concepts) in one's mind, and then later retrieve it quickly and easily at a later time using association. This ability does not represent what is stored in long-term memory. Rather, it represents the process of storing and retrieving information.

### **Link to Achievement**

**Reading:** Long-term retrieval abilities are particularly important for reading. For example, elementary school children who have difficulty naming objects or categories of objects rapidly may have difficulty in reading. Associative memory abilities also play a role in reading achievement (i.e., being able to associate a letter shape to its name and its sound).

**Math:** Long-term retrieval abilities are important to math calculation skills. For example, students with deficits in long-term retrieval may have difficulty recalling basic addition, subtraction, multiplication, and/or division facts when encountered within a math problem.

**Written Expression:** Long-term retrieval abilities and naming facility in particular have demonstrated relations with written expression, primarily with the fluency aspect of writing.

## **Auditory Processing**

### **Technical Definition**

Auditory processing is the ability to perceive, analyze, and synthesize patterns among auditory stimuli. It includes the ability to process sounds, as in identifying, isolating, and analyzing sounds; the ability to process speech sounds, as in identifying, isolating, and blending or synthesizing sounds; and the ability to detect differences in speech sounds under conditions of little distraction or distortion.

### **User Friendly Description**

Auditory processing refers to the ability to perceive, analyze, and synthesize a variety of auditory stimuli (e.g., sounds).

### **Link to Achievement**

**Reading:** Auditory processing or “phonological awareness/processing” is very important to reading achievement or reading development. Students who have difficulty with processing auditory stimuli may experience problems with learning grapheme-to-phoneme correspondence, reading non-sense words, and decoding words due to an inability to segment, analyze, and synthesize speech sounds. Older students will usually have continued problems with decoding unfamiliar words.

**Written Expression:** Auditory processing is also very important for both writing skills and written expression. Students who are weak in auditory processing abilities may have difficulty spelling since this skill requires the ability to attend to the detailed sequence of sounds in words.

**Oral Language:** Auditory processing deficits may be linked to academic difficulties with listening comprehension. Students may have difficulty interpreting lectures, understanding oral directions, and learning a foreign language.

# Processing Speed

## **Technical Definition**

Processing speed is the ability to perform cognitive tasks fluently and automatically, especially when under pressure to maintain focused attention and concentration. It includes the ability to search for and compare visual symbols rapidly, when presented side-by-side or separated in a visual field; the ability to perform tests that are relatively easy or that require very simple decisions rapidly; and the ability to manipulate and deal with numbers rapidly and accurately.

## **User Friendly Description**

Processing speed provides a measure of an individual's ability to process simple or routine visual information quickly and effectively and to quickly perform tasks based on that information. When information is processed slowly, competing stimuli in immediate awareness may cause overload stress on short-term memory. Tasks that involve multiple, complex processes can be particularly confusing and frustrating. Completing tests and assignments within the usual time constraints can also be difficult even when the student has adequate skills and knowledge.

## **Link to Achievement**

**Reading:** Perceptual speed is important during all school years, particularly the elementary school years. Slow processing speed may impact upon reasoning skills since the basic rapid process of symbols (e.g., letters) is often necessary for fluent reading.

**Math:** Processing speed is important to math achievement during all school years, particularly the elementary school years. Slow processing speed leads to a lack of automaticity in basic math operations (e.g., addition, subtraction, and multiplication).

**Written Expression:** Perceptual speed is important during all school years for basic writing and related to all ages for written expression.



# Neuropsychological Functional Approach

The following information was adapted from Korkman, M., Kirk, U., & Kemp, S. (1998). *The NEPSY Manual*. The Psych Corporation

## Attention/Executive Functions

Attention involves the regulation of arousal and vigilance, selective attention, sustained attention, attention span, as well as inhibition and control of behavior. Executive functioning allows for the planning and implementation of complex tasks. In so doing, one is able to monitor performance and correct errors while simultaneously maintaining awareness of task relevant information in the presence of irrelevant information. These abilities are essential to virtually all areas of academic performance.

## Language Functions

Language functions include phonological processing, receptive language comprehension, understanding of the syntactic structure of language, automaticity with which semantic memory can be accessed (naming) and ease and facility of language production. Cognitive processing deficits in this area may be related to difficulty recognizing phonological segments of words, difficulty in decoding, difficulty in word find or naming (accessing semantic memory automatically), and language comprehension. Academic areas affected by these weaknesses would include basic reading skills, reading comprehension, written expression, listening comprehension, oral expression, and math reasoning where the math problem is encoded in language.

## Sensory Functions

Sensory functions are those functions or systems that mediate or bring about the production of speed, smooth and efficient limb and whole body movement, and dexterous movements of the hands and fingers, as well as systems that mediate equilibrium and sensory input at the tactile level and eye movement. Deficits in these areas are primarily related to math calculations and penmanship. Some studies have reported significant correlations between performance on finger discrimination and reading ability.

## Visuospatial Processing

Visuospatial processing could be succinctly defined as visual comprehension, problem solving, and reasoning. It consists of many distinct but interrelated subcomponents, (e.g. visualization, location, directionality, copying, rotating objects mentally, understanding symbolic representations of external space, etc.). Deficits in these processing abilities have been associated with difficulties performing math calculations that present the student with numbers, charts, and math signs, as well as penmanship.

## Memory and Learning

Memory includes the ability to encode, store, and retrieve verbal and nonverbal information. While classic definitions of learning may be viewed as synonymous with memory, psychologists frequently view learning as changes in the amount of information remembered from one trial to the next. Specific memory problems appear to be rare in children with developmental learning disorders. Memory problems occur more frequently as secondary deficits in attention, verbal processing and visual perception, or are a function of low global intelligence. Nevertheless, children with reading disabilities frequently have limited auditory memory span.