Best practices and what we’ve (I’ve) learned the past 25 years.

Kevin S. McGrew, PhD.
Acquired knowledge systems – \( Gc, Grw, Gq, Gkn \).

\( Gsm \) is renamed as \( Gwm \)

\( Ga \) and \( Glr \) both deserve more prominent placement at the CHC round table of CHC cognitive abilities.

\( Gf \) and \( Gq \) – where does numerosity or number sense fit?

\( Gv \) and \( Gwm \) – where does visual working memory fit?
• Problems with the concept of “normative” strengths and weaknesses

• Metrics of relative standing (PR/SS) vs metrics of “real world” levels of functioning (RPI)

• Myth of IQ-score based expectancies/consistencies (Forrest Gump)

• Scales scores (10 + 3) are crude metrics that can lead to erroneous conclusions (when used in discrepancy calculations or when creating pseudo-composite average SS’s)
- Problems with computing pseudo-composite scores from averages of scaled scores or standard scores

- 1.5 SD of difference/discrepancy scores ≠ 23 pts

- Highly correlated IQ tests will often give different results and this is to be expected
  - $SD\ (diff)$
  - IQ Battery DNA Fingerprint Comparisons

Let's select a topic from the wheel of psychometric fortune (misfortune)?
**Attentional Control (Gwm-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.

**Memory for Sound Patterns (Ga-UM).** Ability to retain (on a short-term basis) auditory codes such as tones, tonal patterns, or speech sounds.

**Word Fluency (Glr-FW).** 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 non-semantic features (e.g., fluency of retrieval of words starting with the letter “T”).

**Speed of Lexical Access (Glr-LA).** Ability to rapidly and fluently retrieve words from an individual's lexicon; verbal efficiency or automaticity of lexical access.
This figure is a revised version of Schneider & McGrew's (2012) contemporary CHC model description.
Proposed changes in functional and conceptual organization of broad CHC ability domains.
Gsm has been renamed Gwm at the round table of cognitive CHC abilities

During the past two decades, and the last decade in particular, cognitive neuroscience has indicated that the more narrow Gsm definition was outdated and incorrect (Dehn, 2008).

Working memory refers to a dynamic, temporary storage system that allows information to be held immediate awareness and be manipulated.

Working memory 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.

Short-term memory refers to tasks that involve significant storage but only minimal processing or manipulation.
**Glr:** The ability to store, consolidate, and retrieve information over periods of time measured in minutes, hours, days and years.

Glr differs from acquired knowledge systems (Gc, Grw, Gq, Gkn) in that it includes the processes of memory.

Major implied Glr division made more explicit based on post-Carroll (1993) research. Learning efficiency (level trait) vs retrieval fluency (rate trait)
Glir process distinction – learning (storage) efficiency and retrieval fluency

- Long-Term Memory
  - Storage
  - Retrieval
- Working Memory
  - Focus of Attention
  - Central Executive (Executive functions or control?)
    - Inhibit
    - Shift
    - Update
  - Decisions Output
- Perception
  - Sensation
  - Recently Activated Concepts (Blue-new; Red-old)

???
There has been an explosion of research on auditory abilities since Carroll’s (1993) seminal work (Schneider & McGrew, 2012). A wide-ranging collection of Ga characteristics have been related to disorders of reading, speech, and language. For example, Ga abilities are now recognized as playing a pivotal scaffolding role in the development of language and general cognitive abilities (Conway, Pisoni, & Kronenberger, 2009).
What about **numerosity** or **number sense**? *Gf* or *Gq* or both?

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, and position (McGrew, LaForte, & Schrank, 2014)

Attentional Control (Gwm – AC)

Old attention/concentration (AC) “garbage” narrow ability redefined as **attentional control**, as per contemporary cognitive neuroscience research*

Attentional Control (Gwm-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.

• Attentional Control (focus)
  • Working Memory
  • Executive Functioning

“Quiet the busy mind” to maintain focus on task relevant information

Major hypothesis:
This is (these are) the domain general cognitive mechanism(s) trained by.....

UM Narrow ability **definition expanded** to include phonological storage ability or short-term memory for speech sounds.

• **Carroll (1993)**, in UM factor context, was intrigued with the possibility of distinguishing an auditory factor analogous to visual memory (MV).

• **Neisser (1967)** postulated the existence of echoic memory, a sensory register used to retain auditory information for a brief period of time (3 or 4 seconds).

• **Baddely’s (1970s to current)** model of working memory (**phonological loop**).

• **Gathercole & Baddely et al (1990s to current)** – extensive research on nonword repetition tasks and reading disabilities and language disorders. **Phonological short-term memory.**
UM Narrow ability **definition expanded** to include phonological storage ability or short-term **memory for speech sounds**.

**Memory for Sound Patterns (Ga/Gwm - UM)**. Ability to retain (on a short-term basis) auditory **codes such as tones, tonal patterns, or speech sounds**.
Nonword repetition tasks

Examinee listens to a nonsense word and then must repeat the word exactly.

Requires temporary storage of phonological segments in immediate awareness.

Significant body of research has found such tasks to be significantly related to (and be possible “markers” of) reading disabilities, dyslexia and SLI (specific language impairment)
LA narrow ability proposed for inclusion in CHC model

Speed of Lexical Access (Glr-LA). Ability to rapidly and fluently retrieve words from an individual's lexicon; verbal efficiency or automaticity of lexical access.
Gc/Gwm (broad) influenced Speed of Lexical Access (LA) narrow factor

Speed of Lexical Access (LA). Ability to rapidly and fluently retrieve words from an individual's lexicon; verbal efficiency or automaticity of lexical access.

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(Parameters are median values across 6 WJ IV age groups: Broad+narrow bottom-up model)
Fig. 1. A sample of words from the phonological network analyzed in Vitevitch (2008). The word “speech” and its phonological neighbors (i.e., words that differ by the addition, deletion or substitution of a phoneme) are shown. The phonological neighbors of those neighbors (i.e., the 2-hop neighborhood of “speech”) are also shown.
How can this research-based information be used, particularly in new RTI environment?

• To develop referral-focused selective cognitive assessment for treatment resisters
  
  • “Back to the future” – Kaufman’s “Intelligent” intelligence testing

• To develop early “at risk” screening programs

• For SLD identification within emerging “third method” consistency-concordance SLD models
CHC COG ➔ Basic Reading Skills – ages 6 to 8 research synthesis summary
(McGrew & Wendling, 2010; plus +)

Most relevant WISC-IV clusters and tests

No Glr tests

No Ga tests

CHC COG ➔ Basic Reading Skills – ages 6 to 8 research synthesis summary
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Most relevant WISC-IV clusters and tests

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No Glr tests

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CHC COG → Basic Reading Skills – ages 6 to 8 research synthesis summary
(McGrew & Wendling, 2010; plus +)

Most relevant WJ III clusters

**Gf**
- Induction (I)
- Gen. Seq. Reas. (RG)
- Quant. Reas. (RQ)

**Gwm**
- Memory Span (MS)
- Attentional Control (AC)

**Glr**
- Associative Memory (MA)
- Meaningful Memory (MM)
- Free Recall Memory (M6)
- Ideational Fluency (FI)
- Naming Facility (NA)
- Spd. Lex. Access (LA)

**Gs**
- Perceptual Speed (P)
- Number Facility (N)
- Rate of Test Taking (R9)

**Gc**
- Language Dev. (LD)
- Lexical Knowledge (VL)
- Gen. Information (K0)
- Listening Ability (LS)

**Gv**
- Visualization (Vz)
- Visual Memory (MV)
- Closure Speed (CS)
- Spatial Scanning (SS)
- Flex. Of Closure (CF)

**Ga**
- Phonetic Coding (PC)
- Spch. Snd. Discrim. (US)
- Mem. For Snd. Patt. (UM)
- Maint. & Judge Rhy. (U8)
- Res Aud.St Distort, (UR)

**Short-term Memory (Gwm)**
- Working Memory (WM/AC)

**Processing Speed (Gs)**
- Perceptual Speed (P) - DS

**Comprehension-Knowledge (Gc)**
- Listening Comprehension (LS)

**Phonemic Aware. (PC)**
- Phonemic Aware. 3 (PC/Gwm-WM)

DS = WJ III Diagnostic Supplement cluster or test
**CHC COG → Basic Reading Skills – ages 6 to 8 research synthesis summary**  
(McGrew & Wendling, 2010; plus +)

**Most relevant WJ III tests**

<table>
<thead>
<tr>
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<th>Quant. Reas. (RQ)</th>
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<tr>
<td>Gv</td>
<td>Visual-ization (Vz)</td>
<td>Visual Memory (MV)</td>
<td>Closure Speed (CS)</td>
</tr>
</tbody>
</table>

- Numbers Reversed (WM/AC)
- Understanding Directions (WM/Gc-LS)
- Aud. Working Memory (WM)
- Vis.-Aud.-Lrng. (MA)
- Rapid. Pic. Nam. (NA)
- Retrieval Fluency (FI)
- Verbal Comprehension (LD/VL)
- Oral Comprehension (LS)
- General Information (K0)
- Picture Vocabulary (VL)
- Sound Awareness (PC/Gwm-WM)
- Sound Blending (PC)

**DS = WJ III Diagnostic Supplement cluster or test**

**CHC COG**

- CHC COG
- Basic Reading Skills – ages 6 to 8 research synthesis summary
- (McGrew & Wendling, 2010; plus +)

**Most relevant WJ III tests**

- Induction (I)
- General Seq. Reas. (RG)
- Quant. Reas. (RQ)
- Memory Span (MS)
- Attentional Control (AC)
- Associative Memory (MA)
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- Closure Speed (CS)
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- Spch. Snd. Discrim. (US)
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- Maint. & Judge Rhy. (U8)
- Res Aud.St Distort, (UR)

**DS = WJ III Diagnostic Supplement cluster or test**
CHC COG → Basic Reading Skills – ages 6 to 8 research synthesis summary
(McGrew & Wendling, 2010; plus+)

Most relevant WJ III clusters

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  - Naming Facility (NA)
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  - Number Facility (N)
  - Rate of Test Taking (R9)

- **Gc**
  - Language Dev. (LD)
  - Lexical Knowledge (VL)
  - Gen. Information (K0)
  - Listening Ability (LS)

- **Gv**
  - Visual-ization (Vz)
  - Visual Memory (MV)
  - Closure Speed (CS)
  - Spatial Scanning (SS)
  - Flex. Of Closure (CF)
  - Imagery (IM)

- **Ga**
  - Phonetic Coding (PC)
  - Spch. Snd. Discrim. (US)
  - Mem. For Snd. Patt. (UM)
  - Maint. & Judge Rhy. (U8)
  - Res Aud.St Distort., (UR)

- **Short-term Memory (Gwm)**
  - Working Memory (WM/AC)

- **Processing Speed (Gs)**
  - Perceptual Speed (P) - DS

- **Comprehension-Knowledge (Gc)**
  - Listening Comprehension (LS)

- **Long-term Ret. (Gl(r))**
  - Assoc. Mem. (MA) - DS
  - Cognitive Fluency (NA/FI)

**DS** = WJ III Diagnostic Supplement cluster or test
Most relevant WJ III tests

- Numbers Reversed (WM/AC)
- Understanding Directions (WM/Gc-LS)
- Auditory Working Memory (WM)
- Vis.-Aud.-Lrng. (MA)
- Rapid. Pic. Nam. (NA)
- Retrieval Fluency (FI)

**CHC COG** ➔ Basic Reading Skills – ages 6 to 8 research synthesis summary

(McGrew & Wendling, 2010; plus +)

**Most relevant WJ III tests**

- Numbers Reversed (WM/AC)
- Understanding Directions (WM/Gc-LS)
- Auditory Working Memory (WM)

**Vis.-Aud.-Lrng. (MA)**
- Rapid. Pic. Nam. (NA)
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**Gs**
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**Gs**
- Visual Memory (MV)
- Closure Speed (CS)
- Spatial Scanning (SS)

**Gv**
- Visual-iz. (Vz)
- Visual Memory (MV)

**Ga**
- Mem. For Snd. Patt. (UM)
- Maint. & Judge Rhy. (U8)
- Res Aud. St Distort, (UR)

**Gc**
- Listening Ability (LS)
- Flex. Of Closure (CF)

**Ga**
- Sound Awareness (PC/Gwm-WM)

**DS** = WJ III Diagnostic Supplement cluster or test
CHC COG → Basic Reading Skills – ages 9 to 18 research synthesis summary
(McGrew & Wendling, 2010; plus +)

Most relevant WJ III clusters

\[ Gf \]
- Induction (I)
- Gen. Seq. Reas. (RG)
- Quant. Reas. (RQ)

\[ Gwm \]
- Memory Span (MS)
- Attentional Control (AC)

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- Associative Memory (MA)
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- Perceptual Speed (P)
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Short-term Memory (Gwm)
Working Memory (WM/AC)
Memory Span (MS) - DS

Processing Speed (Gs)
Perceptual Speed (P) - DS

Comprehension-Knowledge (Gc)

Phonemic Aware. (PC)
Phonemic Aware. 3 (PC/Gwm-WM)

DS = WJ III Diagnostic Supplement cluster or test
CHC COG → **Basic Reading Skills – ages 9 to 18** research synthesis summary
(McGrew & Wendling, 2010; plus +)

**Most relevant WJ III Tests**

- **Gf**
  - Induction (I)
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  - Memory Span (MS)
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- **DS** = WJ III Diagnostic Supplement cluster or test

**Most relevant WJ III Tests**

- Numbers Reversed (WM/AC)
- Memory for Words (MS)
- Understanding Directions (WM/Gc-LS)
- Auditory Working Memory (WM)
- Visual Matching (P)
- Cross Out (P) - DS
- Verbal Comprehension (LD/VL)
- General Information (K0)
- Picture Vocabulary (VL)
- Sound Aware. (PC/Gwm-WM)
- Sound Blending (PC)
- Sound Patterns-Voice (US/UR) - DS
### CHC COG→Reading Comp.– ages 6 to 8 research synthesis summary
(McGrew & Wendling, 2010; plus +)

#### Most relevant WJ III clusters

*CHC COG* refers to the Cattell-Horn-Carroll model of intelligence, and *WJ III* is the Woodcock-Johnson III battery of tests. The diagram and table summarize the relevant clusters and tests for reading comprehension in children ages 6 to 8.

**Gf** (Fluid Intelligence)
- Induction (I)
- Generative Sequential Reasoning (RG)
- Quantitative Reasoning (RQ)

**Gwm** (Growth in Working Memory)
- Working Memory Capacity (WM)
- Memory Span (MS)
- Attentional Control (AC)

**Glr** (Growth in Long-Term Retrieval)
- Associative Memory (MA)
- Meaningful Memory (MM)
- Free Recall Memory (M6)
- Ideational Fluency (FI)
- Naming Facility (NA)
- Spd. Lex. Access (LA)

**Gs** (Growth in Speed)
- Perceptual Speed (P)
- Number Facility (N)
- Rate of Test Taking (R9)

**Gc** (Growth in Comprehension-Knowledge)
- Language Development (LD)
- Lexical Knowledge (VL)
- Generative Information (K0)
- Listening Ability (LS)

**Gv** (Growth in Visualization)
- Visual-Imagery (Vz)
- Visual Memory (MV)
- Closure Speed (CS)
- Spatial Scanning (SS)
- Flexibility of Closure (CF)
- Imagery (IM)

**Ga** (Growth in Auditory Coding)
- Phonetic Coding (PC)
- Spch. Snd. Discrim. (US)
- Mem. For Snd. Patt. (UM)
- Maint. & Judge Rhy. (U8)
- Res Aud.St Distort., (UR)

**DS** = WJ III Diagnostic Supplement cluster or test

- **Working Memory (WM/AC)**
- **Assoc. Mem. (MA) - DS**
- **Cognitive Fluency (NA/FI)**
- **Perceptual Speed (P) - DS**
- **Comprehension-Knowledge (Gc)**
- **Listening Comprehension (LS)**
- **Auditory Processing (Ga)**
  - Phonemic Aware. (PC)
  - Phonemic Aware. 3 (PC/Gwm-MW)

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*McGrew & Wendling, 2010; plus +* refer to the research synthesis included in these materials, indicating additional relevant studies.
CHC COG→Reading Comp.– ages 6 to 8 research synthesis summary
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**Most relevant WJ III tests**

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- Numbers Reversed (WM/AC)
- Understanding Directions (WM/Gc-LS)
- Memory for Sentences (MS/Gc-LS)-DS
- Auditory Working Memory (WM)
- Vis.-Aud.-Lrng. (MA)
- Rapid. Pic. Nam. (NA)
- Retrieval Fluency (FI)
- Verbal Comprehension (LD/VL)
- General Information (K0)
- Oral Comprehension (LS)
- Picture Vocabulary (VL)
- Imagery (IM)
- Sound Awareness (PC/Gwm-WM)
- Sound Blending (PC)
- Incomplete Words (PC)

**DS** = WJ III Diagnostic Supplement cluster or test

(Refer to McGrew & Wendling, 2010; plus+)
CHC COG → Reading Comp.– ages 9 to 13 research synthesis summary
(McGrew & Wendling, 2010; plus +)

Most relevant WJ III clusters

- **Gf**
  - Induction (I)
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  - Phonemic Aware. 3 (PC/Gwm-MW)

**DS** = WJ III Diagnostic Supplement cluster or test

Long-term Ret. (Glr)
Cognitive Fluency (NA/FI)

Comprehension-Knowledge (Gc)
Listening Comprehension (LS)

Perceptual Speed (P) - DS
### CHC COG → Reading Comp. – ages 9 to 13 research synthesis summary
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#### Most relevant WJ III tests

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**DS = WJ III Diagnostic Supplement cluster or test**

- Numbers Reversed (WM/AC)
- Understanding Directions (WM/Gc-LS)
- Memory for Sentences (MS/Gc-LS) - DS
- Auditory Working Memory (WM)
- Story Recall (MM/Gc-LS)
- Rapid. Pic. Nam. (NA)
- Retrieval Fluency (Fl)
- Visual Matching (P)
- Cross Out (P) - DS
- Verbal Comprehension (LD/VL)
- General Information (K0)
- Oral Comprehension (LS)
- Picture Vocabulary (VL)
- Imagery (IM)
- Sound Awareness (PC/Gwm-WM)
- Sound Blending (PC)
Most relevant WJ III Clusters

**Gf**
- Induction (I)
- Gen. Seq. Reas. (RG)
- Quant. Reas. (RQ)

**Gwm**
- Memory Span (MS)
- Attentional Control (AC)

**Glr**
- Associative Memory (MA)
- Meaningful Memory (MM)
- Free Recall Memory (M6)
- Ideational Fluency (FI)
- Naming Facility (NA)
- Spd. Lex. Access (LA)

**Gs**
- Perceptual Speed (P)
- Number Facility (N)
- Rate of Test Taking (R9)

**Gc**
- Language Dev. (LD)
- Lexical Knowledge (VL)
- Gen. Information (K0)
- Listening Ability (LS)

**Gv**
- Visualization (Vz)
- Visual Memory (MV)
- Closure Speed (CS)
- Spatial Scanning (SS)
- Flex. Of Closure (CF)
- Imagery (IM)

**Ga**
- Phonetic Coding (PC)
- Spch. Snd. Discrim. (US)
- Mem. For Snd. Patt. (UM)
- Maint. & Judge Rhy. (U8)
- Res Aud.St Distort, (UR)

CHC COG → Reading Comp.– ages 14 thru 18 research synthesis summary (McGrew & Wendling, 2010; plus +)

**Working Memory (WM/AC)**
- Memory Span (MS) - DS

**Comprehension-Knowledge (Gc)**
- Listening Comprehension (LS)

**Perceptual Speed (P) - DS**
- Perceptual Speed (P)
- Number Facility (N)
- Rate of Test Taking (R9)

**Cog. Fluency (FI/NA)**
- Ideational Fluency (FI)
- Naming Facility (NA)
- Spd. Lex. Access (LA)

**DS = WJ III Diagnostic Supplement cluster or test**
CHC COG → **Reading Comp.– ages 14 thru 18** research synthesis summary  
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### Most relevant WJ III Tests

- **Induction (I)**
- **Gen. Seq. Reas. (RG)**
- **Quant. Reas. (RQ)**
- **Memory Span (MS)**
- **Attentional Control (AC)**
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- **Ideational Fluency (FI)**
- **Spd. Lex. Access (LA)**
- **Understanding Directions (WM/Gc-LS)**
- **Memory for Sentences (MS/Gc-LS)**
- **Numbers Reversed (WM/AC)**
- **Auditory Working Memory (WM)**
- **Verbal Comprehension (LD/VL)**
- **General Information (K0)**
- **Oral Comprehension (LS)**
- **Picture Vocabulary (VL)**
- **Language Dev. (LD)**
- **Lexical Knowledge (VL)**
- **Gen. Information (K0)**
- **Listening Ability (LS)**
- **Visual Matching (P)**
- **Cross Out (P) - DS**
- **Visual Memory (MV)**
- **Closure Speed (CS)**
- **Spatial Scanning (SS)**
- **Flex. Of Closure (CF)**
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- **Rate of Test Taking (R9)**
- **Rapid. Pic. Nam. (NA)**
- **Retrieval Fluency (FI)**
- **Sound Awareness (PC/Gwm-WM)**
- **Sound Blending (PC)**

**DS** = WJ III Diagnostic Supplement cluster or test
**CHC COG → Basic Math Skills—ages 6 through 8 research synthesis summary**
(McGrew & Wendling, 2010; plus +)

**DS** = WJ III Diagnostic Supplement cluster or test

**Most relevant WJ III Clusters**

- **Fluid Reasoning (Gf)**
  - Numerical Reasoning (RQ)-DS

- **Working Memory (WM/AC)**
  - Working Memory (WM)
  - Attentional Control (AC)

- **Processing Speed (Gs)**
  - Perceptual Speed (P) - DS

- **Comprehension-Knowledge (Gc)**
  - Listening Comprehension (LS)

- **Associative Memory (MA)**

- **Cognitive Fluency (FI)**
  - Naming Facility (NA)
  - Spd. Lex. Access (LA)

- **Perceptual Speed (P)**

- **Number Facility (N)**

- **Rate of Test Taking (R9)**

- **Language Dev. (LD)**
  - Lexical Knowledge (VL)
  - Gen. Information (K0)

- **Listening Ability (LS)**

- **Visual- Packaging (Vz)**
  - Visual Memory (MV)
  - Closure Speed (CS)
  - Spatial Scanning (SS)

- **Imagery (IM)**

- **Phonetic Coding (PC)**
  - Spch. Snd. Discrim. (US)
  - Mem. For Snd. Patt. (UM)

- **Phonemic Aware. 3 (PC/Gwm-WM)**

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**CHC COG → Basic Math Skills—ages 6 through 8 research synthesis summary**

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**DS = WJ III Diagnostic Supplement cluster or test**

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- **Number Series (RQ)-DS**
- **Number Matrices (RQ)-DS**
- **Analysis-Synthesis (RG)**
- **Numbers Reversed (WM/AC)**
- **Auditory Working Memory (WM)**
- **Understanding Directions (WM/Gc-LS)**
- **Retrieval Fluency (FI)**
- **Rapid. Pic. Nam. (NA)**
- **Vis.-Aud.-Lrng (MA)**
- **Visual Matching (P/N?)**
- **Cross Out (P) - DS**
- **Pair Cancellation (AC/EF?)**

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CHC COG → Basic Math Skills—ages 9 through 18 research synthesis summary (McGrew & Wendling, 2010; plus+)

**DS = WJ III Diagnostic Supplement cluster or test**

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- Number Series (RQ)-DS
- Number Matrices (RQ)-DS
- Analysis-Synthesis (RG)
- Numbers Reversed (WM/AC)
- Auditory Working Memory (WM)
- Understanding Directions (WM/LS)

**Most relevant WJ III tests**

- Retrieval Fluency (FI)
- Rapid. Pic. Nam. (NA)
- Visual Matching (P/N?)
- Cross Out (P)
- Pair Cancellation (AC/EF?)
- Verbal Comprehension (LD/VL)
- Imagery (IM)
- Sound Aware. (PC/Gwm-WM)

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### CHC COG Math Reasoning—ages 6 through 8 research synthesis summary

(McGrew & Wendling, 2010; plus +)

**DS** = WJ III Diagnostic Supplement cluster or test

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**Most relevant WJ III Clusters**

- Fluid Reasoning (Gf)
- Numerical Reasoning (RQ) - DS
- Working Memory (WM/AC)
- Processing Speed (Gs)
- Perceptual Speed (P) - DS
- Comprehension-Knowledge (Gc)
- Visual Proc. (Gv)
- Visualization (Vz) - DS
- Phonemic Aware. 3 (PC/Gwm-WM)

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Number Matrices (RQ)-DS
Number Series (RQ)-DS
Analysis-Synthesis (RG)
Numbers Reversed (WM/AC)
Auditory Working Memory (WM)
Understanding Directions (WM/Gc-LS)

Visual Matching (P/N?)
Cross Out (P)
Pair Cancellation (AC/EF?)

Verbal Comprehension (LD/VL)
General Information (K0)
Oral Comprehension (LS)

Spatial Relations (Vz)
Picture Recog (MV)
Block Rotation (Vz) – DS

Sound Aware. (PC/Gwm-WM)

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DS = WJ III Diagnostic Supplement cluster or test
# CHC COG Math Reasoning—ages 9 through 18 research synthesis summary

(McGrew & Wendling, 2010; plus+)

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## Fluid Reasoning (Gf)

Numerical Reasoning (RQ) - DS

## Working Memory (WM/AC)

## Perceptual Speed (P) - DS

## Comprehension-Knowledge (Gc)

## Visual Proc. (Gv)

Visualization (Vz) - DS

## Phonemic Aware. 3 (PC/Gwm-WM)

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<tr>
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<tr>
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<tr>
<td>Glr Long-term retrieval</td>
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<td>Associative Memory (MA)</td>
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<td>Gc Comprehension-Knowledge</td>
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<tr>
<td>Lexical Knowledge (VL)</td>
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<td>Spc-Snd Disc/Res to ASD (US/UR)</td>
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<td>X</td>
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<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>Gf Fluid Reasoning</td>
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<tr>
<td>Visualization</td>
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<tr>
<td>Visual Memory (MV)/Imagery (MI)</td>
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<td>?</td>
<td>?</td>
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</tr>
</tbody>
</table>
## CHC Selective Referral-Focused Assessment Worksheet (McGrew, 2009)

### Age/grade: _____  Academic referral concern ____________________________

<table>
<thead>
<tr>
<th>Broad/Narrow CHC Abilities</th>
<th>Referral Relevant domain?</th>
<th>Selective/focused set of starting tests</th>
<th>Selective/focused possible additional tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gwm</td>
<td>Memory Span (MS)</td>
<td>Y  N</td>
<td></td>
</tr>
<tr>
<td>Working Memory (WM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gs</td>
<td>Perceptual Speed (P)</td>
<td>Y  N</td>
<td></td>
</tr>
<tr>
<td>Number Facility (N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glr</td>
<td>Associative Memory (MA)</td>
<td>Y  N</td>
<td></td>
</tr>
<tr>
<td>Naming Facility (NA)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningful Memory (MM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gc</td>
<td>Language Development (LD)</td>
<td>Y  N</td>
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</tr>
<tr>
<td>General Information (K0)</td>
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</tr>
<tr>
<td>Listening Ability (LS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lexical Knowledge (VL)</td>
<td>Y  N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ga</td>
<td>Phonetic Coding (PC)</td>
<td>Y  N</td>
<td></td>
</tr>
<tr>
<td>Spch-Snd Disc/Res to ASD (US/UR)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gf</td>
<td>Gen. Seq. Reasoning (RG)</td>
<td>Y  N</td>
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</tr>
<tr>
<td>Quantitative Reasoning (RQ)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EF</td>
<td>Vigilance/inhibition/planning/Attentional control</td>
<td>Y  N</td>
<td></td>
</tr>
<tr>
<td>Gkn</td>
<td>Domain-specific knowledge (_)</td>
<td>Y  N</td>
<td></td>
</tr>
<tr>
<td>Gv</td>
<td>Visualization (Vz)</td>
<td>Y  N</td>
<td></td>
</tr>
<tr>
<td>Visual Memory (MV)/Imagery (IM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>???</td>
<td>Orthographic processing</td>
<td>Y  N</td>
<td></td>
</tr>
</tbody>
</table>
Most of the “action” appears to be at the narrow (vs broad) CHC ability level – **narrow abilities**

Some CHC abilities appear to be important across reading AND math – **domain general**

Some CHC abilities appear to be differentially important for reading vs math – **domain specific**

Are some CHC abilities more important at certain ages – **developmentally specific**
90+ % of the empirical CHC designed studies are based on the WJ-R/WJ III

The professional ice is thicker if you apply this information to use of the WJ III

Not all CHC narrow ability test classifications are equal

Almost all narrow CHC ability test classifications are logical or expert-consensus based

Even when evidenced-based, tests with identical narrow ability test classifications cannot be assumed to be 100 % interchangeable

(see Floyd’s broad cluster exchangeability study – Floyd, 2005, SPR)
Current research and assessment technology does not allow us to accurately predict which individual children will be at a specific level of proficiency/mastery at any given time (e.g., who will be in the top half of the achievement distribution for a given level of general intelligence)
Our intelligence tests are *fallible* predictors of current and future achievement.

At best, typical IQ-Ach correlations are in the .55 to .65+ range.

Our IQ tests can only account for 35 to 50% of school achievement.
We are focusing on just one personal competence domain within a larger system of proximal (close) and distal (far) influences on the child.

Our test instruments only “sample” select conceptual abilities within this one domain.

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Model is a revision of McGrew’s Model of Academic Competence and Motivation (McGrew et al., 2004; McGrew. 2007) which is grounded in Snow’s model of academic aptitude (Corono, 2002). Due to space limitations the model only lists general categories under the two areas under Social Ability and excludes the domains of physical, cognitive, affective/emotional and personality.

McGrew Motivation and Academic Competence Model (MACM)
Beyond IQ

Simplified MACM-based adaptation and extension of Snow’s *dynamic model of conation in the academic domain* (Corno, 1993)

Institute for Applied Psychometrics (IAP), 01-05-13 – Dr. Kevin S. McGrew
Let’s assume we have a simplified measurement tape that retains the 12 in = 1 foot relationship (with no finer gradations between the inch tick marks). This will be our height SS scale.

If one then crafts a 20 % less precise (more crude) measuring tape, tick marks would not be every inch but would be every 2.4 inches.

We measure an individual, who is exactly 68 inches tall (5 feet, 8 inches). Using the SS tape measure we would measure this person’s height accurately as 68 inches.

With less-precise ss tape the person’s head would fall somewhere between the 28th (67.2 inches) and 29th (69.6) tick marks. 68 inches is closer to the 28th tick mark—we would thus conclude that this person is 67.2 inches tall (all people between 66.0 to 68.4 inches would be 67.2 inches tall)
Scaled scores \((10 + 3)\) are based on a crude scale -- 20% less precise than standard scores \((100 + 15)\). Converting to a scale with 100+15 and then comparing (or combining with other test scores) can introduce error into the comparison of composites.

\[ 88 - 78 = 10 \text{ SS pts!} \]
A. If difference/discrepancy implies predictive relationship, then regression to the mean needs to be accounted for and the proper statistic is the $SE(est)$

B. If difference/discrepancy is for a simple difference score, and the explicit emphasis is on the cohesiveness of tests within a composite/CHC domain (unitary vs non-unitary composite principle) then the $SD(diff)$ is the proper statistic

C. Third method will be presented later – reliability of simple difference scores----$SE(diff)$
Arithmetic Average of “OTHER” cluster SSs

Standard Score Scale

- Comp – Knowledge \( Gc \)
- Fluid Reasoning \( Gf \)
- Long-Term Retrieval \( Glr \)
- Vis-Spatial Thinking \( Gv \)
- Auditory Processing \( Ga \)
- Short-Term Memory \( Gsm \)
- Processing Speed \( Gs \)

Predicted/expected \( Glr \) Standard Score (incorporates predictor-criterion correlation – accounts for regression to the mean)

Difference is calculated and score is compared to distribution of \( Glr \) discrepancy norms

Real Discrepancy Score Norms
Ability Domain Cohesion

CHC factors and test composites are a *constellation* or combination of elements that are *related* and are *combined* together in a functional fashion. Imply a form of a centrally inward directed force that *pulls* elements together much like magnetism (high intercorrelations of tests).
Commonly used **1 SD (3)** or **1.5 SD (5)** scaled score points on WISC-IV tests not accurate for all potential test score difference comparisons

<table>
<thead>
<tr>
<th>WISC-IV within domain/composite scaled score (M=10; SD = 3) comparison</th>
<th>Average correlation between tests (Table 5.1 tech. manual)</th>
<th>1 SD(diff)</th>
<th>1.5 SD(diff)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCI (Gc) - Sim/Vocab</td>
<td>.74</td>
<td>2.2</td>
<td>3.3</td>
</tr>
<tr>
<td>VCI (Gc) - Vocab/Comp</td>
<td>.68</td>
<td>2.4</td>
<td>3.6</td>
</tr>
<tr>
<td>VCI (Gc) - Sim/Comp</td>
<td>.62</td>
<td>2.6</td>
<td>3.9</td>
</tr>
<tr>
<td>PRI (Gv/Gf) - BD/MR</td>
<td>.55</td>
<td>2.8</td>
<td>4.2</td>
</tr>
<tr>
<td>WMI (Gsm) – DS/LNS</td>
<td>.49</td>
<td>3.0</td>
<td>4.5</td>
</tr>
<tr>
<td>PRI (Gv/Gf) - BD/PicCn</td>
<td>.41</td>
<td>3.2</td>
<td>4.8</td>
</tr>
<tr>
<td>PRI (Gv/Gf) – PicCn/MR</td>
<td>.42</td>
<td>3.2</td>
<td>4.8</td>
</tr>
</tbody>
</table>

**Note:** Equation includes correlation of tests which addresses the cohesion, inter-correlation, or unitary/non-unitary characteristics of composite/ability.

\[
SD(\text{diff}) = 3 \times [\sqrt{2 - 2 \times r}]
\]

[Note: \(\sqrt{\text{SQRT}} = \text{square root}\)]

Gc domain/composite is a “tight/cohesive” (highly inter-correlated).

(Note. The WISC-IV statistical significance tables and software generated values are correct and reflect a simple score difference method—to third method to be discussed later. The above is a recommended alternative diff score method within CHC domains.)
Commonly used **1 SD (15)** or **1.5 SD (23)** standard score points on WJ III tests not accurate for all potential test score difference comparisons

<table>
<thead>
<tr>
<th>WJ III within domain/composite scaled score (M=100; SD = 15) comparison</th>
<th>Average correlation between tests (Computed by KMcGrew in norm data)</th>
<th>1 SD(diff)</th>
<th>1.5 SD(diff)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gc - Verb Comp/Gen Info</td>
<td>.78</td>
<td>9.9</td>
<td>14.8</td>
</tr>
<tr>
<td>Gf - Anl Syn/Conc Form</td>
<td>.55</td>
<td>14.2</td>
<td>21.3</td>
</tr>
<tr>
<td>Gs - Vis Match/Dec Speed</td>
<td>.54</td>
<td>14.4</td>
<td>21.4</td>
</tr>
<tr>
<td>Gsm - Num Rev/Mem Wrds</td>
<td>.40</td>
<td>16.4</td>
<td>24.6</td>
</tr>
<tr>
<td>Ga - Snd Blend/Aud Attn</td>
<td>.36</td>
<td>16.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Glr - VAL/Ret Fluency</td>
<td>.27</td>
<td>18.1</td>
<td>27.2</td>
</tr>
<tr>
<td>Gv - Spat Rels/Pic Recog</td>
<td>.21</td>
<td>18.8</td>
<td>28.2</td>
</tr>
</tbody>
</table>

\[ SD(diff) = 15 \times \sqrt{2 - 2 \times r} \]

[Note: \( \sqrt{} \) = square root]

Gc domain/composite is a “tight/cohesive” (highly inter-correlated)

Glr & Gv domains/composites are “loose” or “broad” or weakly inter-correlated
If difference/discrepancy is for a simple difference score, and the explicit emphasis is on the cohesiveness of tests within a composite/CHC domain (unitary vs non-unitary composite principle) then the $SD(diff)$ is the proper statistic (McGrew, 2011, 2012, in press).

Ability domain cohesion, or the degree of inter-correlation of abilities/tests within a ability domain/composite.

Remember:

- If the domain is loose, $SD=15$ SS (ss=3) will cook your goose
- If the domain is tight, $SD=15$ SS (ss=5) will not be right

$vive$ la différence – long live the $SD(diff)$

$SD(diff) = 15 \times [\sqrt{2 - 2 \times r}]$

[Note: SQRT = square root]
Do **NOT** blindly use the 1 SD = 15 SS (3 ss) or 1.5 SD = 23 SS (5 ss) point rules-of-thumb.

This is wrong as a blanket rule-of-thumb and may over/under-identify significant real discrepancies, S/W’s, etc.

If you use the XBA software, recognize that the identification of significant SW may be based on different discrepancy statistics associated with the 2nd and 3rd editions of Essentials of XBA. 3rd edition should be more psychometrically sound.
A third approach to evaluating simple binary test differences is to use the $SE(\text{diff})$ for the reliability of difference scores.

This approach simply asks whether the difference between two tests scores reflects a difference that is not due to measurement error.

Statistical procedures are available for making these comparisons, but it is cumbersome and requires knowledge of the standard error of the difference between any pair of tests and the number of comparisons made (the standard error of the difference will be approx. 1.4 times the average $SEM$ for the two tests).

Woodcock has done the math to provide a sound, elegant set of guidelines to implement this approach in practice (WJ-R TM; McGrew, Werder & Woodcock, 1991)

(Does not incorporate information re: ability domain cohesion)
Most test manuals and scoring software use this approach. It is a proper and correct approach, as long as one knows that one is not taking the correlation (either predictive or ability domain cohesion models) between the compared scores into consideration.

(Does not incorporate information re: ability domain cohesion)
Highly correlated IQ tests will often give different results and this is to be expected

- SD \((\text{diff})\)
- IQ Battery DNA Fingerprint Comparisons

“Moses may have gone to the mountain to get the 10 commandments...but where is it written that Wechsler went to the mountain to get the 10 subtests” (McGrew, 1986)
Figure 1: Scatterplot of WAIS-R and WJ-R IQs

The line is the "linear" trend and represents a correlation coefficient of 0.706.

Figure 3: Bar chart of WAIS-R/WJ-R IQ differences
\[ SD(diff) = 15 \times [\text{SQRT}(2 - 2x r)] \]

[Note: SQRT = square root]

<table>
<thead>
<tr>
<th>IQ-IQ correlation</th>
<th>SD of estimated IQ-IQ differences ([SD(diff)])</th>
<th>Range of typical (68%; ± 1 SD) IQ-IQ differences (based on whole numbers in prior column)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.60</td>
<td>13.4</td>
<td>26</td>
</tr>
<tr>
<td>.65</td>
<td>12.5</td>
<td>24</td>
</tr>
<tr>
<td>.70</td>
<td>11.6</td>
<td>22</td>
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<td>.75</td>
<td>10.6</td>
<td>20</td>
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<tr>
<td>.80</td>
<td>9.5</td>
<td>18</td>
</tr>
<tr>
<td>.85</td>
<td>8.2</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 1. SD of estimated IQ-IQ differences for different IQ-IQ correlations
Two (of many) advantages of CHC-based analysis IQ test batteries

Understanding and comparing IQ scores across editions within the same IQ battery

Understanding and comparing IQ scores between different IQ batteries

IQ test CHC DNA Fingerprint
The evolution of the CHC ability content of the various WISC FS IQ scores

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<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gc</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Gv</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>15</td>
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<td>Gs</td>
<td>10</td>
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<td>10</td>
<td>15</td>
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<td>Gq</td>
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<td>Gsm</td>
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<td>Glr</td>
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</tr>
<tr>
<td>Ga</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Broad CHC cognitive ability domains *

Gc = Comprehension-knowledge
Gf = Fluid reasoning
Glr = Long-term storage/retrieval
Gq = Quantitative knowledge
Ga = Auditory processing
Gv = Visual-spatial processing
Gsm = Short-term memory
Gs = Processing speed

Note: WJ III/BATIII figures are based on median g-loading weights used in calculation of GIAN-Standard cluster across all ages in WJ III norm sample

IQ Test CHC DNA Fingerprint comparison of proportional coverage of broad CHC ability domains for WJ III/BAT III, WISC-IV and WAIS-IV

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* CHC definitions and background information can be found at: http://tinyurl.com/y9uh845 and http://tinyurl.com/ykzesml
CHC IQ Test DNA Fingerprint comparison of proportional coverage of broad CHC ability domains for BAT-R and TONI-2

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Problems with the concept of “normative” strengths and weaknesses

• Stat/measurement issue: Metrics of relative standing (PR/SS) vs metrics of “real world” levels of functioning (RPI)

• Philosophical/conceptual definition issue
The Relative Proficiency Index (RPI)

Reflects the individual’s proficiency on tasks which would be typically performed with 90% proficiency at that age/grade level. Presents a statement of likely success for similar tasks based upon performance within the tests.

Examples

Susan’s obtains an RPI score of 3/90 on Basic Writing Skills when compared with grade peers. She obtains an RPI of 98/90 on Math Reasoning.

"When presented with grade level tasks in basic writing skills that would be typically performed with 90% success, Susan may perform with only 3% success. This suggests a very limited level of proficiency."

"Susan's RPI of 98/90 on Math Reasoning indicates her performance would be very advanced compared to grade peers."
The perplexing issue/question often heard

Example: 12 year old

• WJ III Numbers Reversed  SS = 86  RPI = 48/90

• WJ III Auditory Working Memory  SS = 88  RPI = 69/90

• How can similar standard scores be associated with such different RPI scores?

• How can this be?

• Is this some kind of voodoo statistics?
Different abilities or traits have different distributions of talent – different spread.

Same standing in a group (-1 SD or SS = 85)...but proficiency difference on the order of 3 times  !!!!!
What is more informative and reality based re: Jill’s Letter-Word ID growth over x-years?

[Which was 10 W points ]

On the WJ III Letter-Word Identification, Jill improved from a SS of 85 (16 PR) to a SS of 94 (35 PR)

• What does it mean to a teacher/parent to know that Jill grew 9 SS points?

• How do you explain to parent that all 19 point PR changes do not mean the same thing given that PR’s are not equal interval?

OR

On the WJ III Letter-Word Identification, Jill improved from 25 % proficiency (RPI = 25/90) to 50 % proficiency (RPI = 50/90)

• Doesn’t this make more sense to a teacher/parent? Jill’s proficiency, when compared to her age-(or grade) mates who typically demonstrate 90 % proficiency, has improved from 25% to 50%.

• Jill has doubled her real-world LWID proficiency.
<table>
<thead>
<tr>
<th>W Difference Values</th>
<th>Reported RPIs</th>
<th>Proficiency</th>
<th>Functionality</th>
<th>Development</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>+31 &amp; above</td>
<td>100/90</td>
<td>very advanced</td>
<td>very advanced</td>
<td>very advanced</td>
<td>extremely easy</td>
</tr>
<tr>
<td>+14 to +30</td>
<td>98/90 to 100/90</td>
<td>advanced</td>
<td>advanced</td>
<td>advanced</td>
<td>very easy</td>
</tr>
<tr>
<td>+7 to +13</td>
<td>95/90 to 98/90</td>
<td>average to advanced</td>
<td>WNL to advanced</td>
<td>age-appropriate to advanced</td>
<td>easy</td>
</tr>
<tr>
<td>-6 to +6</td>
<td>82/90 to 95/90</td>
<td>average</td>
<td>WNL</td>
<td>age-appropriate</td>
<td>manageable</td>
</tr>
<tr>
<td>-13 to -7</td>
<td>67/90 to 82/90</td>
<td>limited to average</td>
<td>mildly impaired to WNL</td>
<td>mildly delayed to age-approp.</td>
<td>difficult</td>
</tr>
<tr>
<td>-30 to -14</td>
<td>24/90 to 67/90</td>
<td>limited</td>
<td>mildly impaired</td>
<td>mildly delayed</td>
<td>very difficult</td>
</tr>
<tr>
<td>-50 to -31</td>
<td>3/90 to 24/90</td>
<td>very limited</td>
<td>moderately impaired</td>
<td>moderately delayed</td>
<td>extremely difficult</td>
</tr>
<tr>
<td>-51 &amp; below</td>
<td>0/90 to 3/90</td>
<td>negligible</td>
<td>severely impaired</td>
<td>severely delayed</td>
<td>impossible</td>
</tr>
</tbody>
</table>
In summary, if \( C \) is an individual’s composite score and \( \bar{S} \) is the corresponding averaged pseudo-composite score, the difference between them \((C - \bar{S})\) is influenced by three factors.

1. \((\bar{S} - \mu)\) = The extremity of the pseudo-composite score (i.e., its distance from the population mean \( \mu \))
2. \(\bar{r}\) = The average intercorrelation between the subtests in the composite.
3. \(k\) = The number of subtests in the composite

**Additional wrinkle:** Correlations between tests may vary developmentally...e.g.

<table>
<thead>
<tr>
<th>Test combos</th>
<th>6-8</th>
<th>9-13</th>
<th>14-19</th>
<th>20-39</th>
<th>40+</th>
</tr>
</thead>
<tbody>
<tr>
<td>• SR/PR (Gv)</td>
<td>.12</td>
<td>.16</td>
<td>.22</td>
<td>.27</td>
<td>.27</td>
</tr>
<tr>
<td>• CF/AS (Gf)</td>
<td>.51</td>
<td>.57</td>
<td>.58</td>
<td>.61</td>
<td>.65</td>
</tr>
</tbody>
</table>
XBA has principles re: use of norm-based composites (was in prior editions) that should be followed regarding use of norm-based composites.

XBA has now incorporated reliability and test correlation information in its software (reviewed over 1,750 coefficients; Flanagan, pers. comm., Nov. 2013).