

APPLIED PSYCHOMETRICS 101:

#3: MDS Analysis of the CHC-based WJ III Battery: Implications for possible refinements and extensions of the CHC model of human intelligence

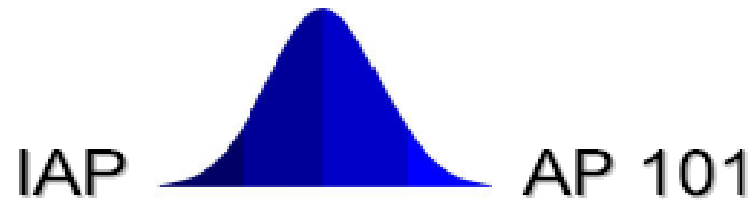
The WJ III Battery is comprised of both cognitive (intelligence) and achievement components. As reported in the technical manual, the Cattell-Horn-Carroll (CHC) theory of cognitive abilities organizational structure of the WJ III has been validated. The current investigation analyzed the cognitive and achievement tests for all WJ III norm subjects from ages 6-18 years of age. Multidimensional scaling (MDS—Guttman Radex model) of the 50 WJ III tests suggested new facets from which to interpret the WJ III. The results suggested three to four higher-order intermediate CHC model stratum abilities that varied along the dimensions of (a) controlled vs automatic cognitive processing and (b) product- vs process-dominant abilities. The results, together with recent similar analysis of the WAIS-IV, support Woodcock's Cognitive Performance Model (CPM). Implications for possible minor changes in the CPM model are suggested. More importantly, the WJ III and WAIS-IV results collectively suggest hypothesized refinements and extensions of the CHC intelligence framework. Research focused on exploring the compatibility of a combined CHC and Berlin Model of Intelligence Structure (BIS) theory is recommended.

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MDS Analysis of the CHC-based WJ III
Battery: Implications for possible refinements
and extensions of the CHC model of human
intelligence

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Author information and conflict of interest disclosure

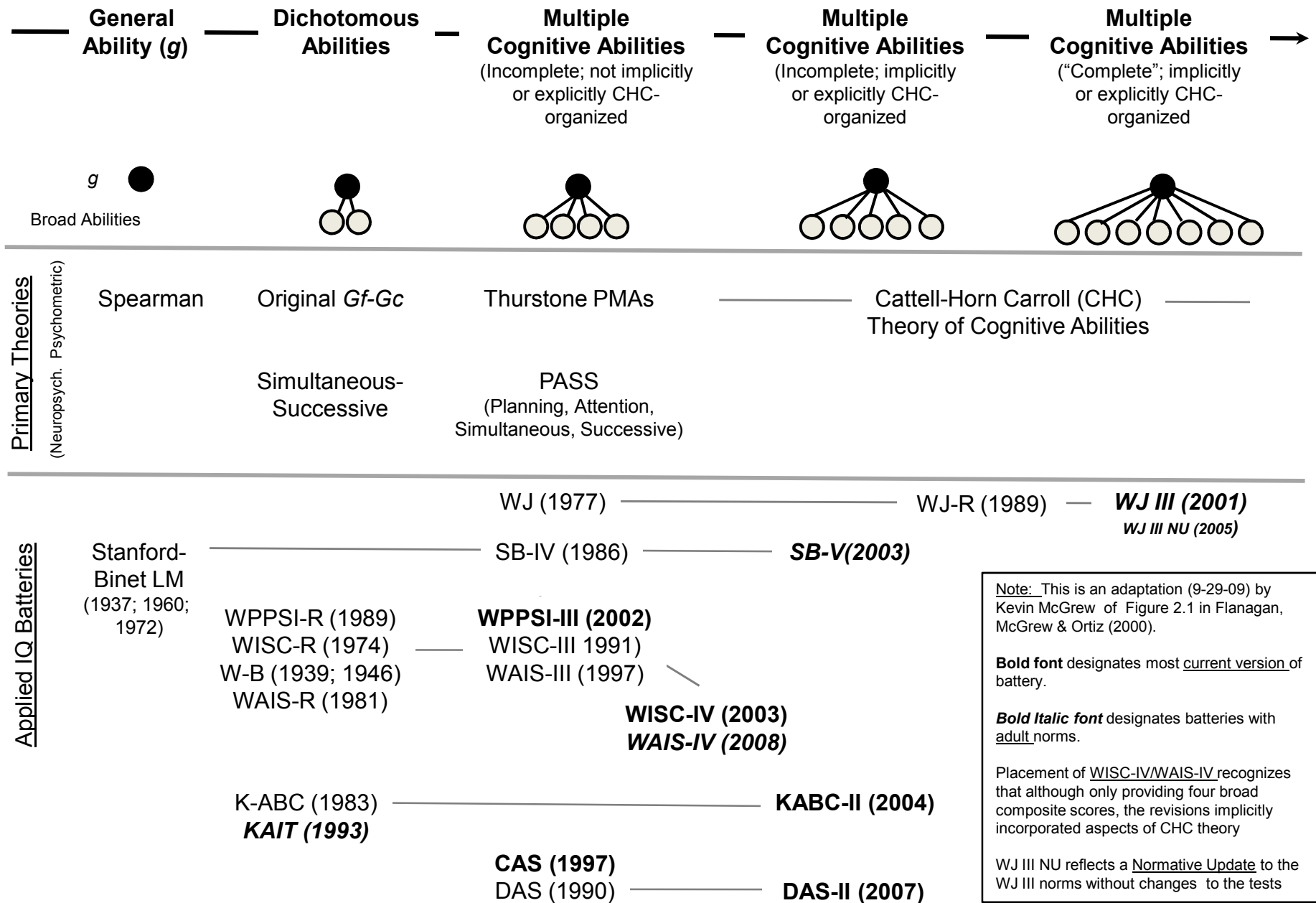
Dr. Kevin S. McGrew, Ph.D., is an Educational Psychologist with expertise and interests in applied psychometrics, intelligence theories and testing, human cognition, cognitive and non-cognitive individual difference variables impacting school learning, models of personal competence, conceptualization and measurement of adaptive behavior, measurement issues surrounding the assessment of individuals with disabilities, brain rhythm and mental timing research, and improving the use and understanding of psychological measurement and statistical information by professionals and the public. Prior to establishing IAP, Dr. McGrew was a practicing school psychologist for 12 years. McGrew received his Ph.D. in Educational Psychology (Special Education) from the University of Minnesota in 1989.

Dr. McGrew is currently Director of the *Institute for Applied Psychometrics* (IAP), a privately owned applied research organization established by McGrew. He is also the *Research Director for the Woodcock-Munoz Foundation* (WMF), Associate Director for *Measurement Learning Consultants* (MLC), and a *Visiting Professor in Educational Psychology* (School Psychology) at the University of Minnesota.

Dr. McGrew authored the current document in his role as the Director of IAP. The opinions and statements included in this report do not reflect or represent the opinions of WMF, MLC, or the University of Minnesota. More complete professional information, including his professional resume, can be found at www.iapsych.com.

Conflict of Interest Disclosure: Dr. McGrew is a co-author (with a financial interest) in the *Woodcock-Johnson Battery—Third Edition (WJ III; 2001)* as well as the *Bateria III Woodcock-Muñoz (BAT III, 2005)*, published by *Riverside Publishing*. He was a paid consultant, but was not a co-author, for the *Woodcock-Johnson Psychoeducational Battery—Revised* (WJ-R; 1989).

Continuum of Progress: Intelligence Theories and Test Batteries



Note: This is an adaptation (9-29-09) by Kevin McGrew of Figure 2.1 in Flanagan, McGrew & Ortiz (2000).

Bold font designates most current version of battery.

Bold Italic font designates batteries with adult norms.

Placement of *WISC-IV/WAIS-IV* recognizes that although only providing four broad composite scores, the revisions implicitly incorporated aspects of CHC theory

WJ III NU reflects a Normative Update to the WJ III norms without changes to the tests

Contemporary psychometric research has converged on the Cattell-Horn-Carroll (CHC) theory of cognitive abilities as the consensus working taxonomy of human intelligence

Intelligence 37 (2009) 1–10



Contents lists available at [ScienceDirect](#)

Intelligence



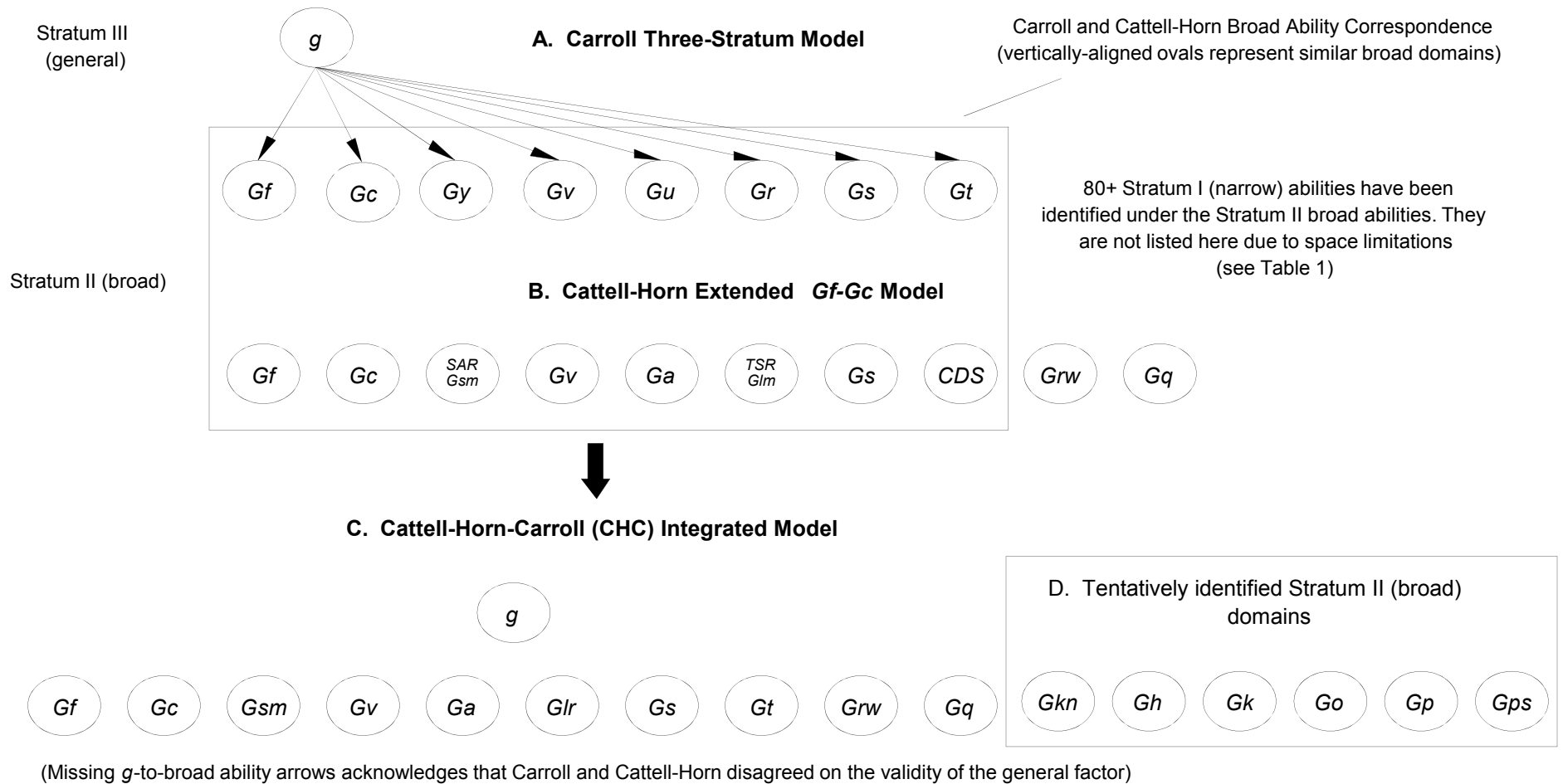
Editorial

CHC theory and the human cognitive abilities project: Standing on the shoulders of the giants of psychometric intelligence research

Kevin S. McGrew*

Woodcock-Muñoz Foundation, University of Minnesota, United States

McGrew, K. (2009). Editorial: CHC theory and the human cognitive abilities project: Standing on the shoulders of the giants of psychometric intelligence research, *Intelligence*, 37, 1-10.



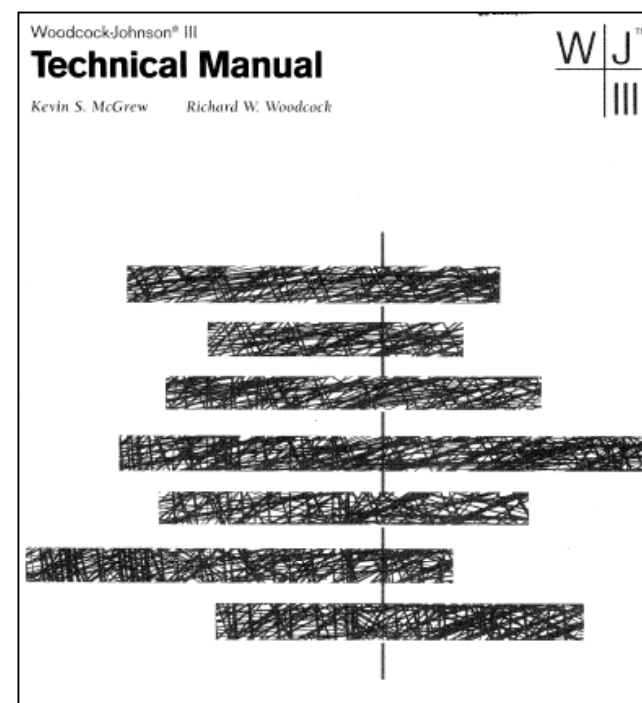
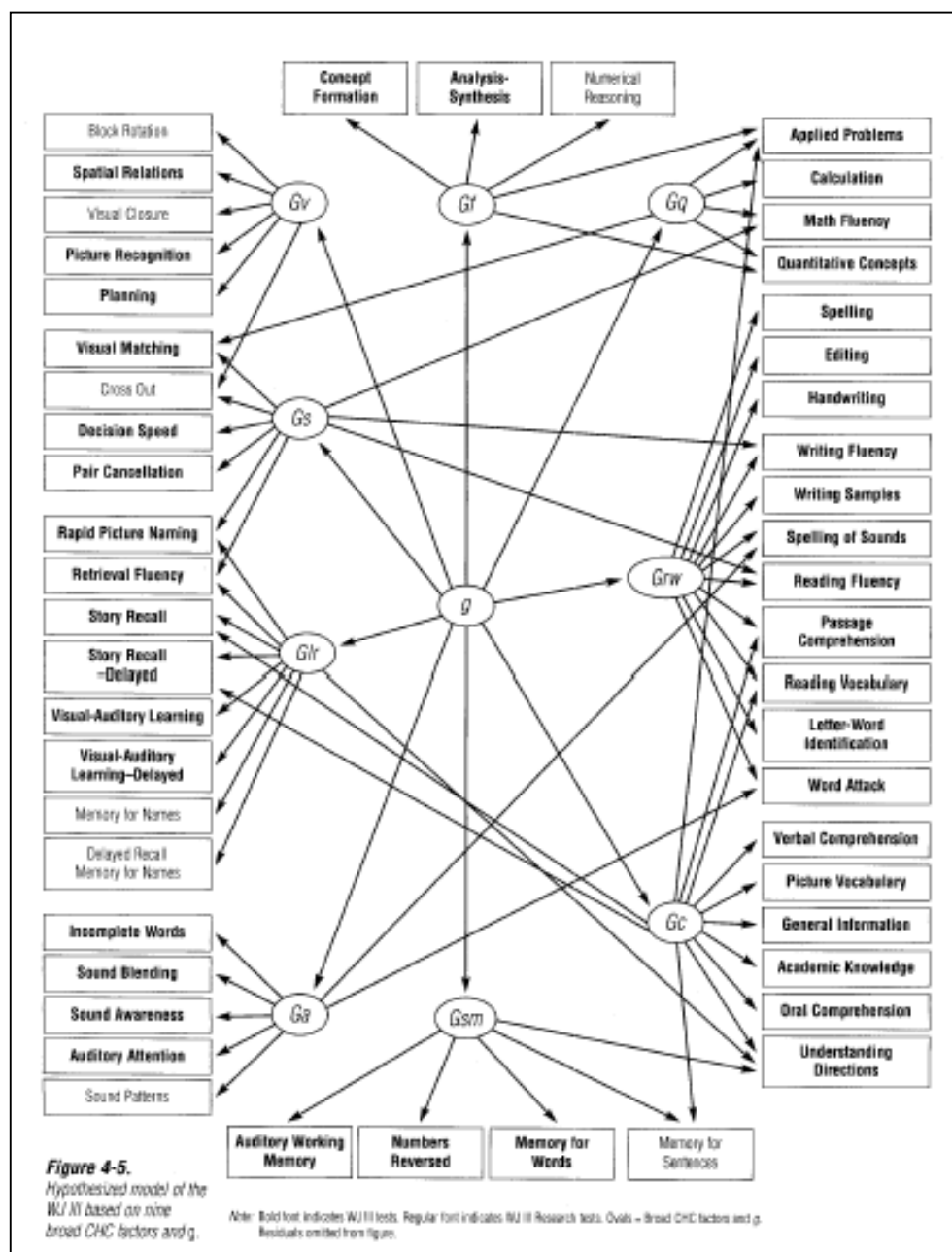
CHC Broad (Stratum II) Ability Domains

<i>Gf</i>	Fluid reasoning	<i>Gkn</i>	General (domain-specific) knowledge
<i>Gc</i>	Comprehension-knowledge	<i>Gh</i>	Tactile abilities
<i>Gsm</i>	Short-term memory	<i>Gk</i>	Kinesthetic abilities
<i>Gv</i>	Visual processing	<i>Go</i>	Olfactory abilities
<i>Ga</i>	Auditory processing	<i>Gp</i>	Psychomotor abilities
<i>Glr</i>	Long-term storage and retrieval	<i>Gps</i>	Psychomotor speed
<i>Gs</i>	Cognitive processing speed		
<i>Gt</i>	Decision and reaction speed		
<i>Grw</i>	Reading and writing		
<i>Gq</i>	Quantitative knowledge		

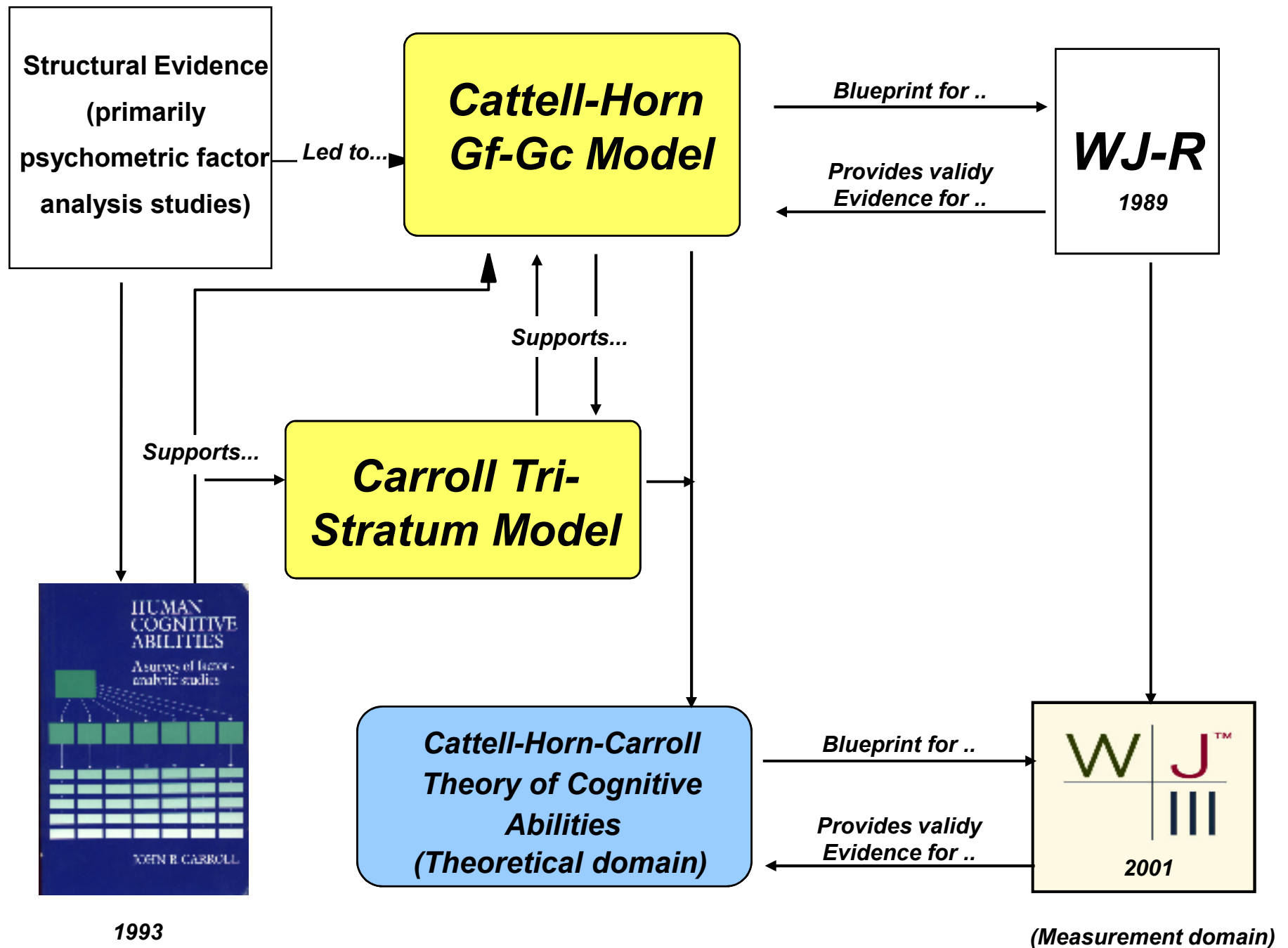
(see Table 1 for definitions)

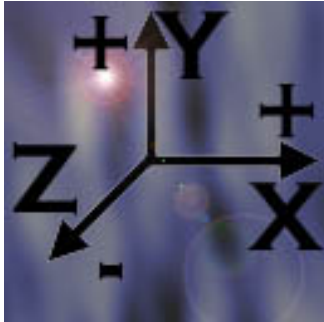
Complete CHC model and description of abilities can be found in:

McGrew, K. (2009). Editorial: CHC theory and the human cognitive abilities project: Standing on the shoulders of the giants of psychometric intelligence research, *Intelligence*, 37, 1-10.



CFA studies provide solid empirical support for CHC internal (structural) validity of WJ III battery





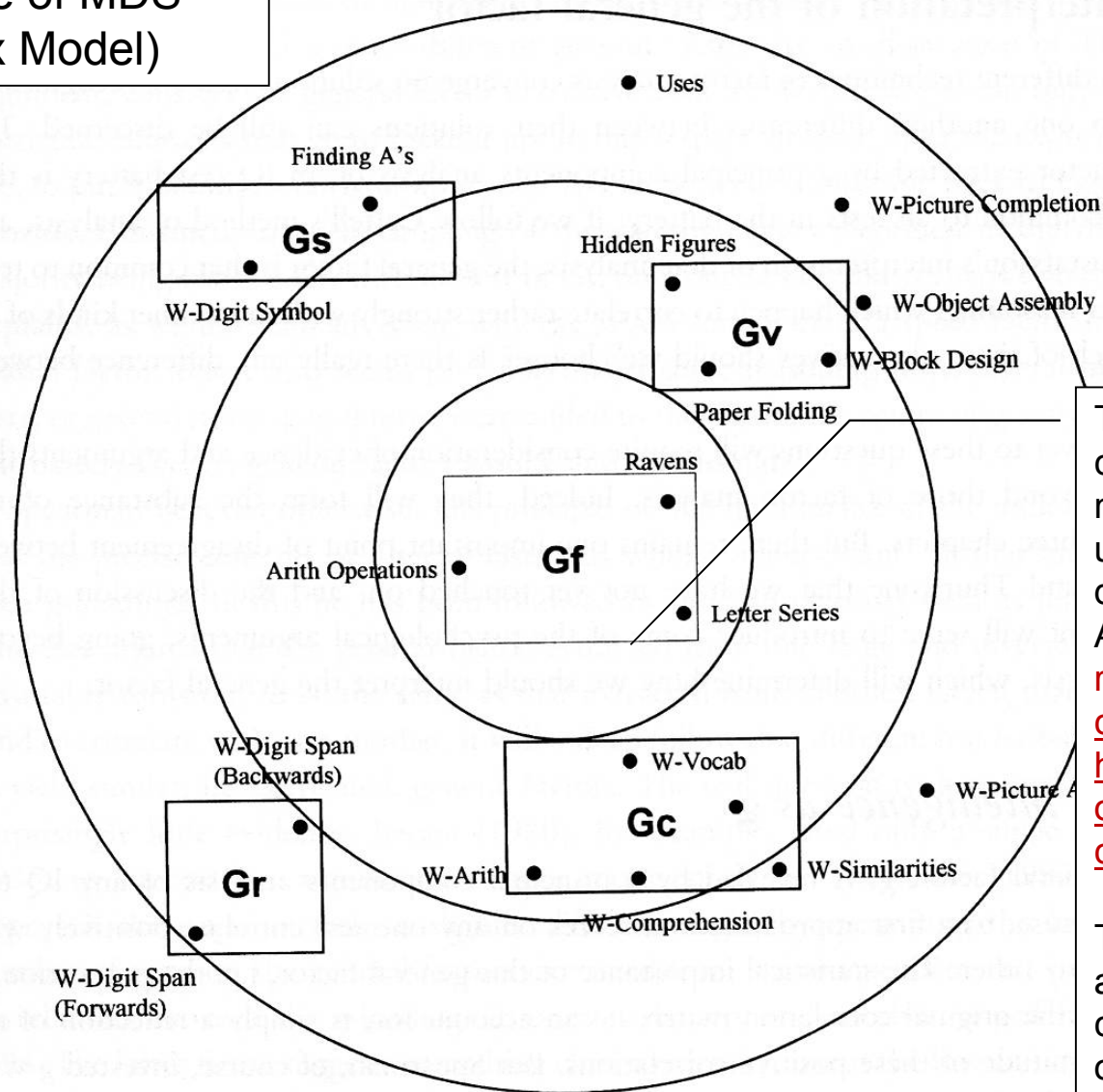
Guttman's Radex Theory

Ability tests can be classified by:

- Degree of cognitive complexity
- Differences in kind of content
- Differences in type of processes

Uses MDS (multidimensional scaling)

Example of MDS (Radex Model)



The closer a test is to the center of the figure, the more it is related to the underlying general dimension of the battery. Also, the center represents the most cognitively complex (i.e., have the largest number of performance components) tests.

Tests that group together are interpreted as sharing common stimulus content or cognitive processing characteristics

Fig. 6.2 The interrelationships between various types of IQ test represented as distances between two-dimensional space. Tests at the centre of the space are more closely related to all other tests than are those nearer the periphery. Solid lines are drawn round groups of tests defining some of Cattell's major factors, Gf, Gc, Gv, Gs. Tests labelled W are sub-tests of the WAIS. (Adapted from Snow *et al.*, 1984).

WJ III test abbreviations used figures

VCL = Visual Closure
PR = Picture Recognition
SPR = Spatial Relations
BR = Block Rotation
PLN = Planning
MN = Memory for Names
DRM = DR: Memory for Names
VAL = Visual-Auditory Learning
DRV = DR: Visual-Auditory Learning
AS = Analysis-Synthesis
CF = Concept Formation
AP = Applied Problems
NS = Number Series
NM = Number Matrices
AWM = Auditory Working Memory
NR = Numbers Reversed
MW = Memory for Words
MS = Memory for Sentences
VC = Verbal Comprehension
AK = Academic Knowledge
GI = General Information
OC = Oral Comprehension
STR = Story Recall
DRS = DR: Story Recall

CO = Cross Out
PC = Pair Cancellation
VM = Visual Matching
RDF = Reading Fluency
REF = Retrieval Fluency
MF = Math Fluency
WF = Writing Fluency
DS = Decision Speed
RPN = Rapid Picture Naming
AA = Auditory Attention
SB = Sound Blending
SA = Sound Awareness
SNP = Sound Patterns-Voice
IW = Incomplete Words
AP = Applied Problems
QC = Quantitative Concepts
CAL = Calculation
RV = Reading Vocabulary
PSC = Passage
Comprehension
WA = Word Attach
LW = Letter-Word Identification
ED = Editing
SOS = Spelling of Sounds
SPL = Spelling
WS = Writing Samples

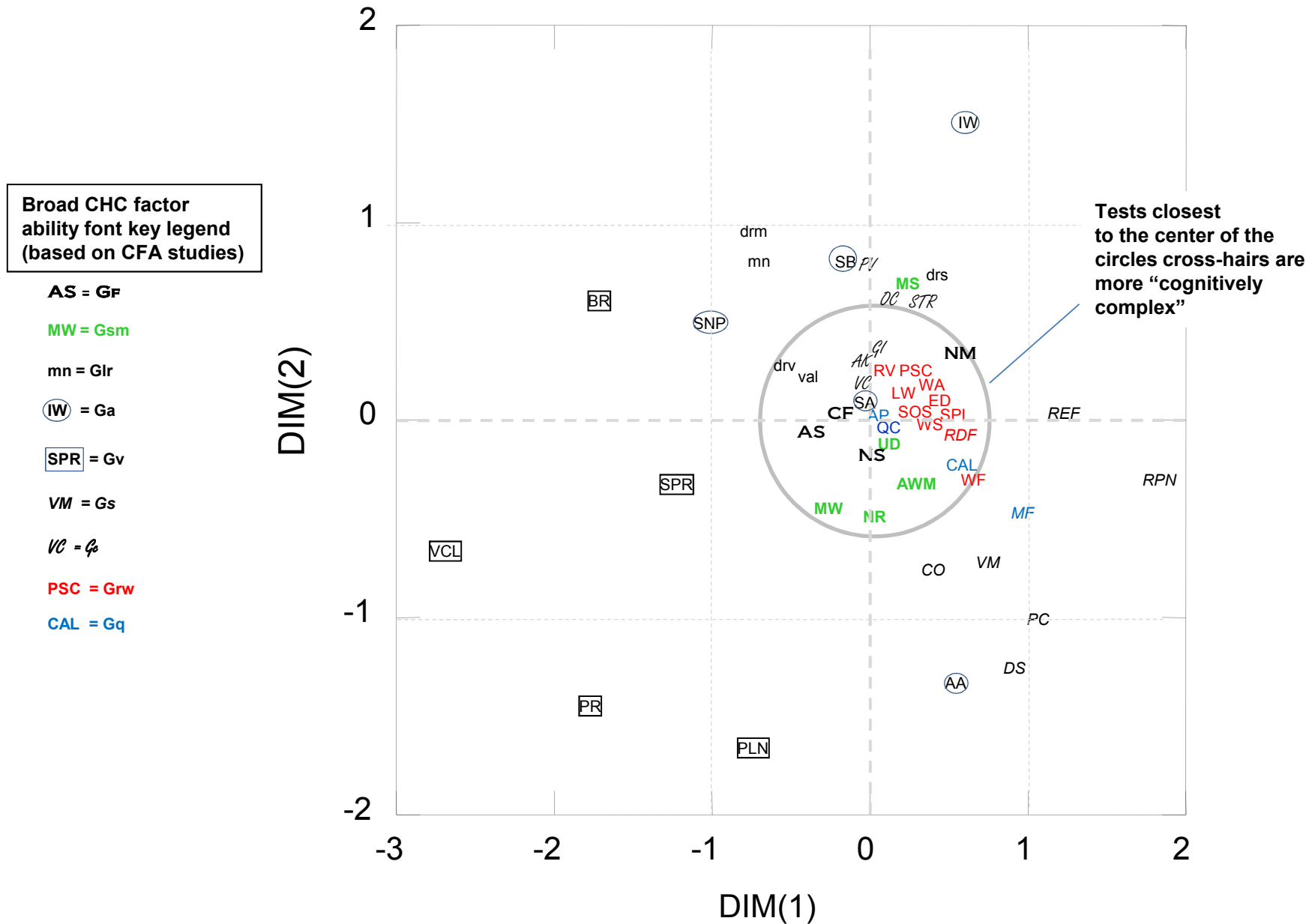
Test descriptions and CHC classifications can be found at:

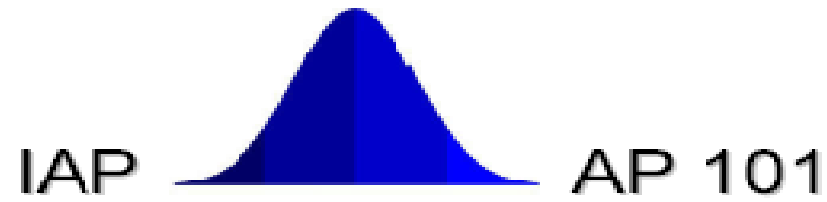
<http://intelligencetesting.blogspot.com/2005/10/wj-iii-chc-test-classifications.html>

Copy is included at the end of the PDF version of this PPT-based report

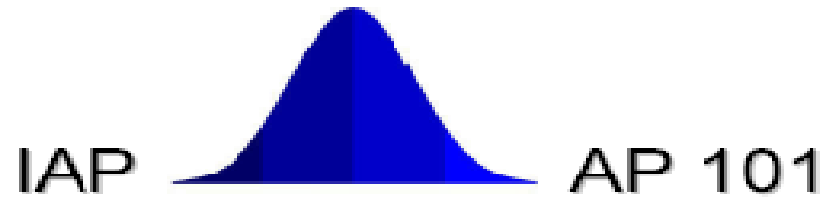
2-D MDS (Guttman's Radex Model) results for WJ III test (NU norms)

[Note - Sample is all WJ III norm subjects from ages 6-18]





What about the WJ III CHC factor cluster tests? Do they group together in the MDS analysis?.....see next slide.



Are there any other process (operations)
or content characteristic dimensions by
which the WJ III MDS results might be
viewed?....see next slide.

2

What common characteristic/dimension do the tests below the blue dividing line have in common?

Broad CHC factor
ability font key legend
(based on CFA studies)

GF

Gsm

glr

Ga

Gv

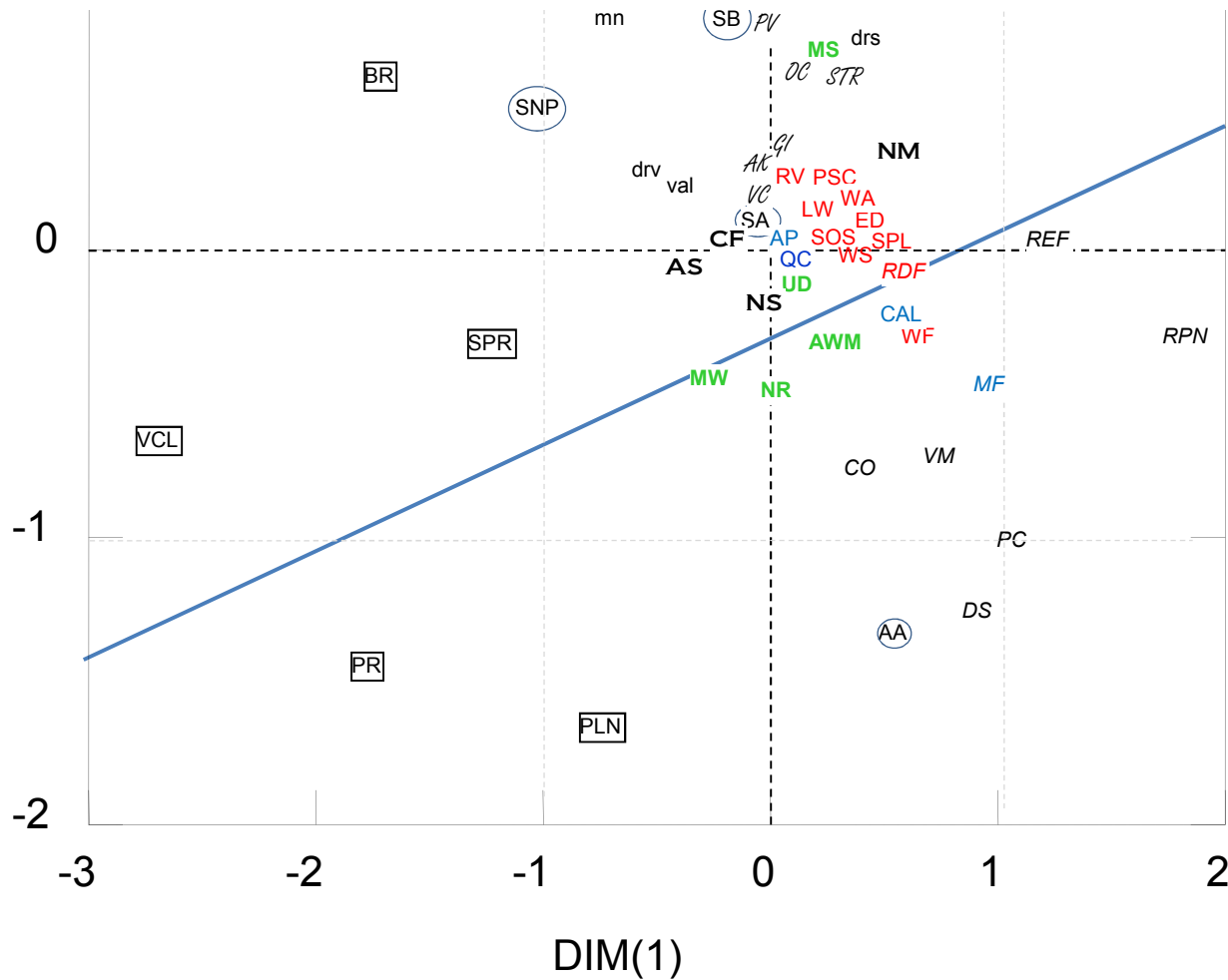
Gs

Ge

Grw

Gq

DIM(2)



**Broad CHC factor
ability font key legend
(based on CFA studies)**

GF

Gsm

glr

Ga

Gv

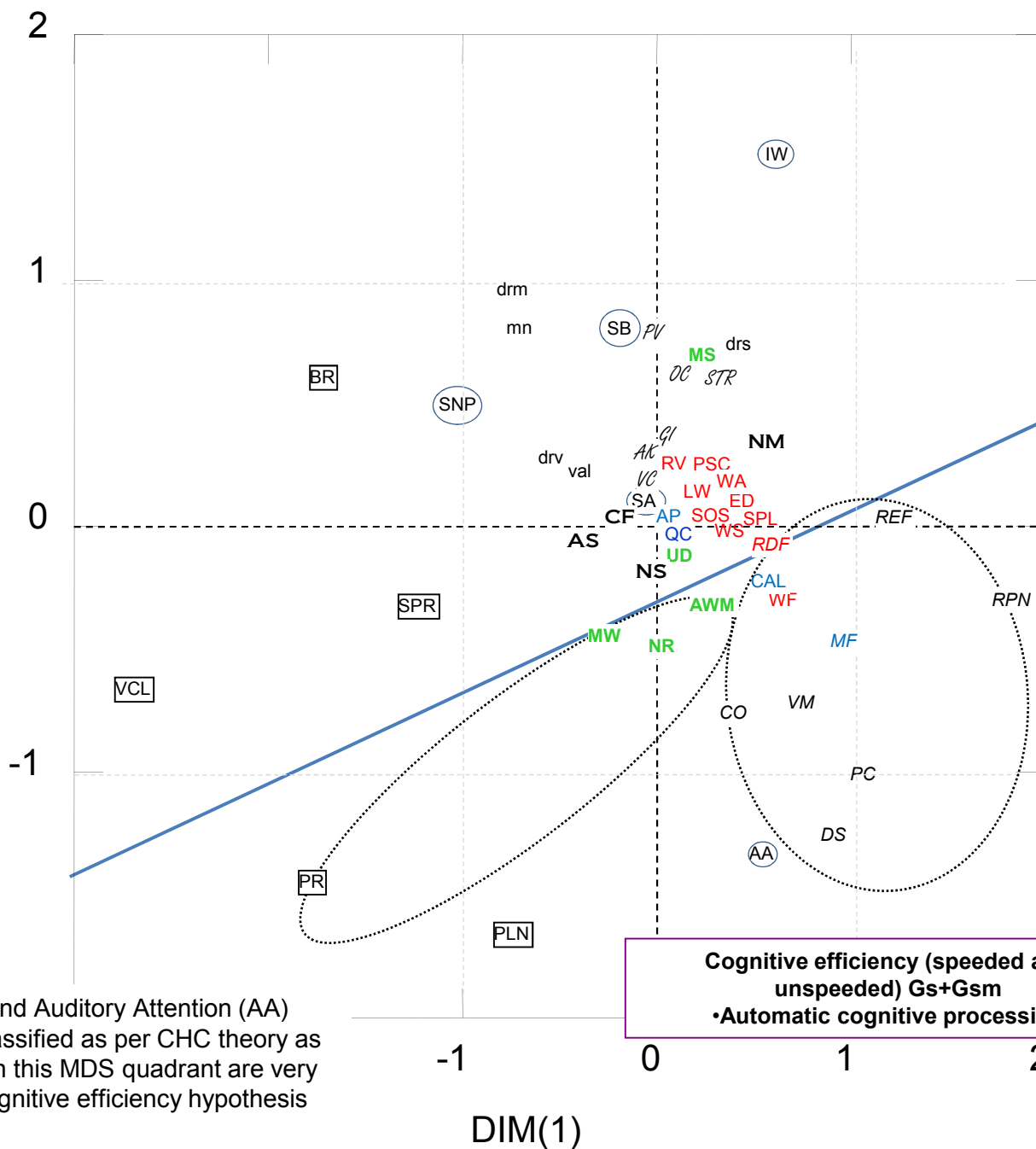
Gs

Gc

Grw

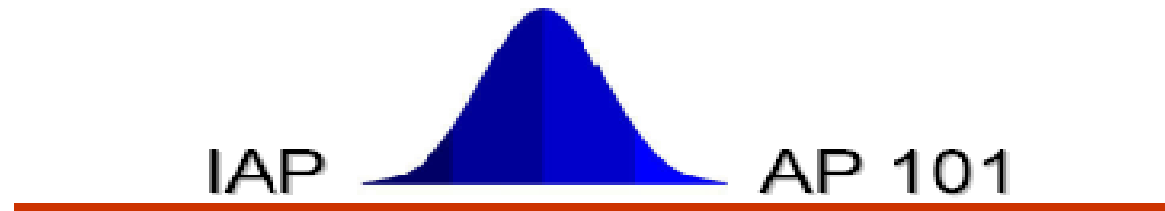
Gq

DIM(2)



**Cognitive efficiency (speeded and
unspeeded) Gs+Gsm
•Automatic cognitive processing**

The Planning (PLN) and Auditory Attention (AA) tests (although not classified as per CHC theory as Gs or Gsm) location in this MDS quadrant are very consistent with the cognitive efficiency hypothesis



Given the Cognitive Efficiency (CE) broad quadrant, let's draw an orthogonal (perpendicular) line to the CE dimension line and see what we find.

**Broad CHC factor
ability font key legend
(based on CFA studies)**

GF

Gsm

glr

Ga

Gv

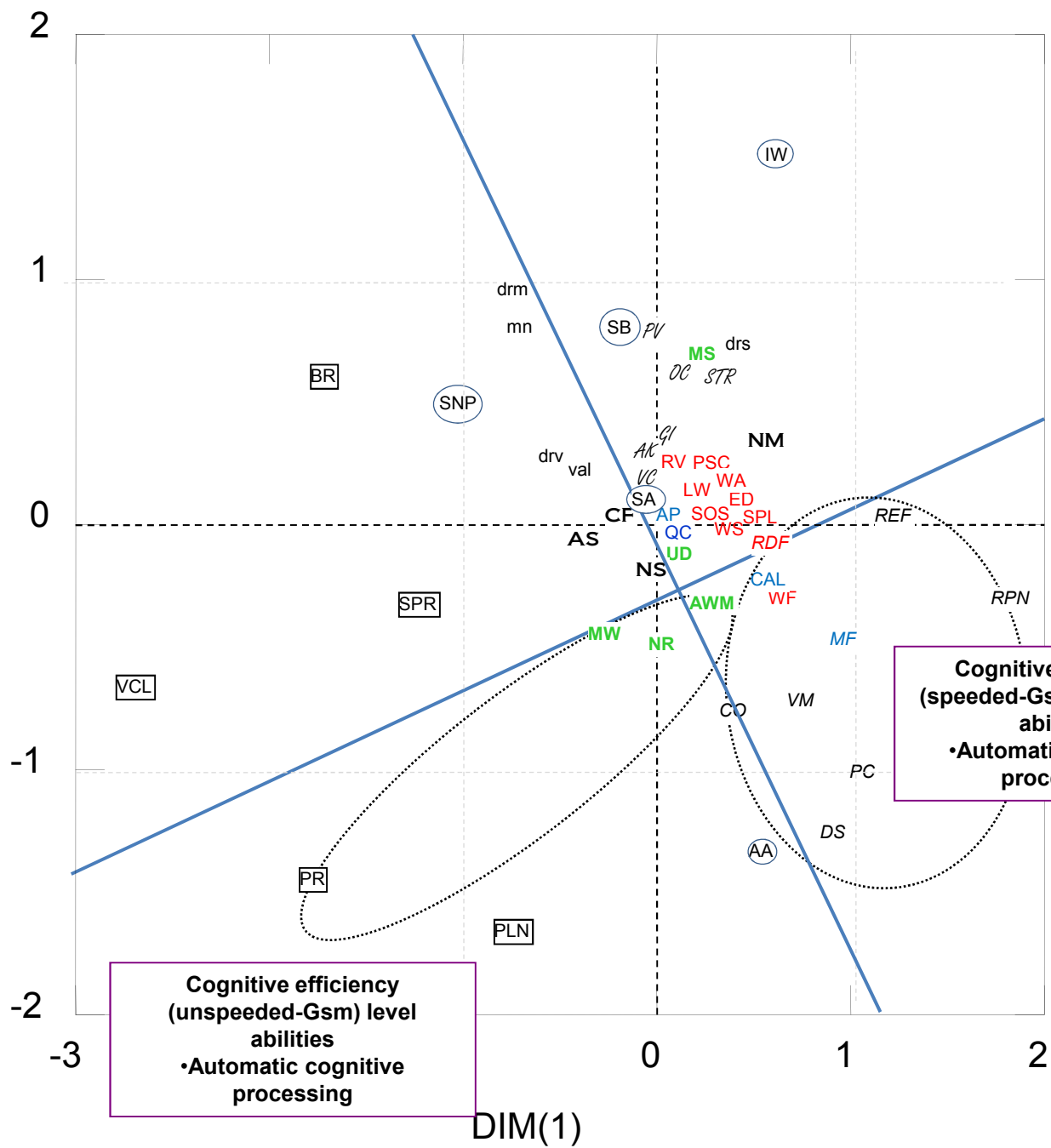
Gs

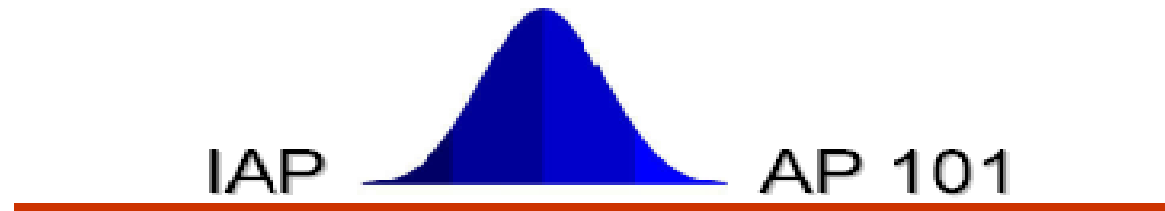
Ge

Grw

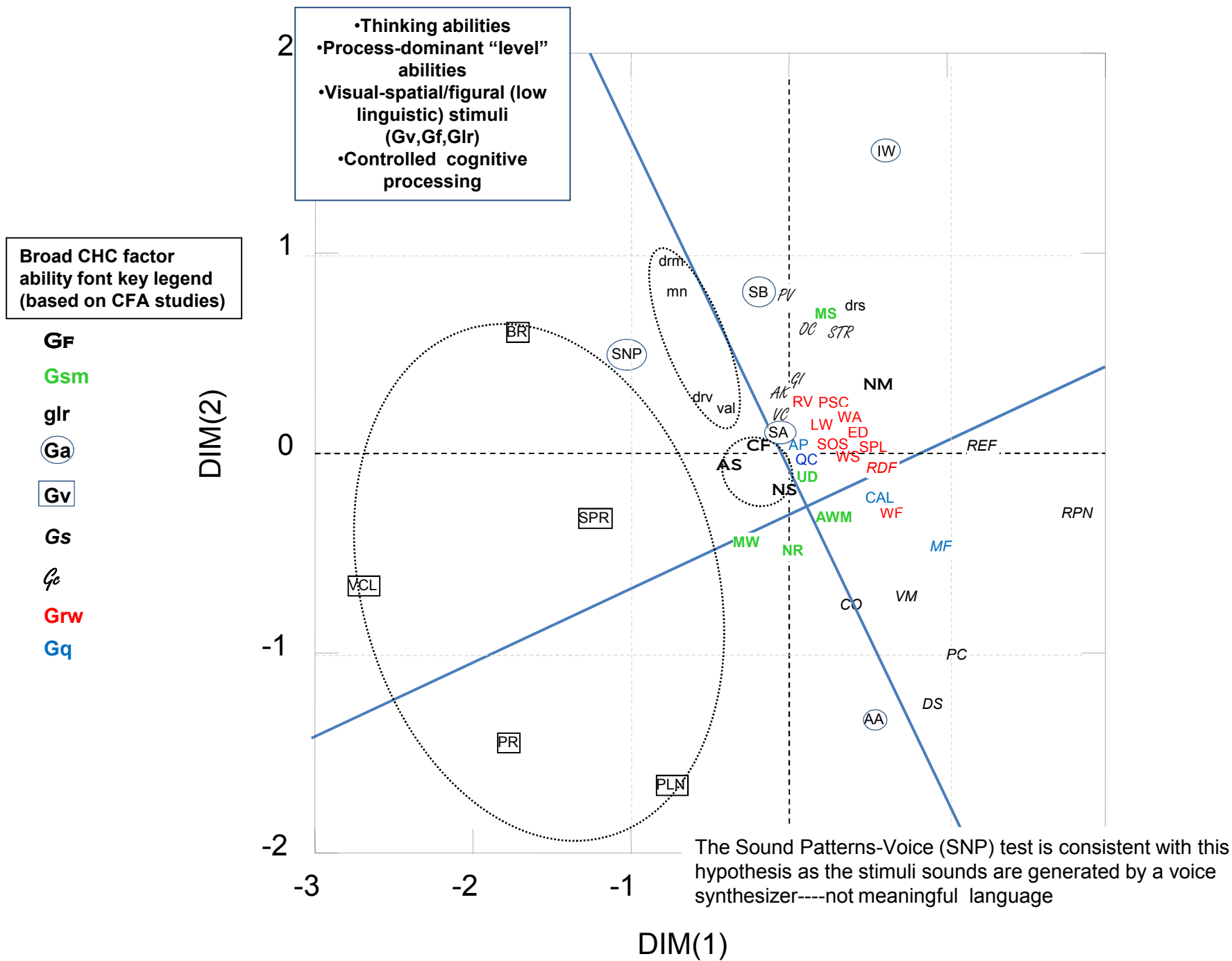
Gq

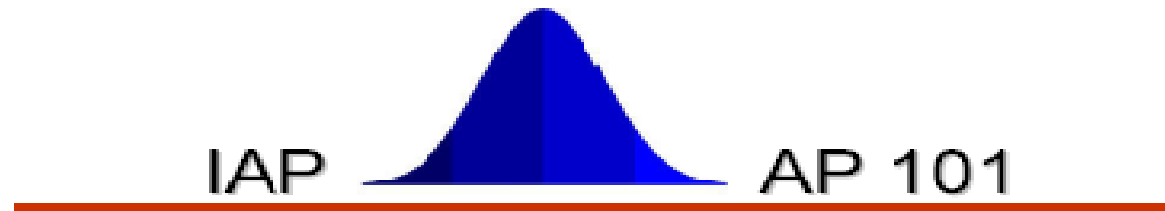
DIM(2)





Lets examine the upper left-hand corner quadrant. Any common features among most of the tests in this quadrant?



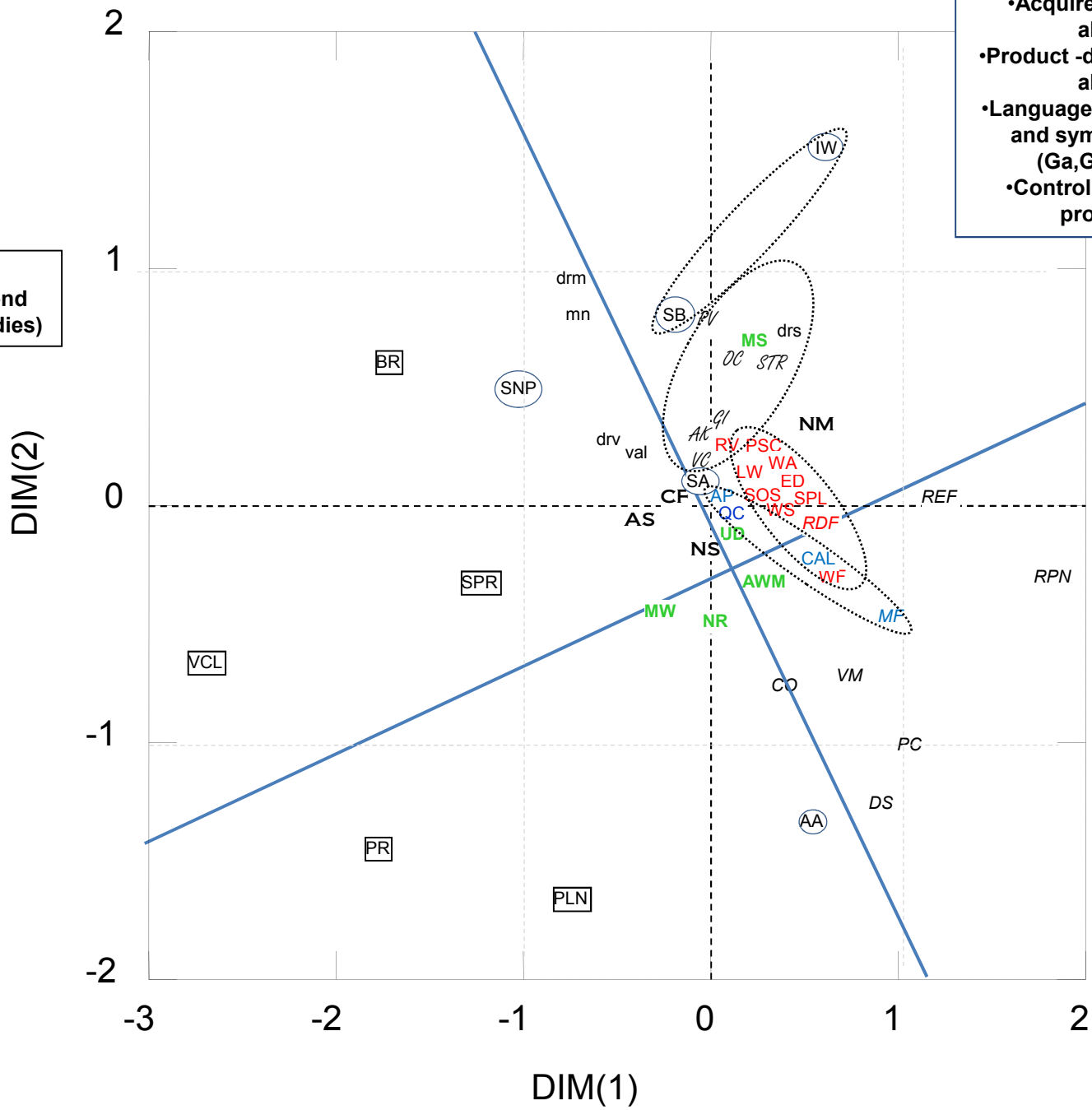


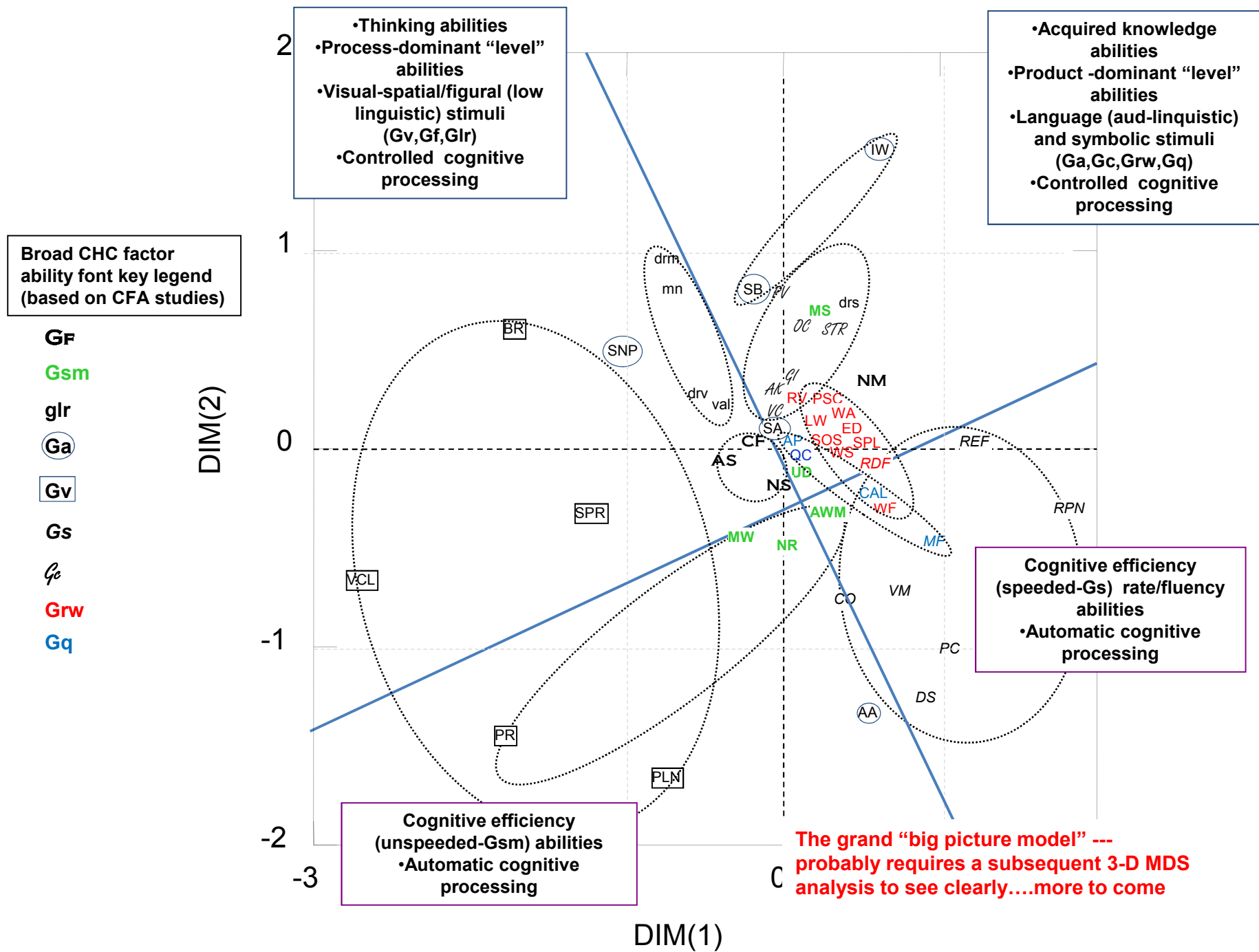
Lets examine the final right upper corner quadrant. Any common features among most of the tests in this quadrant?

Broad CHC factor
ability font key legend
(based on CFA studies)

GF
Gsm
glr
Ga
Gv
Gs
Ge
Grw
Gq

- Acquired knowledge abilities
- Product -dominant “level” abilities
- Language (aud-linguistic) and symbolic stimuli (Ga,Gc,Grw Gq)
- Controlled cognitive processing





Dual cognitive processes distinction in cognitive psychology

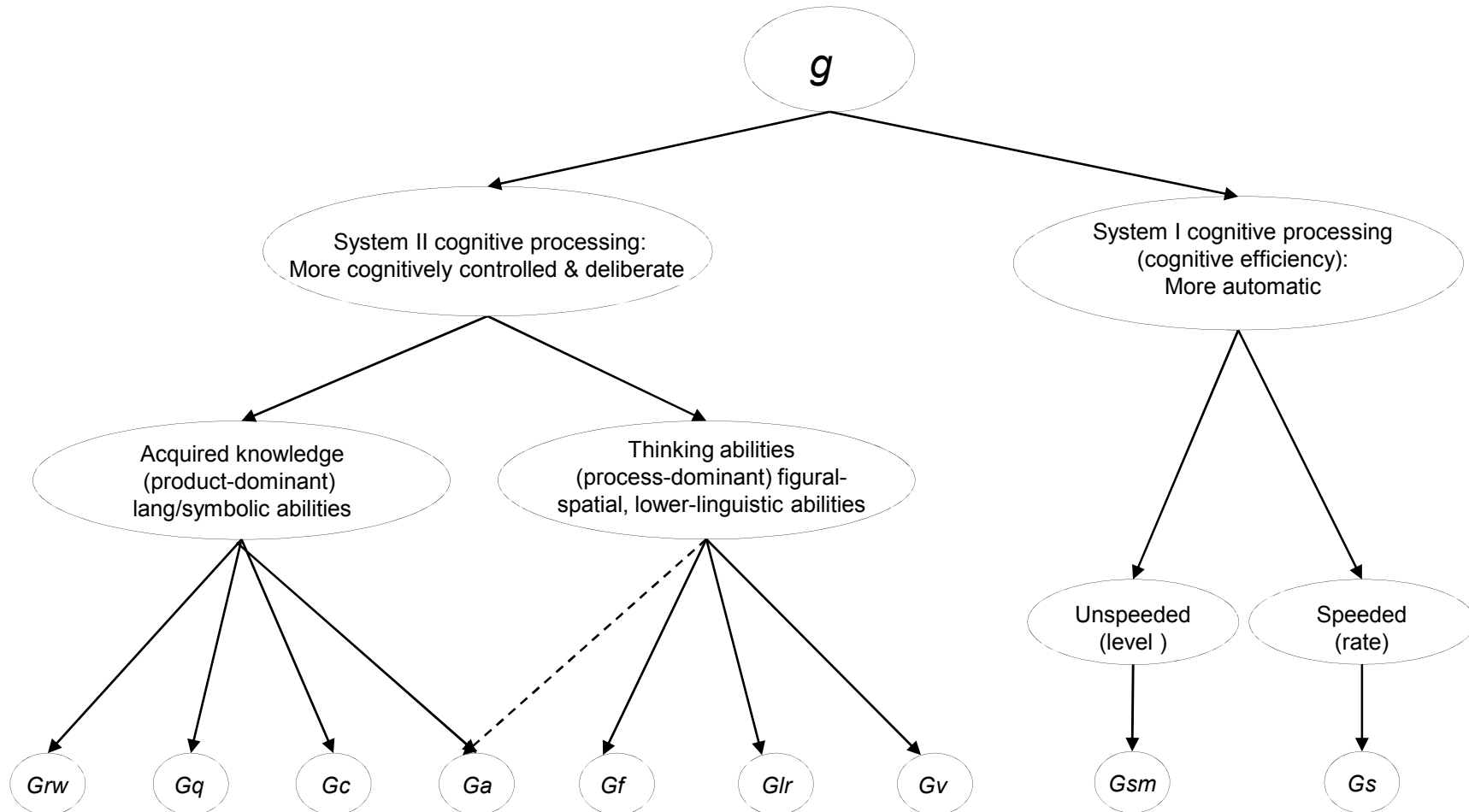
Kahneman, D. (2003). A perspective on judgment and choice.
American Psychologist, 58, 9, 697-720.

There is considerable agreement on the characteristics that distinguish the two types of cognitive processes, which Stanovich and West (2000) labeled System 1 and System 2.The operations of **System 1 are typically fast, automatic, effortless, associative, implicit (not available to introspection), and often emotionally charged; they are also governed by habit and are therefore difficult to control or modify.** The operations of **System 2 are slower, serial, effortful, more likely to be consciously monitored and deliberately controlled; they are also relatively flexible and potentially rule governed.** The effect of concurrent cognitive tasks provides the most useful indication of whether a given mental process belongs to System 1 or System 2. Because the overall capacity for mental effort is limited, effortful processes tend to disrupt each other, whereas effortless processes neither cause nor suffer much interference when combined with other tasks (Kahneman, 1973; Pashler, 1998). P. 698

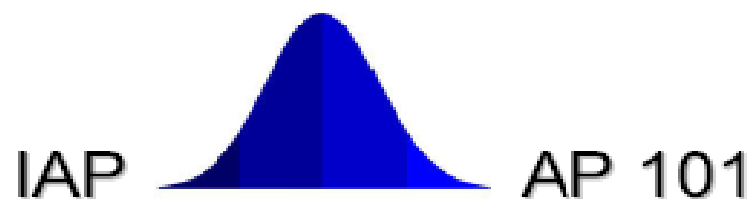
The WJ III MDS findings suggest a hypothesized modified Cattell-Horn-Carroll (CHC) theory of cognitive abilities framework

[with proposed intermediate factors/dimensions
between broad (stratum II) and general (stratum III) levels]

(Kevin McGrew 11-11-09)



Note: In a previous IAP AP 101 report of similar analysis of the WAIS-IV, very similar findings and conclusions were noted (can be found at (www.iqscorner.com)).....see next few slides



What does the WAIS-IV measure?
CHC analysis and beyond

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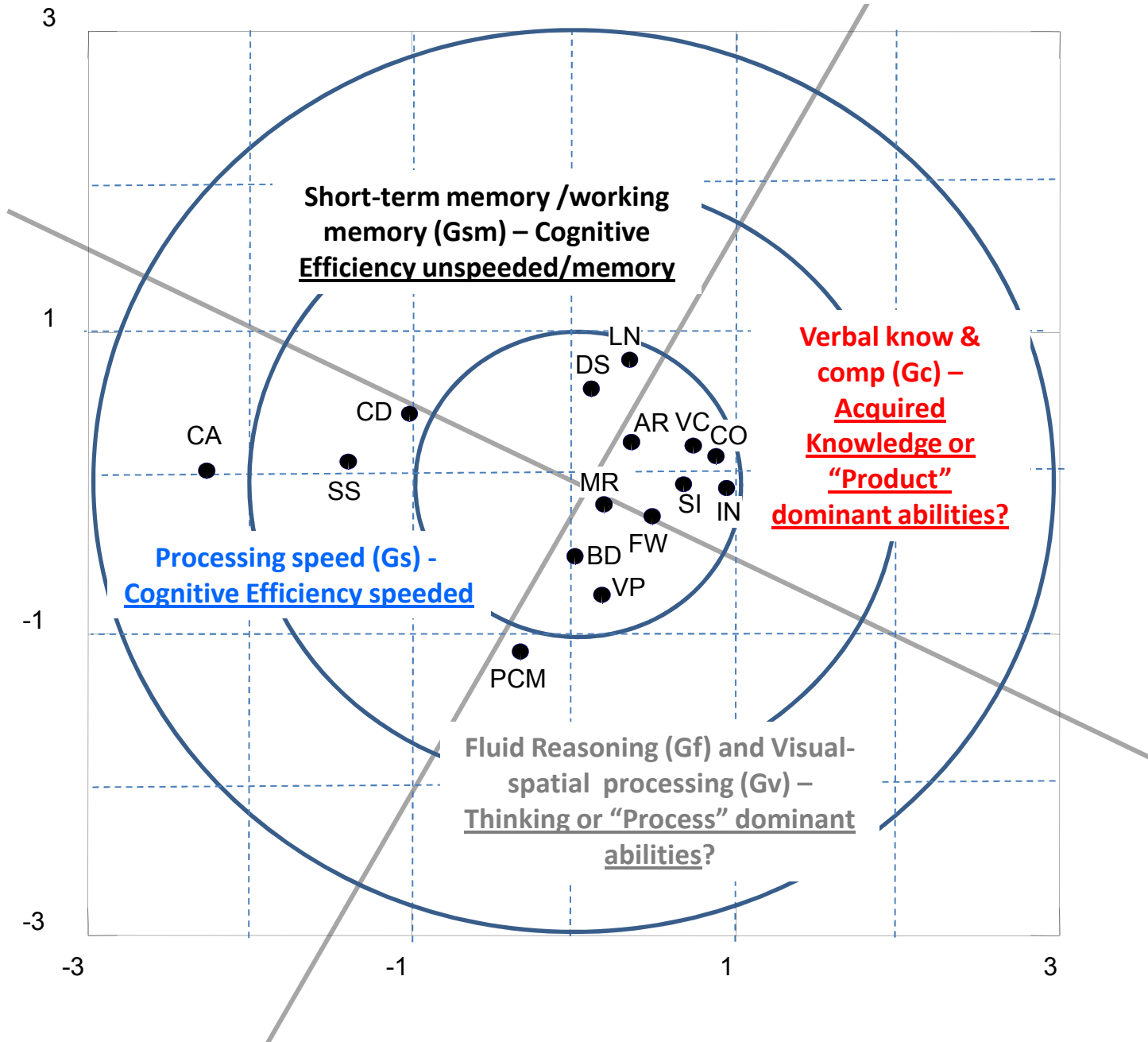
Director
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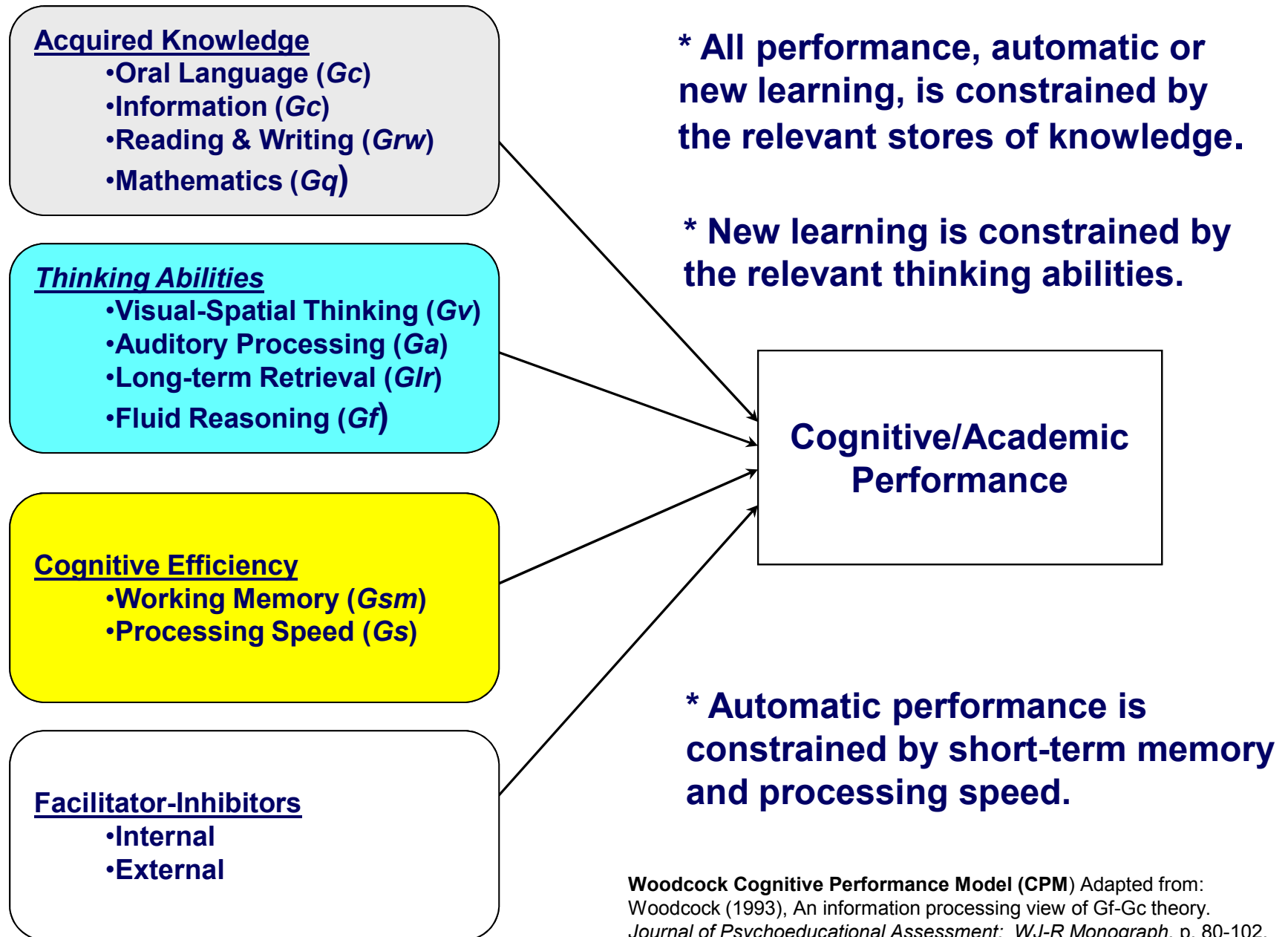
MDS (Guttman Radex model) of **WAIS-IV** subtest intercorrelations

It is a common practice in MDS analysis to visually partition the MDS spatial configuration into broader dimensions and consider interpretation at a higher-order level.

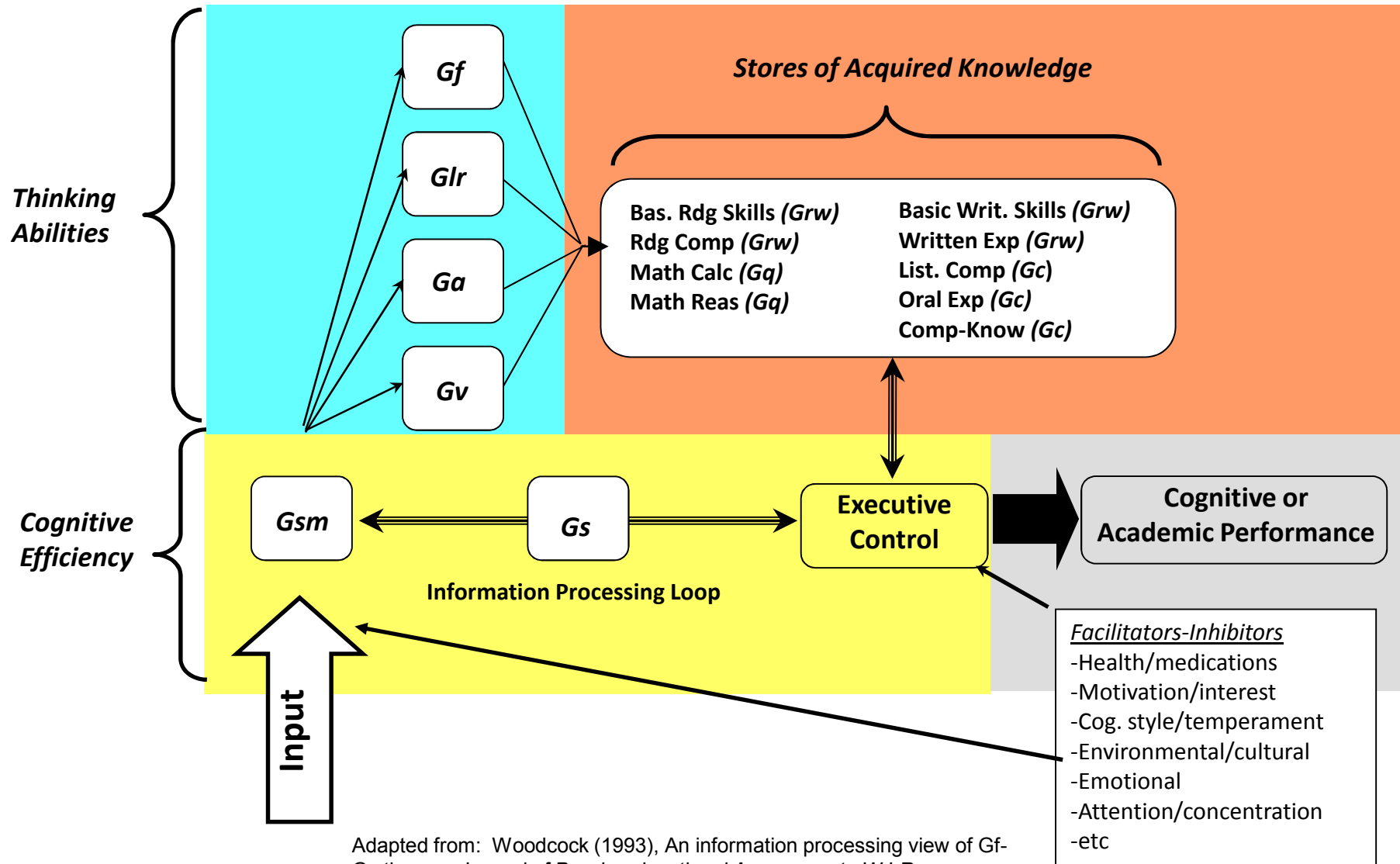
The current WAIS-IV MDS revealed the following hypothesized higher-order structure

Note – similar to hand rotation of factors in early days of EFA, K. McGrew took the cross-hair lines and hand rotated them (simultaneously) until a meaningful pattern emerged. The four-broad dimensions are interpreted as being very similar to the four cognitive domains of **Woodcock's Cognitive Performance Model (CPM)** – see next two slides



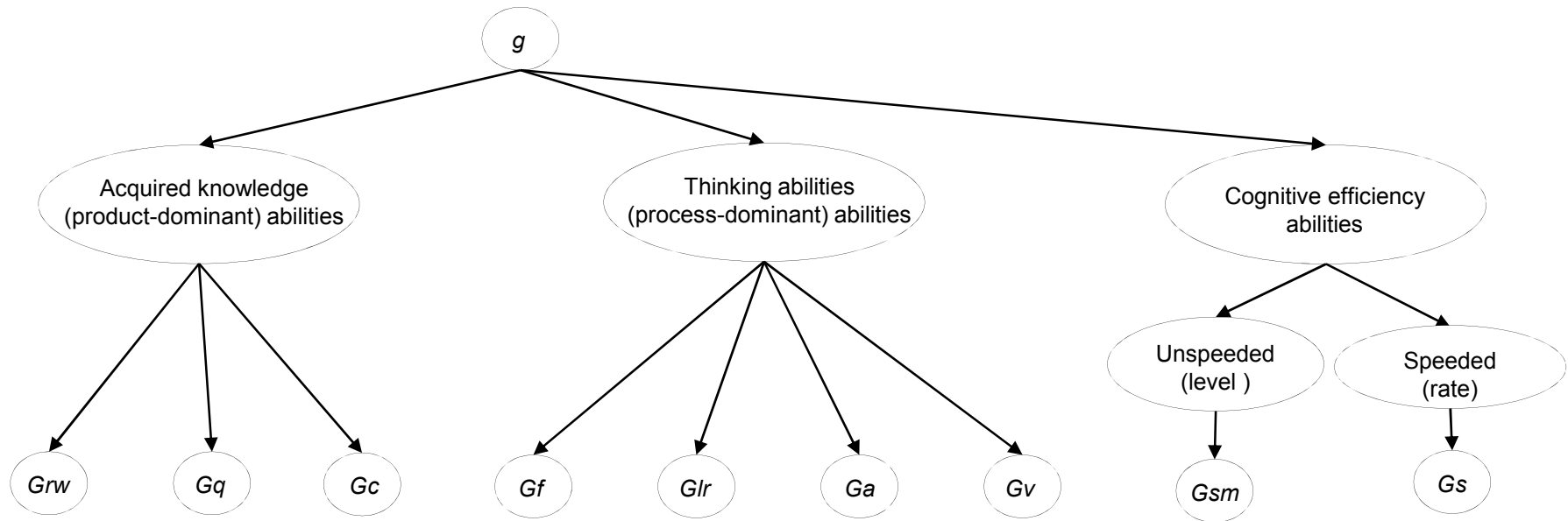


The CHC Information Processing Model



Adapted from: Woodcock (1993), An information processing view of Gf-Gc theory. *Journal of Psychoeducational Assessment: WJ-R Monograph*, p. 80-102.

The WAIS-IV MDS findings * suggest the possibility of a modified hypothesized Cattell-Horn-Carroll (CHC) theory of cognitive abilities [with proposed intermediate factors/dimensions between broad (stratum II) and general (stratum III) levels]
(Kevin McGrew 11-4-09)



70+ narrow (stratum I) abilities have been identified but are not included in figure for readability purposes)

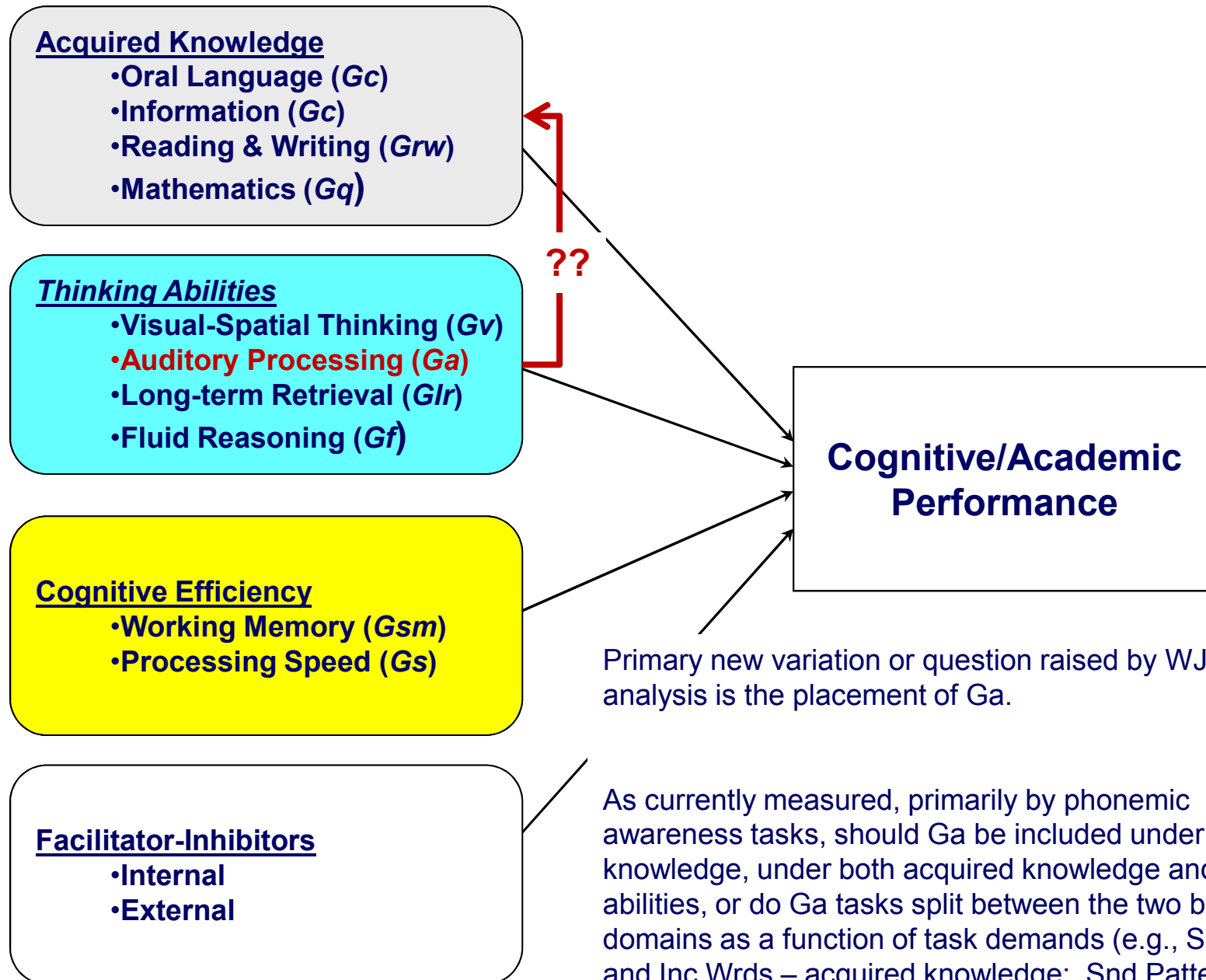
**CHC Broad (Stratum II) ability domains
included across cognitive and achievement
test batteries**

<i>Gf</i>	Fluid reasoning
<i>Gc</i>	Comprehension-knowledge
<i>Gsm</i>	Short-term memory
<i>Gv</i>	Visual processing
<i>Ga</i>	Auditory processing
<i>Glr</i>	Long-term storage and retrieval
<i>Gs</i>	Cognitive processing speed
<i>Grw</i>	Reading and writing
<i>Gq</i>	Quantitative knowledge

Note. Analysis of the WJ III battery via similar MDS (both 2D and 3D model analyses) and CA methods, as well as a Carroll Schmeid-Leimen EFA/CFA analysis, has suggested similar higher-order intermediate dimensions. Results can be found at **IQs Corner blog** (www.iqscorner.com)

* The current WAIS-IV conclusions, when combined with those for the WJ III, suggest the possibility that the unspeeded/speeded cognitive efficiency intermediate dimensions might best be conceptualized as merging into a single cognitive efficiency dimension.

More information re: these hypotheses in future presentations/reports





ELSEVIER

Intelligence 30 (2002) 261–288



Working-memory capacity explains reasoning ability—and a little bit more

Heinz-Martin Süß*, Klaus Oberauer, Werner W. Wittmann,
Oliver Wilhelm, Ralf Schulze

Food for thought: Are the MDS quadrants or
partitions reflecting content “facets” or a combination
of content “facets and “operations” as per the BIS
model of intelligence....see next slide

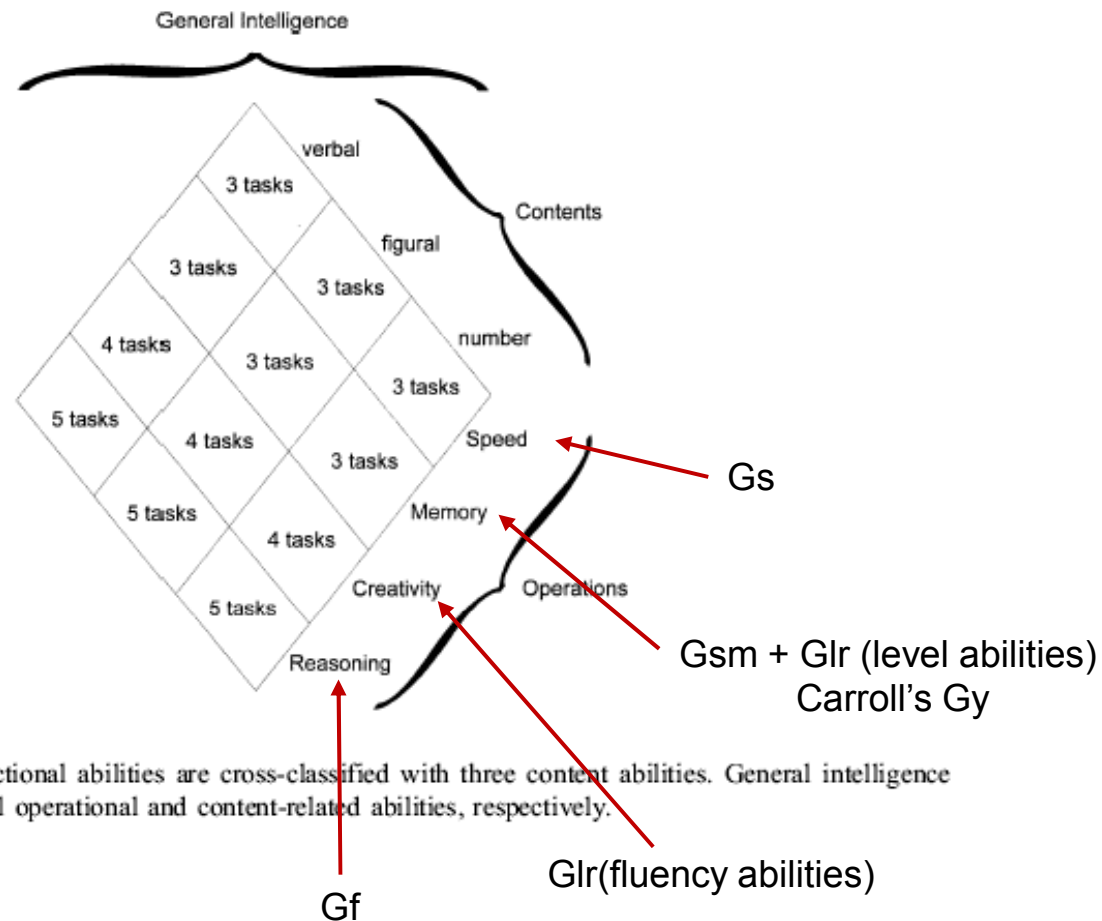


Fig. 1. The BIS. Four functional abilities are cross-classified with three content abilities. General intelligence represents the integral of all operational and content-related abilities, respectively.

The next steps in this research (with WJ III tests) is to run (a) 3-D MDS models, (b) CFA models that specify the hypothesized modified CHC model in prior slides, and (c) CFA models that specify both "content" and CHC "operation" (e.g., Gf, Gs, etc.) dimensions (a mixed CHC BIS model)

Revised/Updated Cattell-Horn-Carroll (CHC) Theory of Cognitive Ability Classifications of the WJ III Cognitive and Achievement Tests

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(www.iapsych.com & www.intelligencetesting.blogspot.com)

The revised/updated CHC classifications included in this document are based on the author's review of a variety of published and unpublished WJ III research (since the publication of the WJ III in 2001). A large portion of the reviewed analyses are unpublished multivariate exploratory analyses (exploratory/confirmatory factor analyses; cluster analyses; multidimensional scaling) of the WJ III norm data (by this author), some results which have been posted at www.iapsych.com or www.intelligencetesting.blogspot.com. These test classifications do not necessarily represent the position of other WJ III co-authors or the publisher of the WJ III (Riverside Publishing).

As outlined in previous writings (McGrew, 1997, 2005), most all of the broad CHC classifications are based on empirical research. Most all narrow ability classifications are based on expert consensus task analysis.

The current CHC test classifications should be considered more “relaxed” or “liberal” than prior published classifications. That is, all probable hypotheses, regardless of the number of times suggested in the research reviewed, if supported by theoretical and logical task analysis considerations, are included. The author has “erred” on the side of being more inclusive (liberal) in the range of narrow abilities measured by tests. This philosophy was embraced in the spirit of stimulating additional research and to guard against the “*premature hardening of WJ III CHC test categories*.” Furthermore, these classifications *do not* reflect additional test interpretations that have been offered by this author (in presentations or via the internet) in the context of contemporary cognitive information processing/neuropsychological research and theory.

The reader is strongly encouraged to read McGrew (2005) for important background information that was used in the development of this document. A critical table and figure from McGrew (2005) are included at the end of this document.

McGrew, K. S. (2005). The Cattell-Horn-Carroll (CHC) theory of cognitive abilities: Past, present and future. In D. Flanagan, & Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (p.136-202). New York: Guilford Press.

For on-line version of McGrew (2005) see <http://www.iapsych.com/CHCPP/CHCPP.html>

Broad CHC Domain/WJ III Cognitive (COG) & Achievement (ACH) tests	Hypothesized CHC Narrow Ability Classifications	Test Description
Short-term Memory (<i>Gsm</i>)		
Numbers Reversed (COG)	Working Memory (MW) Memory Span (MS) Temporal Tracking (<i>Ga</i> -UK)	Measures the ability to repeat a series of random numbers backward. The number sequences are presented by audio tape.
Memory for Words (COG)	Memory Span (MS)	Measures the ability to repeat lists of unrelated words in the correct sequence. The words are presented by audio tape.
Auditory Working Memory (COG)	Working Memory (MW) Memory Span (MS) Temporal Tracking (<i>Ga</i> -UK)	Measures the ability to retain two types of orally presented information and then repeat them in a specified order. The subject is presented a mixed series of words and digits and is asked to rearrange them by first saying the words in order and then the numbers. The task requires divided attention as the subject must perform two different mental operations simultaneously.
Memory for Sentences (COG)	Memory Span (MS) Listening Ability (<i>Gc</i> -LS)	Measures the ability to remember and repeat simple words, phrases, and sentences presented auditorily by a tape player.
Processing Speed (<i>Gs</i>)		
Visual Matching (COG)	Perceptual Speed: Scanning (Ps)	There are two different versions of this test. The Early Development (Edv) version is designed for use with preschool children and individuals who have developmental delays or reduced functioning. The task requires the person to point to the two matching shapes in a row of four to five shapes. This section has a 2-minute time limit and does not require the subject to write. The second version is designed for individuals above the developmental level of an average 5-year-old. On this section, the subject is asked to locate and circle the two identical numbers in a row of six numbers. This task proceeds in difficulty from single-digit numbers to triple-digit numbers and has a 3-minute time limit.
Decision Speed (COG)	Speed of Reasoning (RE) Semantic Processing Speed (<i>Gt</i> -R4)	Measures the ability to rapidly scan a row of pictures and decide which of the two drawings are the most related. The decisions become slightly more abstract as the test progresses. The subject is instructed to complete as many rows of drawings as possible within a three-minute time limit.
Rapid Picture Naming (COG)	Naming Facility (NA)	Measures the ability to rapidly identify and orally name pictures of common objects. The stimulus pictures are presented in rows of five. The test has a two-minute time limit.
Pair Cancellation (COG)	Perceptual Speed: Complex (Pc) Sustained Attention (AC)	Measures the capacity for sustained attention (vigilance). The subject is presented with rows that contain repeating pictures of a dog and a ball (in no particular sequence) and must circle all instances of when the “ball is followed by the dog”. The test has a three-minute time limit.
Cross Out (COG)	Perceptual Speed: Scanning (Ps)	Measures the ability to quickly scan and compare visual information. The subject must mark the five drawings in a row of 20 drawings that are identical to the first drawing in the row. The subject is given a 3-minute time limit to complete as many rows of items as possible.

Comprehension-Knowledge (Gc)		
Verbal Comprehension (COG)	Language Development (LD) Lexical Knowledge (VL)	Measures knowledge of word meanings and general language development. Test is comprised of four subtests. In Picture Vocabulary, the subject must name familiar and unfamiliar pictured objects. In Oral Vocabulary: Synonyms, the subject must say a word similar in meaning to the word presented. In Oral Vocabulary: Antonyms, the subject must say a word that is opposite in meaning to the word presented. In Verbal Analogies the subject must complete phrases with words that indicate appropriate analogies.
General Information (COG)	General (verbal) Information (K0)	Measures knowledge of the common or typical characteristics of certain objects. The test has two subtest components: "what" and "where" questions. The questions are presented orally and the subject must state the answer to "where you would find...." and "what you would do with..." questions.
Story Recall (ACH)	Listening Ability (LS) Meaning Memory (<i>Glr</i> -MM) Working Memory (<i>Gsm</i> -MW)	Measures the ability to recall increasingly complex stories presented orally to the subject. The subject is asked to tell back as much of the story as they can. The score is based on the number of correctly recalled story elements.
Story Recall-Delayed Recall (ACH)	Meaningful Memory (<i>Glr</i> -MM)	Measures the ability to recall (after 1 to 8 days) the stories presented in Oral Recall.
Understanding Directions (ACH)	Listening Ability (LS) Working Memory (<i>Gsm</i> -MW) Induction (<i>Gf</i> -RG)	Measures comprehension of linguistic concepts (receptive language). The subject is asked to follow oral directions by pointing to different items in a picture.
Picture Vocabulary (ACH)	Lexical Knowledge (VL)	Measures knowledge of word meanings. The subject must name familiar and unfamiliar pictured objects.
Oral Comprehension (ACH)	Listening Ability (LS)	Measures the ability to listen to a short tape-recorded passage and to verbally supply the single word missing at the end of the passage.
Academic Knowledge (ACH)	General (verbal) Information (K0) Information about Culture (K2) General Science Info (<i>Gkn</i> -K1) Geography Achievement (<i>Gkn</i> -A5)	Test is comprised of three subtests that collectively measure knowledge in various areas of the biological and physical sciences, history, geography, government, economics, art, music, and literature.
Long-term Retireval (Glr)		
Visual-Auditory Learning (COG)	Associative Memory (MA) Meaningful Memory (MM)	Measures the ability to associate new visual symbols (rebuses) with familiar words in oral language and to translate a series of symbols presented as a reading passage (a visual-auditory association task). This is a "learning" test where corrective feedback is provided to the subject.
Visual-Auditory Learning-Delayed Recall (COG)	Associative Memory (MA)	Measures the ability to recall and relearn (after 1 to 8 days) the symbols (rebuses) presented in Visual-Auditory Learning. This is a "relearning" task as the subject relearns forgotten associations. Corrective feedback is provided to the subject during the task.
Retrieval Fluency (COG)	Ideational Fluency (FI) Naming Facility (NA)	Measures fluency in retrieving the names of objects. The subject is asked to state as many items as they can of three different types, "things to eat or drink", "names of people", and "animals."
Memory for Names (COG)	Associative Memory (MA)	Measures the ability to learn associations between unfamiliar auditory and visual stimuli (an auditory—visual association task). The task requires learning the names of a series of space creatures. This is a "learning" test where corrective feedback is provided to the subject.

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Memory for Names-Delayed Recall (COG)	Associative Memory (MA)	Measures the ability to recall (after 1 to 8 days) the space creatures presented in Memory for Names.
Visual-Spatial Processing (Gv)		
Spatial Relations (COG)	Spatial Relations (SR) Visualization (Vz)	Measures the ability to visually match and combine shapes. The subject must select from a series of shapes, the component parts composing a given whole shape.
Picture Recognition (COG)	Visual Memory (MV) Associative Memory (<i>Glr</i> -MA)	Measures the ability to recognize a subset of previously presented pictures within a larger set of pictures
Planning (COG)	Spatial Scanning (SS)	Measures the ability to plan a tracing route that covers as many segments of a dotted line drawing as possible without lifting the pencil or tracing over the same segment twice. The test requires "forward thinking" in that the subject is required to plan a sequence of steps prior to initializing the plan.
Visual Closure (COG)	Closure Speed (CS)	Measures the ability to name a drawing or picture of a simple object that is represented by disconnected lines. The test requires the subject to visually combine the disconnected lines into a meaningful whole.
Block Rotation (COG)	Visualization (Vz) Spatial Relations (SR)	Measures the ability to recognize two geometric designs (in a row of five) that are identical, although rotated to a different visual perspective from the target geometric design. Below the target stimulus are five pictures of geometric shapes or three-dimensional block strings that have been rotated in space. The subject must identify which two drawings are replications of the target item.
Auditory Processing (Ga)		
Sound Blending (COG)	Phonetic Coding (PC)	Measures the ability to perform auditory synthesis on segments of speech. After hearing the recorded parts (syllables and/or phonemes) of a word the subject must "blend" the parts together to make a whole word (synthesis task).
Incomplete Words (COG)	Phonetic Coding (PC)	Measures the ability to perform auditory closure on segments of speech. After hearing a recorded word with one or more phonemes missing, the subject must name the complete word (analysis task).
Auditory Attention (COG)	Speech Sound Discrimination (US) Attention/Concentration (AC)	Measures the ability to discriminate similar sounding words. An audio tape is used to present the words to the subject with increasing levels of background noise as a distracter.
Sound Patterns-Voice (COG)	General Sound Discrimination (U3)	Measures the ability to indicate whether pairs of complex sounds are the same or different. The sound patterns resemble human speech sounds. The pairs may differ in pitch, rhythm, or sound content.
Sound Patterns-Music (COG)	Musical Discrimination & Judgement (U1,U9)	Measures the ability to indicate whether pairs of musical sounds are the same or different. The pairs may differ in pitch, rhythm, or sound content.
Sound Awareness (ACH)	Phonetic Coding (PC) Working Memory (Gsm-MW)	Measures oral sound analysis skills at the preschool and primary level of development. It contains four subtests: Rhyming, Substitution, Deletion, and Reversal. The items are presented orally by the examiner, or by tape, and the subject responds orally.

Fluid Reasoning (<i>Gf</i>)		
Concept Formation (COG)	Induction (I)	Measures the ability to identify and state the rule for a concept about a set of colored geometric figures when shown instances and non-instances of the concept. This is a "learning" test with corrective feedback and reinforcement of correct answers provided to the subject.
Analysis-Synthesis (COG)	General Sequential (deductive) Reasoning (RG) Quantitative Reasoning (RQ)	Measures the ability to analyze the components of an incomplete logic puzzle and to determine and name the missing components. This is a "learning" test with corrective feedback and reinforcement of correct answers provided to the subject.
Number Series (COG)	Quantitative Reasoning (RQ)	Measures the ability to identify the quantitative principle that underlies a sequence of numbers in a series of numbers and then apply the principle to supply a missing number in the series.
Number Matrices (COG)	Quantitative Reasoning (RQ)	Measures the ability to identify the quantitative principle that underlies a series of numbers in matrices and then apply the principle to supply a missing number in the matrix.
Quantitative Knowledge (<i>Gq</i>)		
Calculation (ACH)	Math Achievement (A3)	Measures the ability to perform mathematical calculations ranging from simple addition to calculus. The subject is not required to make any decisions about what operations to use or what data to include.
Applied Problems (ACH)	Math Achievement (A3) Math Knowledge (KM) Quantitative Reasoning (<i>Gf</i> -RQ)	Measures the ability to analyze and solve problems in mathematics. The subject must decide not only the appropriate mathematical operations to use but also which of the data to include in the calculation.
Math Fluency (ACH)	Math Achievement (A3) Number Facility (<i>Gs</i> -N)	Measures the ability to quickly perform single-digit addition, subtraction, and multiplication facts. The subject is presented a series of simple arithmetic problems on a worksheet. The subject has two minutes to complete as many problems as possible.
Quantitative Concepts (ACH)	Math Knowledge (KM) Quantitative Reasoning (<i>Gf</i> -RQ) Lexical Knowledge (<i>Gc</i> -VL)	Measures the subject's mathematical vocabulary, concepts and quantitative reasoning. The test consists of two subtests that collectively represent a mixture of number series (Number Series(items and items requiring the subject to display mathematical knowledge (Concepts). The number series items require the subject to identify the underlying numerical relation in a series of numbers and then apply this principle by supplying a missing number in the series.
Reading and Writing (<i>Grw</i>)		
Letter-Word Identification (ACH)	Reading Decoding (RD) Lexical Knowledge (<i>Gc</i> -VL)	Measures the subject's reading skills in identifying isolated letters and words. It is not necessary that the subject knows the meaning of any words correctly identified.
Reading Fluency (ACH)	Reading Speed (RS) Semantic Processing Speed (<i>Gt</i> -R4)	Measures the ability to quickly comprehend the correctness of simple sentences. The subject is presented a series of simple sentences and must circle whether each sentence is true or false. The subject is required to complete as many items as possible within a 3-minute time limit.
Passage Comprehension (ACH)	Reading Comprehension (RC) Cloze Ability (CZ) Verbal (lang) Comprehension (V)	Measures the subject's skill in reading a short passage and identifying a missing keyword. In this modified cloze procedure, the subject must exercise a variety of comprehension and vocabulary skills.
Word Attack (ACH)	Reading Decoding (RC) Phonetic Coding (PC)	Measures the ability to apply phonic and structural analysis skills to the pronunciation of unfamiliar printed words. The subject reads aloud letter combinations that are linguistically logical in English but that do not form actual words (nonsense word), or words that constitute low-frequency words in

		the English language.
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Reading Vocabulary (ACH)	Reading Comprehension (RC) Lexical Knowledge (Gc -VL)	Measures subject's skill in reading and understanding the meanings of words. The test consists of three subtests. In Part A: Synonyms, the subject must read a word and provide a word similar in meaning to the word presented. In Part B: Antonyms, the subject must read a word and provide a word that is opposite in meaning to the word presented. In Part C: Analogies, the subject must read an analogy and provide the missing word.
Spelling (ACH)	Spelling Ability (SG)	Measures the ability to write correct spellings of orally presented words.
Writing Fluency (ACH)	Writing Ability (WA) Speed of Writing (Gps -WS)	Measures the ability to formulate and write simple sentences quickly. This subtest has a 7-minute time limit.
Writing Samples (ACH)	Writing Ability (WA)	Measures the ability to write responses to a variety of demands. The subject must phrase and present written sentences that are evaluated with respect to the quality of expression. The subject is not penalized for errors in the basic mechanics of writing (spelling; punctuation).
Editing (ACH)	English Usage Knowledge (EU)	Measures the ability to identify, and indicate how to correct, mistakes in typewritten passages. The error in the passage may be incorrect punctuation or capitalization, inappropriate word usage, or a misspelling.
Spelling of Sounds (ACH)	Spelling Ability (SG) Phonetic Coding (Ga -PC)	Measures the ability to listen to a nonsense word and produce a written response representing the likely spelling of that word if it were a real English word. It is a measure of the subject's comprehension of the "alphabetic principle." The subject is presented the nonsense word from an audio tape and is asked to write it.
Punctuation and Capitalization (ACH)	English Usage Knowledge (EU)	Measures knowledge of punctuation and capitalization.