IAP AP 101

APPLIED PSYCHOMETRICS 101: IQ TEST SCORE DIFFERENCE SERIES

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

The WAIS-IV (2008) is the latest revision of the adult Wechsler battery. The addition of new, and deletion of old tests, plus a more-factor based foundation for the composite indexes, requires psychologists to be familiar with the best possible interpretative structure of the venerable battery. In this PowerPoint based report, the available published and unpublished confirmatory factor studies of the WAIS-IV subtests are summarized. They are then augmented via a series of new exploratory data analysis of the WAIS-IV. It is concluded that the currently available structural research argues for a CHC-based organization of WAIS subtest scores that differs from the suggested structure provided by the test publisher. In addition, exploratory methods, when combined with similar analysis of the WJ III battery, provide support for possible intermediate level CHC dimensions (between *g* and the Gf-Gc broad abilities) in the contemporary CHC theory of intelligence

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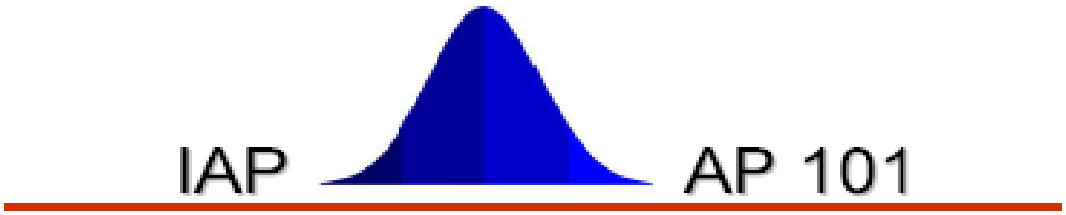

What does the WAIS-IV measure? CHC analysis and beyond

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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 *Batería 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).

References cited in this presentation/report

Bensen, J. (1998). Developing a strong program of construct validation: A test anxiety example. *Educational Measurement: Issues and Practice*, 10-22.

Benson, N, Hulac, D. M. & Kranzler, J. H. (in press). Independent examination of the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV): What does the WAIS-IV measure? *Psychological Assessment.*

Flanagan, D. P. Personal communication, November 2, 2009.

Flanagan, D. P., McGrew, K. S., & Ortiz, S. O. (2000). *The Wechsler Intelligence Scales and Gf-Gc theory: A contemporary approach to interpretation*. Boston: Allyn & Bacon.

Keith, T. Personal communication, October, 20, 2009.

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.

McGrew, K., & Flanagan, D. (1998). *The Intelligence Test Desk Reference (ITDR): Gf-Gc cross-battery assessment*. Boston: Allyn & Bacon.

McGrew, K., & Woodcock (2001). *Technical Manual. Woodcock-Johnson III .* Itasca, IL: Riverside.

Phelps, L., McGrew, K. S., Knopik, S. N., & Ford, L. (2005). The general (g), broad, and narrow CHC stratum characteristics of the WJ III and WISC-III tests: A confirmatory cross-battery investigation. *School Psychology Quarterly, 20(1),* 66-88.

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale-Fourth Edition: Technical and interpretive manual*. San Antonio, TX: Pearson Assessment.

Woodcock (1990). Theoretical foundations of the WJ-R measures of cognitive ability. *Journal of Psychoeducational Assessment, 8,* 231-258.

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

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

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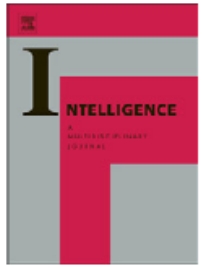


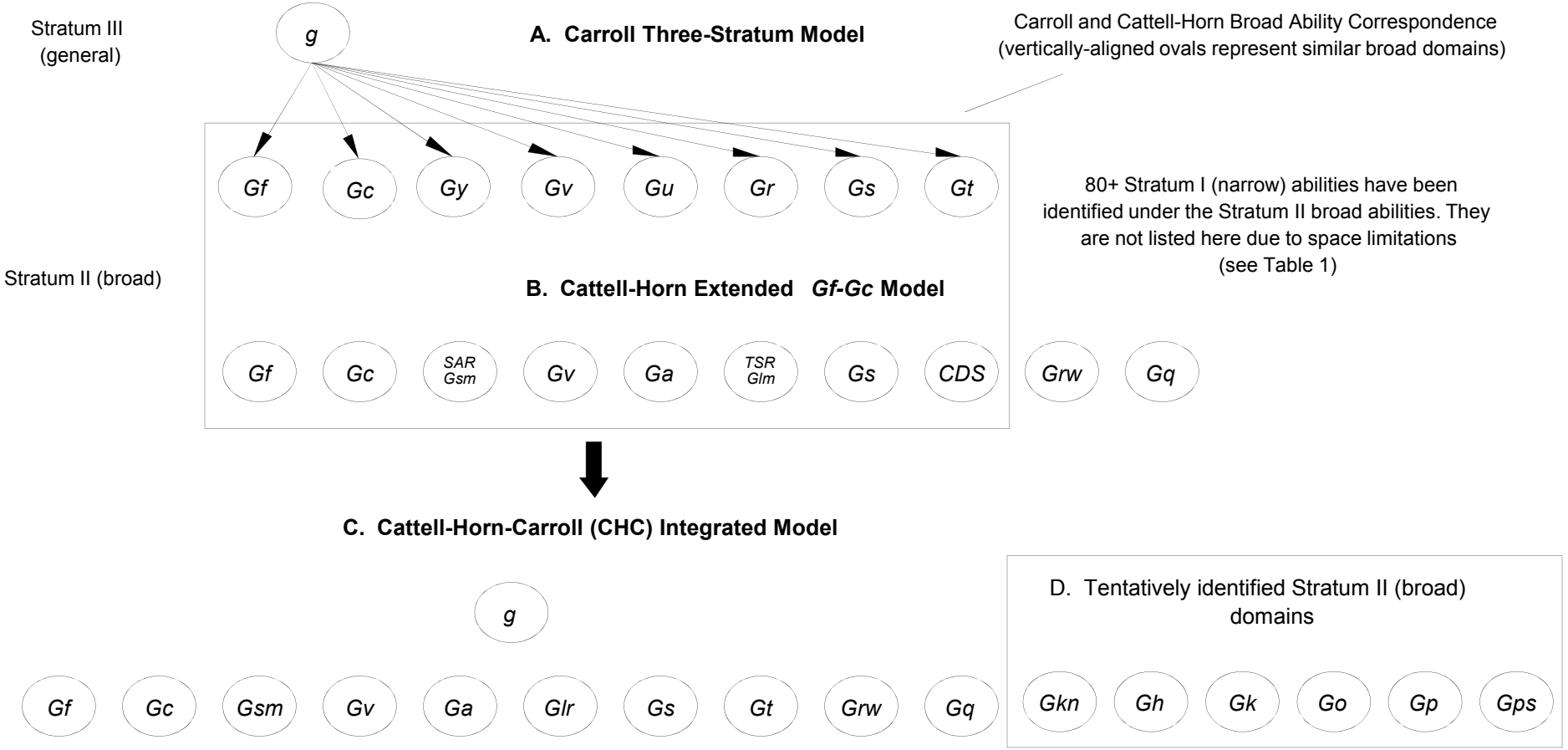
Editorial

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.



(Missing *g*-to-broad ability arrows acknowledges that Carroll and Cattell-Horn disagreed on the validity of the general factor)

CHC Broad (Stratum II) Ability Domains

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

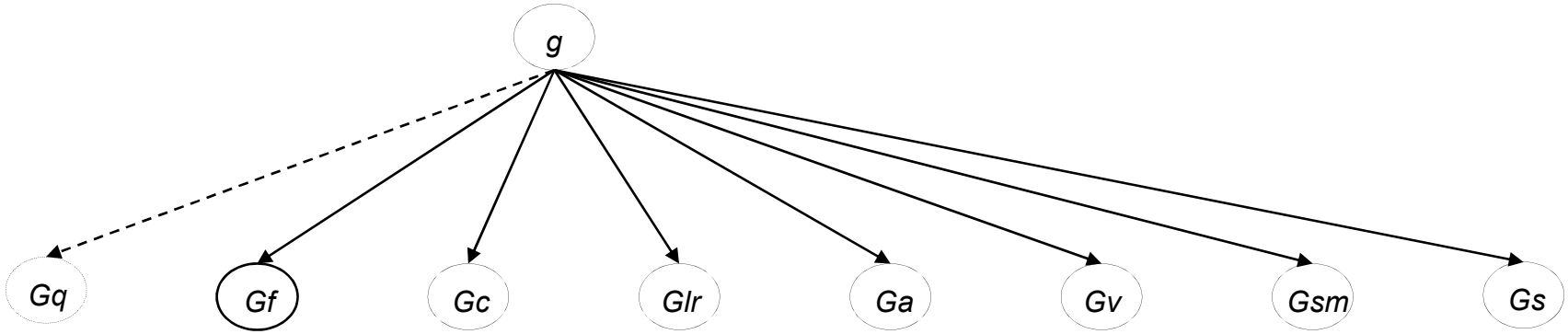
(see Table 1 for definitions)

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.

Portions of Cattell-Horn-Carroll (CHC) theory of cognitive abilities measured by some or all major contemporary intelligence batteries

(Kevin McGrew 11-4-09)



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

Dashed *Gq* broad ability arrow and oval, which is also deliberately set off to the left side, designates that math achievement abilities are typically found in achievement tests, but have been shown to be measured by some tests in some cognitive/IQ batteries

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

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

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.

Stratum III *g*-factor is offset to left as per Carroll (1993) to reflect degree to which broad (stratum II) *Gf-Gc* abilities are correlated with *g* in the extant literature.

WAIS-IV subtests and two-letter abbreviations used in the technical manual (Wechsler, 2008). Abbreviations will be used in some of the subsequent output in this report. See manual for definition and description of tests

VC-Vocabulary
SI-Similarities
AR-Arithmetic
CO-Coding
FW-Figure Weights
IN-Information
MR-Matrix Reasoning
DS-Digit Span
BD-Block Design
VP-Visual Puzzles
LN-Letter-Number Sequencing
CD-Coding
PCm-Picture Completion
SS-Symbol Search
CA-Cancellation

WAIS-IV TM CFA final model summaries (p. 72-73)

	(16-69 yrs of age)						(70-90 yrs of age)			
WAIS-IV Tests	Gc	Gs	Gv+Gf	Gsm			Gc	Gs	Gv+Gf	Gsm
Vocabulary	0.89						0.87			
Comprehension	0.83						0.83			
Similarities	0.82						0.85			
Information	0.79						0.82			
Symbol Search		0.79						0.78		
Coding		0.79						0.89		
Visual Puzzles			0.78						0.68	
Block Design			0.79						0.75	
Figure Weights			0.43	0.37						
Digit Span				0.73						0.83
Letter-Number Sequencing				0.69						
Arithmetic	0.08			0.75			0.33			0.48
Matrix Reasoning			0.72						0.75	
Cancellation		0.56								
Picture Completion			0.61						0.67	

Note: CHC factor labels in above table are Kevin McGrew's CHC interpretation of the factors. In the WAIS-IV TM (Wechsler, 2008) the factors were labeled Verbal Comprehension---Gc above; Processing Speed--Gs above; Perceptual Reasoning--Gv+Gf above; Working Memory--Gsm above

Figure Weights, Letter-Number Sequencing and Cancellation not normed for 70-90 year olds

First independent CFA analysis of WAIS-IV standardization data

Benson, N, Hulac, D. M. & Kranzler, J. H. (in press). Independent examination of the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV): What does the WAIS-IV measure? *Psychological Assessment.*

Abstract

Published empirical evidence for the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV) does not address some essential questions pertaining to the applied practice of intellectual assessment. In this study the structure and cross-age invariance of the latest WAIS-IV revision were examined to (a) elucidate the nature of the constructs measured and (b) determine if the same constructs are measured across ages. Results suggest that a Cattell-Horn-Carroll (CHC)-inspired structure provides a better description of test performance than the published scoring structure does. Broad CHC abilities measured by the WAIS-IV include crystallized ability (G*c*), fluid reasoning (G*f*), visual processing (G*v*), short-term memory (G*sm*), and processing speed (G*s*); although some of these abilities are measured more comprehensively than others. Additionally, the WAIS-IV provides a measure of quantitative reasoning (QR). Results also suggest a lack of cross-age invariance resulting from age-related differences in factor loadings. Formulas for calculating CHC indexes and suggestions for interpretation are provided.

(Note. Emphasis in abstract added by K. McGrew)

Comparison of Benson, Hulac & Kranzler (in press) and Keith (pers. communication, 10-30-09) CFA of WAIS-IV

WAIS-IV Tests	Gc	Gs	Gv	Gf	Gsm
Vocabulary	**X**				
Comprehension	**X**				
Similarities	**X**				
Information	**X**				
Symbol Search		**X**			
Coding		**X**			
Visual Puzzles			**X**		
Block Design			**X**		
Figure Weights				**X**	
Digit Span					**X**
Letter-Number Sequencing					**X**
Arithmetic	x			**X**	
Matrix Reasoning				**X**	
Cancellation		**X**			
Picture Completion			**X**		

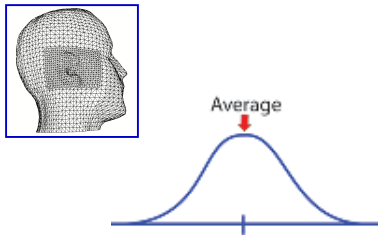
Note. Large bold **X** indicate salient loadings on CHC factors and agreement in results between research groups. Keith only analyzed the single grand correlation matrix in Table 5.1 of WAIS-IV TM

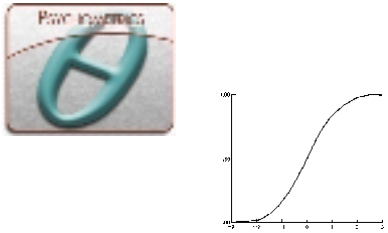
Only major difference was secondary Gc loading (small regular font x) by Benson et al. (in press).

Expert consensus broad WAIS-IV subtest classifications by Flanagan et al. cross-battery research group (Flanagan, pers. communication, 11-2-09)

Gc	Gs	Gv	Gf	Gsm	Gq
X					
X					
x			**x**		
X					
	X				
	X				
		X			
		X			
			X		
				X	
				X	
			x	**x**	**x**
			X		
	X				
x		**x**			

Note. Large X designates single CHC factor broad classifications. Small x designates cross CHC factor classifications



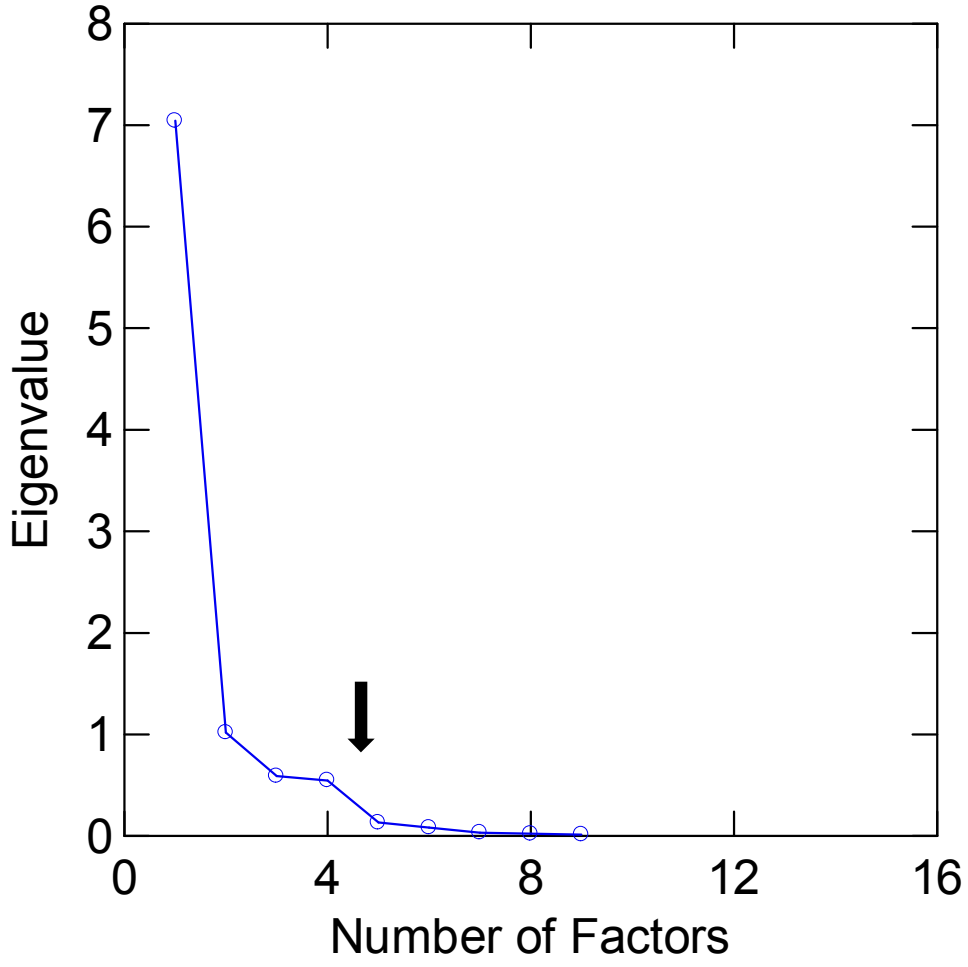


Kevin McGrew completed exploratory analysis of the single grand WAIS-IV subtest correlation matrix reported in Table 5.1 in WAIS-IV TM. Analyses included:

- EFA – Exploratory factor analysis (iterated common-factor model with oblique rotation)
- MDS – Multidimensional scaling analysis (Guttman Radex model)
- CA – Cluster analysis

(the results of these analyses follow on next series of slides)

Scree Plot for WAIS-IV subtest intercorrelation matrix across all ages in norm sample (Table 5.1 WAIS-IV technical manual, p. 62)



As per common EFA factor analysis methods, inspection of eigenvalue scree plot suggested 4 factors.

Thus, 4- and 5- factor solutions were extracted. The deliberate “over-factoring” (5-factors) is often used during EFA to ascertain if certain variables (tests) that do not load strong on the primary factors end up on a “singleton” or “junk factor” --- which helps clarify the underlying factor structure and also provides useful information regarding any tests that load on this extra factor.

Summary of exploratory factor analysis (iterative principal-axes common factoring with oblique rotation) of WAIS-IV subtest intercorrelation matrix across all ages in norm sample (Table 5.1 WAIS-IV technical manual, p. 62) – analysis by Kevin McGrew

	4-factor solution					5-factor solution				
WAIS-IV Subtests	**Gc**	**Gs**	**Gv+Gf**	**Gsm**		**Gc**	**Gs**	**Gv+Gf**	**Gsm**	**?**
Vocabulary (VC)	0.91					0.91				
Comprehension (CO)	0.80					0.81				
Similarities (SI)	0.76					0.80				
Information (IN)	0.75					0.74				
Symbol Search (SS)		0.85					0.84			
Coding (CD)		0.71					0.80			
Visual Puzzles (VP)			0.85					0.83		
Block Design (BD)			0.73					0.70		
Figure Weights (FW)			0.53					0.65		
Digit Span (DS)				0.87					0.88	
Letter-Number Sequencing (LN)				0.75					0.77	
Arithmetic (AR)	*0.25*			0.43				0.30	0.33	
Matrix Reasoning (MR)			0.42					0.48		
Cancellation (CA)		0.36					0.45			
Picture Completion (PCm)			0.38					0.30		*0.28*

-Factor loadings < .30 omitted for readability. Loadings in italics are loadings > .24 and < .30
-Shading reflects subtests with salient dual factor loadings
-Subtest abbreviations from Table 5.1 in WAIS-IV technical manual
-CHC factor interpretations by Kevin McGrew

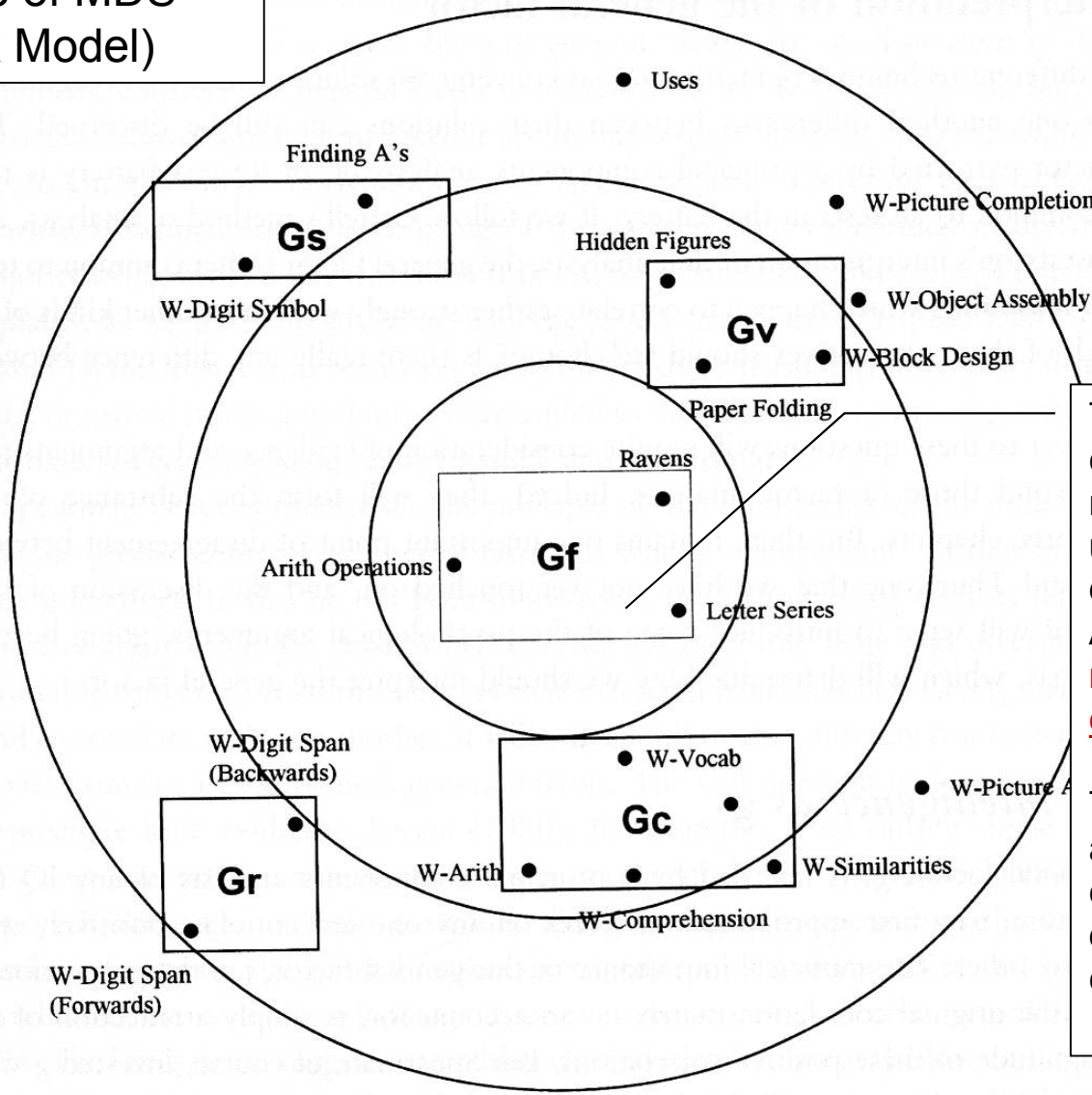
Guttman's Radex Theory

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)

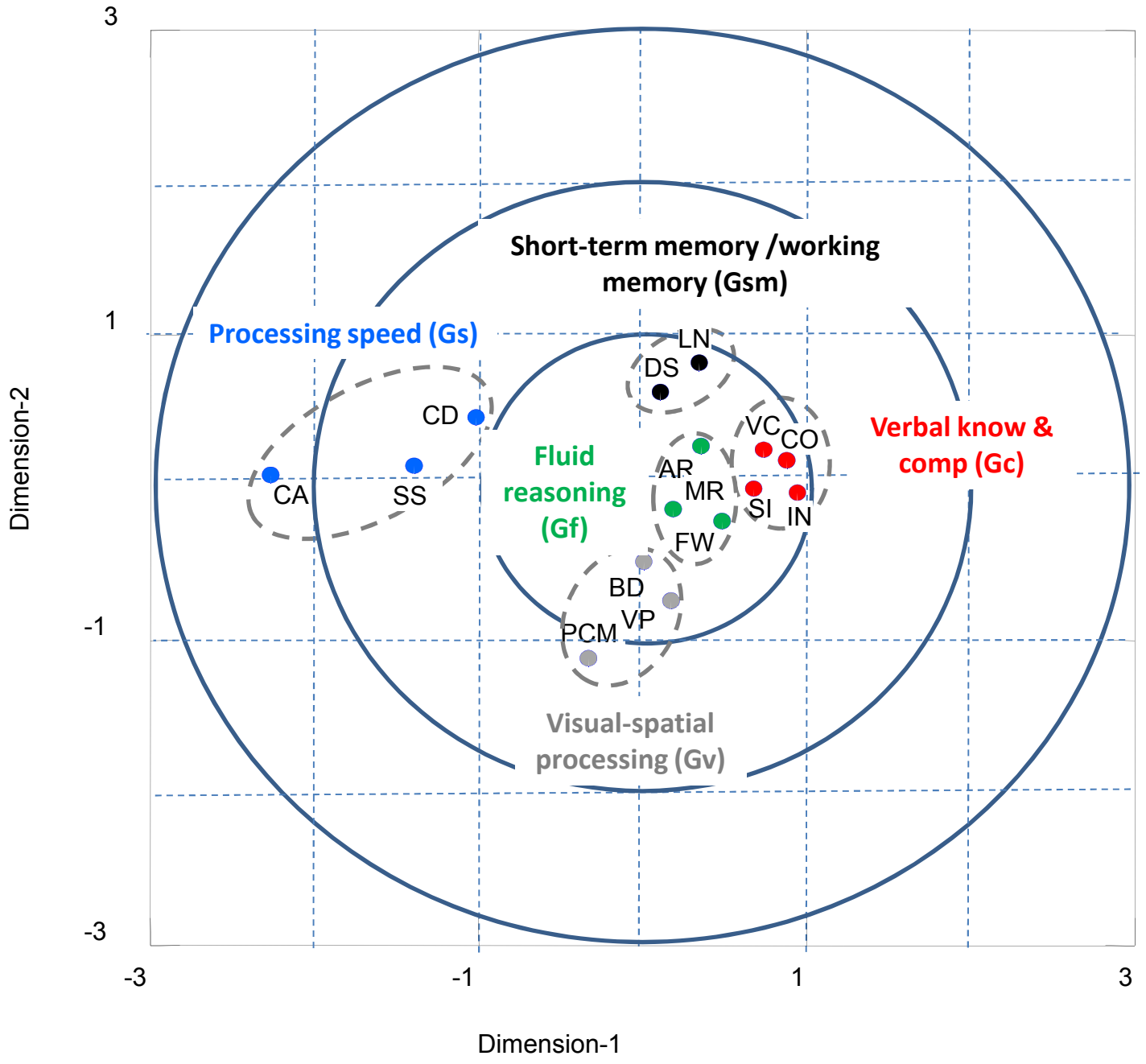


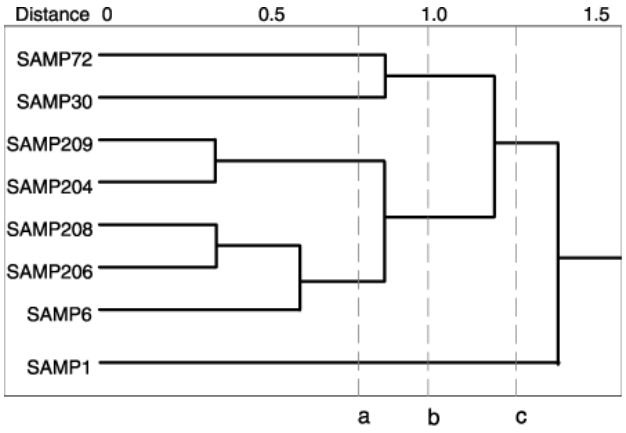
The closer a test is to the center of the figure, the more it is related to the underlying general dimension of the battery. Also, the center represents the most cognitively complex tests.

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 the tests in 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).

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



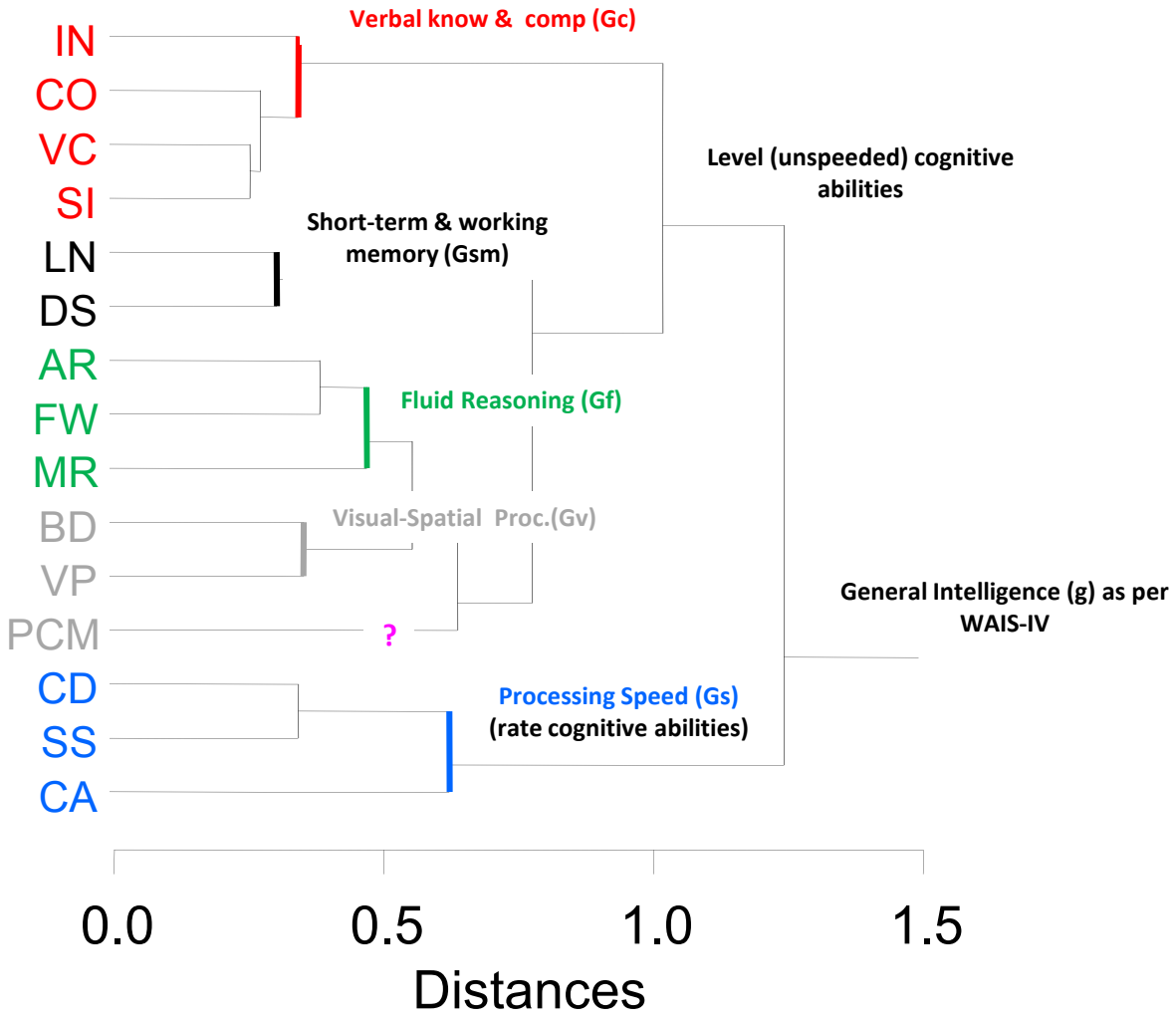


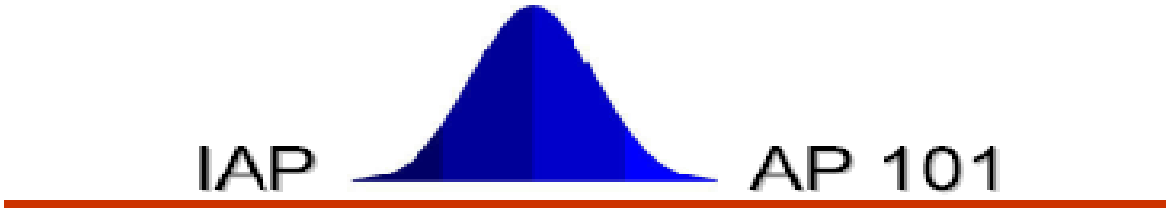
Cluster Analysis

Cluster analysis is an set of exploratory (structure discovering) data analysis tools for solving classification problems. Sometimes it has been called a “poor mans” factor analysis. Its object is to sort cases (people, things, events, tests, etc) into groups, or clusters, so that the degree of association is strong between members of the same cluster and weak between members of different clusters. Each cluster thus describes, in terms of the data collected, the class to which its members belong; and this description may be abstracted through use from the particular to the general class or type.

CA often helps confirm EFA results and similar to MDS, can spatially represent the degree of similarity of tests measuring a common dimension (dimension cohesion). Its hierarchical sequential structure is often useful in suggesting higher-order dimensions/factors.

WAIS-IV test Cluster Tree (Wards method) of WAIS-IV subtest intercorrelations

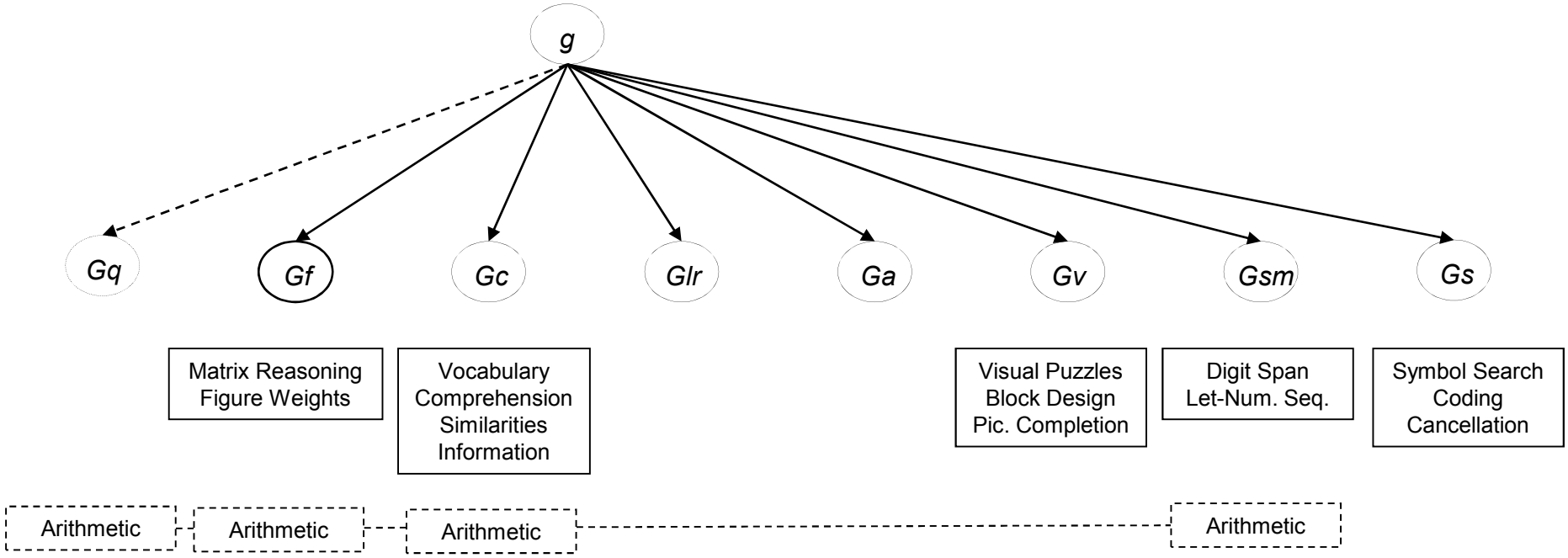




So…….what does the WAIS-IV measure?
Conclusion and discussion

K. McGrew's WAIS-IV Cattell-Horn-Carroll (CHC) summary conclusion

(Kevin McGrew 11-4-09)



Dashed *Gq* broad ability arrow and oval, which is also deliberately set off to the left side, designates that math achievement abilities are typically found in achievement tests, but have been shown to be measured by some tests in some cognitive/IQ batteries

Dashed multiple rectangles for Arithmetic subtest reflects conclusion that Arithmetic is factorially complex and has been suggested to tap 2-4 different broad Gf-Gc broad domains. This was evident in the preceding analysis and prior Wechsler joint or cross-battery factor analysis studies that have included a greater breadth of ability indicators, particularly Gq. See Wechsler related posts at **IQs Corner blog** (www.iqscorner.com) for information on these studies and McGrew & Flanagan (1998) and Flanagan, McGrew & Ortiz (2000) synthesis of this research. **See next set of slides for additional explanation….**

Kevin McGrew's synthesized conclusion re: WAIS-IV CHC structure based on synthesis of all data analysis and information in preceding slides

It must be remembered that factor analysis is an internal (structural) validity evidence method and needs to be supplemented by other forms of substantive and external construct validity evidence. Factor analysis (and other data reduction methods) should not stand-alone as the "magic bullet" method. Often highly related abilities (e.g., Grw and Gc; Gv and Gf) are hard to identify as separate factors via data reduction methods. External validity evidence (e.g., prediction of outcomes; heritability; neuro-cognitive; developmental) and substantive evidence needs to be integrated with internal validity data reduction methods to identify the best underlying structure of an intelligence battery. It is the entire nomological network of evidence that needs to evaluated……see next slide for "big picture" construct validity framework.

Test/Battery Development:
Common Conceptual Psychometric Validity Framework
(Bensen, 1998 summary)

	Substantive Stage/Component	Structural Stage/Component	External Stage/Component
Purpose	• Define the *theoretical* and *empirical* domains of intelligence	• Examine the *internal* relations among the measures used to operationalize the theoretical construct domain (i.e., intelligence)	• Examine the *external* relations among the focal construct (i.e., intelligence) and other constructs and/or subject characteristics
Question Asked	• How should intelligence be defined and be operationally measured?	• Do the observed measures "behave" in a manner consistent with the theoretical domain definition of intelligence?	• Do the focal constructs and observed measures "fit" within a network of expected construct relations (i.e., the nomological network)
Methods & Concepts	• Theory development & validation • Generate definitions • Item and scale development • Content validation • Evaluate construct underrepresentation and construct irrelevancy	• Internal domain studies • Item/subscale intercorrelations • Exploratory/confirmatory factor analysis • Item response theory (IRT) • Multitrait-Multimethod matrix • Generalizability theory	• Group differentiation • Structural equation modeling • Correlation of observed measures with other measures • Multitrait-Multimethod matrix
Characteristics of *strong* validation programs	• A strong psychological theory plays a prominent role • Theory provides a well-specified and bounded domain of constructs • The empirical domain includes measures of all potential constructs (i.e., adequate construct representation) • The empirical domain includes measures that do not contain reliable variance unrelated to the theoretical constructs (i.e., construct irrelevancy)	• Moderate to high item internal consistency • Measures covary in a manner consistent with the intended theoretical structure • Factors reflect trait rather than method variance • Items/measures are reprsentative of the empirical domain • Items fit the theoretical structure • The theoretical/empirical model is deemed plausible (especially when compared against other competing models) based on substantive and statistical criteria	• Focal constructs vary in theorized ways with other constructs • Measures of the constructs differentiate existing groups that are know to differ on the constructs • Measures of focal constructs correlate with other validated measures of the same constructs • Theory-based hypotheses are supported, particularly when compared to rival hypotheses

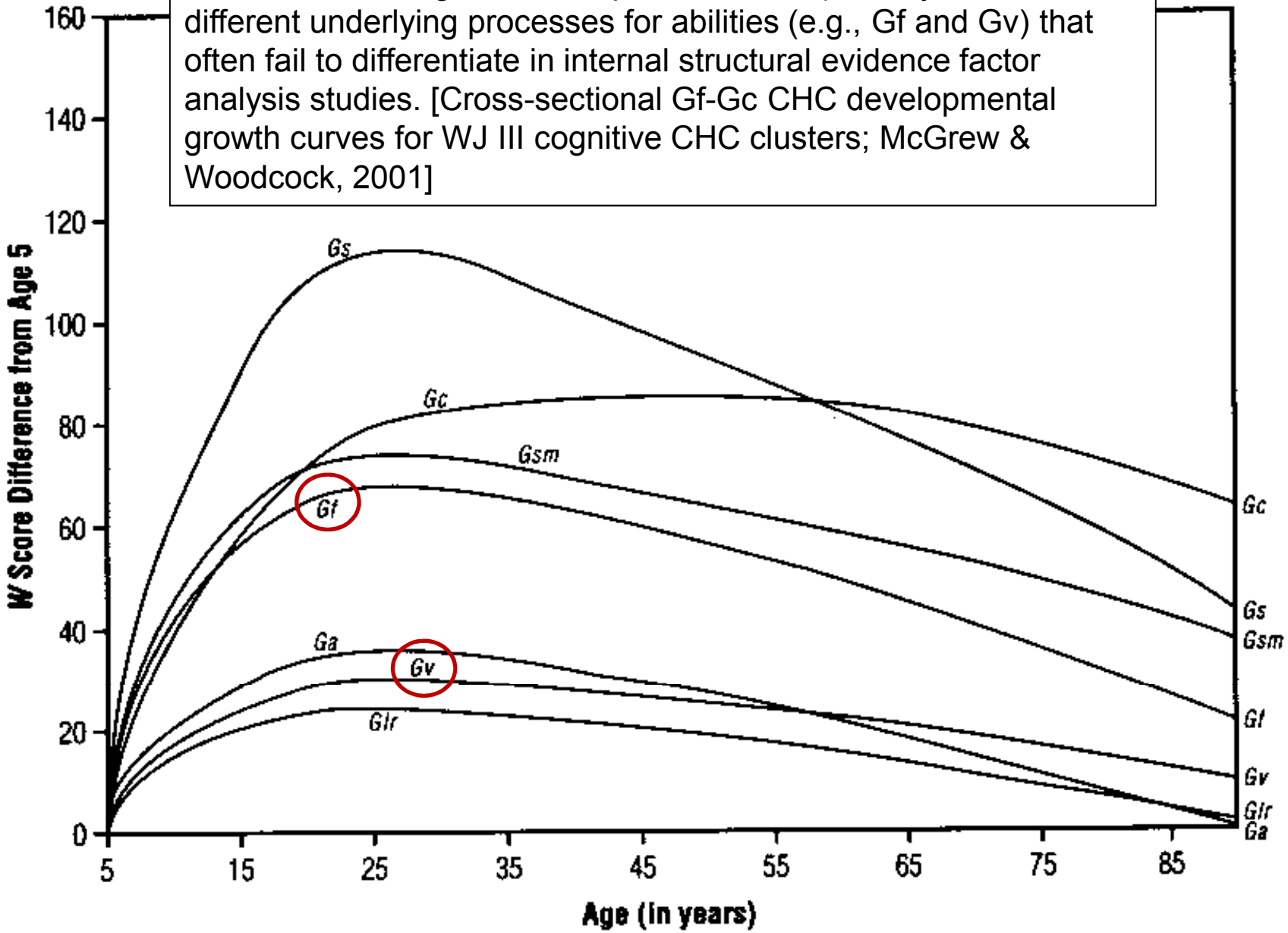
Substantive Stage of Test Development	
Purpose	Define the *theoretical* and *empirical/measurement* domains of interest (e.g., intelligence or cognitive abilities –cognitive + achievement)
Questions asked	How should intelligence be defined and operationally measured?
Method and concepts	• Theory development & validation • Generate definitions • Item and scale development • Content validation (expert-based task analysis) • Evaluate construct underrepresentation and construct irrelevancy
Characteristics of strong test validity program	• A strong psychological theory plays a prominent role • Theory provides a well-specified and bounded domain of constructs • The empirical domain includes measures of all potential constructs (i.e., adequate construct representation) • The empirical domain includes measures that only contain reliable variance related to the theoretical constructs (i.e., construct relevance)

Structural (Internal) Stage of Test Development

Purpose	Examine the *internal* relations among the measures used to operationalize the theoretical construct domain (i.e., intelligence or cognitive abilities)
Questions asked	Do the observed measures "behave" in a manner consistent with the theoretical domain definition of intelligence?
Method and concepts	• Internal domain studies • Item/subscale intercorrelations • Exploratory/confirmatory factor analysis • Item response theory (IRT) • Multitrait-Multimethod matrix • Generalizability theory
Characteristics of strong test validity program	• Moderate item internal consistency • Measures co-vary in a manner consistent with the intended theoretical structure • Factors reflect trait rather than method variance • Items/measures are representative of the empirical domain • Items fit the theoretical structure • The theoretical/empirical model is deemed plausible (especially when compared against other competing models) based on substantive and statistical criteria

External Stage of Test Development	
Purpose	Examine the *external* relations among the focal construct (i.e., intelligence or cognitive abilities) and other constructs and/or subject characteristics
Questions asked	Do the focal constructs and observed measures "fit" within a network of expected construct relations (i.e., the nomological network)
Method and concepts	• Group differentiation • Structural equation modeling • Correlation of observed measures with other measures • Multitrait-Multimethod matrix
Characteristics of strong test validity program	• Focal constructs vary in theorized ways with other constructs • Measures of the constructs differentiate existing groups that are known to differ on the constructs • Measures of focal constructs correlate with other validated measures of the same constructs • Theory-based hypotheses are supported, particularly when compared to rival hypotheses

For example, external validity evidence (relations of measures of CHC abilities to age or developmental status) clearly shows different underlying processes for abilities (e.g., Gf and Gv) that often fail to differentiate in internal structural evidence factor analysis studies. [Cross-sectional Gf-Gc CHC developmental growth curves for WJ III cognitive CHC clusters; McGrew & Woodcock, 2001]



Keith et al. 2006 CFA of WISC IV

Important note: No indicators of *Gq* present in this "within internal battery" WISC IV analysis

What happens when external measures of a broader arrange of ability constructs are added to such analyses (joint or cross-battery factor analysis)? **See next few slides…….**

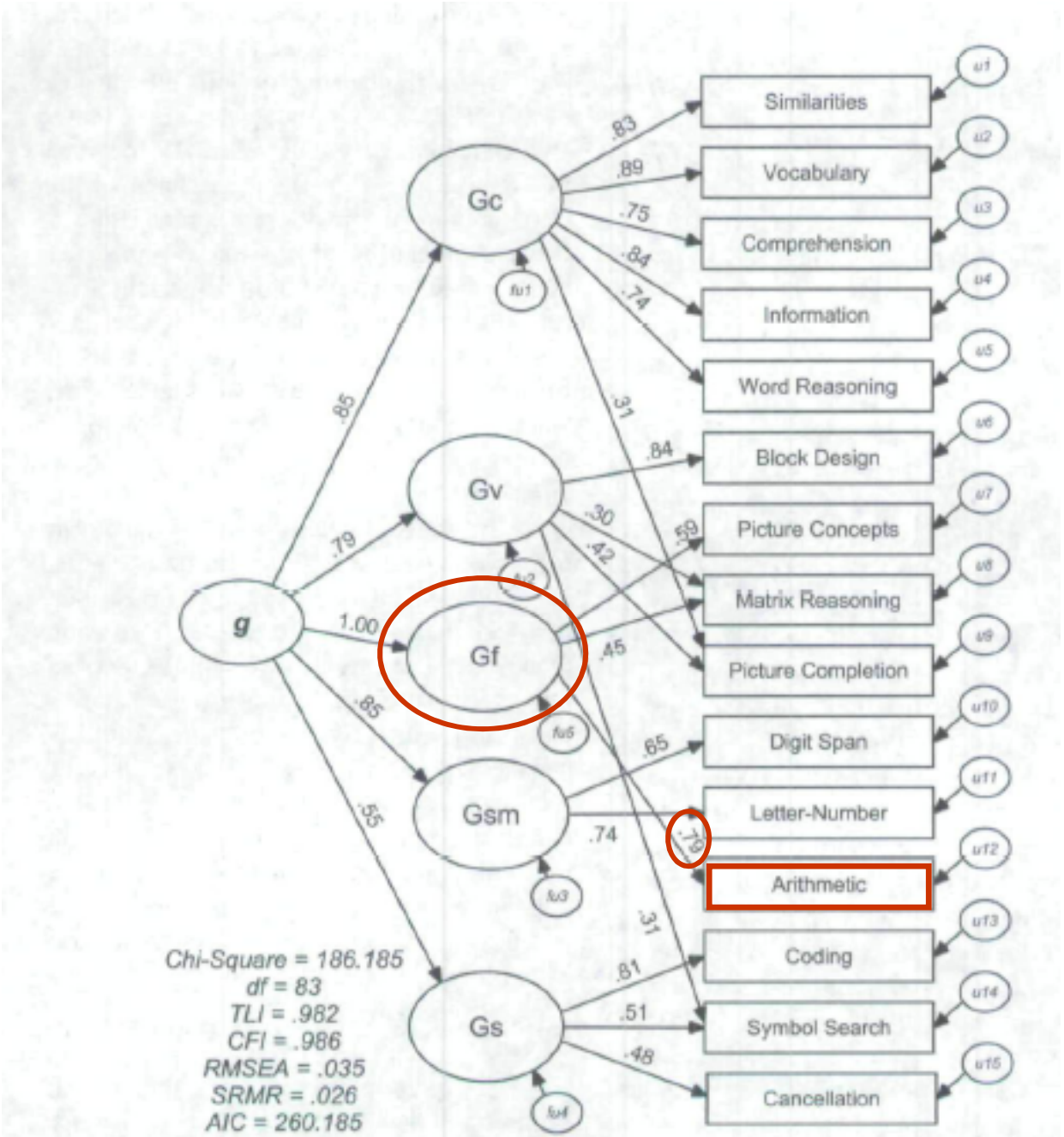


Figure 4. The final cross-validated model estimated using all data.

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1990, *8*, 231-258

THEORETICAL FOUNDATIONS OF THE WJ-R MEASURES OF COGNITIVE ABILITY

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(summary of 8 different cross-battery or joint CFA)

Table 5 (Continued)

Test	Number of analyses	Median loading							
		Glr	*Gsm*	*Gs*	*Ga*	*Gv*	*Gc*	*Gf*	*Gq*
WISC-R/WAIS/WAIS-R									
Information	8	0	0	0	0	0	.670	0	0
Similarities	8	0	0	0	0	0	.600	0	0
Arithmetic	8	0	0	0	0	0	0	0	.753
Vocabulary	8	0	0	0	0	0	.809	0	0
Comprehension	8	0	0	0	0	0	.692	0	0
Digit Span	8	0	.692	0	0	0	0	0	0
Picture Completion	8	0	0	0	0	.453	.248	0	0
Picture Arrangement	8	0	0	0	0	.197	.315	0	0
Block Design	8	0	0	0	0	.578	0	.123	0
Object Assembly	8	0	0	0	0	.622	0	0	0
Coding (Digit Symbol)	8	0	0	.582	0	0	0	0	0
Mazes	4	0	0	0	0	.464	0	0	0

Phelps et al. (2005)
WISC-III and WJ III
Cross-battery (joint)
CFA

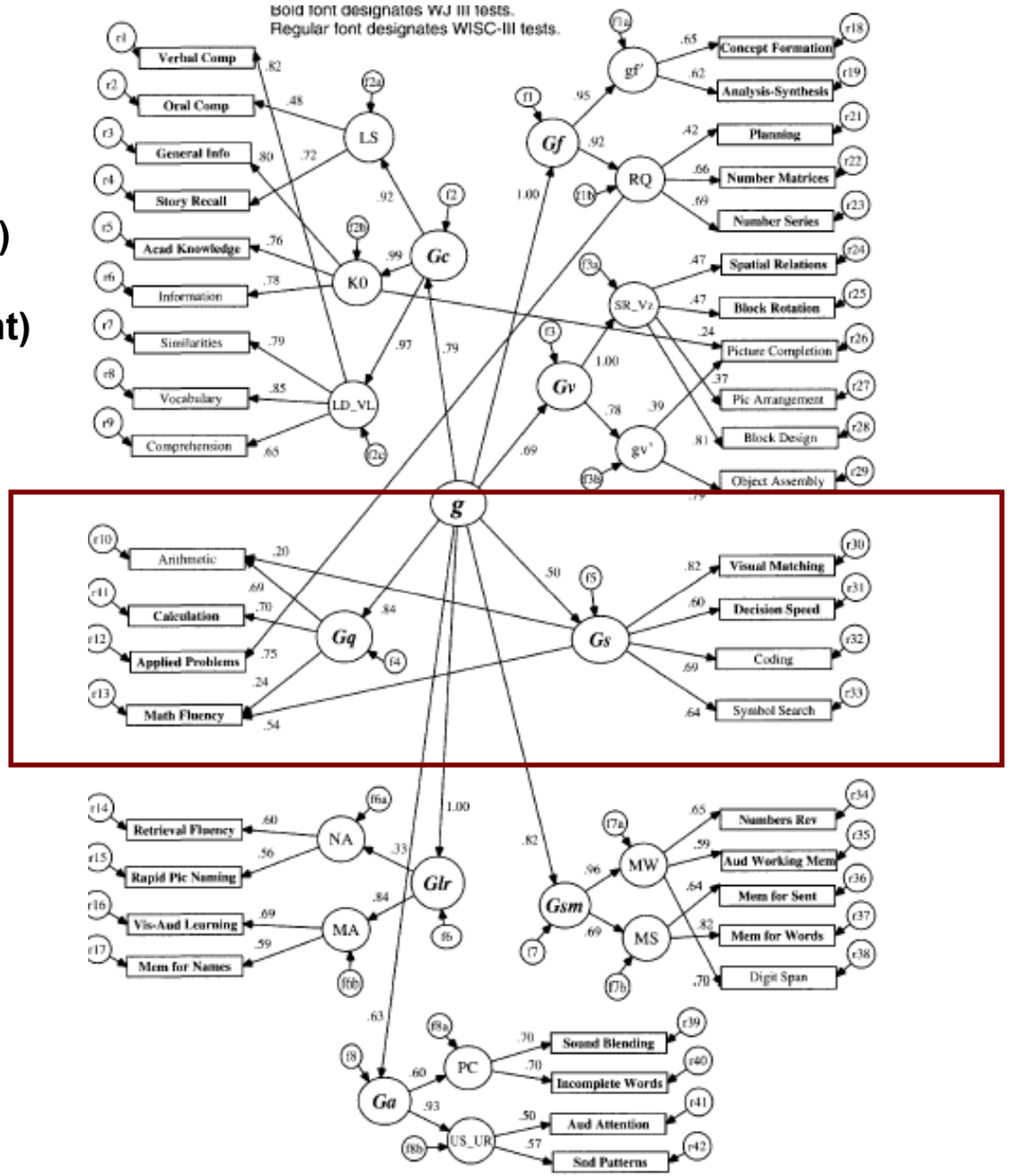
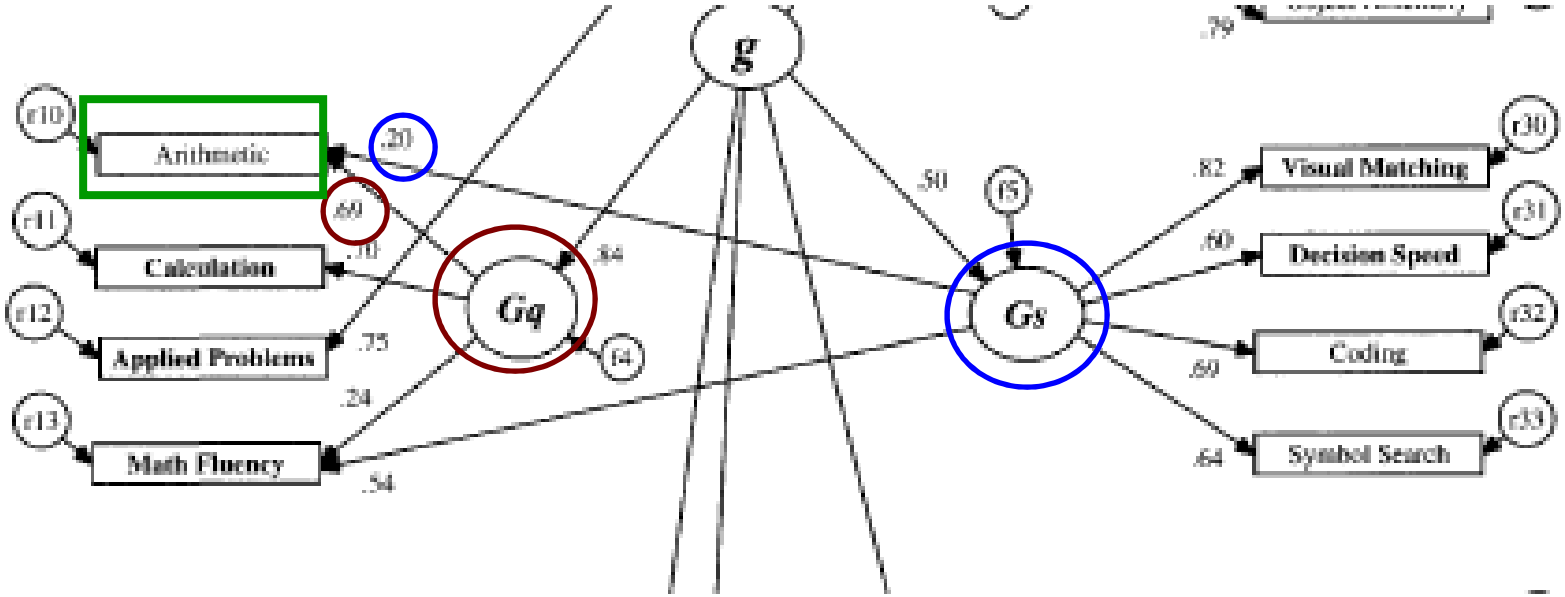


FIGURE 2. *Narrow+Broad+ g* Model

Phelps et al. (2005)
WISC-III and WJ III
Cross-battery (joint)CFA

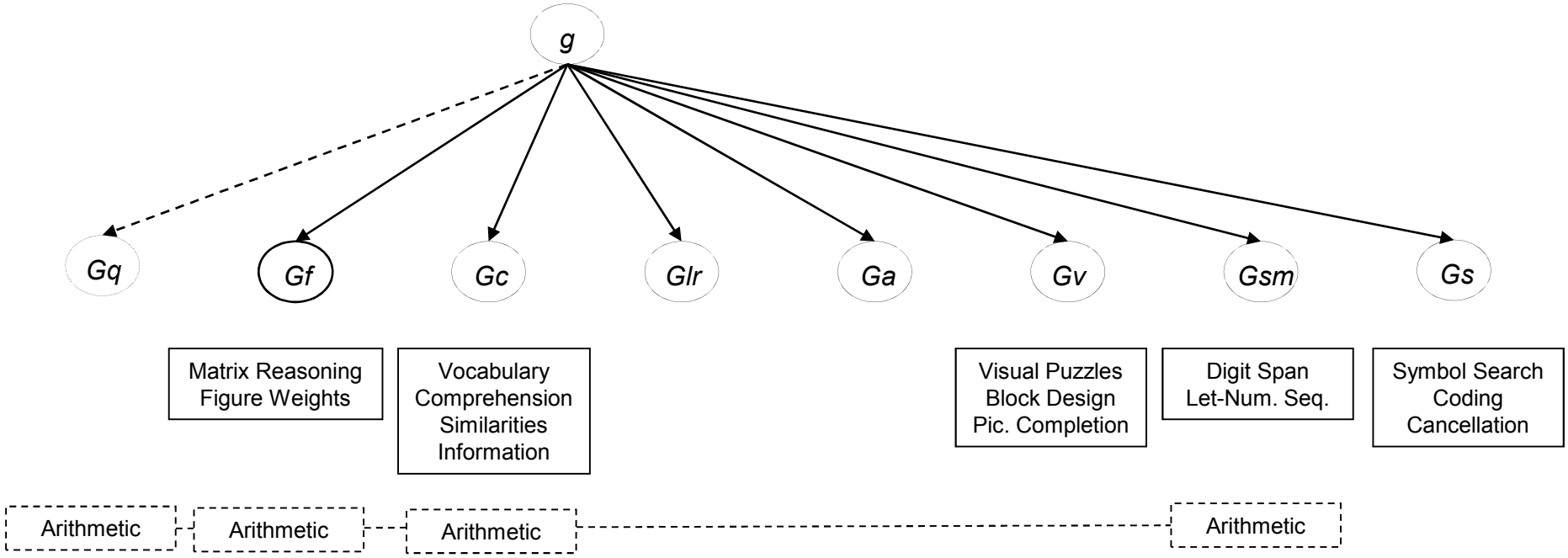


No significant Gf→Arithmetic loading.
Arithmetic loaded on Gq (.69) and Gs (.20)

The totality of construct validity evidence, based on independent CFA studies reported here and a considerable number of prior joint or cross-battery CFA studies (McGrew & Flanagan, 1998; Flanagan, McGrew & Ortiz, 2000), plus other forms of validity evidence (developmental, differential prediction of outcome variables, expert content validity consensus, etc.), suggests that the previous CHC WAIS-IV interpretation makes the most sense. This interpretation is repeated again in the next slide

K. McGrew's WAIS-IV Cattell-Horn-Carroll (CHC) summary conclusion

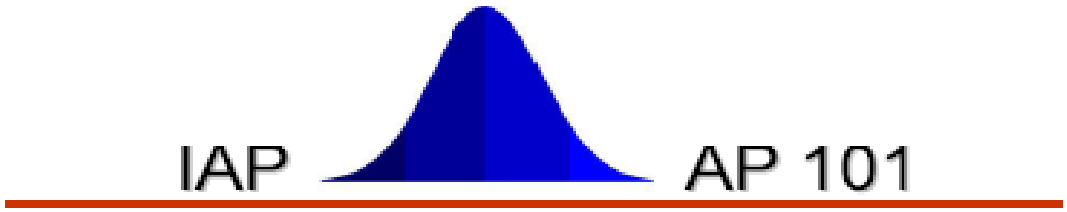
(Kevin McGrew 11-4-09)



Dashed *Gq* broad ability arrow and oval, which is also deliberately set off to the left side, designates that math achievement abilities are typically found in achievement tests, but have been shown to be measured by some tests in some cognitive/IQ batteries

Dashed multiple rectangles for Arithmetic subtest reflects conclusion that Arithmetic is factorially complex and has been suggested to tap 2-4 different broad Gf-Gc broad domains. This was evident in the preceding analysis and prior Wechsler joint or cross-battery factor analysis studies that have included a greater breadth of ability indicators, particularly Gq. See Wechsler related posts at **IQs Corner blog** (www.iqscorner.com) for information on these studies and McGrew & Flanagan (1998) and Flanagan, McGrew & Ortiz (2000) synthesis of this research. **See next set of slides for additional explanation….**

Kevin McGrew's synthesized conclusion re: WAIS-IV CHC structure based on synthesis of all data analysis and information in preceding slides



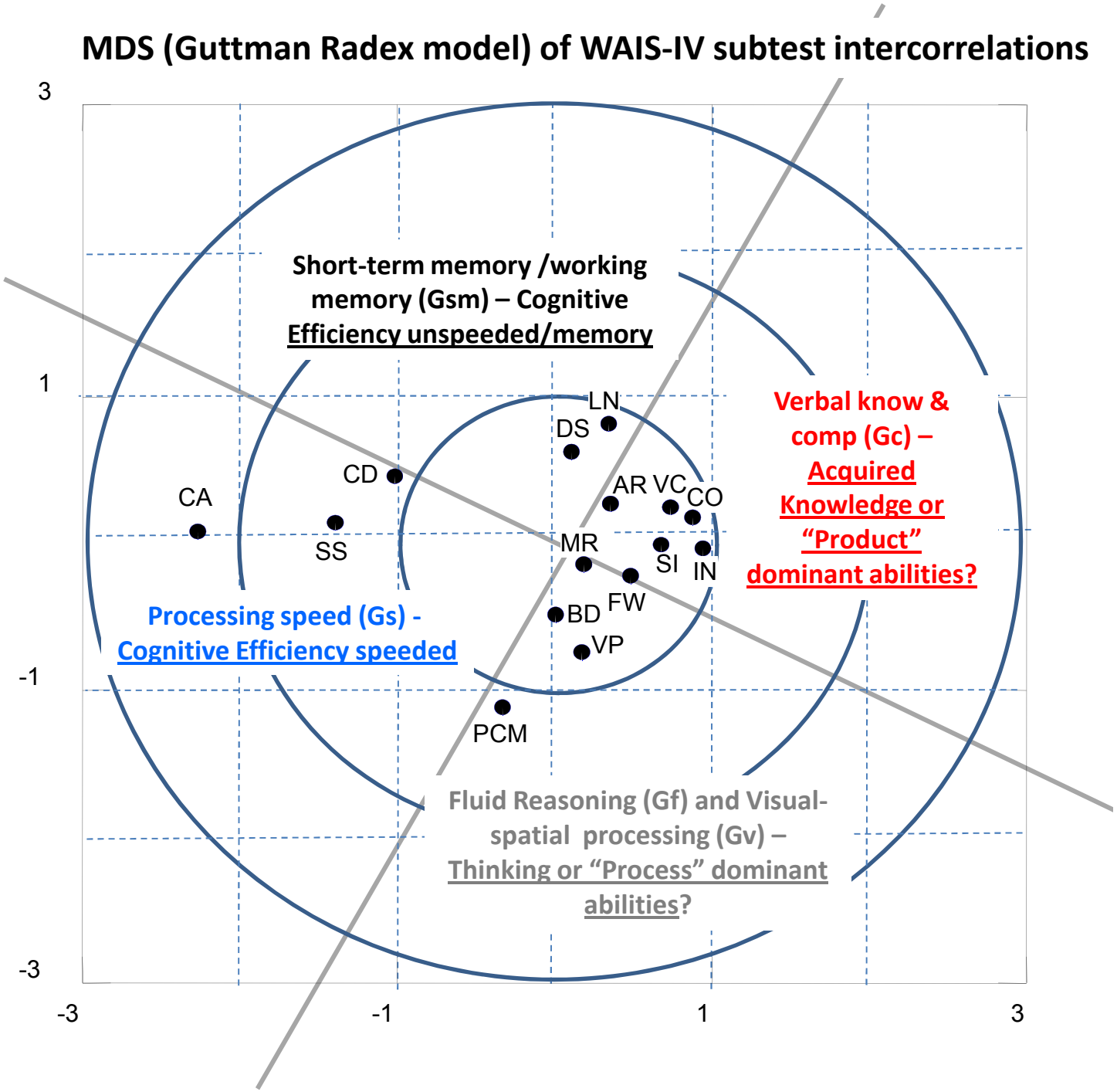
What does the WAIS-IV measure?

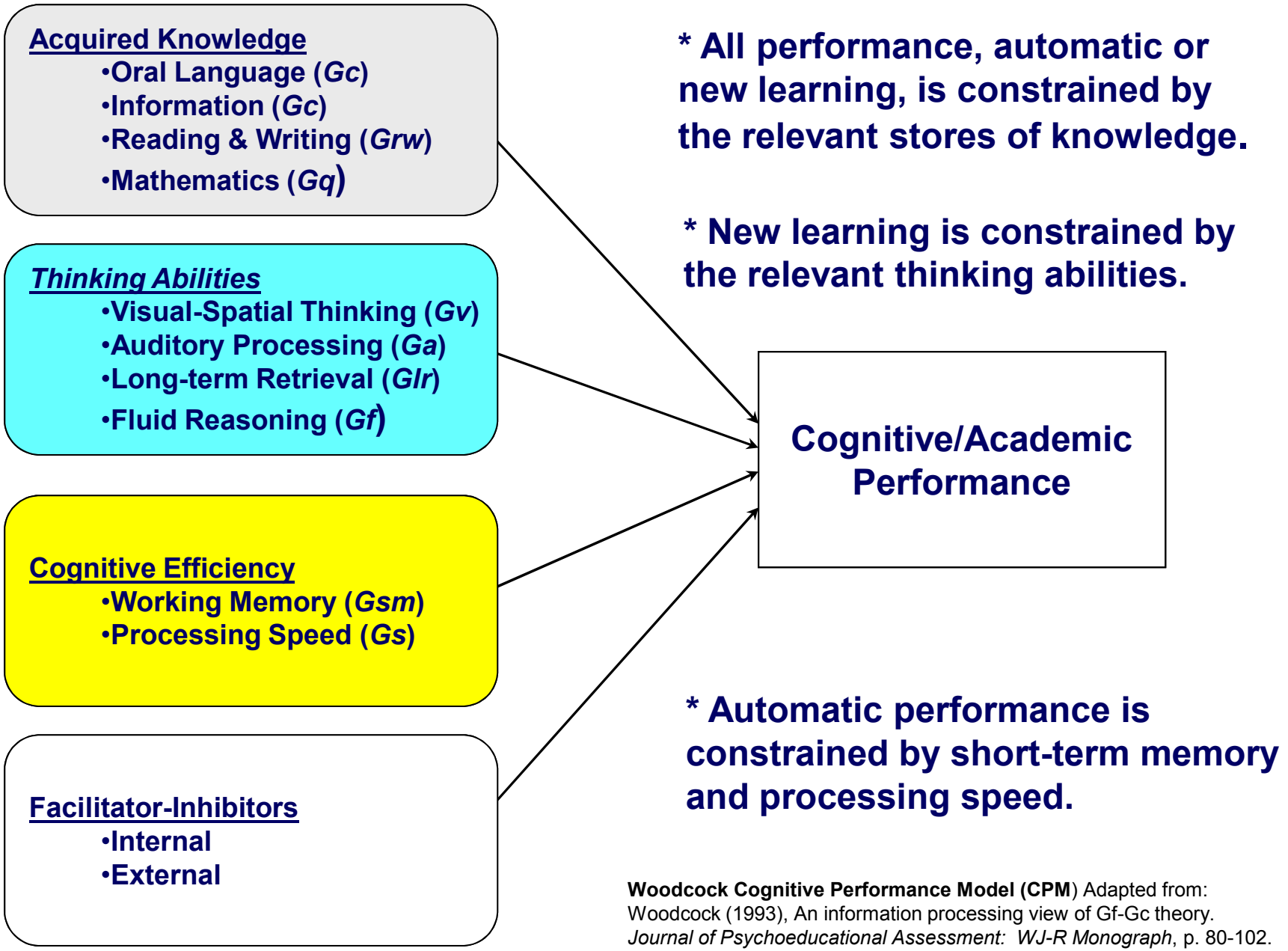
CHC analysis **and beyond** →

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

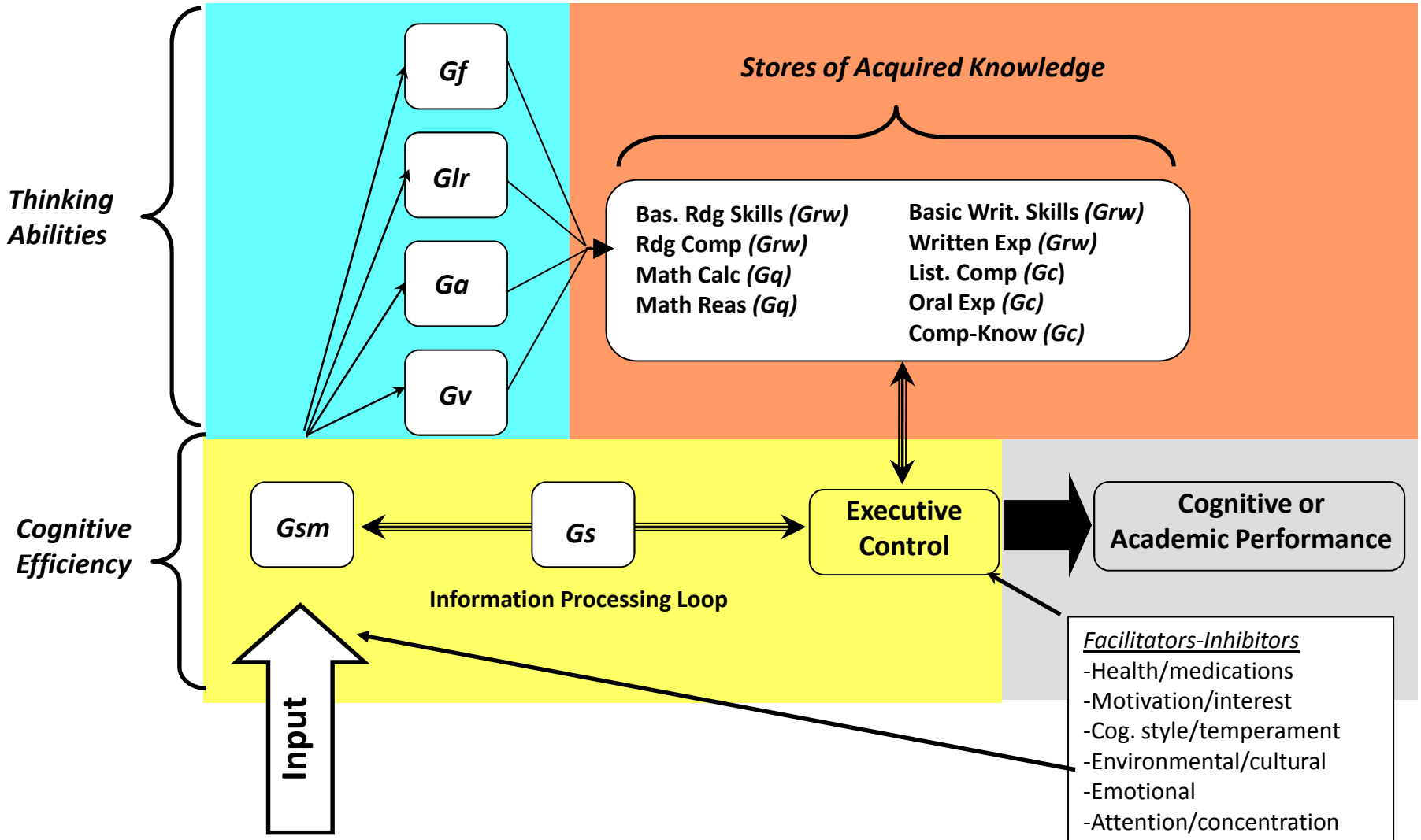
Note – similar to hand rotation of factors in early days of EFA, K. McGrew took the cross-hair lines and hand rotated them (simultaneosly) until a meaningful pattern emerged. The four-broad dimensions are interpreted as being very similar to the four cognitive domains of **Woodcock's Cognitive Performance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





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

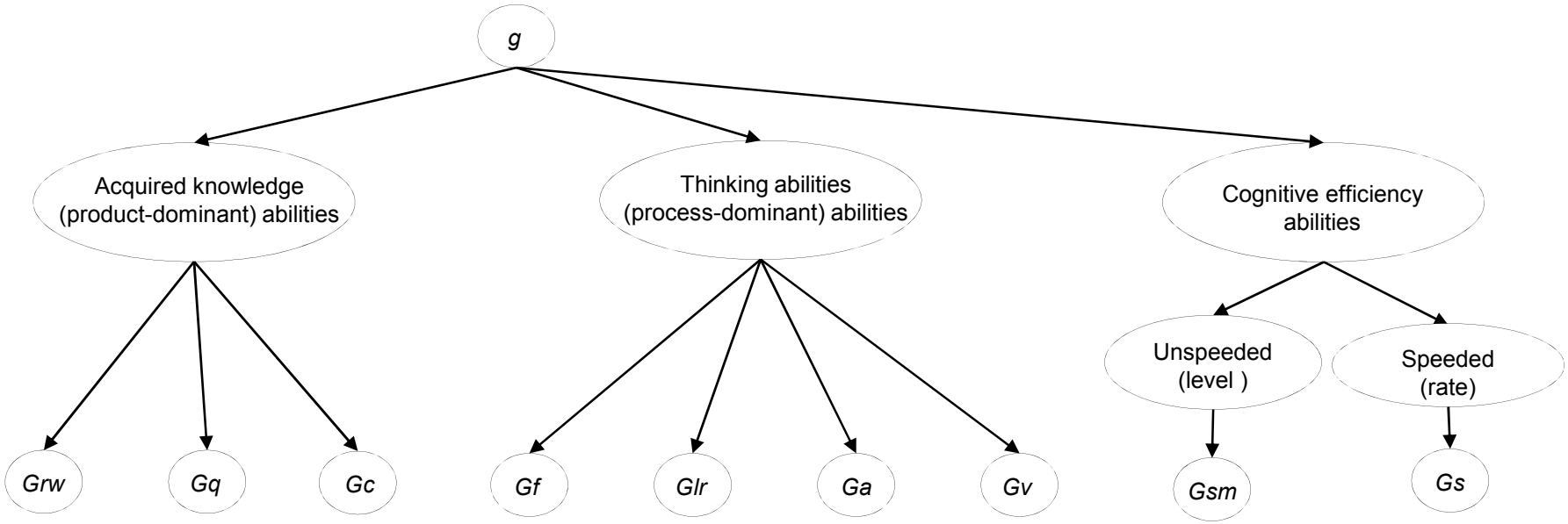
The CHC Information Processing Model



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 and CA 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

Gf	Fluid reasoning
Gc	Comprehension-knowledge
Gsm	Short-term memory
Gv	Visual processing
Ga	Auditory processing
Glr	Long-term storage and retrieval
Gs	Cognitive processing speed
Grw	Reading and writing
Gq	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 effficiency dimension.

More information re: these hypotheses in future presentations/reports