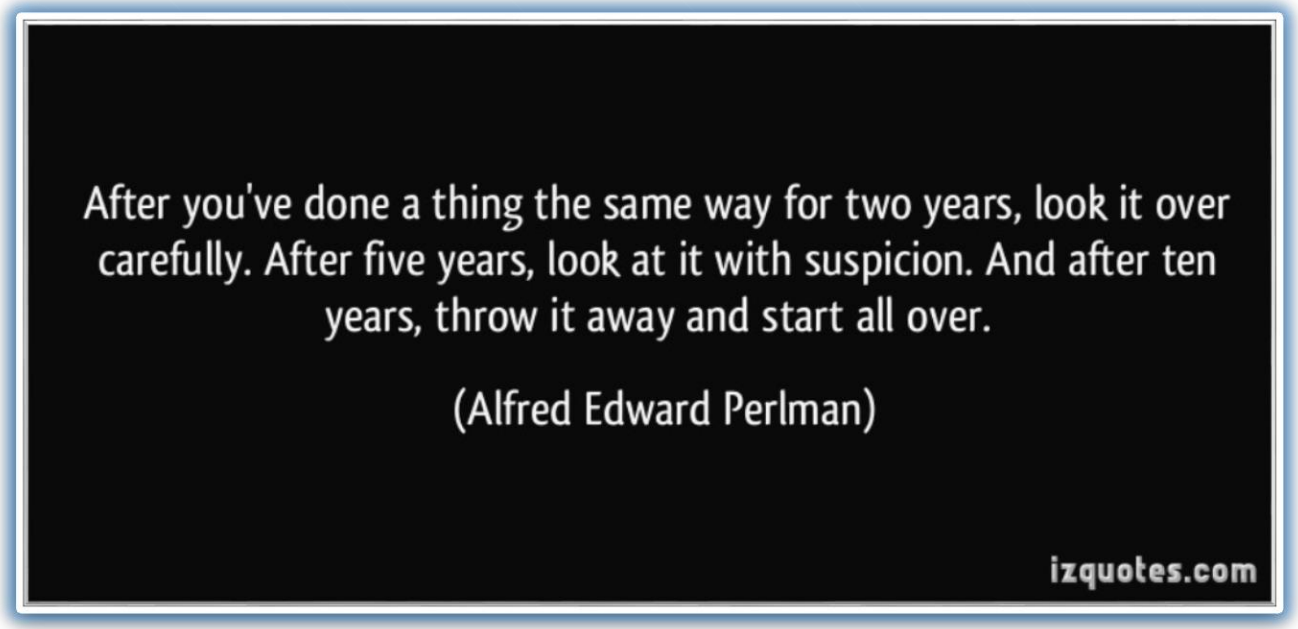
Has *Glr* been incorrectly conceptualized in the CHC taxonomy since 1997?

A proposed CHC model revision (v2.4)

Kevin McGrew, PHD
Institute for Applied Psychometrics (IAP)



Dr. Kevin McGrew, coauthor of the WJ IV, is responsible for the content of this PPT module

The information, hypotheses, and opinions expressed in this PPT module do not necessarily represent the opinions of the other WJ IV authors or HMH (the publisher of the WJ IV)

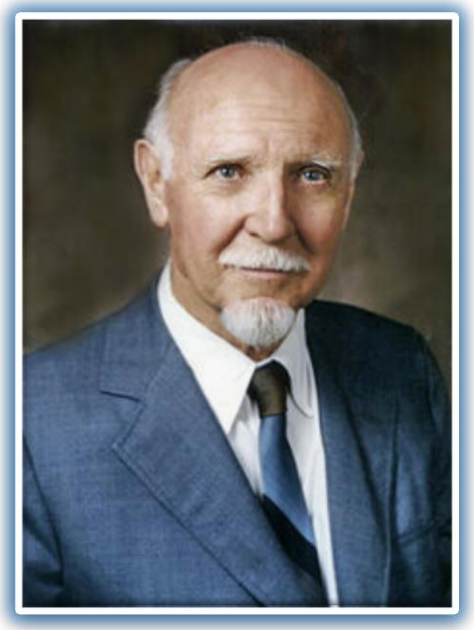
Conflict of interest disclosure: McGrew has a financial interest in the WJ IV

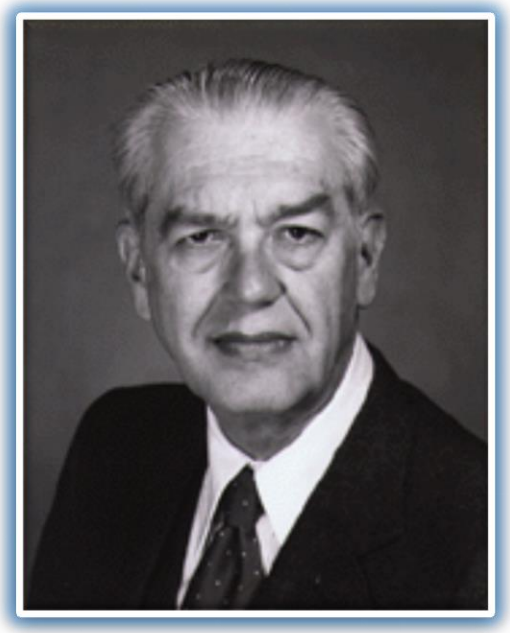
A significant portion (but not all) of this PPT presentation was first presented as a keynote address (Beyond CHC: Playing in sandboxes) by Dr. Kevin McGrew at the 2015 (July 8; Grapevine, TX) School Neuropsychology Summer Institute

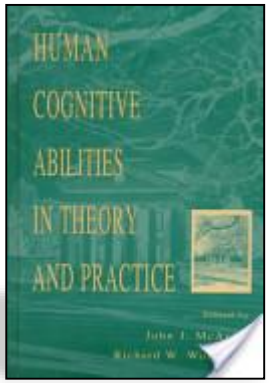
A special thanks to Dr. Joel Schneider for his keen questions, insights, and CHC-based data analyses, all that made a significant contribution to the thinking contained in this set of slides

The chief architects of the CHC model would not allow the model to remain static (would not allow a "hardening of the categories"). As scholars, they were devoted to the constant need to critique their own work and to expand and revise the framework (Schneider & McGrew, 2012)

"You must unlearn what you have learned."
– Yoda







Carroll (1994/1998) on Carroll (1993)

The Human Cognitive Abilities Conference
(University of Virginia, 1994)

To honor and discuss Carroll's (1993) masterwork. Cattell, Horn, Carroll and many other luminaries in the field were in attendance.

Published several years later, Carroll's address was called "Human Cognitive Abilities: A Critique" (Carroll, 1998). He stated,

> "Although all these reviews were in one sense gratifying, in another sense they were disappointing. They didn't tell me what I wanted to know: What was wrong with my book and its ideas, or at least what might be controversial about it?...Thus, ever since these reviews came out, I've been brooding about their authors might have said but didn't "(p. 6).

SEVEN

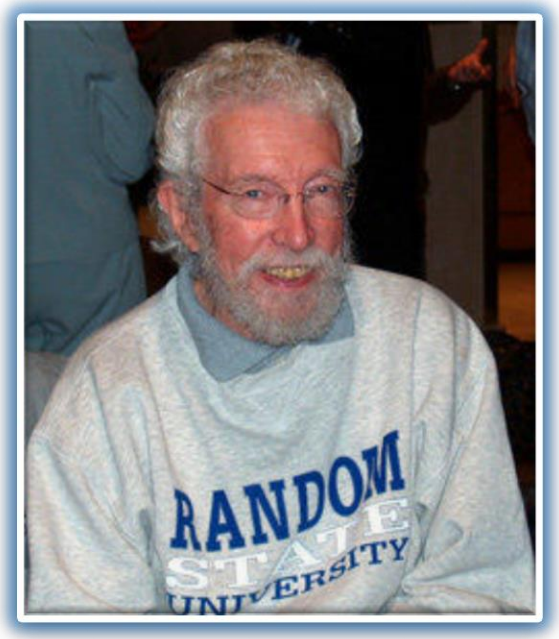
REMODELING OLD MODELS OF INTELLIGENCE 1985

JOHN L. HORN
University of Denver
Denver, Colorado

PROBLEMS WITH OLD MODELS

Beliefs are very curious phenomena. They can enter our cultures on the basis of only the very slimmest of evidence, but once they have become embedded in a culture—once they have been passed from one generation to the next—they can become strangely resistant to change, very difficult to eliminate. They can persist and persist despite the mounting of huge amounts of evidence that they are wrong. The inertia of tradition keeps them alive.

John Horn on the
"inertia of tradition"



How did the *Glr* domain come to include both learning efficiency (e.g., associative memory; meaningful memory, etc.) and retrieval fluency (e.g., ideational fluency, word fluency, etc.) abilities?

Is this conceptualization correct given the extant research literature?

The master keeper(s) of the CHC definition scrolls

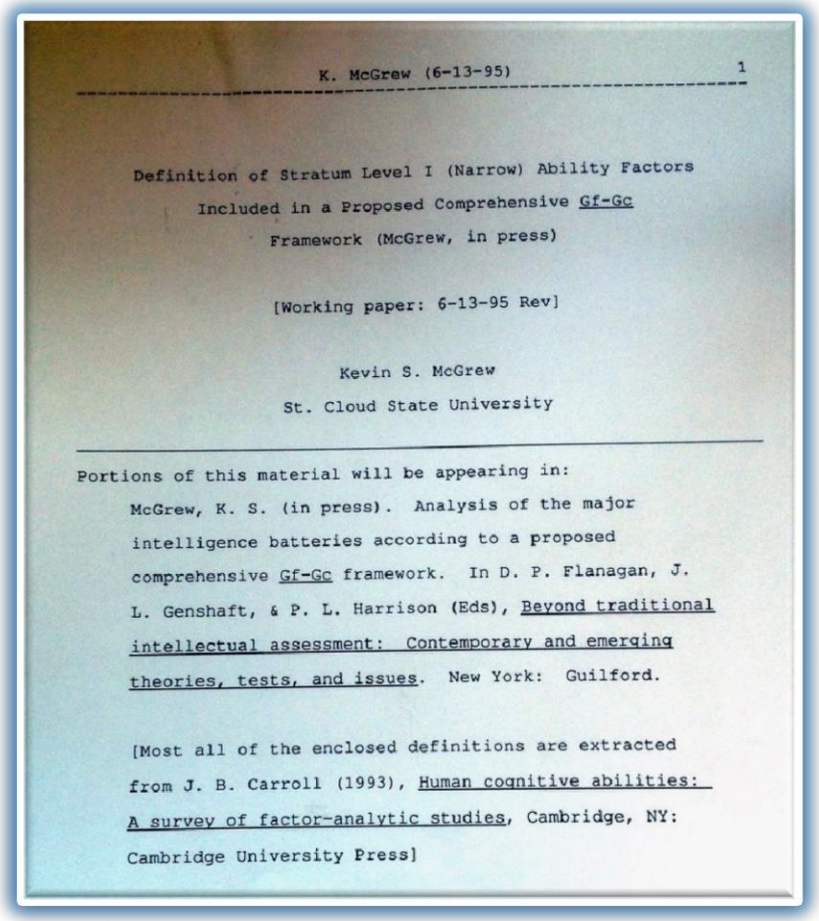
Through a series of serendipitous events (see McGrew, 2005 CHC chapter in Flanagan et al., CIA text), Dr. Kevin McGrew had established an ongoing professional relationship with John Horn and Jack Carroll through their consultation role in both the WJ-R and WJ III. When preparing a 1997 chapter that analyzed all tests from the major intelligence batteries as per the CHC model (then called a "synthesized Carroll and Horn-Cattell *Gf-Gc* framework"), McGrew developed the first set of "official" broad and narrow CHC definitions (derived from a review of Carroll's 1993 seminal work) via a series of communication exchanges with Jack Carroll. As a result, historical events resulted in McGrew being informally drafted as the "master keeper of the CHC definition scrolls" (McGrew, 1997, McGrew 2005, McGrew 2009). Dr. Joel Schneider has now become a co-default gatekeeper of these important scrolls (Schneider & McGrew, 2012)

CHAPTER 9

Analysis of the Major Intelligence Batteries According to a Proposed Comprehensive Gf-Gc Framework

KEVIN S. McGREW

1997



K. McGrew (6-13-95) 1

Definition of Stratum Level I (Narrow) Ability Factors Included in a Proposed Comprehensive Gf-Gc Framework (McGrew, in press)

[Working paper: 6-13-95 Rev]

Kevin S. McGrew

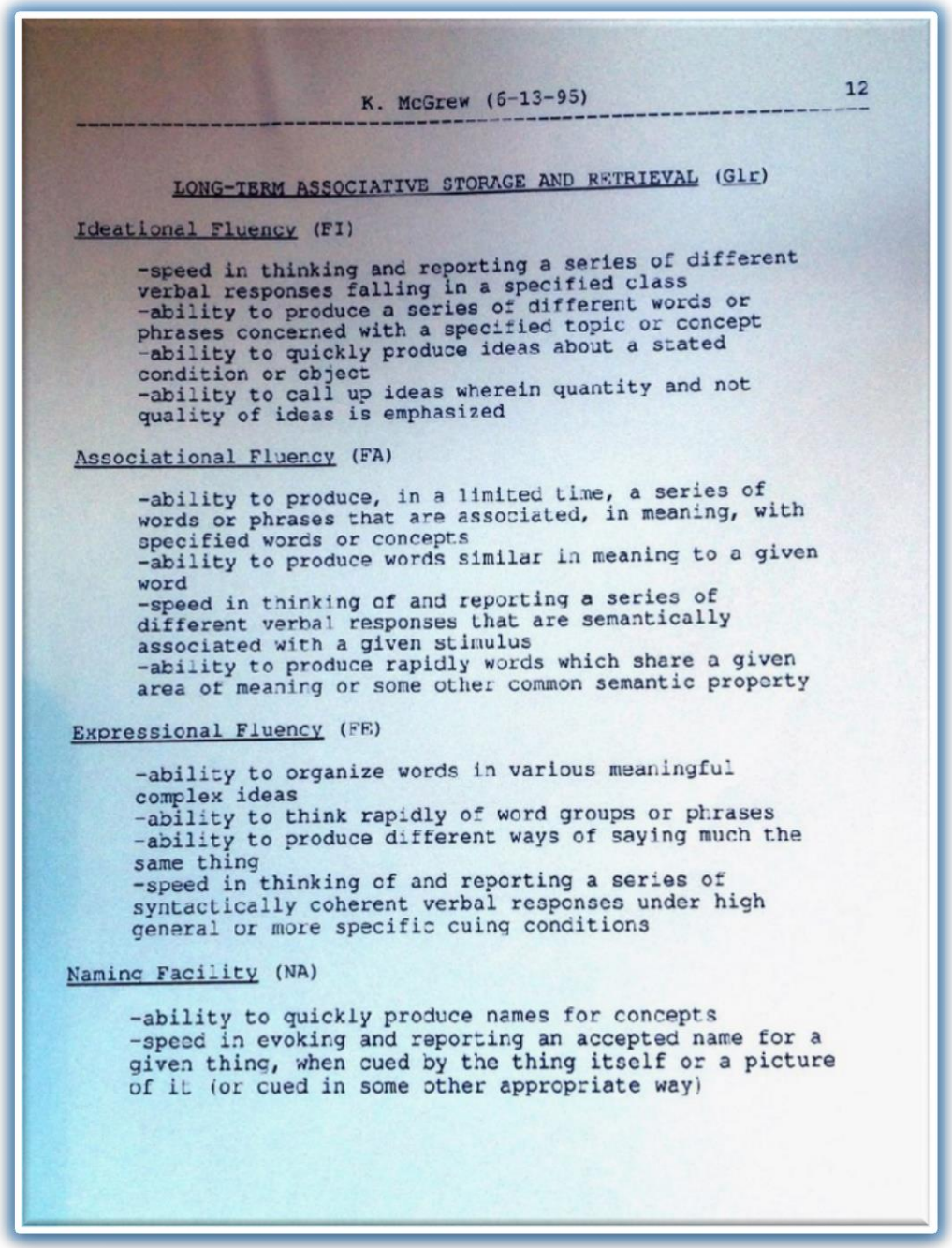
St. Cloud State University

Portions of this material will be appearing in:

McGrew, K. S. (in press). Analysis of the major intelligence batteries according to a proposed comprehensive Gf-Gc framework. In D. P. Flanagan, J. L. Genshaft, & P. L. Harrison (Eds), Beyond traditional intellectual assessment: Contemporary and emerging theories, tests, and issues. New York: Guilford.

[Most all of the enclosed definitions are extracted from J. B. Carroll (1993), Human cognitive abilities: A survey of factor-analytic studies, Cambridge, NY: Cambridge University Press]

Through an iterative process of email and phone conversations with Jack Carroll, in 1995 McGrew finalized a “working document” that listed the key elements of each narrow CHC ability as per Carroll’s 1993 book. This *Glr* page is an example. This document was revised and finalized with Jack Carroll’s approval.



K. McGrew (6-13-95) 12

LONG-TERM ASSOCIATIVE STORAGE AND RETRIEVAL (Glr)

Ideational Fluency (FI)

-speed in thinking and reporting a series of different verbal responses falling in a specified class
-ability to produce a series of different words or phrases concerned with a specified topic or concept
-ability to quickly produce ideas about a stated condition or object
-ability to call up ideas wherein quantity and not quality of ideas is emphasized

Associational Fluency (FA)

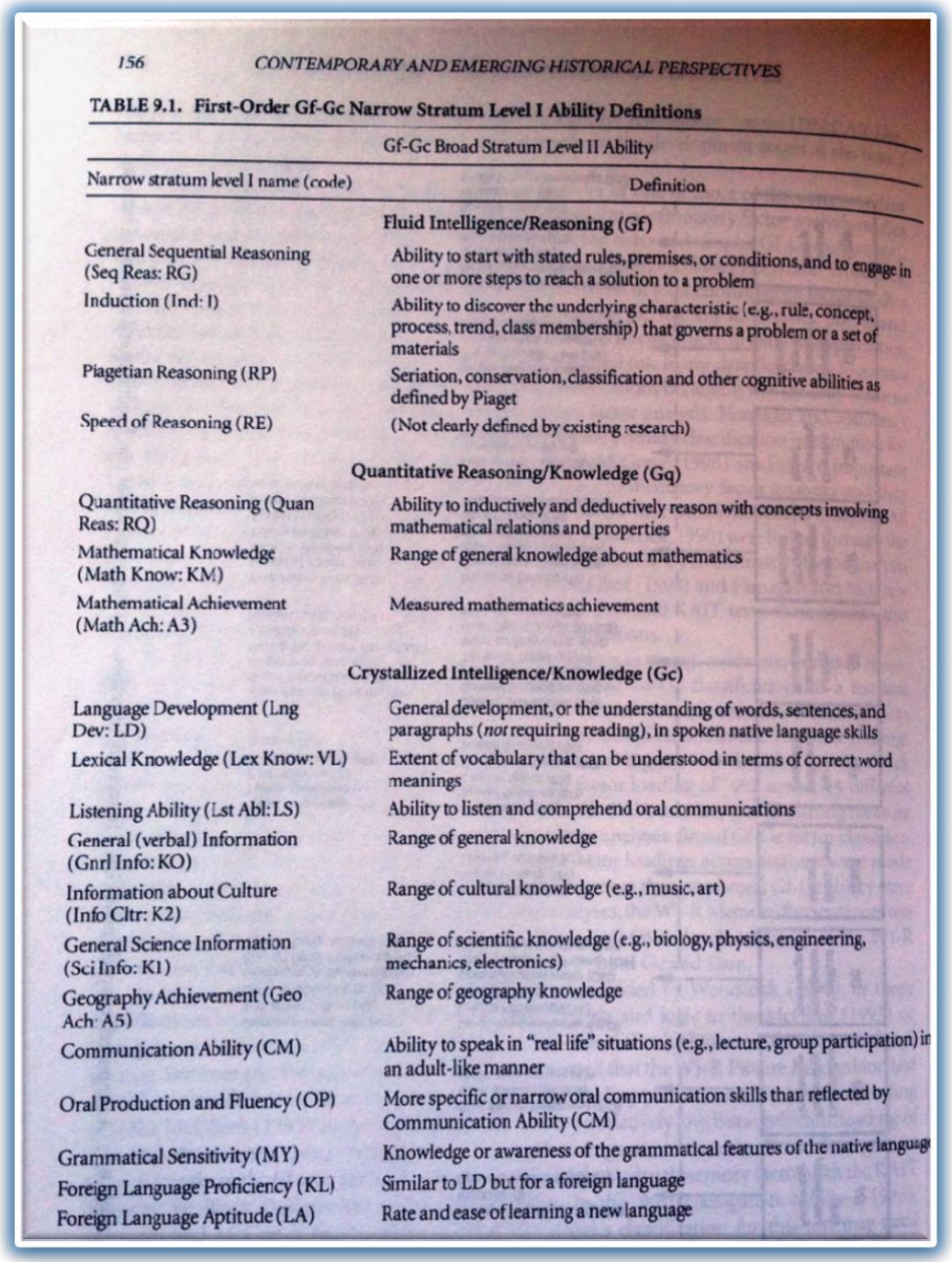
-ability to produce, in a limited time, a series of words or phrases that are associated, in meaning, with specified words or concepts
-ability to produce words similar in meaning to a given word
-speed in thinking of and reporting a series of different verbal responses that are semantically associated with a given stimulus
-ability to produce rapidly words which share a given area of meaning or some other common semantic property

Expressional Fluency (FE)

-ability to organize words in various meaningful complex ideas
-ability to think rapidly of word groups or phrases
-ability to produce different ways of saying much the same thing
-speed in thinking of and reporting a series of syntactically coherent verbal responses under high general or more specific cuing conditions

Naming Facility (NA)

-ability to quickly produce names for concepts
-speed in evoking and reporting an accepted name for a given thing, when cued by the thing itself or a picture of it (or cued in some other appropriate way)

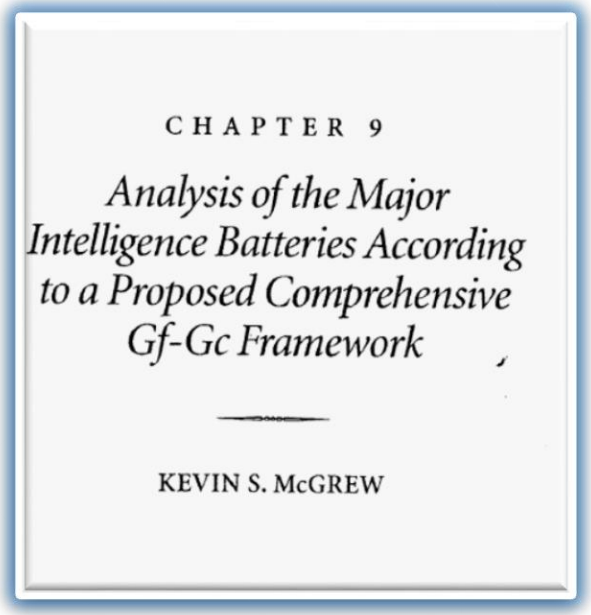


156 CONTEMPORARY AND EMERGING HISTORICAL PERSPECTIVES

TABLE 9.1. First-Order Gf-Gc Narrow Stratum Level I Ability Definitions

Gf-Gc Broad Stratum Level II Ability	
Narrow stratum level I name (code)	Definition
Fluid Intelligence/Reasoning (Gf)	
General Sequential Reasoning (Seq Reas: RG)	Ability to start with stated rules, premises, or conditions, and to engage in one or more steps to reach a solution to a problem
Induction (Ind: I)	Ability to discover the underlying characteristic (e.g., rule, concept, process, trend, class membership) that governs a problem or a set of materials
Piagetian Reasoning (RP)	Seriation, conservation, classification and other cognitive abilities as defined by Piaget
Speed of Reasoning (RE)	(Not clearly defined by existing research)
Quantitative Reasoning/Knowledge (Gq)	
Quantitative Reasoning (Quan Reas: RQ)	Ability to inductively and deductively reason with concepts involving mathematical relations and properties
Mathematical Knowledge (Math Know: KM)	Range of general knowledge about mathematics
Mathematical Achievement (Math Ach: A3)	Measured mathematics achievement
Crystallized Intelligence/Knowledge (Gc)	
Language Development (Lng Dev: LD)	General development, or the understanding of words, sentences, and paragraphs (*not* requiring reading), in spoken native language skills
Lexical Knowledge (Lex Know: VL)	Extent of vocabulary that can be understood in terms of correct word meanings
Listening Ability (Lst Abl: LS)	Ability to listen and comprehend oral communications
General (verbal) Information (Gnrl Info: KO)	Range of general knowledge
Information about Culture (Info Cltr: K2)	Range of cultural knowledge (e.g., music, art)
General Science Information (Sci Info: K1)	Range of scientific knowledge (e.g., biology, physics, engineering, mechanics, electronics)
Geography Achievement (Geo Ach: A5)	Range of geography knowledge
Communication Ability (CM)	Ability to speak in "real life" situations (e.g., lecture, group participation) in an adult-like manner
Oral Production and Fluency (OP)	More specific or narrow oral communication skills than reflected by Communication Ability (CM)
Grammatical Sensitivity (MY)	Knowledge or awareness of the grammatical features of the native language
Foreign Language Proficiency (KL)	Similar to LD but for a foreign language
Foreign Language Aptitude (LA)	Rate and ease of learning a new language

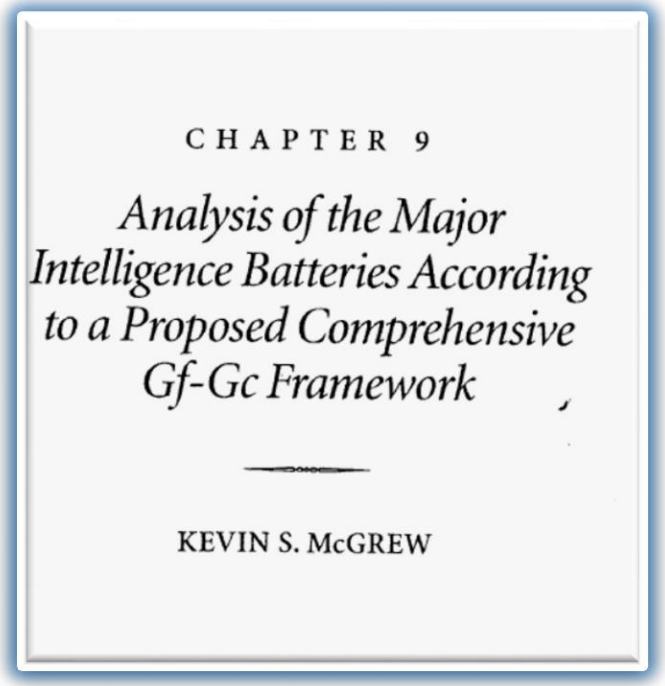
The working draft document served as the basis for the first published list of CHC narrow ability definitions included in the McGrew (1997) chapter. Examples for *Gf*, *Gq*, and *Gc* are presented here. This table was approved by Jack Carroll.



CHAPTER 9

Analysis of the Major Intelligence Batteries According to a Proposed Comprehensive Gf-Gc Framework

KEVIN S. McGREW


CHAPTER 9

Analysis of the Major Intelligence Batteries According to a Proposed Comprehensive Gf-Gc Framework

KEVIN S. McGREW

When preparing this chapter, McGrew attempted to resolve the major differences in how the Carroll and Horn-Cattell models differed in certain domains (Is *Gq* a separate domain? Should *Grw* be included under *Gc* or as a separate domain? How should short-term memory, learning efficiency, and retrieval abilities be organized—*Gsm* and *Glr* vs *Gy* and *Gr*?)

McGrew used both logical analysis and results from a special set of confirmatory analyses of the WJ-R battery to inform the formation of a synthesized model (Table 9.11 in 1997 chapter)

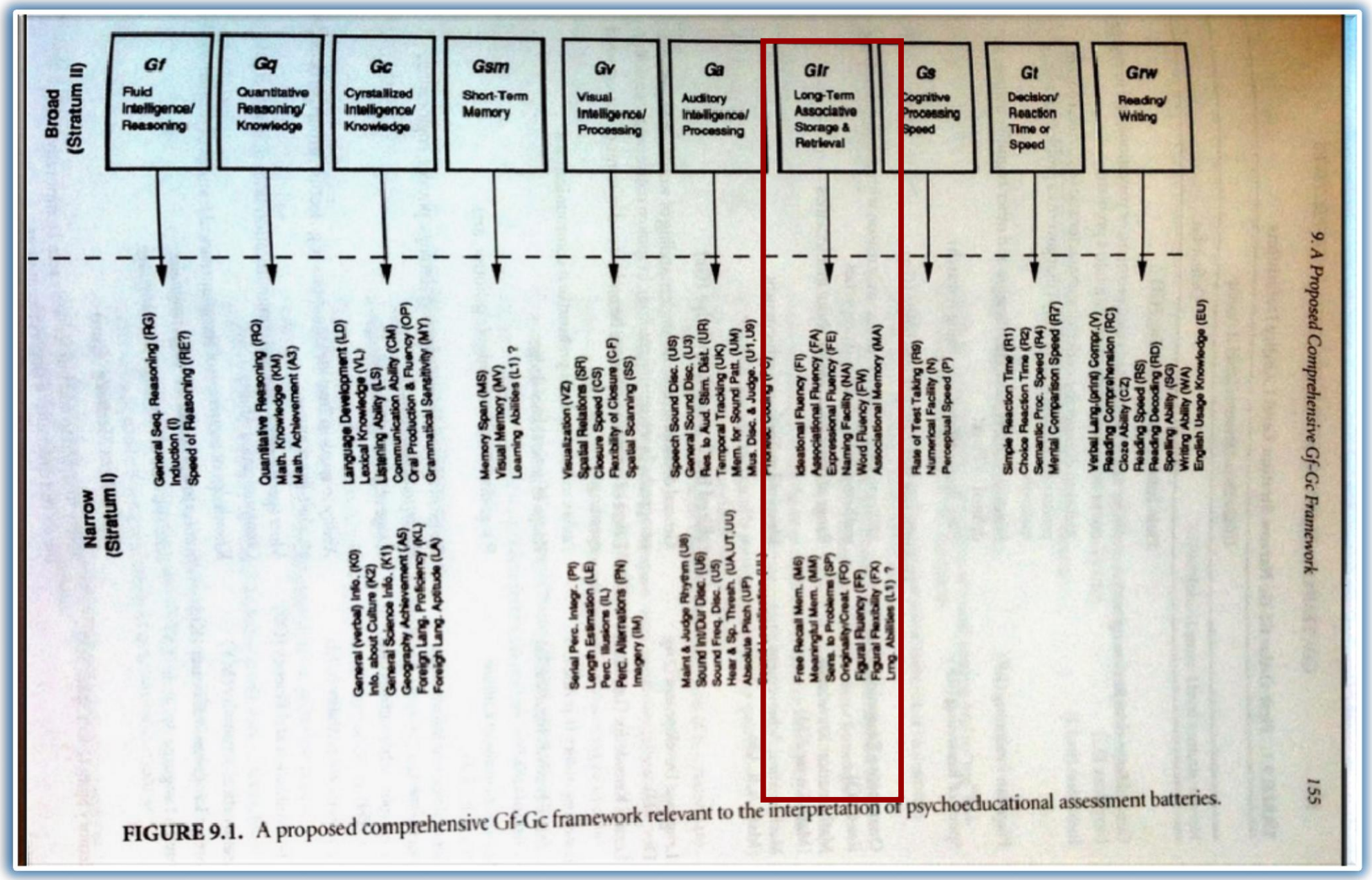


FIGURE 9.1. A proposed comprehensive Gf-Gc framework relevant to the interpretation of psychoeducational assessment batteries.

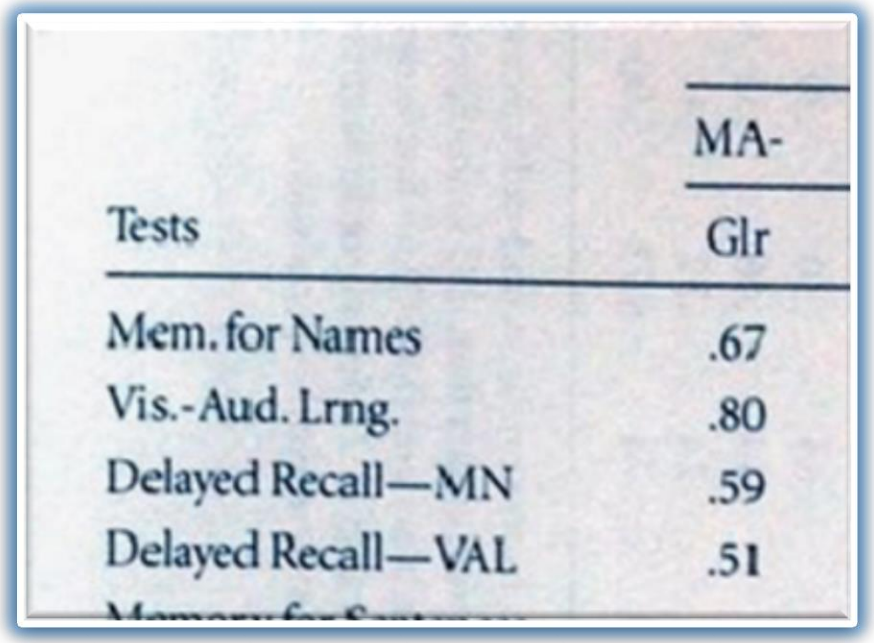
This was McGrew's 1997 "proposed" synthesized comprehen*sive Gf-Gc* framework

Note that *Glr* was comprised of both learning efficiency and retrieval fluency abilities

TABLE 9.11. Final Confirmatory Factor Analysis Solution of 37 Measures from the Complete WJ-R Battery in Kindergarten to Adult Sample (n = 1,291)

		Gf-Gc factor loadings							
Tests	MA-Glr	MS-Gsm	PS-Gs	PC Ga	Gv	Gc	Gf	Gq	Grw
Mem. for Names	.67	—	—	—	—	—	—	—	—
Vis.-Aud. Lrng.	.80	—	—	—	—	—	—	—	—
Delayed Recall—MN	.59	—	—	—	—	—	—	—	—
Delayed Recall—VAL	.51	—	—	—	**.14**	—	—	—	—
Memory for Sentences	—	.51	—	—	—	.50	—	—	—
Memory for Words	—	.71	—	—	—	**.24**	—	—	—
Numbers Reversed	—	.33	—	—	—	—	.49	—	—
Visual Matching	—	—	.86	—	—	—	—	—	—
Cross Out	—	—	.64	—	.25	—	—	—	—
Incomplete Words	—	—	—	.50	—	—	—	—	—
Sound Blending	—	—	—	.73	—	—	—	—	—
Sound Patterns	—	—	—	.26	—	—	.29	—	—
Picture Vocabulary	—	—	—	—	—	.76	—	—	—
Oral Vocabulary	—	—	—	—	—	.69	—	—	.23
Listening Compr.	—	—	—	—	—	.74	—	—	—
Verbal Analogies	—	—	—	—	—	.41	.45	—	—
Science	—	—	—	—	—	.80	—	—	—
Social Studies	—	—	—	—	—	.84	—	—	—
Humanities	—	—	—	—	—	.78	—	—	—
Analysis-Synthesis	—	—	—	—	—	—	.64	—	—
Concept Formation	—	—	—	—	—	—	.67	—	—
Calculation	—	—	—	—	—	—	—	.84	—
Applied Problems	—	—	—	—	—	.21	.18	.54	—
Quant. Concepts	—	—	—	—	—	.33	—	.61	—
Letter-Word Iden.	—	—	—	—	—	—	—	—	.85
Passage Compr.	—	—	—	—	—	.23	—	—	.60
Word Attack	—	—	—	.22	—	—	—	—	.58
Reading Vocabulary	—	—	—	—	—	.44	—	—	.48
Writing Samples	—	—	—	—	—	—	—	—	.74
Writing Fluency	—	—	.31	—	—	—	—	—	.47
Punct. & Cap.	—	—	—	—	—	—	—	—	.76
Spelling	—	—	—	—	—	—	—	—	.84
Usage	—	—	—	—	—	—	—	—	.76
Handwriting	—	—	—	—	—	—	—	—	.26

Note. Factor loadings in bold indicate significant parameters not previously reported by McGrew et al. (1990) or Woodcock (1990). Residual parameters and latent factor correlations not reported in table.



Tests	MA-Glr
Mem. for Names	.67
Vis.-Aud. Lrng.	.80
Delayed Recall—MN	.59
Delayed Recall—VAL	.51

McGrew's (1997) special CFA of the WJ-R norm data indicated that *Gsm* and *Glr* were best considered different broad abilities. However, the *Glr* factor was represented only by narrow MA (associative memory) indicators and **no** indicators of retrieval fluency were present in the analysis.

My classification of the individual tests in the major intelligence batteries is only an initial attempt in light of the emerging Gf-Gc models articulated by Carroll and Horn and are at best informed and reasoned hypotheses that need to be tested. The final Gf-Gc framework that I used to organize the test classifications was based partially on the Carroll versus Horn model analyses that I described in the Appendix, analyses that are based on limited sets of data and indicators. However, any errors in the placement of narrow abilities under the broad Gf-Gc abilities do not affect the narrow ability test classifications reported in this chapter. Future research and scholarly discussions will find that some of my classifications (most of them, I hope) are accurate, whereas others need modification. I fully expect this to happen. What is important is that this initial attempt begins to engage scholars and clinicians in a structured dialogue within a common framework and set of terms. If this is the end result of this chapter, I will be pleased. The monumental works of Carroll and Horn must begin to inform psychoeducational assessment practice, a professional activity that is too often influenced by arm-chair speculation and the inertia of tradition.

Despite appropriate caveats re: the proposed integrated model (e.g., “a proposed framework”; “only an initial attempt”), this published framework (and associated CHC definitions) took on a life of it’s own in almost all subsequent CHC model and assessment literature. It was not until recently that questions about the 1997 conceptualization of *Glr* emerged.

In a 2015 keynote presentation, McGrew, based on a retrospective review of CHC model research, decided he needed to "fall on one's sword" and suggest that the 1997 conceptualization of *Glr* was not 100% correct. Some "missed opportunities" had occurred that suggested a need to revisit the 1997 *Glr* conceptualization

An early "missed opportunity" to question Glr conceptualization

Glr *Gs*

Visual-Auditory Learning	—	—	—	0.80	—	—	—	—	—
Visual-Auditory Learning–Delayed	—	—	—	0.73	—	—	—	—	—
Retrieval Fluency	—	—	—	0.33	—	—	—	0.33	—
Story Recall (Ach)	0.57	—	—	0.11	—	—	—	—	—
Story Recall–Delayed (Ach)	0.55	—	—	—	—	—	—	—	—
Memory for Names	—	—	—	0.65	—	—	—	—	—
Memory for Names–Delayed	—	—	—	0.60	—	—	—	—	—
Visual Matching	—	0.22	—	—	—	—	—	0.71	—
Decision Speed	—	—	—	—	—	—	—	0.71	—
Rapid Picture Naming	—	—	—	0.18	—	—	—	0.41	—
Pair Cancellation	—	—	—	—	—	—	—	0.68	—
Cross Out	—	—	—	—	0.26	—	—	0.65	—

WJ III (2001) ages 6-adult broad CFA (Glr portions only) in technical manual

Glr was primarily defined by learning efficiency (level) abilities (e.g., MA) and the retrieval fluency measures (Retrieval Fluency; Rapid Picture Naming) had much lower *Glr* loadings and secondary loadings on *Gs*

Significant Residual Correlations	*r*
Method or Shared Content Variance	
Memory for Names/Memory for Names–Delayed	0.61
Visual-Auditory Learning/Visual-Auditory Learning–Delayed	0.80
Memory for Names–Delayed/Visual-Auditory Learning–Delayed	0.12
Visual-Auditory Learning–Delayed/Story Recall–Delayed	0.10
Memory for Names–Delayed/Story Recall–Delayed	0.09
Story Recall/Story Recall–Delayed	0.59
Quantitative Concepts/Numerical Reasoning	0.65
Verbal Comprehension/Picture Vocabulary	0.63
Academic Fluency Shared Variance	
Math Fluency/Reading Fluency	0.23
Math Fluency/Writing Fluency	0.12
Reading Fluency/Writing Fluency	0.17
Phonetic Coding (PC) Shared Variance	
Sound Blending/Incomplete Words	0.20
Phoneme/Grapheme Knowledge Shared Variance	
Spelling of Sounds/Word Attack	0.17
Naming Facility (NA) Shared Variance	
Retrieval Fluency/Rapid Picture Naming Speed	0.23
Memory Span (MS) Shared Variance	
Memory for Words/Memory for Sentences	0.32

In the same WJ III analyses, significant correlated residuals between Retrieval Fluency and Rapid Picture Naming were noted and interpreted as shared naming facility (NA) variance. Significant residual correlations are often indicative of unaccounted for factorial variance (possible “missing” non-specified factors).

- Meaningful Memory
- Associative Memory
- Free Recall

Multiple-Trial and/or Delayed Recall

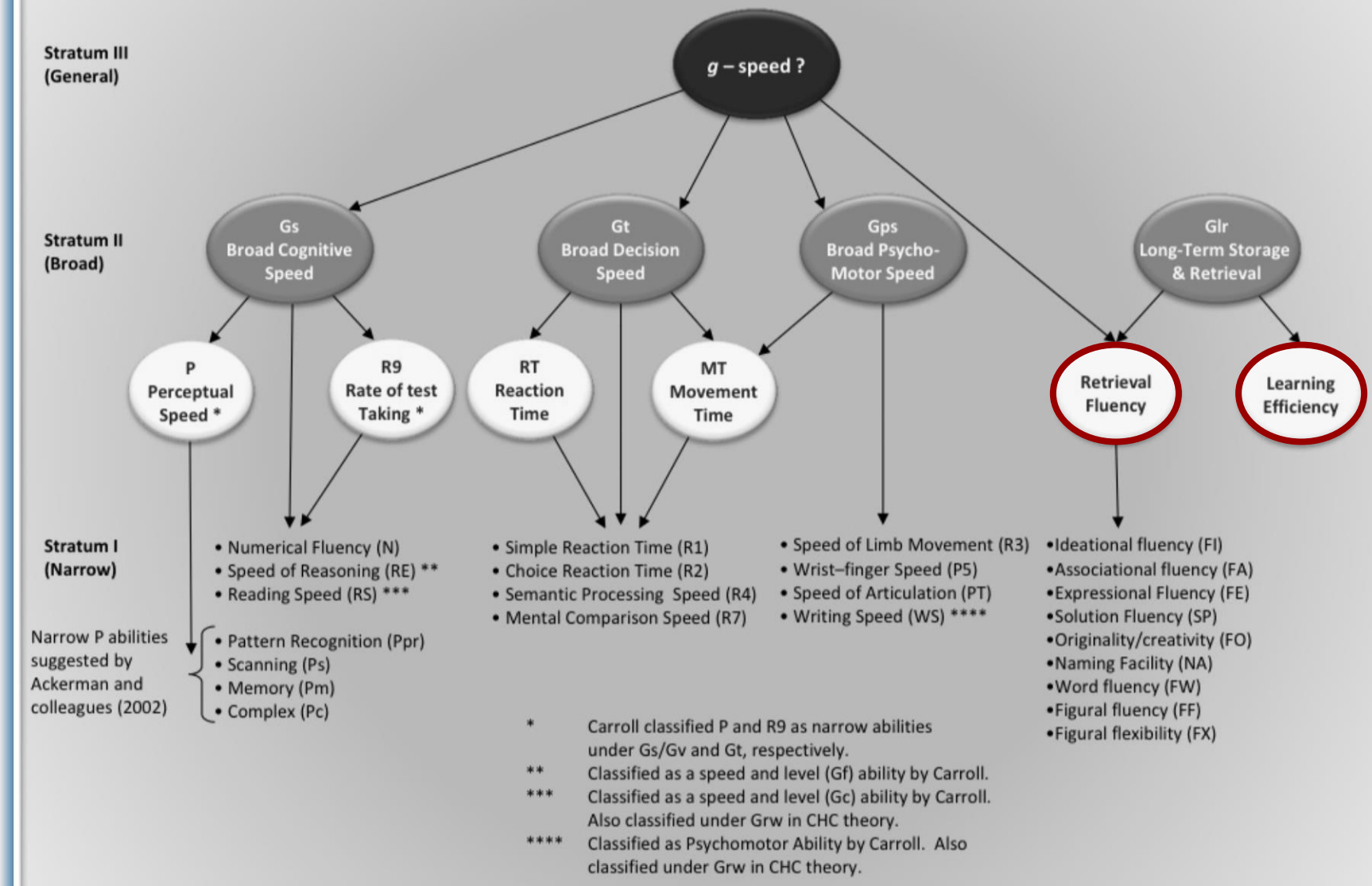
- Naming Facility
- Word Fluency
- Speed of Lexical Access
- Expressional Fluency
- Ideational Fluency
- Associational Fluency
- Solution Fluency
- Originality
- Figural Fluency
- Figural Flexibility

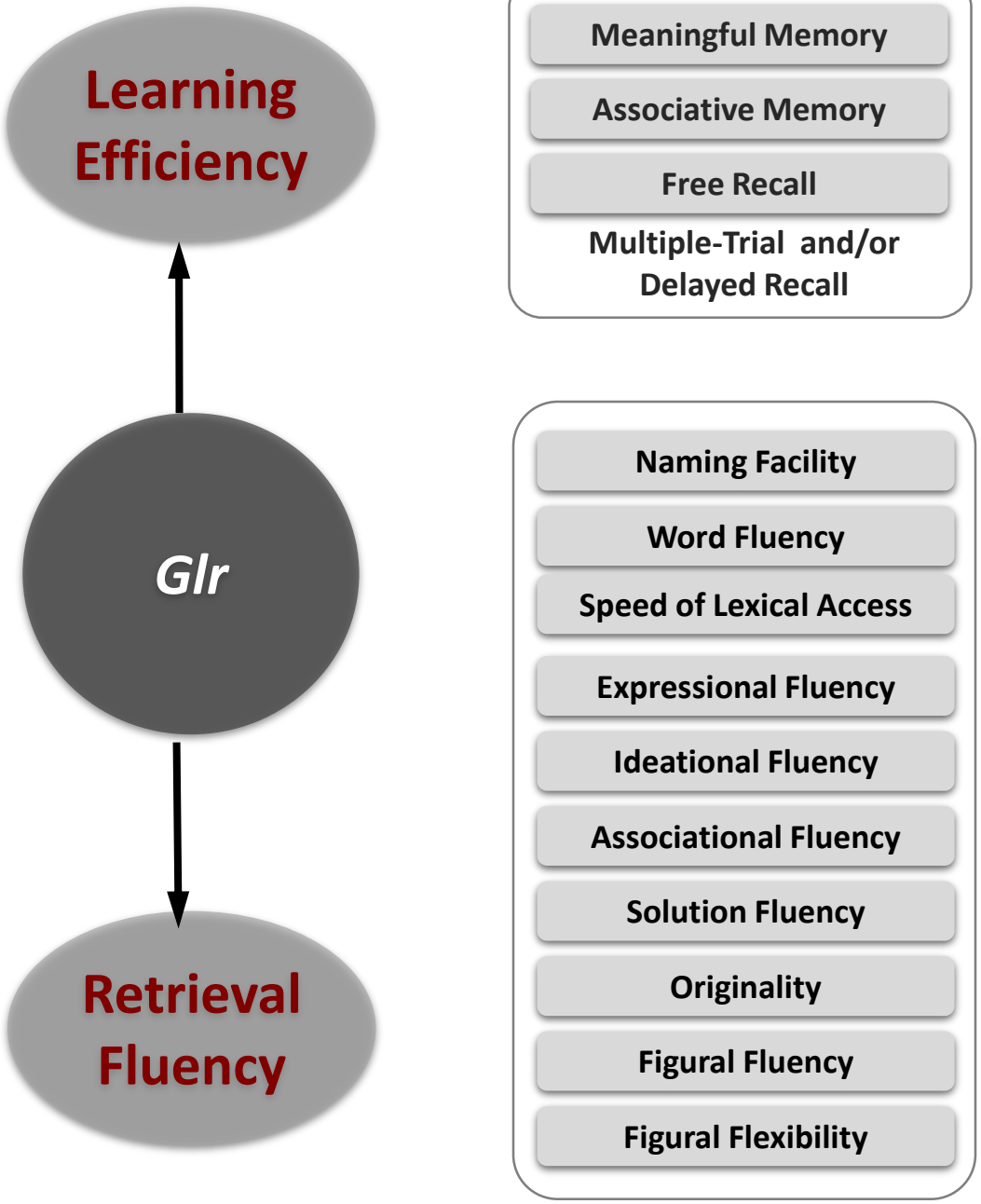
In 2012, Schneider and McGrew started a mid-course correction re: the distinction between learning efficiency and retrieval fluency abilities under the CHC *Glr* domain

"It is important to distinguish between the ability to recall information stored in long-term memory and the fluency with which this information is recalled. That is, people who learn efficiently may not be very fluent in their recall of what they have learned. Likewise, people who are very fluent in producing ideas from their long-term memory may be slow learners. That is, learning efficiency and retrieval fluency are reasonably distinct abilities"(p. 113).

"There is a major division within *Glr* that was always implied in CHC theory but we are making it more explicit here. Some *Glr* tests require efficient learning of new information whereas others require fluent recall of information already in long-term memory" (p. 117)

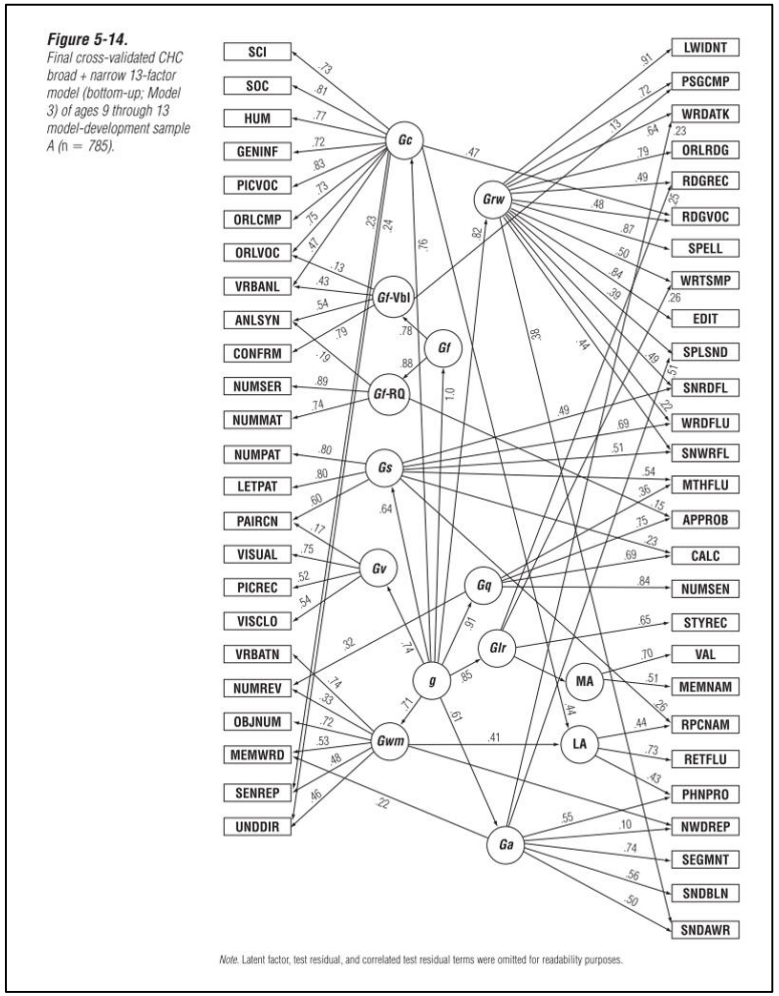
Schneider and McGrew (2012)

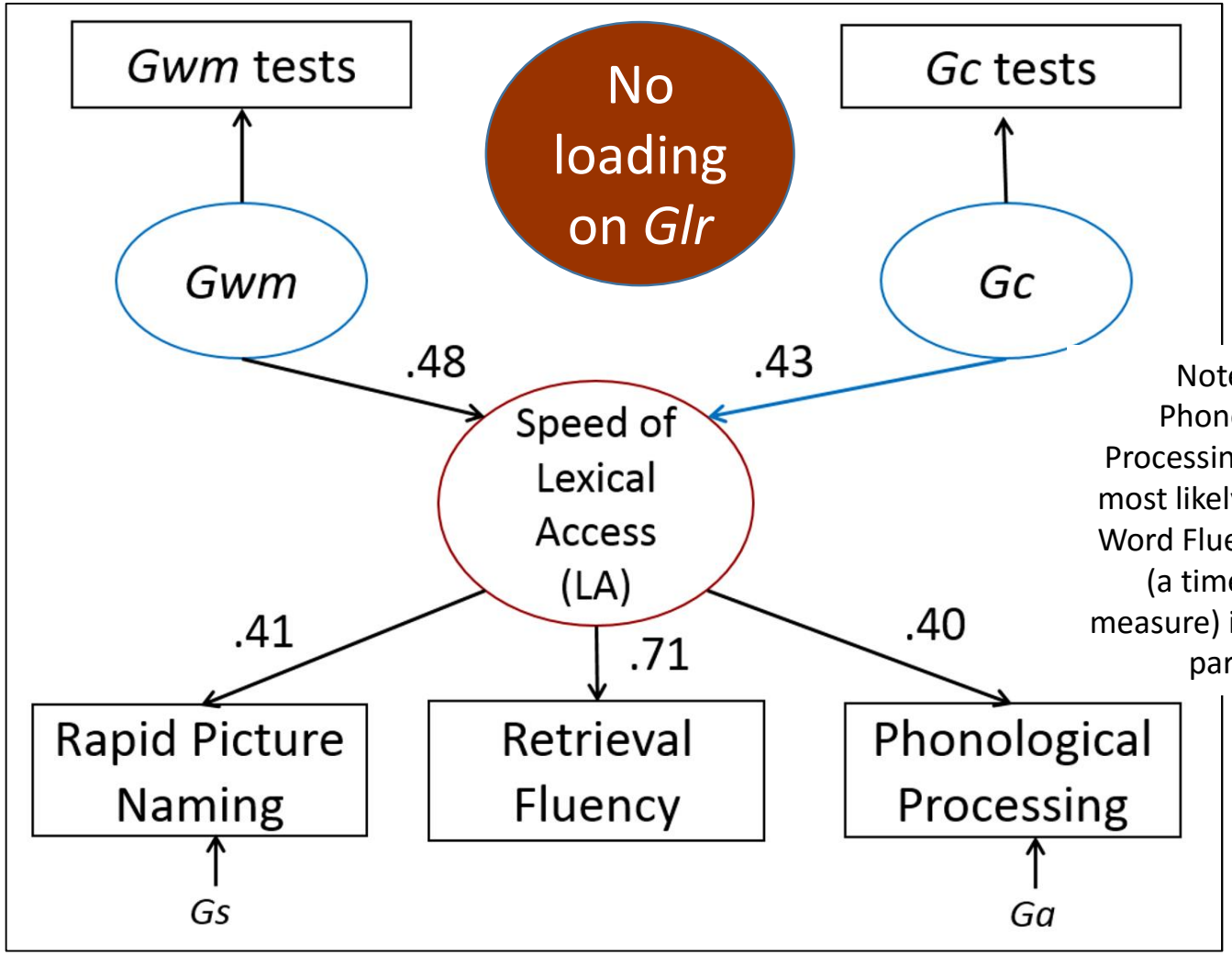




Although not explicitly stated by Schneider and McGrew (2012), the inclusion of learning efficiency and retrieval fluency under *Glr* represented more of a functional classification, and not one that explicitly stated that these two separate domains might better be considered separate latent trait factors.

Additional evidence supportive of a retrieval fluency factor distinct from the learning efficiency component of *Glr* was presented in the WJ IV technical manual (McGrew et al., 2014; the broad+narrow CFA models). The speed of lexical access (LA) factor had loadings on the *Gwm* and *Gc* factors—and did not "hang together" with the associative memory (MA) factor.





Note. The Phonological Processing loading is most likely due to the Word Fluency subtest (a time limited measure) in this three-part test

PREDICTORS OF ACADEMIC OUTCOMES
IN COLLEGE STUDENTS SUSPECTED OF HAVING LEARNING DISORDERS
C. Lee Affrunti, W. Joel Schneider, Renée M. Tobin, & Kimberly D. Collins

ILLINOIS

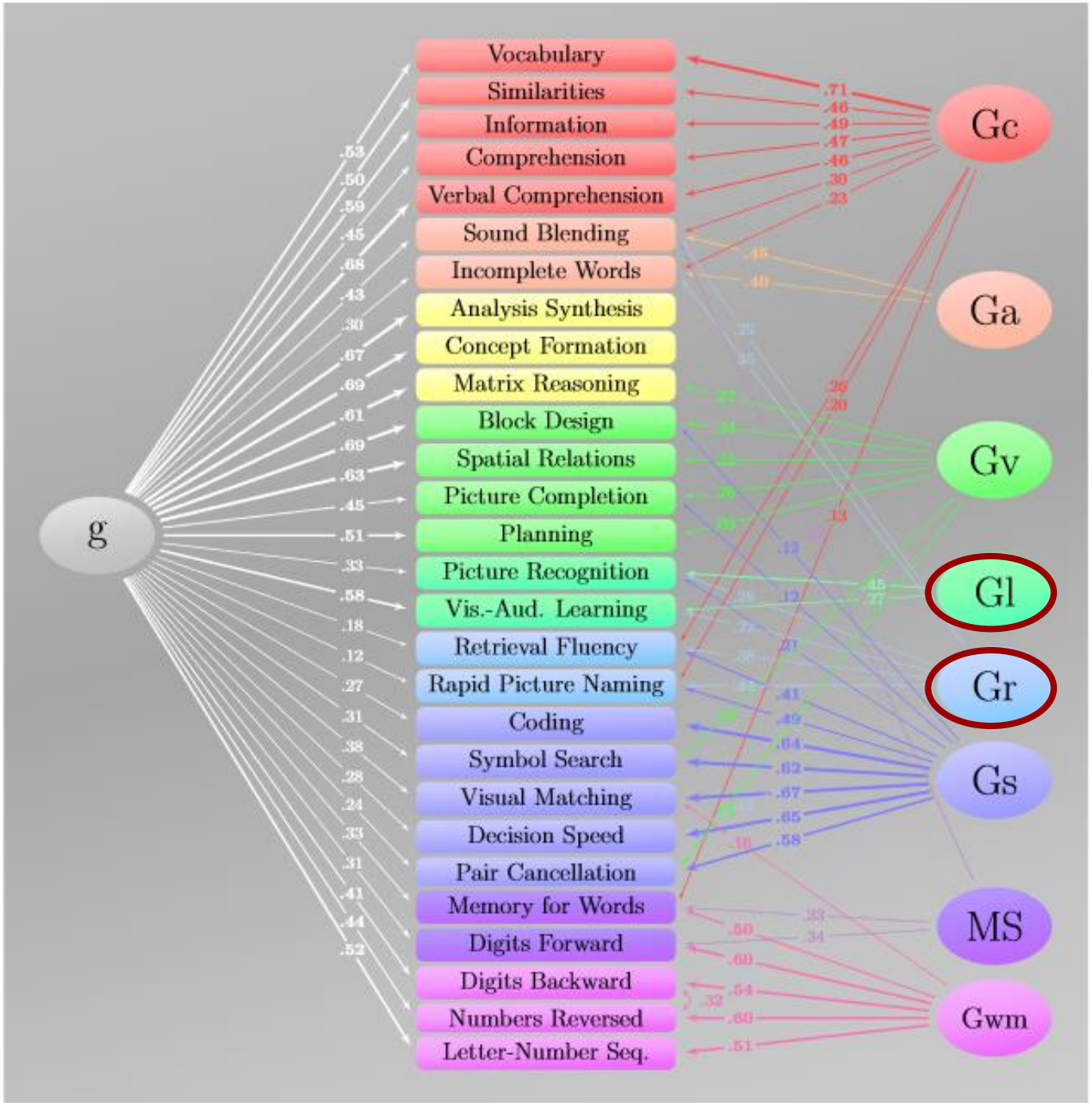
ILLINOIS STATE UNIVERSITY

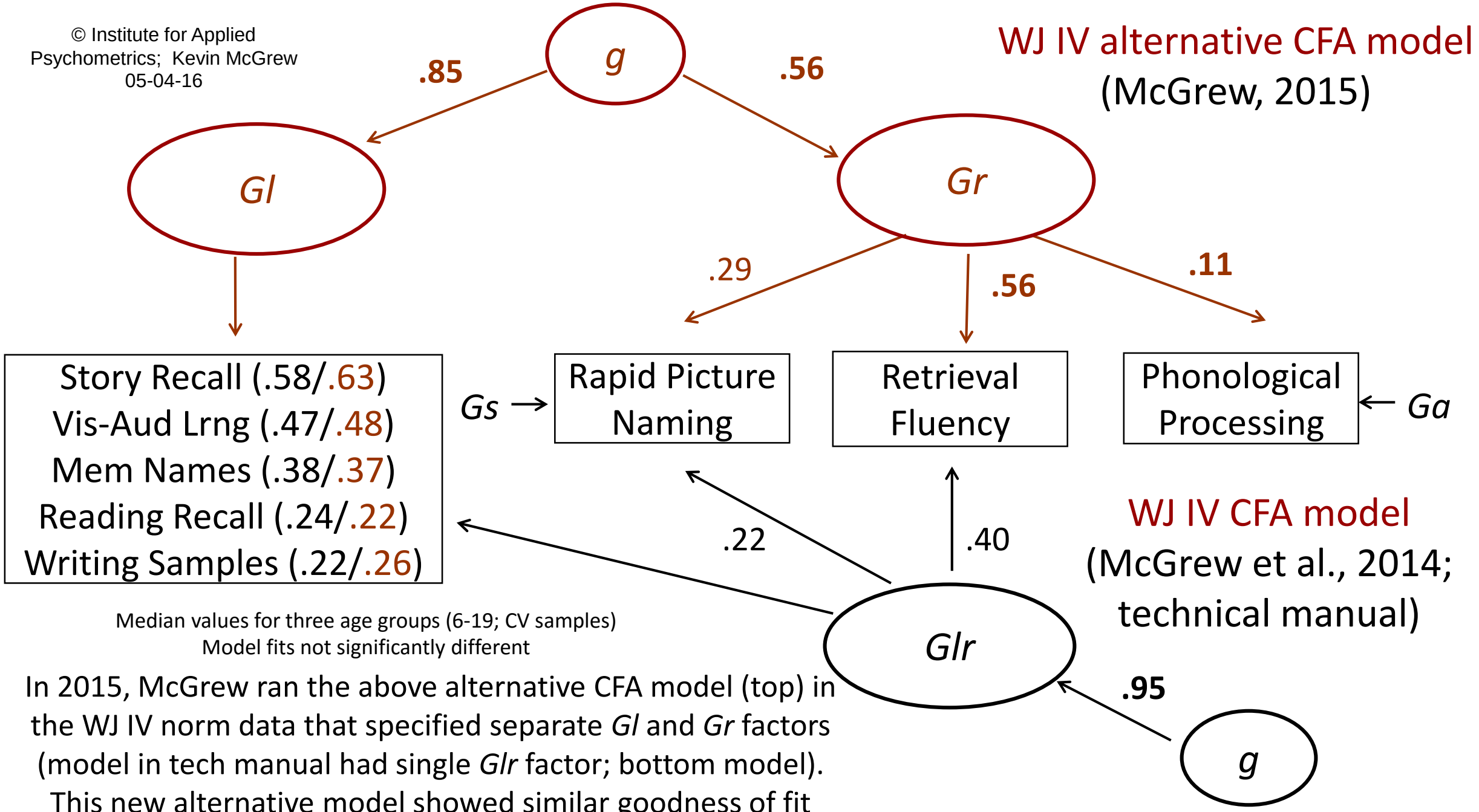
A Large Clinical Data Set

Archival data were obtained from a large Midwestern university at which comprehensive evaluations are provided at no additional fee. Among other measures, each evaluee was administered a substantial portion of the WJ III Cognitive and Academic Batteries and a full WAIS–III ($n = 1040$) or WAIS–IV ($n = 252$). A database of 865 complete cases was used in this study. The mean WAIS FSIQ for this sample fell in the high average range ($M = 112.69$, $SD = 13.59$).

(APA, 2014)

In 2014 Schneider et al. clearly distinguished learning retrieval (*Gl*) from retrieval fluency (*Gr*)…thus initiating formal "divorce" proceedings for the two domains that represented a poor factorial/structural marriage





Median values for three age groups (6-19; CV samples)
Model fits not significantly different

In 2015, McGrew ran the above alternative CFA model (top) in the WJ IV norm data that specified separate *Gl* and *Gr* factors (model in tech manual had single *Glr* factor; bottom model). This new alternative model showed similar goodness of fit

Table 5-10.
WJ IV and Research Test Names and Abbreviations Reported in the WJ IV Technical Manual

Battery/Test Name	Test Name Abbreviation	Battery/Test Name	Test Name Abbreviation
Tests of Cognitive Abilities		**Tests of Achievement**	
1: Oral Vocabulary	ORLVOC	1: Letter-Word Identification	LWIDNT
2: Number Series	NUMSER	2: Applied Problems	APPROB
3: Verbal Attention	VRBATN	3: Spelling	SPELL
4: Letter-Pattern Matching	LETPAT	4: Passage Comprehension	PSGCMP
5: Phonological Processing	PHNPRO	5: Calculation	CALC
6: Story Recall	STYREC	6: Writing Samples	WRTSMP
7: Visualization	VISUAL	7: Word Attack	WRDATK
8: General Information	GENINF	8: Oral Reading	ORLRDG
9: Concept Formation	CONFRM	9: Sentence Reading Fluency	SNRDFL
10: Numbers Reversed	NUMREV	10: Math Facts Fluency	MTHFLU
11: Number-Pattern Matching	NUMPAT	11: Sentence Writing Fluency	SNWRFL
12: Nonword Repetition	NWDREP	12: Reading Recall	RDGREC
13: Visual-Auditory Learning	VAL	13: Number Matrices	NUMMAT
14: Picture Recognition	PICREC	14: Editing	EDIT
15: Analysis-Synthesis	ANLSYN	15: Word Reading Fluency	WRDFLU
16: Object-Number Sequencing	OBJNUM	16: Spelling of Sounds	SPLSND
17: Pair Cancellation	PAIRCN	17: Reading Vocabulary	RDGVOC
18: Memory for Words	MEMWRD	18: Science	SCI
		19: Social Studies	SOC
		20: Humanities	HUM

OVANT – Antonyms
OVSYN – Synonyms

PPSUB – Substitution
PPACC – Word Access
PPFLU – Word Fluency

VZBSPRL – Spatial Relations
VZBLKR – Block Rotation

GIWHAT – What
GIWHER – Where

RVANT – Antonyms
RVSYN – Synonyms

WJ IV test and subtest name abbreviations used in analysis and results included next in this PPT module

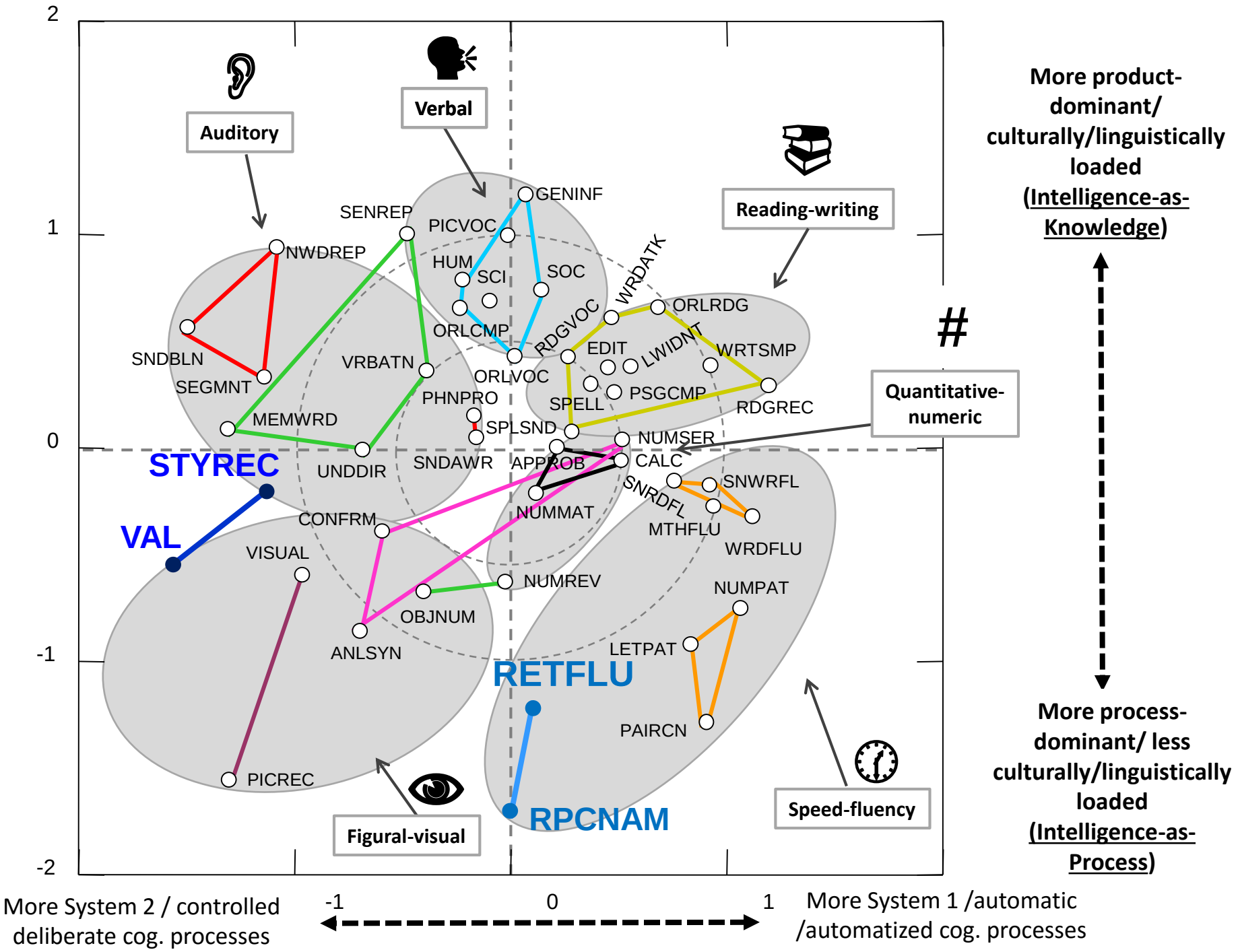
		20: Humanities	HUM
Tests of Oral Language		**Non-WJ IV Research Tests**	
1: Picture Vocabulary	PICVOC	Memory for Names[a]	MEMNAM
2: Oral Comprehension	ORLCMP	Verbal Analogies[a]	VRBANL
3: Segmentation	SEGMNT	Visual Closure[a]	VISCLO
4: Rapid Picture Naming	RPCNAM	Number Sense	NUMSEN
5: Sentence Repetition	SENREP		
6: Understanding Directions	UNDDIR		
7: Sound Blending	SNDBLN		
8: Retrieval Fluency	RETFLU		
9: Sound Awareness	SNDAWR		

[a] Tests or subtests in WJ III COG Diagnostic Supplement.

SADELE – Deletion
SARHYM – Rhyming

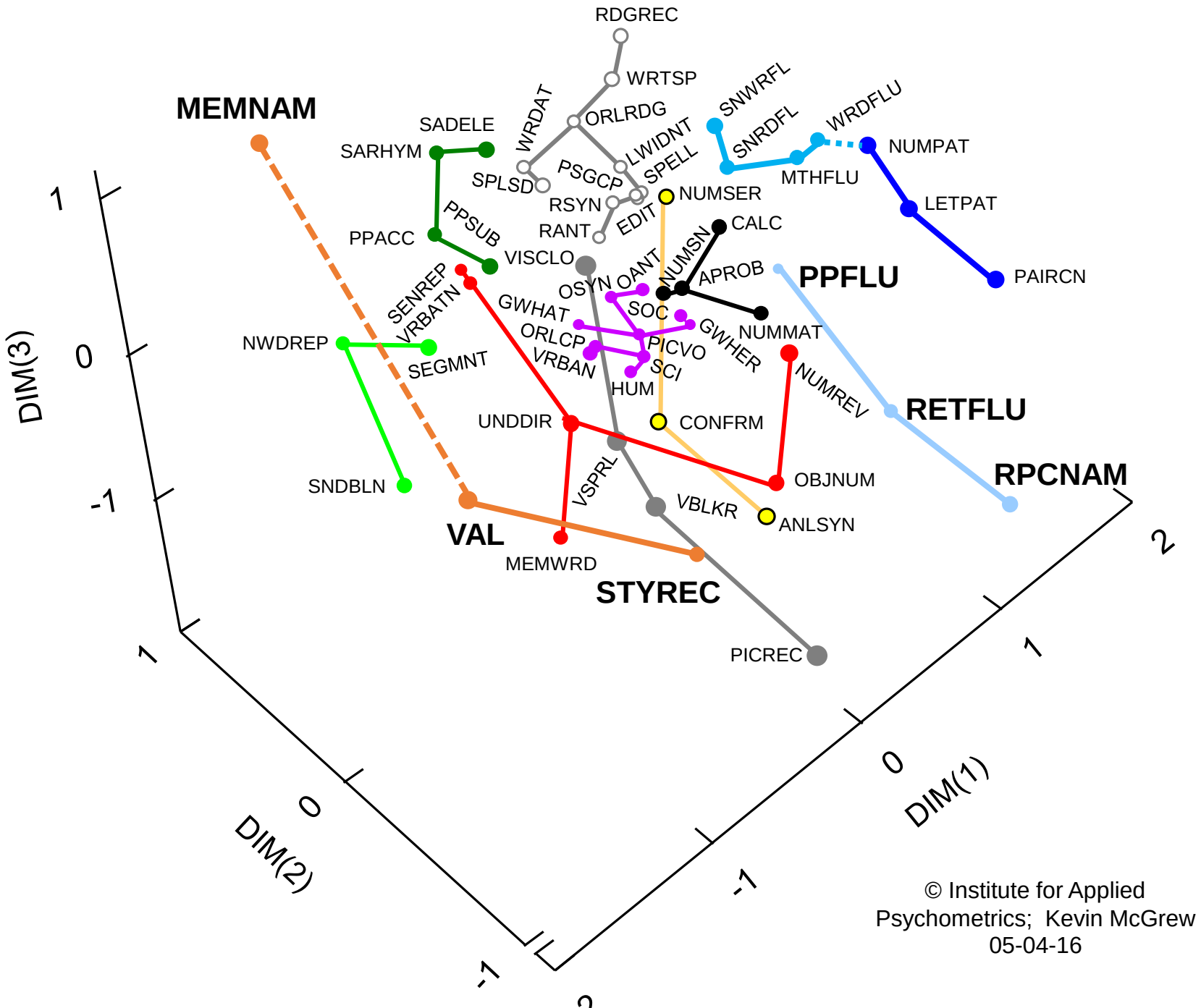
WJ IV test 2D MDS (Ages 6 to 19 norm data; n = 4,082)

Note that in spatial MDS map, where the distance between tests represents degree of association, Retrieval Fluency and Rapid Picture Naming (LA; *Gr*) are quite discrepant from Story Recall and Visual Auditory Learning (*Gl*), and they are in the speed/fluency quadrant



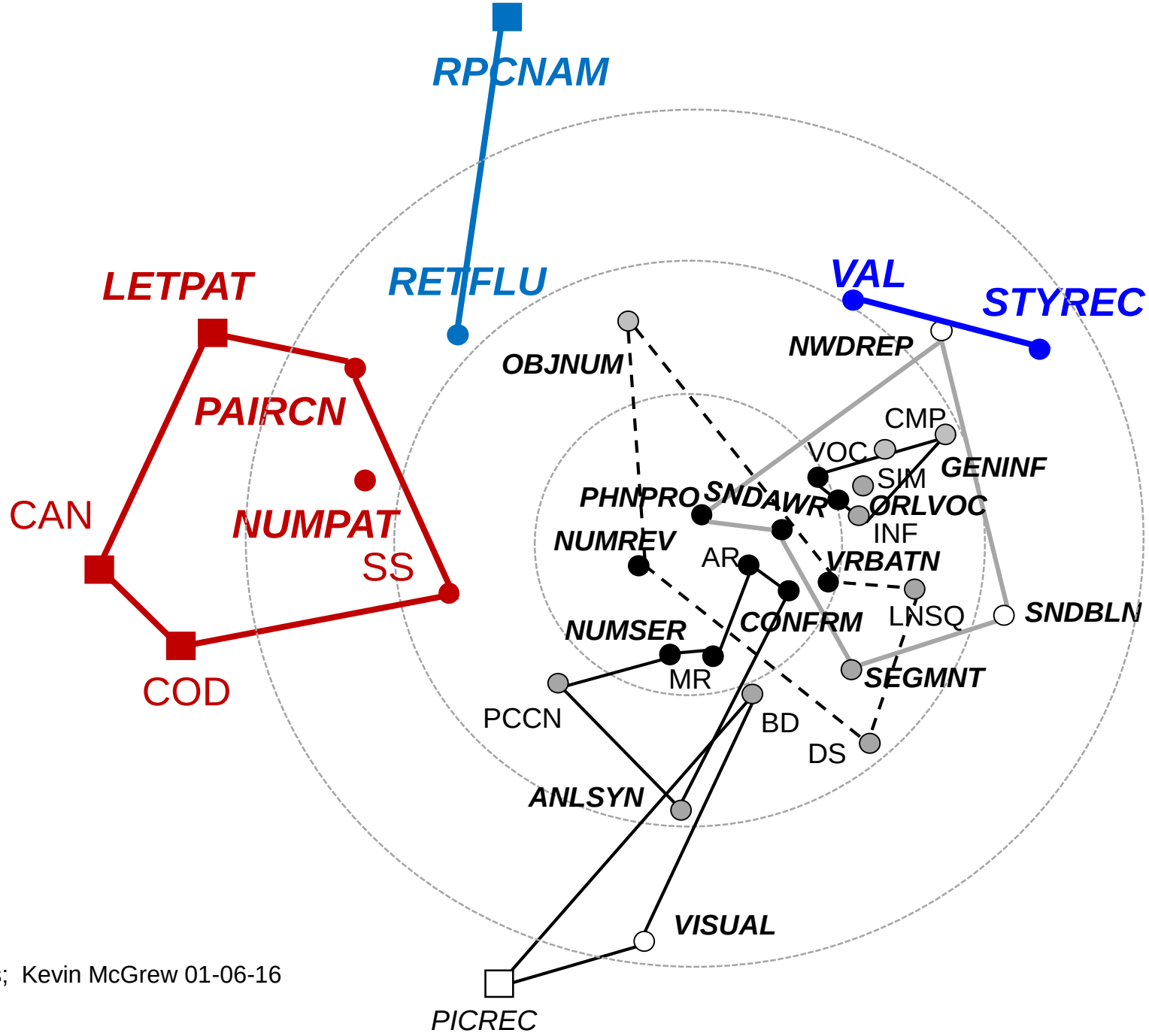
WJ IV test 3D MDS (Ages 6 to 19; n = 4,082). Three dimensions not yet interpreted

Note that in spatial 3-D MDS map that included subtests for subtest-based tests and WJ IV ECAD tests, Retrieval Fluency and Rapid Picture Naming were joined by Phonological Processing: Word Fluency (**LA; *Gr***), and these were distinct from Story Recall, Visual-Auditory Learning and Memory for Names (***Gl***) and the speeded tests, but closer to the speeded tests (***Gs***)

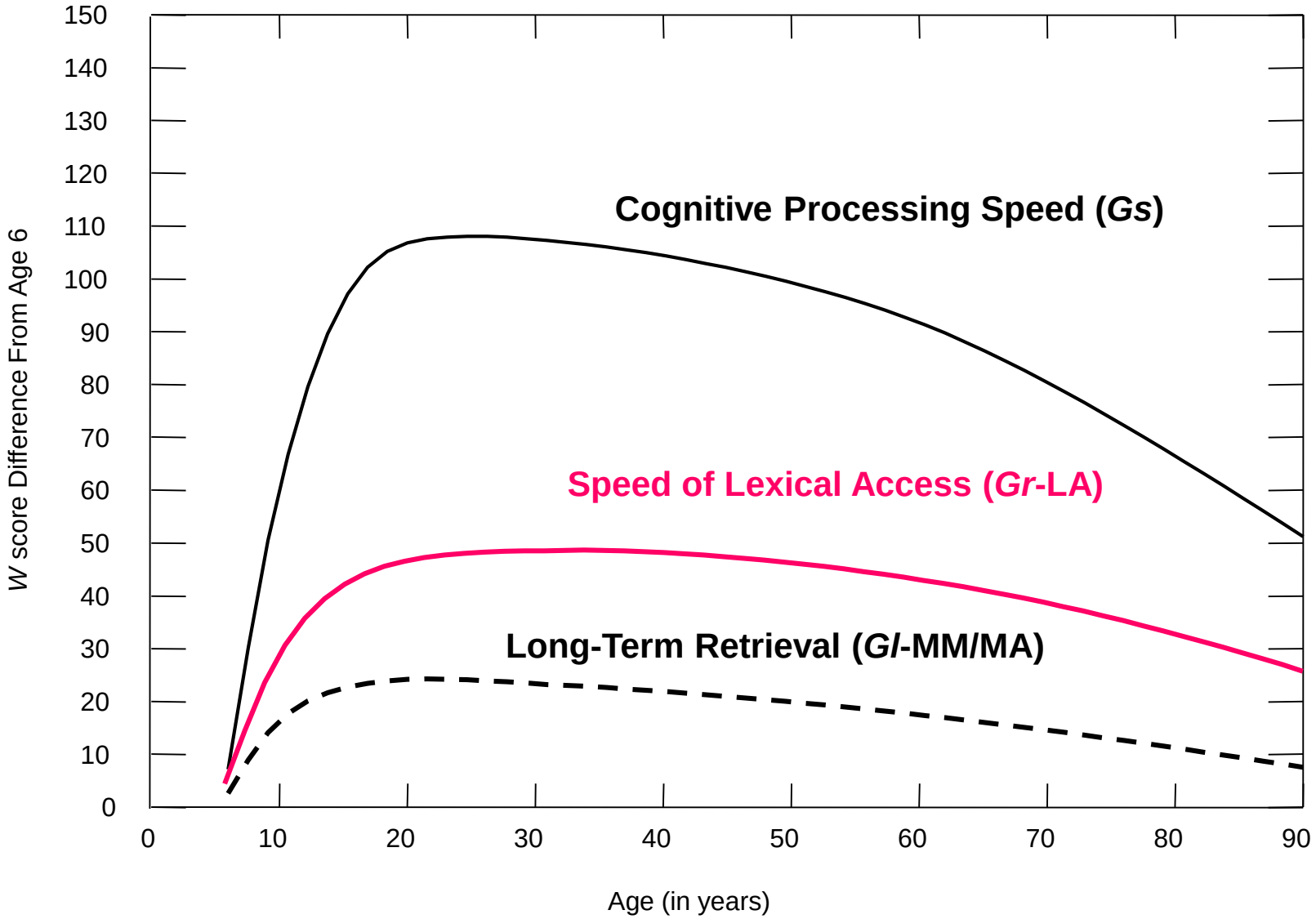


WJ IV and WISC-IV 2D MDS solutions (n=173; see WJ IV tech manual)

Gl and ***Gr*** substructure also supported when external indicators (WISC-IV tests) are included in 2-D MDS. ***Gr*** dimension also distinct from ***Gs***, but closer to ***Gs*** than ***Gl***.



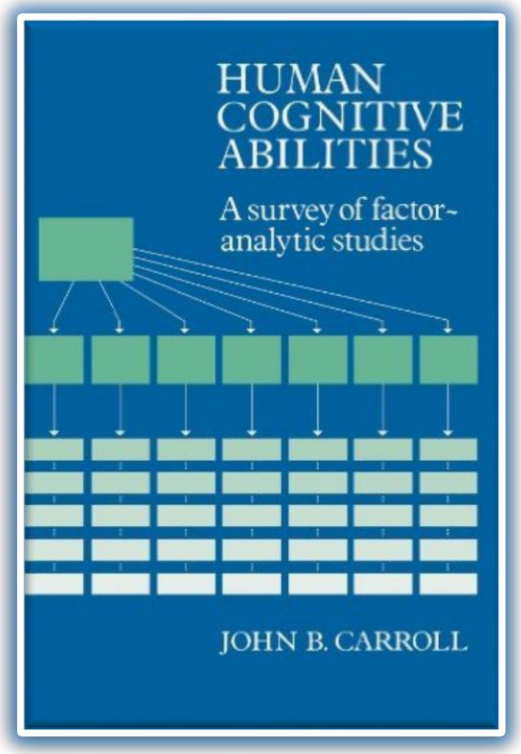
Plot of *Gs, Gl*, and *Gr* (LA) *W* score difference curves by age



Divergent WJ IV developmental growth curves are another form of non-factor evidence indicating that measures of traits are representing different constructs

Curves extracted from WJ IV tech. manual

Other non-WJ IV factor analytic evidence supports the distinction between *Gl* and *Gr*



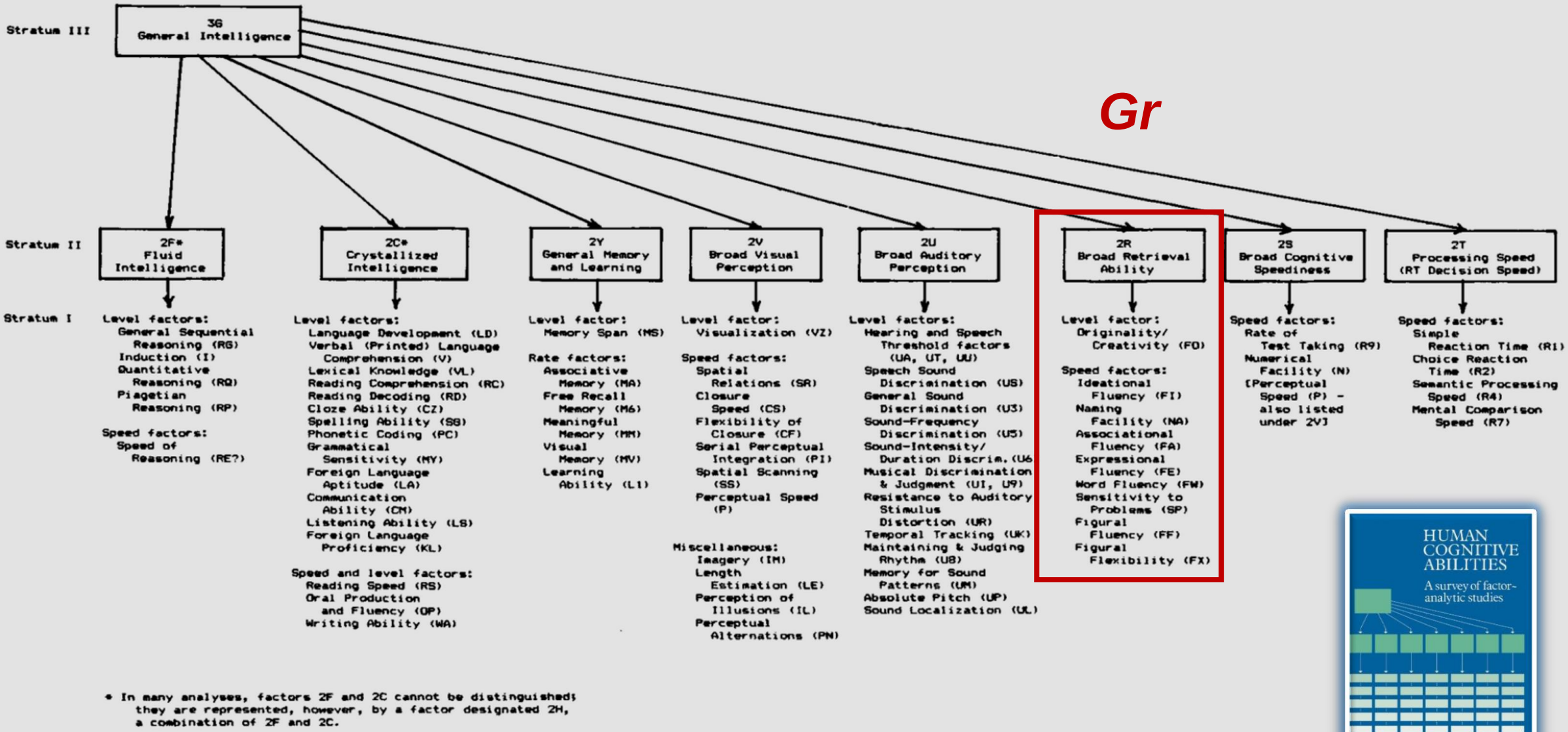
Jack Carroll (1993) specified *Gr* as a separate broad domain construct

10 *Abilities in the Domain of Idea Production*

Whereas creativity involves traits that make a person creative, creating calls upon many resources not intrinsically creative.

David N. Perkins (1981, p. 275)

The ability of the individual to produce ideas expressed in language or other media is an important human characteristic. In this chapter, we consider a variety of factors that measure different aspects of such an ability. Many of these factors may be roughly described as "fluency" and "creativity" factors. These correspond generally to abilities that Guilford (1967) described as concerned with "divergent production," that is, with tasks in which the requirements are relatively unstructured and in which the individual must produce a variety of responses that might meet such requirements. Divergent production is regarded as being opposed to "convergent production," where the task is highly structured and the problem is only to produce a single "correct" or "best" answer. Some of the factors discussed in the present chapter are of a divergent character, but others are of a convergent character.



Gr

Figure 15.1. The structure of cognitive abilities.

are of a convergent character.

In describing this domain as one of idea production, I mean the term *idea* to be taken in its broadest possible sense. An idea can be expressed in a word, a phrase, a sentence, or indeed any verbal proposition, but it may be something expressed in a gesture, a figure, a drawing, or a particular action. It might be a musical phrase or composition, although there are no instances in our datasets where individuals are asked to produce musical materials. (Webster's, 1977, dataset concerning musical improvisation and composition proved to be inadequate for factorial analysis.)

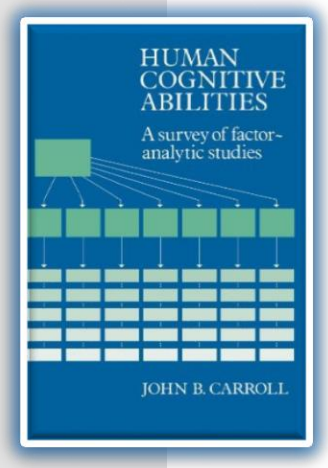
It is characteristic of all the factors considered here that they involve the active *production* of ideas as opposed to the recognition, identification, selection, or comparison of ideas as represented in stimuli presented to subjects.

In his survey of results achieved in the early years of factor-analytic research, French (1951) recognized the following factors that could belong in the category considered here (French's symbols for the factors are given):

Fluency of Expression (FE): "Verbal versatility" (Taylor, 1947) in producing a variety of verbal responses.

Ideational Fluency (IF): "Characterized by tests on which the task is to write down ideas about a given topic as fast as possible" (French, 1951, p. 215).

Gr

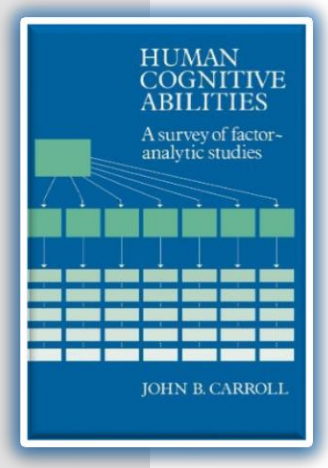


FACTORS CLASSIFIED AS Gr OR 2R (BROAD RETRIEVAL ABILITY)

For these second-stratum factors, I use the term "broad retrieval ability," following the suggestions of such writers as Cattell (1971, p. 40), Hakstian and Cattell (1978), and Horn (1988), to denote a capacity to readily call up concepts, ideas, and names from long-term memory. Such a capacity seems to be involved in the entire domain of abilities discussed in Chapter 10 of the present volume, and also in certain abilities (OP, Oral Production, and WA, Writing Ability) in the domain of language as discussed in Chapter 5. Retrieval is not, of course, the only process involved in these factors; many of them also imply constructive or other processes. Table 15.12 lists 44 higher-order factors, found in 40 datasets of this survey, that have been classified in this category. Most of these factors are found at the second order of analysis, and in most cases a given dataset yielded only one such factor. A tabulation of the first-order factors that most frequently occurred as having one of the two highest loadings on the factor yielded the following:

Gr

Factor FI (Ideational Fluency), 31 times, average loading .68
Factor FO (Originality/Creativity), 7 times, average loading .58
Factor FE (Fluency of Expression), 4 times, average loading .76
Factor FF (Figural Fluency), 4 times, average loading .67
Factor SP (Sensitivity to Problems), 4 times, average loading .55
Factor FA (Associational Fluency), 4 times, average loading .52
Factor WA (Writing Ability), 3 times, average loading .81
Factor FX (Figural Flexibility), 3 times, average loading .63
Factor OP (Oral Production), 3 times, average loading .53



Neuropsychology
2012, Vol. 26, No. 3, 400–405

0894-4105/12/$12.00 DOI: 10.1037/a0027989

Ideational Fluency as a Domain of Human Cognition

Tracy D. Vannorsdall, David A. Maroof, Barry Gordon, and David J. Schretlen
Johns Hopkins University School of Medicine

Objective: Many disorders are characterized by impoverished ideational fluency. Tests of letter word, category word, and design fluency likely invoke different cognitive processes, but they might depend on overlapping cortical circuits. Despite differences in the tasks used to assess it, we hypothesized that ideational fluency represents a dissociable dimension of human cognition. ***Methods:*** Altogether, 317 healthy adults and 280 adults with medical or psychiatric illnesses completed a cognitive test battery that included three measures of ideational fluency. Principal component analyses assessed the factor loadings of these fluency measures along with 10 other cognitive test scores. A series of hierarchical multiple regressions determined the relative contribution of the other fluency measures to the fluency variable of interest after accounting for demographic factors and other cognitive abilities. ***Results:*** In both participant groups all three measures of word and design fluency loaded on a single factor. An ideational fluency composite score was also normally distributed among healthy adults. After accounting for demographic characteristics, intelligence, processing speed, memory, and executive functioning, adding terms for letter- and category-cued word fluency improved multiple regression models predicting design fluency and vice versa. ***Conclusions:*** Despite differences among them, the three fluency measures emerged as clearly distinct from other cognitive abilities. Alternate fluency measures also accounted for significant incremental variability in both word and design fluency, even after accounting for other cognitive abilities. Thus, word and design fluency appear to involve a distinct and dissociable, material-independent dimension of cognitive processing, namely ideational fluency.

Keywords: verbal fluency, lexical retrieval, design fluency, executive function, schizophrenia, bipolar

Gl

Gr

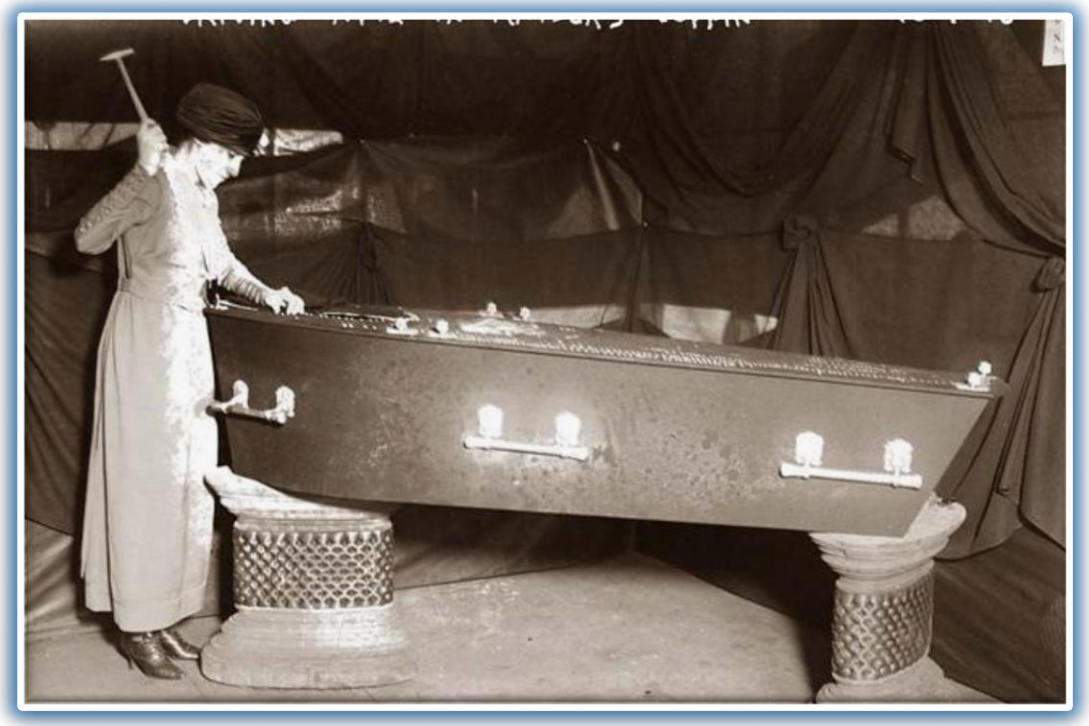
Table 1

Results of Principal Component Analyses in 317 Healthy Adults and 280 Patients

Cognitive measure	Model coefficients for healthy controls				Model coefficients for patients		
	Psychomotor speed	Learning/memory	Executive function	Ideational fluency	Psychomotor speed	Learning/memory & executive function	Ideational fluency
GPT, dominant hand	**.855**	−.158	.173	−.189	**.859**	−.228	−.176
GPT, non-dominant hand	**.859**	−.134	.176	−.176	**.864**	−.181	−.146
Trail Making Test, Part A	**.704**	−.130	.209	−.332	**.701**	−.293	−.318
Trail Making Test, Part B	**.547**	−.243	.485	−.296	**.625**	−.373	−.388
HVLT-R, learning	−.127	**.795**	−.146	.326	−.095	**.659**	.514
HVLT-R, delayed recall	−.099	**.879**	−.163	.176	−.083	**.684**	.493
BVMT-R, learning	−.597	**.630**	−.143	.099	−.453	**.592**	.253
BVMT-R, delayed recall	−.571	**.631**	−.140	.054	−.458	**.598**	.231
M-WCST, category sorts	−.179	.146	**−.902**	.117	−.290	**.785**	.089
M-WCST, persev. errors	.232	−.160	**.882**	−.041	.282	**−.756**	−.029
CIFA, Letter Fluency	−.095	.101	−.033	**.838**	−.255	.013	**.805**
CIFA, Category Fluency	−.259	.242	−.032	**.747**	−.310	.194	**.741**
CIFA, Design Fluency	−.237	.158	−.184	**.716**	−.133	.364	**.611**

Note. GPT = Grooved Pegboard Test; HVLT-R = Hopkins Verbal Learning Test, revised (learning = sum of trials 1–3); BVMT-R = Brief Visuospatial Memory Test, revised (learning = sum of trials 1–3); M-WCST = Modified Wisconsin Card Sorting Test (persev. = perseverative); CIFA = Calibrated Ideational Fluency Assessment. Bold and italicized text indicates the fluency variables from other cognitive variables.

in healthy persons and those without focal brain lesions. We conceptualize this as ideational fluency, and we speculate that it represents a cohesive and dissociable domain of cognitive function, one that involves the ability to retrieve or generate ideas. Just as tests of word and design learning both assess episodic memory but can be selectively impaired by unilateral brain lesions, here we hypothesize that tests of word and design fluency assess a common underlying ability, even though they might also be selectively impaired by unilateral brain lesions.



The final nail in the coffin for separating *Gl* and *Gr* (at least in my mind) occurred in 2016

Paul Jewsbury and Stephen Bowden recently reported convincing evidence for separate *Gl* and *Gr* domains in the CHC model via reanalysis of multiple data sets with multiple indicators (consider these studies mini Carroll-like meta-analyses using CFA methods)

Article

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Construct Validity of Fluency and Implications for the Factorial Structure of Memory

Paul A. Jewsbury[1] and Stephen C. Bowden[1,2]

Abstract

Fluency is an important construct in clinical assessment and in cognitive taxonomies. In the Cattell–Horn–Carroll (CHC) model, Fluency is represented by several narrow factors that form a subset of the long-term memory encoding and retrieval (Glr) broad factor. The CHC broad classification of Fluency was evaluated in five data sets, and the CHC narrow classification was evaluated in an additional two data sets. The results suggest that Fluency tests are more strongly related to processing speed (Gs) and acquired knowledge (Gc) than to Glr, but Fluency may also be represented as a distinct broad factor. In the two additional data sets with a large number of Fluency tests, the CHC Fluency narrow factors failed to replicate with confirmatory factor analysis. An alternative and simpler narrow structure of Fluency was found, supporting the factorial distinction of semantic versus orthographic Fluency. The results have important implications for the factorial structure of memory, the classification of Fluency tests, and the assessment of Fluency.

Keywords

verbal fluency, Cattell–Horn–Carroll, cognitive abilities, semantic fluency, phonetic fluency

CHC-based CFA of 5 major data sets with multiple different cognitive and neuropsychological test indicators

Data set descriptions on subsequent slides

Table 7. Preliminary CHC Structure of Relevant Constructs.

	Gs	~~Gy~~ Gl	Gr
Description	Processing speed, efficiency	Association, encoding, learning	Fluency, ideation, creativity
Narrow structure	Naming Facility (NA) [other Gs narrow factors]	Associative Memory (MA) Free Recall Memory (M6) Meaningful Memory (MM)	Semantic Prose or Phrase (SP) Semantic Word (SW) Orthographic Word (O)

Note. CHC = Cattell–Horn–Carroll; Gs = processing speed; Gy = encoding and association; Gr = retrieval and Fluency.

Article

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Fluency is an important construct in clinical assessment and in cognitive taxonomies. In the Cattell–Horn–Carroll (CHC) model, Fluency is represented by several narrow factors that form a subset of the long-term memory encoding and retrieval (Glr) broad factor. The CHC broad classification of Fluency was evaluated in five data sets, and the CHC narrow classification was evaluated in an additional two data sets. The results suggest that Fluency tests are more strongly related to processing speed (Gs) and acquired knowledge (Gc) than to Glr, but Fluency may also be represented as a distinct broad factor. In the two additional data sets with a large number of Fluency tests, the CHC Fluency narrow factors failed to replicate with confirmatory factor analysis. An alternative and simpler narrow structure of Fluency was found, supporting the factorial distinction of semantic versus orthographic Fluency. The results have important implications for the factorial structure of memory, the classification of Fluency tests, and the assessment of Fluency.

Keywords

verbal fluency, Cattell–Horn–Carroll, cognitive abilities, semantic fluency, phonetic fluency

In conclusion, the CHC representation of Fluency tests as measures of Glr failed to support the data. Instead, the results suggest that Fluency tests may measure a broad factor distinct to the more encoding-specific Glr factor, and that Fluency tests are more related to Gc and Gs than to Glr. Furthermore, in contrast to the current CHC Fluency narrow structure, the factorial distinction of semantic versus orthographic Fluency was instead supported. More research is prompted to fully elucidate the factor structure of Fluency and retrieval abilities.

Appendix

Duff, Schoenberg, Scott, and Adams (2005)

Glr: Verbal Paired Associates I, Verbal Paired Associates II, Visual Paired Associates I, Visual Paired Associates II, Logical Memory I, Logical Memory II, Rey Auditory Verbal Learning Test immediate, Rey Auditory Verbal Learning Test–Delayed, Visual Recall II.
Gc: Comprehension, Information, Vocabulary, Similarities, Logical Memory I, Logical Memory II, Picture Arrangement, Picture Completion.
Gs: Trail Making Test Part-A, Trail Making Test Part-B, Digit Symbol.
Gsm: Digit Span–Forward, Digit Span–Backward, Arithmetic.
Gv/Gf: Wisconsin Card Sorting Test–Perseverative Errors, Block Design, Object Assembly, Rey–Osterrieth Complex Figure Test–Delayed Recall, Visual Recall I, Visual Recall II, Picture Arrangement, Picture Completion, Similarities.

McCabe, Roediger, McDaniel, Balota, and Hambrick (2010)

Glr: Free Recall–16 Words, Free Recall–40 Words, Prose Recall (Logical Memory).
Gc: Synonyms, Antonyms, Shipley Vocabulary, Prose Recall (Logical Memory).
Gs: Letter Comparison, Pattern Comparison, Digit Symbol, Mental Control.
Gsm: Letter Rotation Span, Match Span, Reading Span, Wisconsin Card Sorting Test–Perseverative Errors, Computational Span.
Gq: Arithmetic, Mental Control, Computational Span.

Dowling, Hermann, La Rue, and Sager (2010)

Glr: Rey Auditory Verbal Learning Test 3, Rey Auditory Verbal Learning Test 4, Rey Auditory Verbal Learning Test 5, Rey Auditory Verbal Learning Test–Delayed Recall.
Gc: Similarities, Vocabulary, Boston Naming Test.
Gs: Stroop's Naming Colored Words, Trail Making Test Part-A, Trail Making Test Part-B.
Gsm: Digit Span–Forward, Digit Span–Backward, Letter Number Sequencing.
Gv/Gf: Block Design, Matrix Reasoning, Benton Judgment of Line Orientation, Boston Naming Test.

Greenaway, Smith, Tangalos, Geda, and Ivnik (2009)

Gc: Vocabulary, Information, Similarities Boston Naming Test.
Gs: Digit Symbol, Symbol Search, Trail Making Test Part-A, Trail Making Test Part-B.
Gsm: Digit Span, Letter Number Sequencing, Arithmetic.

Salthouse et al. (1996)

Gs: Letter Comparison, Pattern Comparison, Digit Symbol, Trail Making Test Part-A, Trail Making Test Part-B.
Glr: Paired Associates I, Paired Associates II, Rey Auditory Verbal Learning Test Trial 2, Rey Auditory Verbal Learning Test Trial 6.
Gv/Gf: Wisconsin Card Sorting Test–Perseverative Errors, Wisconsin Card Sorting Test–Conceptual Learning, Object Assembly, Block Design.

Article

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The Cattell–Horn–Carroll Model of Cognition for Clinical Assessment

Paul A. Jewsbury[1], Stephen C. Bowden[1,2], and Kevin Duff[3]

Abstract

The Cattell–Horn–Carroll (CHC) model is a comprehensive model of the major dimensions of individual differences that underlie performance on cognitive tests. Studies evaluating the generality of the CHC model across test batteries, age, gender, and culture were reviewed and found to be overwhelmingly supportive. However, less research is available to evaluate the CHC model for clinical assessment. The CHC model was shown to provide good to excellent fit in nine high-quality data sets involving popular neuropsychological tests, across a range of clinically relevant populations. Executive function tests were found to be well represented by the CHC constructs, and a discrete executive function factor was found not to be necessary. The CHC model could not be simplified without significant loss of fit. The CHC model was supported as a paradigm for cognitive assessment, across both healthy and clinical populations and across both nonclinical and neuropsychological tests. The results have important implications for theoretical modeling of cognitive abilities, providing further evidence for the value of the CHC model as a basis for a common taxonomy across test batteries and across areas of assessment.

Keywords

Cattell–Horn–Carroll, executive function, confirmatory factor analysis, invariance

CHC-based CFA of 9 major data sets with multiple different cognitive and neuropsychological test indicators

Data set descriptions on next slide

Study	Sample size	Number of tests	Marker tests	Special relevance	Tests identified as executive function
Greenaway, Smith, Tangalos, Geda and Ivnik (Greenaway et al., 2009)	314	19	WAIS-III battery	Elderly sample	Yes
Duff et al. (Duff, Schoenberg, Scott, & Adams, 2005)	212	27	WAIS-R and WMS-R batteries	Neuropsychological referral sample	Yes
McCabe, Roediger, McDaniel, Balota, and Hambrick (McCabe, Roediger III, McDaniel, Balota, & Hambrick, 2010)	206	17	Some WAIS-III tests	Diverse sample	Yes
Goldstein & Shelly (Goldstein & Shelly, 1972)	600	25	WAIS battery	Neuropsychological referral sample	No
Dowling, Hermann, La Rue, & Sager (Dowling et al., 2010)	650	17	Some WASI and WAIS-III tests	Sample at risk for Alzheimer's disease	No
Pontón, Gonzalez, Hernandez, Herrera & Higareda (Pontón, Gonzalez, Hernandez, Herrera, & Higareda, 2000)	300	16	Some EIWA tests	Cultural and language generality	No
Salthouse, Fristoe, & Rhee (Salthouse, Fristoe, & Rhee, 1996)	259	15	Some WAIS-R tests	Diverse sample	No
Bowden, Cook, Bardenhagen, Shores, & Carstairs (Bowden et al., 2004)	277	20	WAIS-R and WMS-R batteries	Neuropsychological referral sample	No
Bowden et al. (Bowden et al., 2004)	399	20	WAIS-R and WMS-R batteries	Representative community sample	No

Table 5. Empirically Verified CHC Construct Validity of Popular Neuropsychological Tests.

Test	Gc	Gs	Gl	Gsm	Gv	Gf	Gr	Gq	Ga
Vocabulary	X								
Similarities	X					X			
Comprehension	X								
Information	X								
Boston Naming Test	X				X				
Symbol Search		X							
Trail Making Test–Part A		X							
Trail Making Test–Part B		X		?		?			
Digit Symbol		X							
Stroop test		X							
Porteus Maze Test		X							
Coding		X							
Visual Paired Associates I			X						
Visual Paired Associates II			X						
Verbal Paired Associates I			X						
Verbal Paired Associates II			X						
Logical Memory I	X		X						
Logical Memory II	X		X						
Auditory Verbal Learning Test—Immediate trails			X						
Auditory Verbal Learning Test—Delayed trails			X						
Letter–Number Sequencing				X					
Digit Span—Forward				X					
Digit Span—Backward				X					
Digit Span (combined)				X					

Summary of all analyses

Table continued on two additional slides

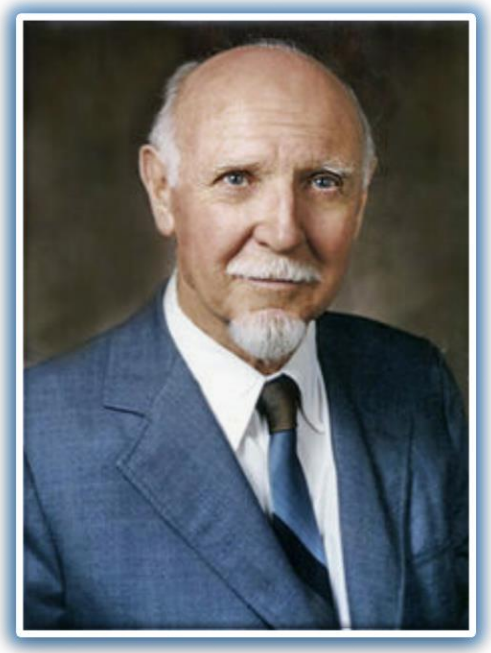
Test	Gc	Gs	Gl	Gsm	Gv	Gf	Gr	Gq	Ga
Visual Span					X				
Block Design					X				
Object Assembly					X				
Picture Completion	X				X				
Picture Arrangement	X				X				
Visual Recall I					X				
Visual Recall II			X		X				
Benton Visual Form Discrimination					X				
Benton Judgment of Line Orientation					X				
Rey–Osterrieth Complex Figure Test—Copy					X				
Rey–Osterrieth Complex Figure Test—Delayed					X				
Figural Memory					X				
Matrix Reasoning					X	X			
Raven Progress Matrices					X	X			
Halstead Category Test					X	X			
Wisconsin Card Sort Test—Perseverative errors					?	X			
Controlled Oral Word Association Test							X		
Category Fluency							X		

(continued)

Table 5. (continued)

Test	Gc	Gs	Gl	Gsm	Gv	Gf	Gr	Gq	Ga
Letter Fluency FAS							X		
Arithmetic								X	
Halstead Speed Sounds Perception Test									X
Seashore Rhythm Test									X
Reitan–Heimburger Aphasia Test	X								X

Note. CHC = Cattell–Horn–Carroll; Gc = acquired knowledge or crystallized ability; Gs = processing speed; Glr = long-term memory encoding and retrieval; Gsm = working memory; Gv = visuospatial ability; Gf = fluid reasoning; FW = word fluency (see Jewsbury & Bowden, in press); Gq = quantitative ability; Ga = auditory ability; X = empirically verified CHC classification; ? = a possible classification that has not been empirically verified or rejected.

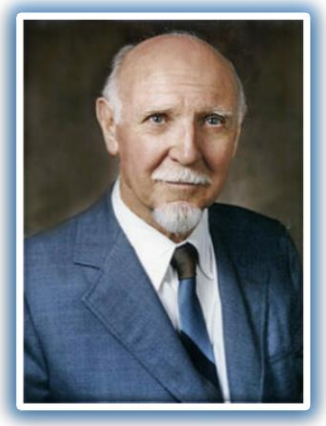


Cattell had *Gr* correct in 1987. It is wise to revisit the writings of the masters

Cattell (1987)

- "A class of alleged ability primaries about which there is much confusion are those variously called fluency, ideational fluency, associational fluency, flexibility, rigidity, dispositional rigidity, etc." (p..46)
- This research is quite old and can be traced to research by Spearman (1927) and others in in the late 1920's to 1950s.
- **"a general fertility or facility of memory retrieval in regard to any kind of material"** (p. 46).
- A broad ability at the second stratum - g_r **"retrieval from memory storage"** (p.127)
- Sometimes called general fluency
- "…factor analyses by Hargreaves (1927), by Bernstein (1924), and by the present writer in Spearman's laboratory, all of which show that such fluency performances over a wide range of test performances of various kinds are independent both of intelligence and speed" (p.127)

(continued…)



- “Thus, any attempt at scoring pure g_r, is likely to require careful test design, paying heed to a balance of various content areas, to speed (g_s), and to certain personality factors of an inhibitory nature” (p. 128)
- ‘But the analysis by Horn (1967) gives us clear indications that a ***general* retrieval or fluency** factor exists (p. 128).
- “Spearman first recognized a **general fluency factor across both verbal and nonverbal** (drawing completion) tests” (p.447)
- **“General retrieval, g_r, is considered an *ability* concerned entirely with the fluency-retrieval performances, and having to do with storage and accessibility facility”** (p.447)
- **“it is theorized that g_r is not power of retrieval alone, but power of retrieval plus the total volume of storage. However, just as the water flow from a reservoir is normally far more dependent on the size of the pipe that the amount in storage, so g_r –until the limits of the person’s reservoir of stored content is reach – is a single factor across the various performances”**

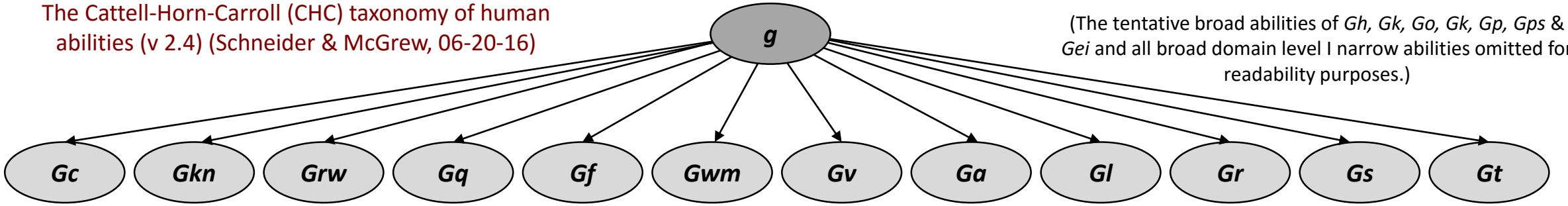
Another voice reinforces the *Gl* and *Gr* distinction (Fred Schrank, WJ IV chapter "in press"— 06-20-16, personal communication – draft copy)

"In contemporary CHC theory and in the WJ IV, an important distinction is made between tests and clusters that measure storage *and* retrieval functions versus tests and clusters that solely measure retrieval functions. This distinction was initially posited by Carroll (1993), whose three-stratum theory articulated separate and distinct Stratum II factors for (1) General Memory and Learning, and (2) Broad Retrieval Ability. However, in the initial (2001) conceptualization of CHC theory, the *Glr* factor spanned both types of functions.

In retrospect, the initial CHC specification of both storage and retrieval and retrieval-only cognitive functions into one common broad factor might be described as a classic "Wrong Turn at Albuquerque[1]". In addition to the misspecification error, many professionals routinely dropped the word "storage" from the name of the *Glr* construct and simply referred to the factor as "long-term retrieval". This tendency may have caused some confusion with the neurocognitive construct of long-term memory. Consequently, because of an initial CHC "Wrong Turn" and simultaneous verbal ("long-term retrieval") short-cut, changes to contemporary CHC theory nomenclature and also represented in the WJ IV provide cleaner distinctions between retrieval measures that do, versus those that do not, involve the storage function."

[1] A "Wrong Turn at Albuquerque" is a catchprase popularized in the Bugs Bunny™ cartoons that humorously refers an incorrectly perceived juncture (sometimes caused by trying to follow an overly-complicated set of directions or map) that lands the traveler in an unintended place.

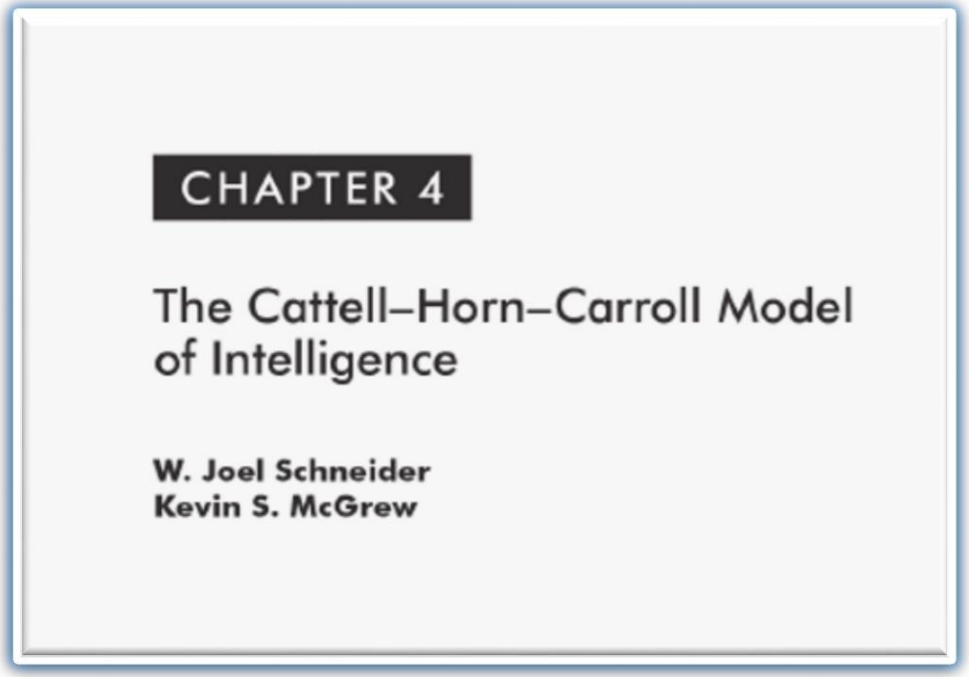
The Cattell-Horn-Carroll (CHC) taxonomy of human abilities (v 2.4) (Schneider & McGrew, 06-20-16)



(The tentative broad abilities of *Gh, Gk, Go, Gk, Gp, Gps* & *Gei* and all broad domain level I narrow abilities omitted for readability purposes.)

Comprehension-knowledge (Gc): The depth and breadth of declarative and procedural knowledge and skills valued by one's culture. Comprehension of language, words, and general knowledge developed through experience, learning and acculturation.	***Visual-spatial processing (Gv):*** The ability to use mental imagery, store images in primary memory, or perform visual-spatial analysis or mental transformation of images in the "mind's eye."
Domain-specific knowledge (Gkn): The depth, breadth, and mastery of specialized declarative and procedural knowledge typically acquired through one's career, hobby, or other passionate interest. The *Gkn* domain is likely to contain more narrow abilities than are currently listed in the CHC model.	***Auditory processing (Ga):*** The ability to perceive, discriminate, and manipulate sounds and information received through the ears. Includes the processing of auditory information in primary memory and/or the activation, restructuring, or retrieval of information from semantic-lexical memory based on phonemes.
Reading and writing (Grw): The depth and breadth of declarative and procedural knowledge and skills related to written language or literacy.	***Learning efficiency (Gl):*** The ability and efficiency to learn, store, and consolidate new information in long-term memory.
Quantitative knowledge (Gq): The depth and breadth of declarative and procedural knowledge related to mathematics. The *Gq* domain is likely to contain more narrow abilities than are currently listed in the CHC model.	***Retrieval fluency (Gr):*** The rate and fluency at which individuals can produce and retrieve verbal and nonverbal information or ideas stored in long-term memory.
Fluid reasoning (Gf): The use of deliberate and controlled focused attention to solve novel "on the spot" problems that cannot be solved solely by using prior knowledge (previously learned habits, schemas, or scripts). Reasoning that depends minimally on learning and acculturation.	***Processing speed (Gs):*** The ability to control attention to automatically and fluently perform relatively simple repetitive cognitive tasks. Attentional fluency.
Short-term working memory (Gwm): The ability to encode, maintain, and/or manipulate auditory or visual information in primary memory (while avoiding distractions) to solve multiple-step problems. The mind's mental "scratchpad" or "workbench."	***Reaction and decision speed (Gt):*** The speed at which very simple perceptual discriminations or decisions can be made.

The *Gl* and *Gr* distinction will be formally discussed in the forthcoming revision of this 2012 chapter


CHAPTER 4

The Cattell–Horn–Carroll Model of Intelligence

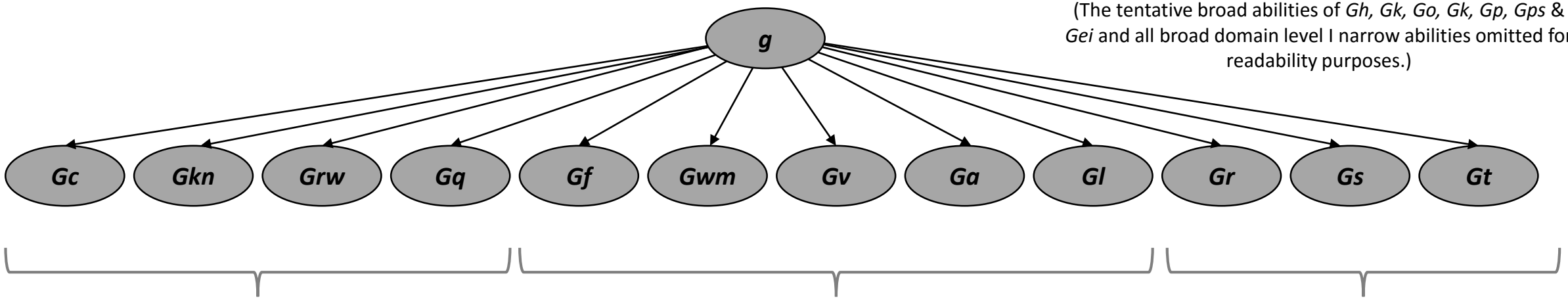
W. Joel Schneider
Kevin S. McGrew

Schneider, W. J., & McGrew, K. (2012) The Cattell-Horn-Carroll model of intelligence. In D. Flanagan & P. Harrison (Eds.), *Contemporary Intellectual Assessment: Theories, Tests, and Issues* (3rd ed.). New York: Guilford

The Cattell-Horn-Carroll (CHC) taxonomy of human abilities (v 2.4)

A higher-order conceptualization based on MDS of the WJ IV norm data (McGrew & Schneider, 06-20-16)

(The tentative broad abilities of *Gh, Gk, Go, Gk, Gp, Gps* & *Gei* and all broad domain level I narrow abilities omitted for readability purposes.)



Intelligence-as-Knowledge (Ackerman)

Acquired knowledge systems

g_c **Cattell**

Intelligence-as-Process (Ackerman)

System 2 (controlled deliberate cognitive operations/processes) (Kahneman)

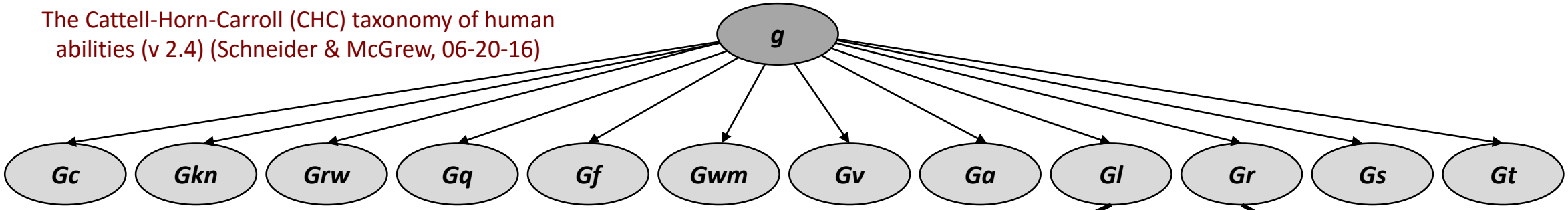
g_f **Cattell**

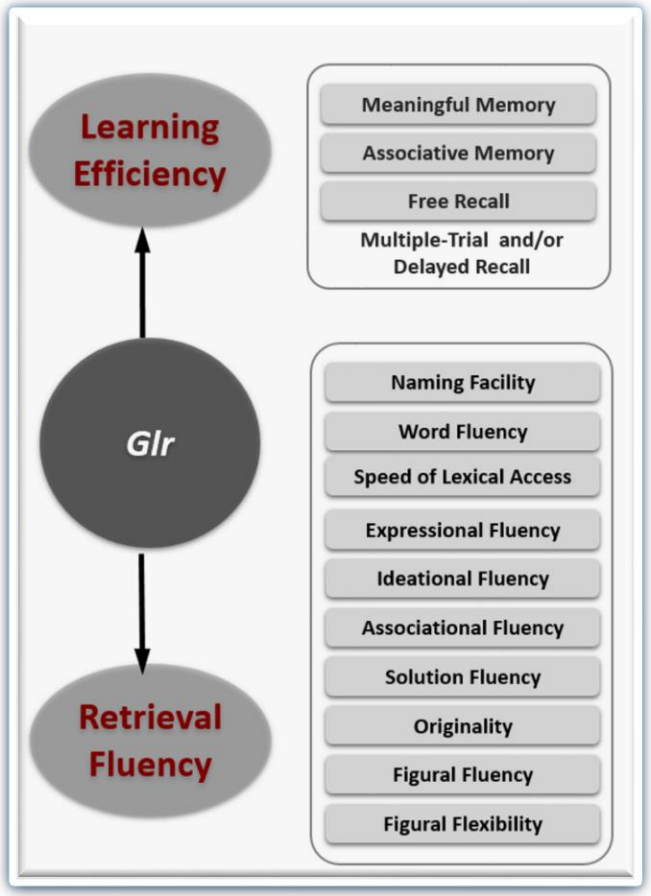
Intelligence-as-Process: Speed/fluency (Ackerman)

System 1 (automatic rapid cognitive processes) (Kahneman)

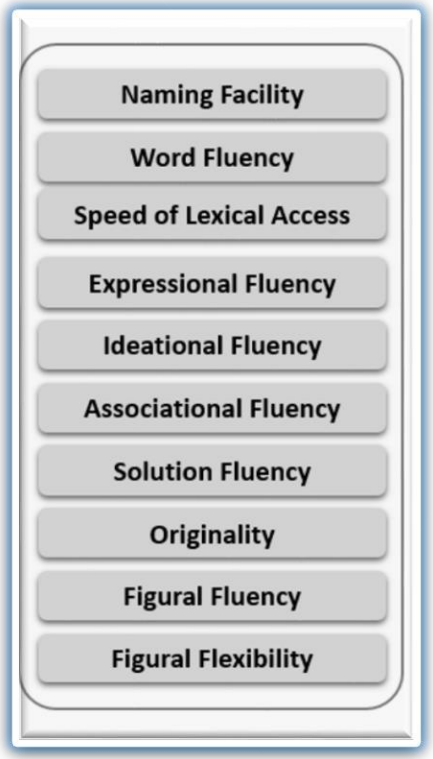
g_s **– General speed factor**

The Cattell-Horn-Carroll (CHC) taxonomy of human abilities (v 2.4) (Schneider & McGrew, 06-20-16)



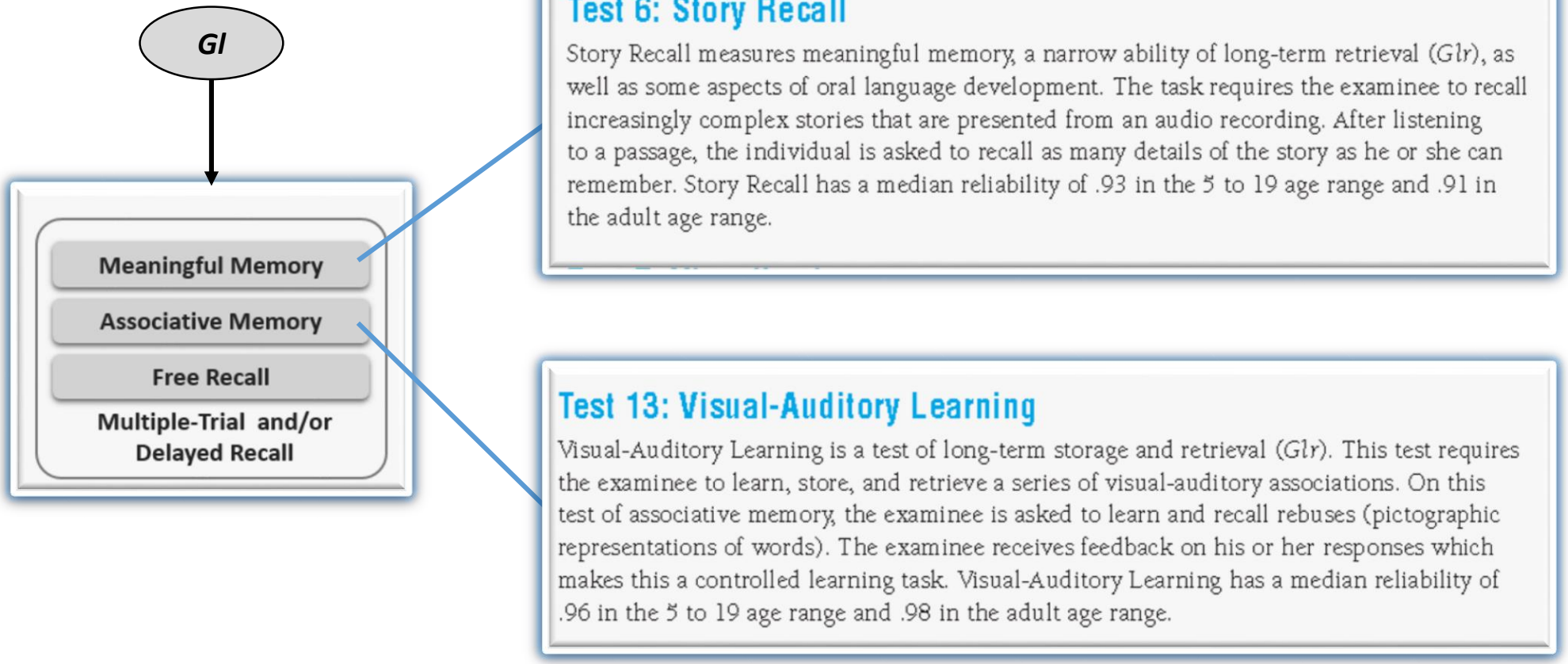


Becomes

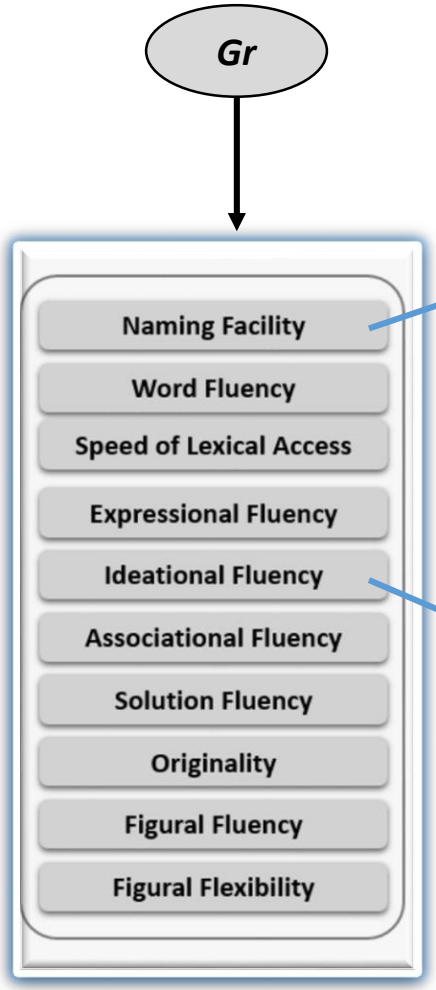


Schneider & McGrew (2012)

Gl is represented in the WJ IV by the currently named COG *Glr* cluster: Reinterpret this cluster as indicator of *Gl*



Gr is represented in the WJ IV by the currently named OL Speed of Lexical Access cluster: Alternative interpretation as indicator of *Gr*



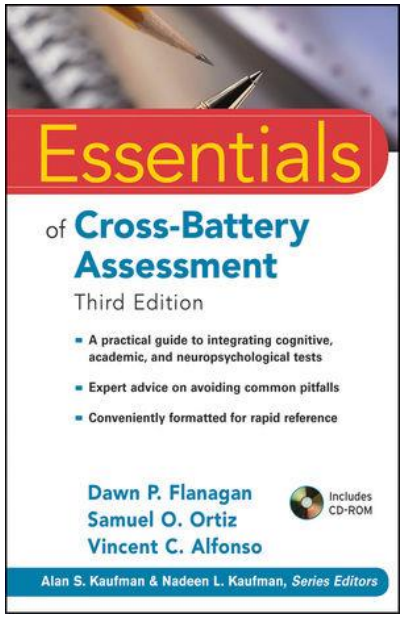
Test 4: Rapid Picture Naming

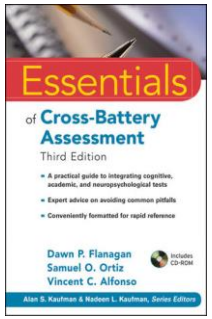
Rapid Picture Naming is a test of cognitive and linguistic fluency that provides information about processing speed (*Gs*) and speed of word retrieval. This test measures the narrow ability of naming facility, or the speed of lexical access, which requires the quick recall of simple pictures. This test has a 2-minute time limit. It has test-retest reliabilities of .90 in the 7 to 11 age range, .74 in the 14 to 17 age range, and .86 in the adult age range.

Test 8: Retrieval Fluency

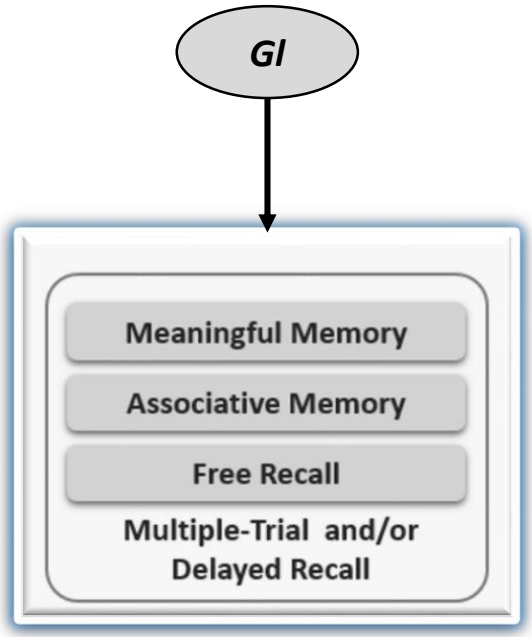
Retrieval Fluency measures an aspect of long-term retrieval (*Glr*), speed of lexical access, which requires fluency of word retrieval from stored knowledge. The examinee is required to name as many examples as possible from a given category within a 1-minute time period. The task consists of three different categories: things to eat or drink, first names of people, and animals. Historically, this task has been identified as ideational fluency. This test has a median reliability of .80 in the 5 to 19 age range and .87 in the adult age range.

Source for finding other test indicators of *Gl* and *Gr*





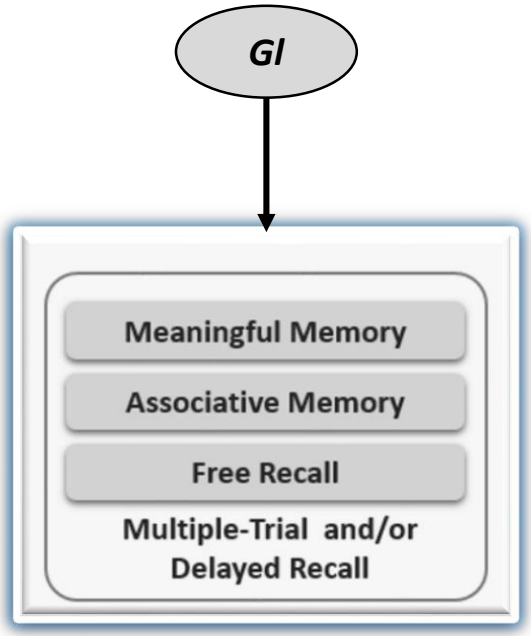
Other *Gl* test indicators from XBA



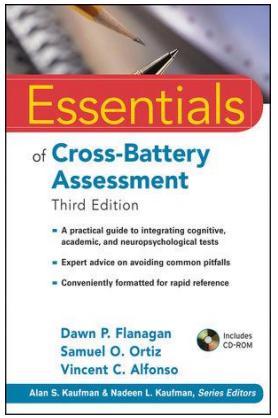
Meaningful Memory (MM)	
The ability to remember narratives and other forms of semantically related information	
APAT CONTENT MEMORY DELAYED	5-12
APAT CONTENT MEMORY IMMEDIATE	5-12
NAB STORY LEARNING	18-97
NESPY-II NARRATIVE MEMORY	3-16
TOMAL-2 MEMORY FOR STORIES	5-59
TOMAL-2 MEMORY FOR STORIES-DELAYED	5-59
WJ III NU ACH STORY RECALL	2-90+
WJ III NU ACH STORY RECALL-DELAYED	3-90+
WMLS-R: NU STORY RECALL	2-90+
WMLS-4 LOGICAL MEMORY I	16-90
WMLS-4 LOGICAL MEMORY II DELAYED RECALL	16-90
WMLS-4 LOGICAL MEMORY II RECOGNITION	16-90
WRAML2 STORY MEMORY	5-85+
WRAML2 STORY MEMORY DELAY RECALL	5-85+
WRAML2 STORY MEMORY RECOGNITION	5-85+
NAB Daily Living Memory (Gsm:MS)	18-97

Associative Memory (MA)	
The ability to remember previously unrelated information as having been paired	
KABC-II ATLANTIS	**3-18**
KABC-II REBUS	**4-18**
WJ III NU COG DR: VISUAL AUDITORY LEARNING	**4-90+**
WJ III NU COG VISUAL-AUDITORY LEARNING	**2-90+**
WJ III NU DS MEMORY FOR NAMES	**2-90+**
WJ III NU DS MEMORY FOR NAMES DELAYED	**4-90+**
APAT UED RECALL	5-12
KABC-II ATLANTIS DELAYED	5-18
KABC-II REBUS DELAYED	5-18
NEPSY-II MEMORY FOR NAMES	5-16
NEPSY-II MEMORY FOR NAMES DELAYED	5-16
TOMAL-2 PAIRED RECALL	5-59
WMS-4 VERBAL PAIRED ASSOCIATES I	16-90
WMS-4 VERBAL PAIRED ASSOCIATES II	16-90
WRAML2 SOUND SYMBOL	5-8
WRAML2 SOUND SYMBOL DELAY RECALL	5-8
WISC-IV/Integrated Coding Recall (Gv:MV)	6-16

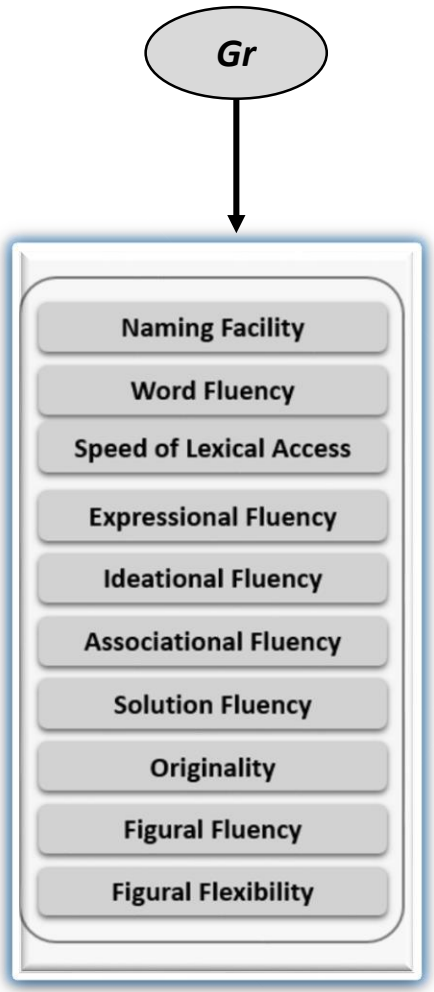
Other *Gl* test indicators from XBA



Free-recall Memory (M6)	
The ability to recall lists in any order	
DAS-II RECALL OF OBJECTS-IMMEDIATE	4-17
DAS-II RECALL OF OBJECTS-DELAYED	4-17
KBNA WORD LISTS 1	20-8
KBNA WORD LISTS 2 (MM)	20-8
NEPSY-II LIST MEMORY DELAYED	7-12
TOMAL-2 OBJECT RECALL	5-59
TOMAL-2 VISUAL SELECTIVE REMINDING	5-59
TOMAL-2 WORD SELECTIVE REMINDING	5-59
TOMAL-2 WORD SELECTIVE REMINDING-DELAYED	5-59
WRAML2 VERBAL LEARNING	5-85+
WRAML2 VERBAL LEARNING RECALL	5-85+
WRAML2 VERBAL LEARNING RECOGNITION	5-85+
NAB List Learning (Gsm:MW)	18-97
NEPSY-II Memory for Designs Delayed (Gv:MV)	3-16
NEPSY-II Memory for Faces Delayed (Gv:MV)	5-16

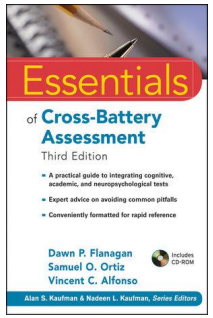


Other *Gr* test indicators from XBA

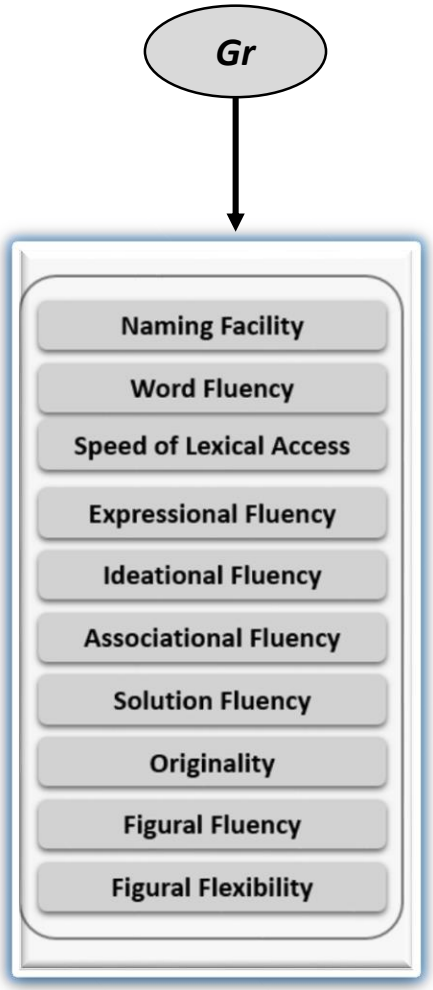


Naming Facility (NA)	
The ability to rapidly call objects by their names	
DAS-II RAPID NAMING (Gs:R9)*	**5-17**
WJ III NU COG RAPID PICTURE NAMING (Gs:R9)*	**4-90+**
D-KEFS COLOR-WORD INTERFERENCE: COLOR-NAMING	8-89
D-KEFS COLOR-WORD INTERFERENCE: INHIBITION	8-89
D-KEFS COLOR-WORD INTERFERENCE: WORD READING	8-89
CELF-4 Rapid Automatic Naming (Gs:R9)	5-21
D-KEFS Color-Word Interference: Inhibition/Switching (Gsm:MW)	8-89
ERA Rapid Orthographic Naming (Grw:RD;Gs:R9)	4-7
GDRT-2 Rapid Naming (Gs:R9)	6-13
KTEA-II Naming Facility (Gs:R9)	4:6-25
NEPSY-II Speeded Naming (Gs:R9)	5-12
RAN/RAS Colors (Gs:R9)	5-18
RAN/RAS Letters (Gs:R9)	5-18
RAN/RAS Numbers (Gs:R9)	5-18
RAN/RAS Objects (Gs:R9)	5-18
RAN/RAS RAS 2-SET (Gs:R9)	5-18
RAN/RAS RAS 3-SET (Gs:R9)	5-18
WRMT-3 Rapid Automatic Naming (Gs:R9)	4-8

Ideational Fluency (FI)	
The ability to rapidly produce a series of ideas, words, or phrases related to a specific condition or object	
WJ III NU COG RETRIEVAL FLUENCY	**6-90+**
CELF-4 WORD ASSOCIATIONS	5-21
D-KEFS VERBAL FLUENCY TEST: CATEGORY FLUENCY	8-89
KTEA-II ASSOCIATIONAL FLUENCY (FW)	4:6-25
NAB WORD GENERATION	18-97
NEPSY-II WORD GENERATION (FW)	3-16
TVCF CATEGORICAL FLUENCY	8-89
D-KEFS Verbal Fluency Test: Category Switching (Gsm:MW)	8-89

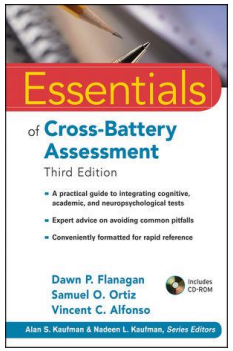


Other *Gr* test indicators from XBA



Figural Fluency (FF)	
The ability to rapidly draw or sketch as many things (or elaborations) as possible when presented with a non-meaningful visual stimulus	
D-KEFS DESIGN FLUENCY TEST: EMPTY DOTS ONLY	8-89
D-KEFS DESIGN FLUENCY TEST: FILLED DOTS	8-89
D-KEFS DESIGN FLUENCY TEST: SWITCHING	8-89

Word Fluency (FW)	
The ability to rapidly produce words that share a non-semantic feature	
D-KEFS VERBAL FLUENCY TEST: LETTER FLUENCY	8-89
KBNA VERBAL FLUENCY (FA)	20-89
TVCF LETTER NAMING	8-89
KBNA Sequences (Gsm:MW)	20-89



The MindHub

IQ's Corner