IAP AP 101

# APPLIED PSYCHOMETRICS 101:

## *#12: CHC Narrow Ability Assessment with the WJ III Battery*

Recently, a special issue of Psychology in the Schools (PITS) "took stock" of the past 20 years of CHC research (Newton & McGrew, 2010). In this special issue McGrew and Wendling (2010) reviewed the extant CHC cognitive-achievement relations research and concluded that "[T]he primary action is at the narrow ability level" (p, 669). McGrew and Wendling concluded if the goal is to better understand, assess, and develop interventions for subareas of reading (e.g., phonics, comprehension) and math (e.g., calculation, problem-solving), *narrow is better*. Broad (stratum II) CHC abilities (e.g., Fluid Reasoning-Gf; Auditory Processing-Ga) best predict and explain broad academic domains (e.g., total or broad reading). However, narrow (stratum I) abilities best predict and explain narrow academic domains (e.g., reading comprehension).

The purpose of this working paper is to present a list of (a) WJ III test-author provided norm-based narrow CHC ability clusters and (b) additional clinical narrow clusters (not provided by the test authors in the published WJ III). A secondary purpose is to list possible supplemental tests or composites from other major intelligence or achievement batteries that might be used to supplement the listed WJ III narrow ability clusters.

Kevin S. McGrew, Ph.D.

Institute for Applied Psychometrics (IAP)



[Note: This is not a peer-reviewed publication]

**CHC Narrow Ability Assessment with the WJ III Battery**

Working Paper: Kevin S. McGrew

(5-13-11 v1.1)

## The Action is at the Narrow CHC Ability Level

Recently, a special issue of *Psychology in the Schools* (PITS) "took stock" of the 20 years of CHC research first jump-started by the1989 publication of the Woodcock-Johnson—Revised battery of cognitive and achievement tests (WJ-R; Woodcock & Johnson, 1989). As articulated by the special issue editors (Newton & McGrew, 2010), the core question addressed was *"has the drawing of a reasonably circumscribed 'holy grail' taxonomy of cognitive abilities led to the promised land of intelligence testing in the schools—using the results of cognitive assessments to better the education of children with special needs?"* (p. 631). Three broad overview articles were the central focus of the special issue.

Keith and Reynolds (2010) reviewed the CHC-organized factor-analytic research regarding seven different intelligence batteries and concluded that most new and revised intelligence batteries were either grounded explicitly in CHC theory, or paid some form of implied *"allegiance to the theory"* (p. 635). Keith and Reynolds (2010) concluded that *"although most new and revised tests of intelligence are based, at least in part, on CHC theory, earlier versions generally were not. Our review suggests that whether or not they were based on CHC theory, the factors derived from both new and previous versions of most tests are well explained by the theory"* (p.635).

McGrew and Wendling's (2010) research synthesis was designed to answer the question *"what have we learned from 20 years of CHC COG-ACH relations research?"* (p. 651). Their review produced a number of important conclusions. First, cognitive abilities contribute to academic achievement in different proportions in different academic domains and these proportions change over the course of development. Second, the most salient CHC cognitive-achievement relations exist for ***narrow*** (stratum I) cognitive abilities. McGrew and Wendling (2010) recommended a refocusing of CHC school-based assessment on selective, referral-focused cognitive assessment of ***narrow*** cognitive and achievement abilities. Finally, McGrew and Wendling (2010) concluded that the developmentally nuanced relations between primarily narrow cognitive and achievement abilities *"argues for more judicious, flexible, selective, 'intelligent' (Kaufman, 1979) intelligence testing where practitioners select sets of tests most relevant to each academic*

*referral. Unless there is a need for a full-scale IQ g score for diagnosis (e.g., MR, gifted), professionals need to break the habit of 'one complete battery fits all' testing"* (p. 669).

The most important conclusion of the McGrew and Wendling (2010) review was that *"[T]he primary action is at the narrow ability level"* (p, 669). That is, if the goal is to better understand and develop interventions for subareas of reading (e.g., phonics, comprehension) and math (e.g., calculation, problem-solving), ***narrow is better!*** Broad (stratum II) CHC abilities (e.g., Fluid Reasoning-Gf; Auditory Processing-Ga) best predict and explain broad academic domains (e.g., total or broad reading). However, narrow (stratum I) abilities best predict and explain narrow academic domains (e.g., reading comprehension). Consistent with the focus of Flanagan and colleagues cross-battery assessment methods (see Flanagan, Ortiz & Alfonso, 2007), McGrew and Wendling (2010) concluded that *"we believe that validated narrow cognitive ability indicators need to be the focus of assessment personnel working in the schools and should be featured in future cognitive battery test development"* (p. 669). [A prepublication on-line PPT show summarizing the primary results included in the McGrew and Wendling (2010) review is available via IQ's Corner Blog (www.iqscorner.com) or more directly at the blog's associated Slideshare site (http://www.slideshare.net/iapsych/chcsignbrs-presentation). A summary table of the McGrew and Wendling (2011) review is included in Appendix B of the current document.

The third integrative PITS article described a "third method" CHC-based approach to the assessment and diagnosis of specific learning disabilities (SLD). Flanagan, Fiorello, and Ortiz's (2010) proposed *Hypothesis-Testing CHC Approach (HT-CHC)* logically followed, and was built upon, the extant factor analytic and cognitive-achievement relations research summarized by Keith and Reynolds (2010) and McGrew and Wendling (2010). Flanagan et al.'s (2010) article highlighted the potential benefits of HT-CHC approach over the old IQ–achievement discrepancy and the new "IQ-free" response-to-intervention (RTI) methods to SLD identification.

Collectively these three "taking stock" review's, and that of McGrew and Wendling (2010) in particular, indicate that assessment professionals should focus more efforts on selective testing to generate referral-related 2-3 test clusters of ***narrow*** CHC abilities that are most related to different ***narrow*** academic domains.

But, this is easier said than done.

**Assessment of Narrow CHC Abilities Via the WJ III Battery**

During the past 10 years the primary emphasis of the revision of most major intelligence batteries has been on providing valid composite measurement of *broad* CHC abilities (e.g., Gf, Gc, Glr, Gv, Ga, Gsm, Gs, etc; Keith & Reynolds, 2010; Schneider & McGrew, in press). Only a handful of intelligence or combined intelligence and achievement batteries include sufficient numbers of tests that provide a reasonable number of norm-based *narrow* CHC ability cluster scores.

The WJ III battery (Woodcock, McGrew & Mather, 2001, 2007), when combined with the WJ III Diagnostic Supplement (DS) battery (Woodcock, McGrew, Mather & Schrank, 2003, 2007), is the one exception. Collectively the complete WJ III system includes 49 different individual tests.[1] These tests can be organized into a variety of broad CHC and achievement composite clusters. More importantly, by augmenting the primary WJ III cognitive and achievement batteries with the WJ III DS battery, examiners have the option to produce six new validated two-test CHC *narrow* ability cluster scores (viz., Numerical Reasoning-RQ; Associative Memory-MA; Visualization-Vz; Sound Discrimination-US; Auditory Memory Span-MS; Perceptual Speed-PS) in addition to the six CHC *narrow* ability cluster scores from the primary batteries (viz., Phonemic Awareness & Phonemic Awareness 3-PC; Working Memory-MW; Listening Comprehension-LS; Knowledge-K0; Cognitive Fluency-NA).[2]

Unfortunately, the 2003 publication of the WJ III DS (two years after the WJ III) flew under the professional radar of many assessment professionals. With the importance of narrow CHC abilities recognized, the value of the WJ III DS is more apparent. Also, narrow ability composite scores from other intelligence batteries (e.g., WISC-IV Working Memory Index-MW; KABC-II Glr-MA; SB5-Quantitative Reasoning-RQ) should receive increased attention by assessment professionals.

Another solution for assessment professionals is to engage in cross-battery assessment (Flanagan et al., 2007) or to create new clinical clusters from within a specific assessment battery. Although steeped in the tradition of clinical and "intelligent" test interpretation, the creation of psychometrically sound pseudo-composite scores from within or across different batteries suffers from a number of significant psychometric issues that may result in inaccurate pseudo-cluster scores (see Schneider & McGrew, 2011 for details; http://www.iqscorner.com/2011/03/iap-applied-psychometrics-101-report-10.htm).

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[1] See author's conflict of interest disclosure at the end of this document

[2] An updated and abbreviated list of the broad and narrow CHC v2.0 ability definitions (see Schneider and McGrew, in press) is included in Appendix A of this report.

The primary purpose of this document is to present a working list of (a) WJ III test-author provided norm-based narrow CHC ability clusters and (b) additional clinical clusters not provided in the published WJ III. A secondary purpose is to list possible supplemental tests or composites from other major intelligence or achievement batteries that might be used to supplement the listed WJ III narrow ability clusters.[3]

The list of CHC narrow ability clusters available from the complete WJ III system are summarized in the table at the end of this document. The clusters are organized by broad and narrow CHC ability domain. As noted in the table, clusters in bold font are norm-based clusters available from the published WJ III software. All other WJ III based clusters are clinical clusters. As such, scores for these clinical clusters should be generated with the *WMF Press* ***Compositator*** [4] software supplement to the WJ III scoring program

[3] In the summary table provided, the final column lists suggested tests or norm-based clusters from other major intelligence or achievement batteries that, according to authoritative cross-battery sources (see Flanagan et al., 2007), measure the same narrow CHC abilities. I have only listed tests or norm-based clusters from major nationally standardized cognitive or achievement batteries, as I believe that the *best practice* principles articulated in the cross-battery assessment books should be taken seriously. The tests/composites listed are those that would result in the crossing of the smallest number of different norm samples and better yet, when possible, provide norm-based composite scores. Although various specialized tests/composites from other cross-battery sources could also be listed (e.g., CTOPP for Ga domain), it is this author's belief that due to the potential source of error introduced when crossing different test batteries, only measures from the premier large-scale and qualitatively sound national standardization norm samples (typical of major cognitive or achievement batteries) should be used. The list is far from exhaustive. Readers who wish to use other specialized psychological assessment batteries should consult Flanagan et al. (2007) for other measures.

Finally, I have made revisions to handful of the CHC narrow ability classifications suggested by Flanagan et al. (2007). These revised classifications are based on more recent published research (e.g., confirmatory factor studies of major intelligence batteries by the research team of Keith and Reynolds), research reported at IQ's Corner Blog, or my own expert judgment. For example, Flanagan et al. (2007) classify the DAS-II Rapid Naming test as a measure of perceptual speed (Gs-P). Based on an inspection of the test's requirements, I agree with the DAS-II authors verbal explanation that this test is primarily a measure of "speed of access to the lexicon" or "efficiency of retrieval of available words from the lexicon" (Elliott, 2007, p. 73)—and thus, is more accurately classified as a measure of Naming Facility, which as per CHC theory, is associated with the rate/fluency (Gs) aspect of Glr defined by the Naming Facility factor. As another example, Schneider and McGrew (in press) have clarified an important initial point of confusion in the implementation of the CHC Gv narrow definitions of visualization (Vz) and spatial relations (SR) during the past 10 years. Based on a review of the foundational sources that produced the CHC framework, it is clear the spatial relations (SR) is associated with the *speed* of mental visualization and is a classification that should be retained only for highly speeded visualization tests with items of relatively easy difficulty. Furthermore, Schneider and McGrew (in press) recommend that the name of this narrow ability be changed to be consistent with the logic and reasoning of David Lohman (1979, 1996) who suggests that speeded visualization tests should be called tests of *Speeded Rotation* (SR). To date, all major visualization tests have been coded as either Vz, SR, or Vz/SR in the CHC assessment literature. Schneider and McGrew (in press) have concluded that all major IQ subtests of visualization and mental rotation are measures of Vz and differ in the methodology and approach used to measuring Vz. No current intelligence battery currently includes measures of speeded rotation (SR). Thus, all prior cross-battery Gv-SR and Gv-Vz classified tests are now all classified as Gv-Vz tests. See Schneider and McGrew (in press) for detailed explanation.

[4] http://www.woodcock-munoz-foundation.org/press/compositator.html

(see Schneider & McGrew, 2011 for why this is recommended; http://www.iqscorner.com/2011/03/iap-applied-psychometrics-101-report-10.htm).

It is important to note that the original names of some WJ III clusters, when viewed with the aid of post-publication data analysis hindsight, are now best conceptualized to measure a specific narrow CHC ability. For example, post-publication research by this author (source information provided below) has suggested that the three tests comprising the WJ III Cognitive Fluency cluster (i.e., Retrieval Fluency, Rapid Picture Naming, Decision Speed), and two of the tests in particular (Retrieval Fluency, Rapid Picture Naming), appear to measure the *intermediate* CHC ability of Glr-Retrieval Fluency, which taps some aspects of what contemporary reading researchers call RAN or speed of lexical access. In the summary table, this revised interpretation is represented by the classification of the Cognitive Fluency cluster as Glr-Retrieval Fluency and parenthetically, speed of lexical access.[5]

It is not possible to list every source of information that served as the basis for the complete list of narrow WJ III clinical clusters included in this brief report. In a manner similar to the "shared ability" approach to test interpretation articulated by Kaufman (Kaufman, 1979), which the current author implemented in two prior books devoted to clinical interpretation of previous editions of the Woodcock-Johnson Tests of Cognitive Ability (McGrew, 1986; 1994), these hypothesized shared narrow CHC ability groupings are based on this author's extensive clinical and data-based experience with the WJ cognitive and achievement tests since 1977. More importantly, since the original 2001 WJ III publication the current author has engaged in extensive re-analysis of the complete WJ III set of tests via exploratory (e.g., exploratory factor analysis; multidimensional scaling, cluster analysis) and blended exploratory-confirmatory factor analysis methods. These results have not been peer-reviewed and have been disseminated via the author's IAP web page (http://www.iapsych.com), IQ's Corner Blog (http://www.iqscorner.com), the WJ III Evolving Web of Knowledge (WJ III EWOK; http://www.iapsych.com/wj3ewok/map.htm), and various on-line SlideShare copies of professional conference presentations (http://www.slideshare.net/iapsych). In addition, published and unpublished WJ III related studies (theses and dissertations) also provide supporting evidence for some of the listed clinical clusters. Most of these published and unpublished dissertation studies have been featured at IQ's Corner Blog and should be accessible via navigation of the site's "*label*" index system.

[5] Glr-Retrieval Fluency is an *intermediate* ability (between broad and narrow abilities) as per Schneider and McGrew's (in press) recent recommendation for changes in the CHC v1.0 model to the CHC v2.0 model. Other CHC v1.0 construct names (e.g., Working Memory; Visualization/Spatial Relations) have also been change or clarified. The definitions in CHC v2.0 are used in this document and summary table. See Appendix A for details.

**Caveats: "Intelligent" Testing Required**

As described above, a significant number of the WJ III CHC narrow ability clusters included in this brief report are based on this author's collective integration of clinical experience and published and unpublished research with the WJ, WJ-R and WJ III batteries. The clinical clusters presented should be taken with a professional grain of salt and are analogous to the experiential + empirical clinical insights offered regarding the various Wechsler scales by Alan Kaufman (e.g., see Kaufman, 1979). The validity of hypotheses based on any clinical (or norm-based) test grouping must be supported by other non-WJ III information such as academic or performance records, teacher or supervisor comments, other test scores, work samples, etc. *"Intelligent" intelligence testing is a necessary requirement for using this information*.

**WJ III CHC Narrow Ability Clusters (K. McGrew; 5-13-11)**

| Broad CHC Ability | CHC Narrow Ability | **Published**/Suggested Cluster Name | WJ III Tests | Supplemental measures from other major IQ/Ach batteries |
|---|---|---|---|---|
| Ga | Phonetic Coding (PC) | **Phonemic Awareness** | **Sound Blending; Incomplete Words** | DAS-II Phon. Processing.<br>KTEA-II Phon. Awareness |
| Ga | Phonetic Coding (PC) | **Phonemic Awareness 3** | **Sound Blending; Incomplete Words; Sound Awareness** | |
| Ga | General Sound Discrimination (U3) | **Sound Discrimination** | ***Sound Patterns-Voice; Sound Patterns-Music*** | |
| Ga | Res. to Auditory Stim. Distortion (UR) | Res. to Auditory Stim. Distortion | Auditory Attention; *Sound Patterns-Voice* | |
| Glr | Associative Memory (MA) | **Associative Memory** | **Visual-Auditory Learning; *Memory for Names*** | KABC-II Learning/Glr * |
| Glr | Glr-Retrieval Fluency [5] ** | **Cognitive Fluency /** Glr-Retrieval Fluency [5] | **Retrieval Fluency; Rapid Picture Naming; Decision Speed** | DAS-II Rapid Naming |
| Glr | Glr-Retrieval Fluency [5] ** | Glr-Retrieval Fluency [5] | Retrieval Fluency; Rapid Picture Naming | |
| Glr | Meaningful Memory (MM) | Meaningful Memory | Visual-Auditory Learning; Story Recall | |
| Gv | Visualization (Vz) [5] | **Visualization** [5] | **Spatial Relations; *Block Rotation*** | DAS-II Spat. Ability (EYB-UL) *<br>DAS-II Pattern Construction<br>DAS-II Match. Letter-Like Forms<br>KABC-II Simultaneous/Gv *<br>SB5 Visual-Spatial Proc. *<br>WECH Block Design<br>WECH Visual Puzzles |

| | | | | |
|---|---|---|---|---|
| Gv | Visual Memory (MV) | Visual Memory | Picture Recognition; Visual-Auditory Learning | DAS-II Recall of Designs<br>DAS-II Recog. of Pictures<br>KABC-II Face Recognition |
| Gf | Quantitative Reasoning (RQ) | **Numerical Reasoning** | ***Number Series; Number Matrices*** | DAS-II Seq. & Qnt. Reason.<br>SB5 Quant. Reason. * |
| Gf | Quantitative Reasoning (RQ) | Quantitative Reasoning 3 | Analysis-Synthesis; *Number Series; Number Matrices* | |
| Gf | Quantitative Reasoning (RQ) | Quantitative Reasoning 4 | Analysis-Synthesis; *Number Series; Number Matrices;* Quantitative Concepts | |
| Gf | General (deductive) Seq. Reason. (RG) | | Analysis-Synthesis | SB5 Fluid Reasoning * |
| Gf | Induction (I) | | Concept Formation | DAS-II NV Reas. Ab. (EYB-UL) *<br>DAS-II Matrices<br>KABC-II Planning/Gf *<br>WECH Matrix Reasoning<br>WISC-IV Picture Concepts |
| Gsm | Memory Span (MS) | **Auditory Memory Span** | **Memory for Words; *Memory for Sentences*** | DAS-II Recall Digits-Fwd<br>KABC-II Seq/Gsm *<br>SB5 Working Memory<br>WECH Digit Span-Fwd |
| Gsm | Attentional Control (Working Memory-WM) [5] | **Working Memory/** Attentional Control [5] | **Numbers Reversed; Auditory Working Memory** | DAS-II Working Memory *<br>WISC-IV Work. Mem. Ind. * |
| Gsm | Attentional Control (Working Memory-WM) [5] | Attentional Control (verbal / language) [5] | Understanding Directions; Sound Awareness | WAIS-IV Let-Num. Seq. |

| | | | | |
|---|---|---|---|---|
| Gc | Listening Ability (LS) | **Listening Comprehension** | **Understanding Directions; Oral Comprehension** | DAS-II Verbal Comp. |
| Gc | Listening Ability (LS) | Listening Comprehension 3 | Understanding Directions; Oral Comprehension; Story Recall | |
| Gc | Listening Ability (LS) | Listening Comprehension 4 | Understanding Directions; Oral Comprehension; Story Recall; Memory for Sentences | |
| Gc | General Verbal Information (K0) | **Knowledge** | **General Information; Academic Knowledge** | SB5 NV Knowledge<br>WECH Information |
| Gc | General Verbal Information (K0) | General (verbal) Information | General Information; Picture Vocabulary | WPPSI-III Pic. Concepts |
| Gc | General Verbal Information (K0) | General (verbal) Information 3 | General Information; Picture Vocabulary; Academic Knowledge | |
| Gc | Lexical Knowledge (VL) | Lexical Knowledge | Picture Vocabulary; Sound Blending | DAS-II Naming Vocab.<br>DAS-II Naming Vocab. |
| Gc | Lexical Knowledge (VL) | Lexical Knowledge 3 | Picture Vocabulary; Sound Blending; Letter-Word Identification | KABC-II Know/Gc *<br>SB5 Verbal Knowledge<br>WECH Vocabulary<br>WECH Word Reasoning<br>WPPSI-III Picture Naming<br>WPPSI-III Rec. Vocab. |
| Gc | Language Development (LD) ** | Verbal Comprehension *** | Verbal Comprehension *** | DAS-II Verbal Ability *<br>SB5 Knowledge *<br>WECH Verbal Comp. Index * |
| **Gs** | **Perceputal Speed (P)** | **Perceptual Speed** | **Visual Matching; *Cross Out*** | WECH Symbol Search<br>WECH Pair Cancellation |
| Gs | Perceputal Speed (P) | Perceptual Speed | Visual Matching; *Cross Out*<br>Pair Cancellation | |

| | | | | |
|---|---|---|---|---|
| Gs | Number Facility (N) | Number Facility/Fluency | Visual Matching; Numbers Reversed | DAS-II Speed of Info. Proc. |
| Gs | Number Facility (N) | Number Facility/Fluency 3 | Visual Matching; Numbers Reversed Calculation | |
| Gs | Number Facility (N) | Number Facility/Fluency 3 | Visual Matching; Numbers Reversed Calculation; Math Fluency | |
| Gs/Gv | Orthographic Matching | | Visual Matching | |
| Exec. Func. | Attention/Concentration (AC) | Attention/Concentration | Auditory Attention; Pair Cancellation | |

Note: Clusters/abilities in bold font represent clusters for which the WJ III battery provides norm-based cluster scores. Creating other suggested narrow ability clusters should be accomplished in a psychometrically sound manner via the use of Joel Schneider's **Compositator** program ( http://www.woodcock-munoz-foundation.org/press/compositator.html ). See Schneider and McGrew (2011) for explanation of the importance of using psychometrically sound procedures to create non-normed-based (pseudo) clusters ( http://www.iqscorner.com/2011/03/iap-applied-psychometrics-101-report-10.html ). Tests in italics are from the WJ III Diagnostic Supplement Battery.

* Designates normed-based composite clusters (2 or more tests) from non-WJ III batteries.
** Schneider and McGrew (in press) argue that Language Development (LD) is at the core of Gc. Although listed as a distinct *narrow* ability in Carroll's model, his description of his analyses make it clear that he meant LD as an *intermediate* category between Gc and more specific *narrow* language-related abilities such as Lexical Knowledge, Grammatical Sensitivity, and Listening Ability. Similarly, Schneider and McGrew's CHC v2.0 model suggests two *intermeidate* Glr abilites: Glr-Retrieval Fluency and Glr-Learning Efficiency.

*** Although only considered an individulal test, the WJ III Verbal Comprehension test is comprised of four subtests (Antonyms, Synonyms, Verbal Analogies, Picture Vocabulary) that collectively tap LD and VL. Thus, given its coverage of two or more Gc narrow abilities and strong psychometric characteristics, the Verbal Comprehension test can function as a single indicator of the intermediate ability of LD.

**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 14 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. Dr. McGrew is a coauthor of the WJ III battery. The opinions and statements included in this report do not reflect or represent the opinions of WMF, MLC, or the University of Minnesota. The opinions and statements included in this document do not necessarily reflect the opinions of the publisher of the WJ III Battery (Riverside Publishing) or the other WJ III co-authors.

More complete professional information, including Dr. McGrew's professional resume, bio, and conflict of interest disclosures can be found at each of his three professional blogs and web page:

- www.iqscorner.com
- www.atkinsmrdeathpenalty.com
- www.ticktockbraintalk.blogspot.com
- www.iapsych.com

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# Appendix A:

## Cattell-Horn-Carroll (CHC) Theory of Cognitive Abilities Definitions (CHC v2.0)

Joel Schneider & Kevin McGrew

(6-18-11)

The following table of CHC definitions is abstracted from a lengthy narrative description of contemporary CHC theory in the forthcoming publication:

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

The current table presents only the "bare bones" definitional information from the above mentioned book chapter. Readers are encouraged to consult the Schneider and McGrew chapter for details when published.

**CHC v2.0** differs from prior **CHC v1.0** organized tables of definitions for a number of reasons. First, we conducted a detailed review of the original writings of the primary architects of CHC theory to ascertain places where CHC v1.0 may have erred (all contemporary CHC v1.0 published tables can be traced to the second author's first CHC table in the first edition of *Contemporary Intellectual Assessment*—McGrew, 1997) . Second, we reviewed contemporary intelligence research to answer unanswered issues regarding various components of CHC v1.0. Third, we attempted to define each of the constructs in CHC theory in terms that clinicians will find useful. Fourth, in the chapter, we provide guidance as to which constructs are more central to the theory or have more validity data available. Fifth, also in the chapter (but not included in this summary table) we alert readers to existing controversies and raise some questions of our own. Finally, we propose a number of additions, deletions, and rearrangements in the list of CHC theory abilities

As stated in the conclusion of our chapter:

> The end goal, however, has always been for CHC theory to undergo continual upgrades so it would evolve toward an ever-more accurate summary of human cognitive diversity. With that end in mind, we have attempted to simplify the model where it needed simplification. We have also elaborated upon aspects of the model that needed elaboration. We hope our research- and reasoning-based conclusions and hypotheses will make CHC theory more accurate, more understandable to practitioners, and ultimately more helpful to people who undergo psychoeducational assessment. We hope many readers, especially long-time CHC users and researchers, are placed into a state of thoughtful disequilibrium regarding their understanding of the prevailing CHC model. Even if such users are unconvinced by our arguments, if the schemas of CHC users are broadened and refined by considering the ideas we have presented, our chapter will have been a success. The original source theorists of CHC theory would not idly stand by and let the current consensus CHC calcify and suffer from hardening of the CHC categories. We believe Cattell, Horn, and Carroll, and all the psychometric giants upon whose shoulders they stood, would smile on our efforts, and would then promptly engage us, and others, in spirited debates and empirical- and theory-based discourse.

## I. Domain-Independent General Capacities

**Fluid Reasoning (Gf):** *The deliberate but flexible control of attention to solve novel "on the spot" problems that cannot be performed by relying exclusively on previously learned habits, schemas, and scripts.* Fluid reasoning is a multi-dimensional construct but its parts are unified in their purpose: solving unfamiliar problems. Fluid reasoning is most evident in abstract reasoning that depends less on prior learning. However, it is also present in day-to-day problem solving. Fluid reasoning is typically employed in concert with background knowledge and automatized responses. That is, fluid reasoning is employed, even if for the briefest of moments, whenever current habits, scripts, and schemas are insufficient to meet the demands of a new situation. Fluid reasoning is also evident in inferential reasoning, concept formation, classification of unfamiliar stimuli, generalization of old solutions to new problems and contexts, hypothesis generation and confirmation, identification of relevant similarities, differences, and relationship among diverse objects and ideas, the perception of relevant consequences of newly acquired knowledge, and extrapolation of reasonable estimates in ambiguous situations.

1. **Induction (I)**. The ability to observe a phenomenon and discover the underlying principles or rules that determine its behavior.
2. **General Sequential Reasoning (RG)**. The ability to reason logically using known premises and principles. This ability is also known as *deductive reasoning* or *rule application*.
3. **Quantitative Reasoning (RQ)**: The ability to reason, either with induction or deduction, with numbers, mathematical relations, and operators.

**Memory**

**Short-Term Memory (Gsm):** *The ability to encode, maintain, and manipulate information in one's immediate awareness*. Gsm refers to individual differences in both the capacity (size) of primary memory and to the efficiency of attentional control mechanisms that manipulate information within primary memory. Gsm is also referred to as *working memory capacity*.

1. **Memory Span (MS).** The ability to encode information, maintain it in primary memory, and immediately reproduce the information in the same sequence in which it was represented.
2. **Attentional Control (WM).**[6] The ability to direct the focus of attention to perform relatively simple manipulations, combinations, and transformations of information within *primary* memory while avoiding distracting stimuli and engaging in strategic/controlled searches for information in *secondary* memory**.**

**Long-Term Storage & Retrieval (Glr):** *The ability to store, consolidate, and retrieve information over periods of time measured in minutes, hours, days, and years*. Short-term memory has to do with information that has been encoded seconds ago and must be retrieved while it is being actively maintained in primary memory. Short-term memory tests often involve information that is stored in long-term memory. What distinguishes Gsm from Glr tests is that there is a continuous attempt to maintain awareness of that information. A Glr test involves information that has been put out of immediate awareness long enough for the contents of primary memory to be displaced completely. In Glr tests, continuous maintenance of information in primary memory is difficult, if not impossible.

**Glr-Learning Efficiency:** All tasks of learning efficiency must present more information than can be retained in Gsm. Most tests of learning efficiency rely on Gsm, some more than others. For example, the first trial of a repeated supraspan task (e.g., WMS-IV Paired Associates), is essentially a Gsm test. However, over multiple trials, individual differences in learning efficiency determine the final performance to a greater degree than does Gsm.

1. **Associative Memory (MA).** The ability to remember previously unrelated information as having been paired.
2. **Meaningful Memory (MM).** The ability to remember narratives and other forms of semantically related information.
3. **Free Recall Memory (M6).** The ability to recall lists in any order.

**Glr-Retrieval Fluency**: The rate and fluency at which individuals they can access information stored in long-term memory.

(Fluency factors they involve the production of ideas)

1. **Ideational Fluency (FI)**. Ability to rapidly produce a series of ideas, words, or phrases related to a specific condition or object. Quantity, not quality or response originality, is emphasized.
2. **Associational Fluency (FA**). Ability to rapidly produce a series of original or useful ideas related to a particular concept. In contrast to Ideational Fluency (FI), quality rather quantity of production is emphasized.

[6] This factor was previously named *working memory*. However, as explained in McGrew (2005), this term does not refer to an individual difference variable but instead to a set of interrelated cognitive structures. Working memory capacity is an individual difference variable that is a property of the working memory system as a whole.

3. **Expressional Fluency (FE).** Ability to rapidly think of different ways of expressing an idea.
4. **Sensitivity to Problems/Alterative Solution Fluency (SP**). Ability to rapidly think of a number of alternative solutions to a particular practical problem
5. **Originality/Creativity (FO).** Ability to rapidly produce original, clever, and insightful responses (expressions, interpretations) to a given topic, situation, or task.

(Fluency abilities that involve the recall of words)

6. **Naming Facility (NA).** Ability to rapidly call objects by their names. In contemporary reading research, this ability is called rapid automatic naming (RAN) or speed of lexical access. This factor is unlike the other retrieval fluency factors in that it is, in J.P. Guilford's terms, an ability involving convergent production rather than divergent production of ideas. That is, instead of generating exemplars fitting certain constraints within a category, the examinee must name a set of objects in the order determined by the test designer. In this regard Naming Facility tests have much in common with Gs tests; they are self-paced tests in which an easy task (naming common objects) is must be done quickly and fluently.
7. **Word Fluency (FW).** Ability to rapidly produce words that share one or more phonemic or orthographic features (e.g., finding words that end with the letter b)

(Fluency abilities related to figures)

8. **Figural Fluency (FF).** Ability to rapidly draw or sketch as many things (or elaborations) as possible when presented with a nonmeaningful visual stimulus (e.g., set of unique visual elements). Quantity is emphasized over quality.
9. **Figural Flexibility (FX).** Ability to rapidly draw different solutions to figural problems.

**General Speed**

**Processing Speed (Gs):** *The ability to perform simple repetitive cognitive tasks quickly and fluently*. This ability is distinguished from Gt in that it refers to the speed at which a person can employ attentional resources adaptively to perform self-paced repetitive tasks quickly.

1. **Perceptual Speed (P).** Speed at which visual stimuli can be compared for similarity or difference. Much like Induction is at the core of Gf, Perceptual Speed is at the core of Gs. Recent research (Ackerman, Beier, & Boyle, 2002; Ackerman & Cianciolo, 2000; see McGrew, 2005) suggests that Perceptual Speed may be an intermediate stratum ability (between narrow and broad) defined by four narrow subabilities: (1) Pattern Recognition (Ppr)—the ability to quickly recognize simple visual patterns; (2) Scanning (Ps)—the ability to scan, compare, and look up visual stimuli; (3) Memory (Pm)—the ability to perform visual perceptual speed tasks that place significant demands on immediate Gsm, and (d) Complex (Pc)—the ability to perform visual pattern recognition tasks that impose additional cognitive demands, such as spatial visualization, estimating and interpolating, and heightened memory span loads.
2. **Rate-of-Test-Taking (R9).** Speed and fluency with which simple cognitive tests are completed. Originally, there were no "Rate-of-Test-Taking" tests. Instead, other tests measuring other abilities were given and the finishing times were recorded. It was found that there are individual differences in people's test-taking tempo, regardless of the type of test. Through the lens of CHC theory, however, the definition

of this factor has narrowed to simple tests that do not require visual comparison (so as not to overlap with Perceptual Speed) or mental arithmetic (so as not to overlap with Number Facility).

Academic Fluency Abilities

3. **Number Facility (N).** Speed at which basic arithmetic operations are performed accurately. Although this factor includes recall of math facts, Number Facility includes speeded performance of any simple calculation (e.g., subtracting 3 from a column of 2-digit numbers). Number Facility does not involve understanding or organizing mathematical problems and is not a major component of mathematical/quantitative reasoning or higher mathematical skills.
4. **Reading Speed (fluency) (RS**). Rate of reading text with full comprehension. Also listed under Grw.
5. **Writing Speed (fluency) (WS):** Rate at which words or sentences can be generated or copied. Also listed under Grw and Gps.

**Reaction and Decision Speed (Gt):** *The speed of making very simple decisions or judgments when items are presented one at a time*. Tests of Gt differ from tests of Gs in that they are not self-paced. Each item is presented singly and there is a short period between items in which no response from the evaluee is required. One of the interesting aspects of Gt is that not only is faster reaction time in these very simple tasks associated with complex reasoning but so is greater consistency of reaction time (less variability).

1. **Simple Reaction Time (R1)**. Reaction time to the onset of a single stimulus (visual or auditory). R1 frequently is divided into the phases of decision time (DT; the time to decide to make a response and the finger leaves a home button) and movement time (MT; the time to move finger from the home button to another button where the response is physically made and recorded).
2. **Choice Reaction Time (R2)**. Reaction time when a very simple choice must be made. For example, examinees see two buttons and must hit the one that lights up.
3. **Semantic Processing Speed (R4)**. Reaction time when a decision requires some very simple encoding and mental manipulation of the stimulus content.
4. **Mental Comparison Speed (R7)**. Reaction time where stimuli must be compared for a particular characteristic or attribute.
6. **Inspection Time (IT)**. The speed at which differences in stimuli can be perceived.

**Psychomotor Speed (Gps):** *The speed and fluidity with which physical body movements can be made*. In skill acquistion, Gps is the ability that determines performance differences after a comparable population (e.g., manual laborers in the same factory) has practiced a simple skill for a very long time.

1. **Speed of Limb Movement (R3).** The speed of arm and leg movement. This speed is measured after the movement is initiated. Accuracy is not important.
2. **Writing Speed (fluency) (WS).** The speed at which written words can be copied. Also listed under Grw and Gps.
3. **Speed of Articulation (PT).** Ability to rapidly perform successive articulations with the speech musculature.
4. **Movement Time (MT).** Recent suggests that MT may be an intermediate stratum ability (between narrow and broad strata) that represents the second phase of reaction time as measured by various elementary cognitive tasks (ECTs). The time taken to physically move a body part (e.g., a finger) to make the required response is movement time (MT). MT may also measure the speed of finger, limb, or multilimb movements or vocal articulation (diadochokinesis; Greek for "successive movements" and is also listed under Gt.

# I. Acquired Knowledge Systems

**Comprehension-Knowledge (Gc):** *Depth and breadth of knowledge and skills that are valued by one's culture.* Every culture values certain skills and knowledge over others. Gc reflects the degree to which a person has learned practically useful knowledge and mastered valued skills. Thus, by definition it is impossible to measure Gc independent of culture. Gc is theoretically broader than what is measured by any existing cognitive battery.

1. **General Verbal Information (K0**). Breadth and depth of knowledge that one's culture deems essential, practical, or otherwise worthwhile for everyone to know. This ability is distinguished from Gkn in that it refers to acquired knowledge across many domains instead of specialized knowledge in a particular domain.
2. **Language Development (LD).** General understanding of spoken language at the level of words, idioms, and sentences. In the same way that Induction is at the core of Gf, Language Development is at the core of Gc. Although listed as a distinct narrow ability in Carroll's model, his description of his analyses make it clear that he meant Language Development as an intermediate category between Gc and more specific language-related abilities such as Lexical Knowledge, Grammatical Sensitivity, and Listening Ability. Language Development appears to be a label for all language abilities working together in concert.
3. **Lexical Knowledge (VL**). Knowledge of the definitions of words and the concepts that underlie them. Whereas Language Development is more about understanding words in context, Lexical Knowledge is more about understanding the definitions of words in isolation.
4. **Listening Ability (LS**). Ability to understand speech. Tests of listening ability typically have simple vocabulary but increasingly complex syntax or increasingly long speech samples to listen to.
5. **Communication Ability (CM).** Ability to use speech to communicate one's thoughts clearly. This ability is comparable to Listening Ability except that it is productive (expressive) rather than receptive.
6. **Grammatical Sensitivity (MY).** Awareness of the formal rules of grammar and morphology of words in speech. This factor is distinguished from English Usage in that it is manifest in oral language instead of written language and that it measures more the awareness of grammar rules rather than correct usage.

**Domain-Specific Knowledge (Gkn):** *Depth, breadth, and mastery of specialized knowledge (knowledge not all members of a society are expected to have).* Specialized knowledge is typically acquired via one's career, hobby, or other passionate interest (e.g., religion, sports).

1. **General Science Information (K1).** Range of scientific knowledge (e.g., biology, physics, engineering, mechanics, electronics).
2. **Knowledge of Culture (K2).** Range of knowledge about the humanities (e.g., philosophy, religion, history, literature, music, and art).
3. **Geography Achievement (A5).** Range of geography knowledge (e.g., capitals of countries).
4. **Mechanical Knowledge (MK).** Knowledge about the function, terminology, and operation of ordinary tools, machines, and equipment.
5. **Knowledge of Behavioral Content (BC).** Knowledge or sensitivity to nonverbal human communication/interaction systems (e.g., facial expressions and gestures). The field of emotional intelligence (EI) research is very large but it is not yet clear which EI constructs should be included in CHC theory. CHC theory is about abilities rather than personality and thus the constructs within it are measured by tests in which there are correct answers (or speeded performance).

6. **Foreign Language Proficiency (KL).** Similar to Language Development but in another language. This ability is distinguished from Foreign Language Aptitude in that it represents achieved proficiency instead of potential proficiency. Presumably, most people with high Foreign Language Proficiency have high Foreign Language Aptitude but not all people with high Foreign Language Aptitude have yet developed proficiency in any foreign languages. This ability was previously classified as an aspect of Gc. However, since Gkn was added to CHC theory, it is clear that specialized knowledge of a particular language should be reclassified. Although Knowledge of English as a Second Language was previously listed as a separate ability in Gkn, it now seems clear that it is a special case of the more general ability of Foreign Language Proficiency. Note that this factor is unusual because it is not a single factor. There is a different Foreign Language Proficiency factor for every language.
7. **Knowledge of Signing (KF).** Knowledge of finger-spelling and signing (e.g., American Sign Language).
8. **Skill in Lip-Reading (LP).** Competence in the ability to understand communication from others by watching the movement of their mouths and expressions.

**Reading and Writing (Grw):** *Depth and breadth of knowledge and skills related to written language*. People with high Grw read with little effort and write with little difficulty. When Grw is sufficiently high, reading and writing become perfect windows for viewing a person's language development. Whatever difficulties they have understanding text or communicating clearly, it is most likely a function of Gc or Gkn. For people with low Grw, however, high language skills may not be evident in reading and writing performance. Although reading and writing are clearly distinct activities, the underlying sources of individual differences in reading and writing skills do not differentiate between the two activities cleanly. It appears that the ability that is common across all reading skills also unites all writing skills.

1. **Reading Decoding (RD)**. Ability to identify words from text. Typically this ability is assessed by oral reading tests with words arranged in ascending order of difficulty. Tests can consist of phonetically regular words (words that are spelled how they sound such as bathtub or hanger), phonetically irregular words (words that do not sound how they are spelled such as sugar or colonel), or phonetically regular pseudowords (fake words that conform to regular spelling rules such as gobbish or choggy).
2. **Reading Comprehension (RC)**. Ability to understand written discourse. Reading comprehension is measured in a variety of ways.
3. **Reading Speed (RS)**. Rate at which a person can read connected discourse with full comprehension. Reading Speed is classified as a mixed measure of Gs (Broad cognitive Speed) and Grw in a hierarchical speed model.
4. **Spelling Ability (SG)**. Ability to spell words. This factor is typically measured with traditional written spelling tests. However, just as with Reading Decoding, it can also be measured via spelling tests consisting of phonetically regular nonsense words (e.g., "grodding"). It is worth noting that Carroll (1993) considered this factor to be weakly defined and in need of additional research.
5. **English Usage (EU)**. Knowledge of the mechanics of writing (e.g., capitalization, punctuation, and word usage).
6. **Writing Ability (WA)**. Ability to use text to communicate ideas clearly.
7. **Writing Speed (WS)**. Ability to copy or generate text quickly. Writing Speed tasks are considered to measure both Grw and Gps (Broad Psycho-Motor Speed) as per a hierarchical speed hierarchy.

**Quantitative Knowledge (Gq):** *Depth and breadth of knowledge related to mathematics.* Gq is distinct from Quantitative Reasoning (a facet of Gf) in the same way that Gc is distinct from the non-quantitative aspects of Gf. It consists of acquired knowledge about mathematics such as knowledge of mathematical symbols (e.g., $\int$, $\pi$, $\Sigma$, $\infty$, $\neq$, $\leq$, $+$, $-$, $\times$, $\div$, $\surd$, and many others), operations (e.g., addition/subtraction, multiplication/division, exponentiation/$n^{th}$ rooting, factorials, negation, and many others), computational procedures (e.g., long division, reducing fractions, quadratic formula, and many others), and other math-related skills (e.g., using a calculator, math software, and other math aids).

1. **Mathematical Knowledge (KM)**. Range of general knowledge about mathematics. Not the performance of mathematical operations or the solving of math problems. This factor is about "what" rather than "how" knowledge (e.g., What does π mean? What is the Pythagorean theorem?)
2. **Mathematical Achievement (A3).** Measured (tested) mathematics achievement.

## II. Sensory/Motor-Linked Abilities

**Sensory**

**Visual Processing (Gv):** *The ability to make use of simulated mental imagery (often in conjunction with currently perceived images) to solve problems*. Once the eyes have transmitted visual information, the visual system of the brain automatically performs a large number of low-level computations (e.g., edge detection, light/dark perception, color-differentiation, motion-detection, and so forth). The results of these low-level computations are used by various higher-order processors to infer more complex aspects of the visual image (e.g., object recognition, constructing models of spatial configuration, motion prediction, and so forth).

1. **Visualization (Vz).** The ability to perceive complex patterns and mentally simulate how they might look when transformed (e.g., rotated, changed in size, partially obscured, and so forth). In the same way that Induction is central to Gf and Language Development is central to Gc, this is the core ability of Gv.
2. **Speeded Rotation (Spatial Relations; SR).** The ability to solve problems quickly using mental rotation of simple images. This ability is similar to visualization because it involves rotating mental images but it is distinct because it has more to do with the *speed* at which mental rotation tasks can be completed. Speeded Rotation tasks typically involve fairly simple images.
3. **Closure Speed (CS).** Ability to quickly identify a familiar meaningful visual object from incomplete (e.g., vague, partially obscured, disconnected) visual stimuli, without knowing in advance what the object is. This ability is sometimes called Gestalt Perception because it requires people to "fill in" unseen or missing parts of an image to visualize a single percept.
4. **Flexibility of Closure (CF)**. Ability to identify a visual figure or pattern embedded in a complex distracting or disguised visual pattern or array, when knowing in advance what the pattern is.
5. **Visual Memory (MV).** Ability to remember complex images over short periods of time (less than 30 seconds). The tasks that define this factor involve being shown complex images and then identifying them soon after then stimulus is removed.
6. **Spatial Scanning (SS).** Ability to visualize a path out of a maze or a field with many obstacles. This factor is defined by performance on paper and pencil maze tasks. It is not clear whether this ability is related to complex large-scale real-world navigation skills.
7. **Serial Perceptual Integration (PI)**. Ability to recognize an object after only parts of it are shown in rapid succession.
8. **Length Estimation (LE).** The ability to visually estimate the length of objects.
9. **Perceptual Illusions (IL)**. The ability to not be fooled by visual illusions
10. **Perceptual Alternations (PN)**. Consistency in the rate of alternating between different visual perceptions..
11. **Imagery (IM)**. Ability to mentally imagine very vivid images. Small scale brain imaging studies have suggested that visual spatial imagery may not be a single faculty, rather, visualizing spatial location and mentally transforming location relying on distinct neural networks. This research suggests a transformational process versus memory for location substructure. An objective versus spatial imagery dichotomy has also been suggested as well as the possibility of quality and speed of imagery abilities.

**Auditory Processing (Ga):**. *The ability to detect and process meaningful nonverbal information in sound*. This definition may cause confusion because we do not have a well developed vocabulary for talking about sound unless we are talking about speech sounds or music. Ga encompasses both of these domains but also much more. There are two common misperceptions about Ga. First, although Ga depends on sensory input, it is not sensory input itself. Ga is what the brain does with sensory information from the ear, sometimes long after a sound has been heard. The second extremely common misconception is that Ga is oral language comprehension. It is true that one aspect of Ga (parsing speech sounds or Phonetic Coding) is related to oral language comprehension but this is simply a precursor to comprehension, not comprehension itself.

1. **Phonetic Coding (PC)**. Ability to hear phonemes distinctly. This ability is also referred to as phonological processing and phonological awareness. People with poor phonetic coding have difficulty hearing the internal structure of sound in words.
2. **Speech Sound Discrimination (US):** Ability to detect and discriminate differences in speech sounds (other than phonemes) under conditions of little or no distraction or distortion**.** Poor speech sound discrimination can produce difficulty in the ability to distinguish variations in tone, timbre, and pitch in speech.
3. **Resistance to Auditory Stimulus Distortion (UR)**. Ability to hear words correctly even under conditions of distortion or loud background noise.
4. **Memory for Sound Patterns (UM).** Ability to retain (on a short-term basis) auditory events such as tones, tonal patterns, and voices.
5. **Maintaining and Judging Rhythm (U8)**. Ability to recognize and maintain a musical beat. This may be an aspect of Memory for Sound Patterns as short-term memory is clearly involved. However, it is likely that there is something distinct about rhythm that warrants a distinction.
6. **Musical Discrimination and Judgment (U1 U9)**. Ability to discriminate and judge tonal patterns in music with respect to melodic, harmonic, and expressive aspects (phrasing, tempo, harmonic complexity, intensity variations).
7. **Absolute Pitch (UP)**. Ability to perfectly identify the pitch of tones. As a historical tidbit, John Carroll had perfect pitch.
8. **Sound Localization (UL)**. Ability to localize heard sounds in space.

**Olfactory Abilities (Go)**: *The ability to detect and process meaningful information in odors*. Go refers not to sensitivity of the olfactory system but to the cognition one does with whatever information the nose is able to send. The Go domain is likely to contain many more narrow abilities than currently listed in the CHC model as a cursory skim of Go-related research reveals reference to such abilities as olfactory memory, episodic odor memory, olfactory sensitivity, odor specific abilities, odor identification and detection, odor naming, olfactory imagery, to name but a few.

1. ***Olfactory Memory (OM).*** *Ability to recognize previously encountered distinctive odors*. OM is involved in the oft-noted experience of smelling a distinctive smell and being flooded with vivid memories of the last time that odor was encountered. Memory for distinctive odors has a much flatter forgetting curve than many other kinds of memory.

**Tactile Abilities (Gh)**: *The ability to detect and process meaningful information in haptic (touch) sensations*. Gh refers not to sensitivity of touch but to the cognition one does with tactile sensations. Because this ability is not yet well defined and understood, it is hard to describe it authoritatively. The domain may include such abilities as tactile visualization (object identification via palpation), tactile localization (i.e., where has one been touched), tactile memory (i.e., remembering where one has been touched), texture knowledge (naming surfaces and fabrics by touch), and many others. There are no well-supported narrow cognitive ability factors within Gh yet. *Tactile Sensitivity* (TS), a sensory acuity ability, refers

to the ability to make fine discriminations in haptic sensations (e.g., if two caliper points are placed on the skin simultaneously, we perceive them as a single point if they are close together. Some people are able to make finer discriminations than others).

**Motor**

**Kinesthetic Abilities (Gk)**: *The ability to detect and process meaningful information in proprioceptive sensations*. Proprioception refers to the ability to detect limb position and movement via *proprioreceptors* (sensory organs in muscles and ligaments that detect stretching). Gk refers not to the sensitivity of proprioception but to the cognition one does with proprioceptive sensations. There are no well-supported narrow cognitive ability factors within Gk yet. *Kinesthetic Sensitivity* (KS), a sensory acuity ability, refers to the ability to make fine discriminations in proprioceptive sensations (e.g., whether and how much a limb has been moved).

**Psychomotor Abilities (Gp):** *The ability to perform physical body motor movements (e.g., movement of fingers, hands, legs) with precision, coordination, or strength.*

1. **Static Strength (P3)**. The ability to exert muscular force to move (push, lift, pull) a relatively heavy or immobile object.
2. **Multilimb Coordination (P6**). The ability to make quick specific or discrete motor movements of the arms or legs.
3. **Finger Dexterity (P2)**. The ability to make precisely coordinated movements of the fingers (with or without the manipulation of objects).
4. **Manual Dexterity (P1)**. Ability to make precisely coordinated movements of a hand or a hand and the attached arm.
5. **Arm-Hand Steadiness (P7)**. The ability to precisely and skillfully coordinate arm–hand positioning in space.
6. **Control Precision (P8)**. The ability to exert precise control over muscle movements, typically in response to environmental feedback (e.g., changes in speed or position of object being manipulated).
7. **Aiming (AI).** The ability to precisely and fluently execute a sequence of eye–hand coordination movements for positioning purposes.
8. **Gross Body Equilibrium (P4).** The ability to maintain the body in an upright position in space or regain balance after balance has been disturbed.

## Appendix B: Broad and Narrow CHC Cognitive-Achievement Relations Summary Table [i]

(Kevin McGrew 5-12-11)

| | Achievement Domains | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Basic Reading Skills BRS | | | Reading Comp. RC | | | Basic Math Calc. Skills MCS | | | Math Reasoning MR | | |
| **Age Range (in years)** | 6-8 | 9-13 | 14-19 | 6-8 | 9-13 | 14-19 | 6-8 | 9-13 | 14-19 | 6-8 | 9-13 | 14-19 |
| **Broad/Narrow CHC Abilities** | | | | | | | | | | | | |
| **Gsm**: **Short-term memory** | X | X | X | | | | | | | | | |
| Working Memory (MW) | X | X | X | X | X | X | X | X | X | X | X | X |
| Memory Span (MS) | | X | X | | | X | | | | | | |
| **Gs**: **Processing speed** | X | X | | | | | X | X | X | | | |
| Perceptual Speed (P) | X | X | X | X | X | X | X | X | X | X | X | X |
| Number Facility (N) | | | | | | | | | | | | |

| | BRS 6-8 | BRS 9-13 | BRS 14-19 | RC 6-8 | RC 9-13 | RC 14-19 | MCS 6-8 | MCS 9-13 | MCS 14-19 | MR 6-8 | MR 9-13 | MR 14-19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Glr**: **Long-term storage and retrieval** | X | | | | | | | | | | | |
| Associative Memory (MA) | X | | | X | | | X | | | | | |
| Naming Facility (NA) (aka. RAN or speed of lexical access) | X | | | X | X | X | X | X | X | | | |
| Meaningful Memory (MM) | | | | | X | X | | | | | | |
| **Gc**: **Comprehension-Knowledge** | X | X | X | X | X | X | | X | X | X | X | X |
| Language Development (LD) | X | X | X | X | X | X | | X | X | X | X | X |
| General Information (K0) | X | X | X | X | X | X | | | | X | X | X |
| Listening Ability (LS) | X | | | X | X | X | | X | X | X | X | X |
| Lexical Knowledge (VL) | X | X | X | X | X | X | | | | | | |

| | BRS 6-8 | BRS 9-13 | BRS 14-19 | RC 6-8 | RC 9-13 | RC 14-19 | MCS 6-8 | MCS 9-13 | MCS 14-19 | MR 6-8 | MR 9-13 | MR 14-19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ga**: **Auditory Processing** | | | | X | | | | | | | | |
| Phonetic Coding (PC) (aka. Phonemic Awareness) | X | X | X | X | X | X | | | | | | |
| Spch Snd. Disc. (US)/Res Auditory Stimulus Distortion (UR) | | X | X | | | | | | | | | |
| **Gf**: **Fluid Reasoning** | | | | | | | X | X | X | X | X | X |
| Gen. Seq. (Deductive) Reasoning (RG) | | | | | | | X | X | X | X | X | X |
| Quantitative Reasoning (RQ) | | | | | | | X | X | X | X | X | X |
| **Gv: Visual-Spatial Processing** | | | | | | | | | | | | |
| Visualization (Vz) | | | | | | | | | | | | |
| Imagery (IM) | | | | | | | | | | | | |
| Visual Memory (MV)/Visual-wrk.mem. (??) | | | | | | | | | | | | |
| Orthographic Processing (??) | | | | | | | | | | | | |

| | BRS 6-8 | BRS 9-13 | BRS 14-19 | RC 6-8 | RC 9-13 | RC 14-19 | MCS 6-8 | MCS 9-13 | MCS 14-19 | MR 6-8 | MR 9-13 | MR 14-19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gkn: Domain-specific knowledge (Gkn)** | | | | | | | | | | | | |
| **EF: Executive Functions** (vigilance, inhibition, planning, self-regulation, attention, etc. | | | | | | | X | X | X | | | |

[i] This table is a tabular summary of the major conclusions of McGrew and Wendling's (2010) synthesis of the CHC cognitive-achievement relations research completed during the past 20 years. *X's* designate broad or narrow CHC abilities that were reported as significantly related to the specific achievement domain (as a function of age). The summary table does not include other findings that McGrew and Wendling characterized as *tentative* or *speculative.* The reader should consult the original review for a more detailed discussion of all conclusions of McGrew and Wendling (http://www.iapsych.com/articles/mcgrew2010.pdf).

The shaded areas reflect the nuanced discussions of other possible important CHC and, other yet-to-be classified CHC abilities (e.g., orthographic processing), discussed by McGrew and Wendling. For example, Gv abilities were not found to be significantly related to any area of mathematics. However, McGrew and Wendling reported that there is clear and convincing evidence for the importance of some Gv abilities (e.g., Visualization-Vz; Imagery-IM) in mathematics, especially higher-order math achievement (i.e., geometry, trigonometry, calculus, etc.), but that the measures included in their review failed to represent this important source of variance in math achievement. Or, it is possible that select Gv math related abilities did not surface due to methodological limitations of the extant research reviewed.

The McGrew and Wendling (2010) review expanded upon, and supplemented, the prior narrative research syntheses by Flanagan et al. (2006). In their paper, McGrew and Wendling "choose not to devote pages to detailed comparisons of the similarities and differences between the conclusions of the current review and that of Flanagan and colleagues (2006, p. 668)." McGrew and Wendling concluded that their systematic review "reveals a much more nuanced set of CHC COG-ACH relations as a function of (a) breadth of cognitive abilities and measures (broad vs. narrow), (b) breadth of achievement domains (e.g., BRSand RC vs. broad reading), and (c) developmental (age) status" (p. 668) than that reflected in prior narrative research syntheses. More recently, Flanagan, Alfonso and Mascolo (2011) have provided the field with a detailed point-by-point comparison of the McGrew and Wendling (2011) and Flanagan et al (2006) reviews. Readers should consult both sources to secure a thorough grasp of the extant CHC cognitive-achievement relations literature.

## References

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