Why do some individuals obtain markedly different scores on different *Gwm* tests?

Data and theory-based hypotheses for evaluating differences between scores on the different WJ IV tests of *Gwm*

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)

“Intelligent” intelligence testing & interpretation:
We are the instrument !!!!

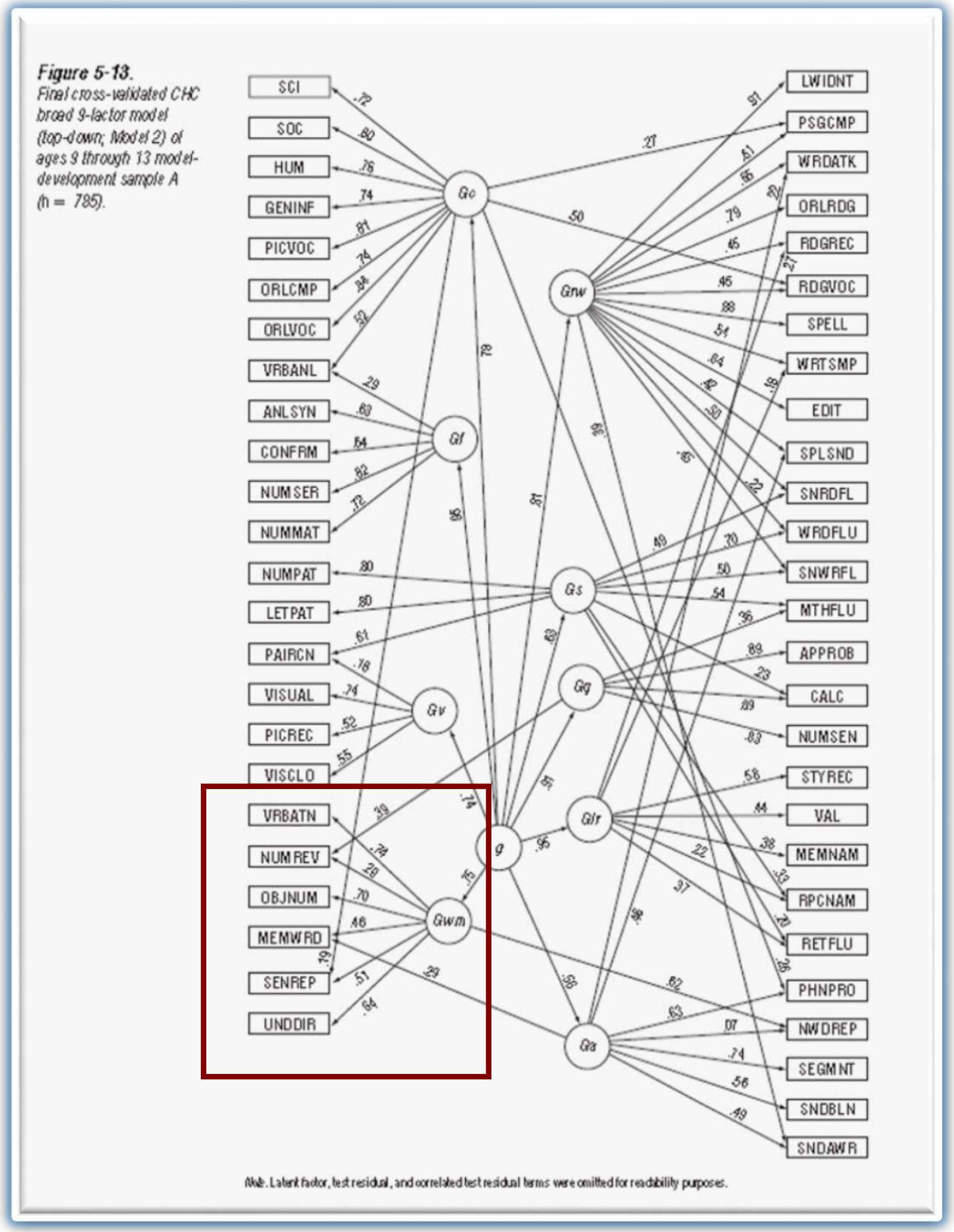
Evaluating within CHC domain test score differences

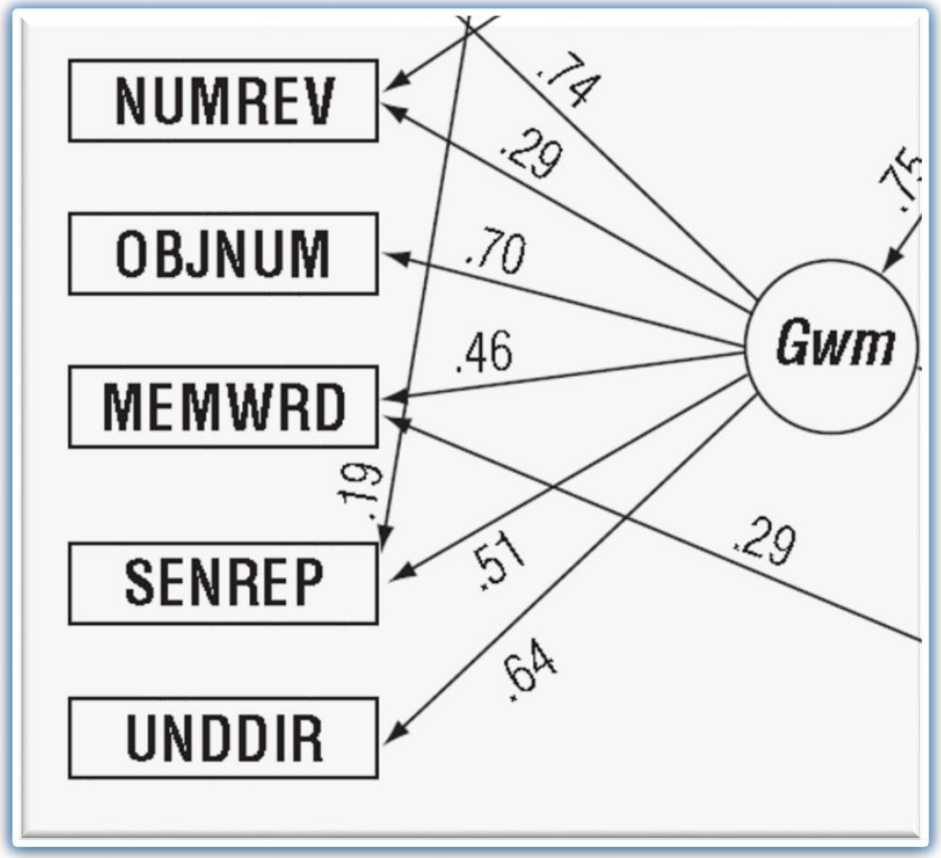
Deciding when the scores from two tests, which are from the same CHC domain (e.g., *Gwm*), and which may have the same narrow CHC classifications, are different enough to warrant clinical interpretation.

The reader is strongly encouraged to first view the above brief PPT module to learn when differences between scores are unusual and may warrant clinical interpretation

http://www.iqscorner.com/2016/05/intelligent-intelligence-testing-with.html

SENREP .19 secondary loading on Gc
NUMREV .39 secondary loading on Gq

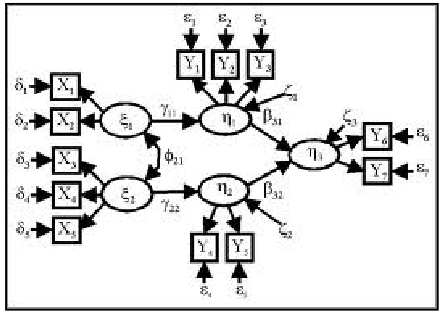




CFA of WJ IV norm data (example here is for ages 9-13) supported a single *Gwm* factor. Models with *Gwm* narrow factors, specified in the model-development sample, were not possible to fit.
From WJ IV technical manual (McGrew et al., 2014)

Jöreskog (or LISREL) syndrome

American psychology, and mainstream quantitative school psychology, have expressed little interest in non-confirmatory statistical methodological tools (e.g., exploratory cluster analysis; MDS) in favor of what I call *Jöreskog (LISREL) syndrome*—an almost blind allegiance and belief in structural equation modeling confirmatory factor analysis (SEM-CFA) methods as *the* only way to see the "true light" of the structure of intelligence and intelligence tests (McGrew, 2012)



Jöreskog (or LISREL) syndrome

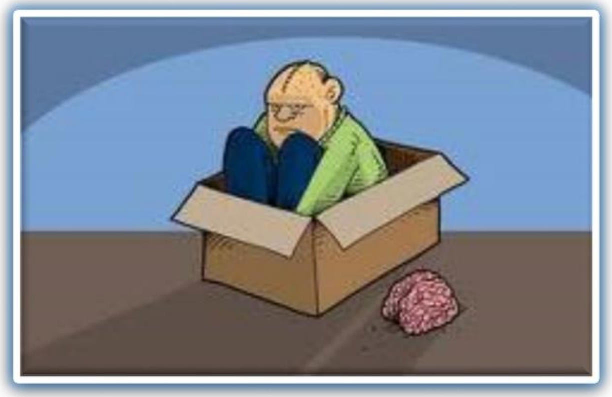
The law of the instrument

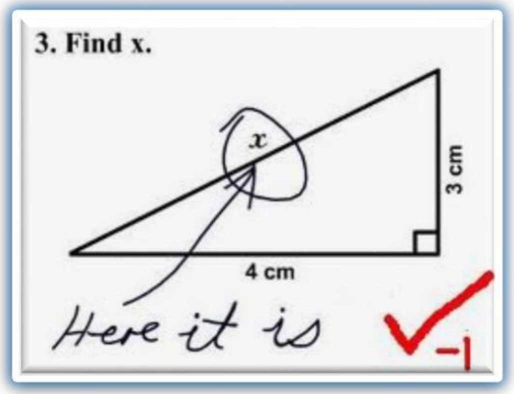
"Give a small boy a hammer, and he will find that everything he encounters needs pounding"

Important Reminder: All statistical methods, such as factor analysis (EFA or CFA), have limitations and constraints.

EFA/CFA methods only provide evidence of structural/internal validity and typically nothing about external, developmental, heritability, or neurocognitive validity evidence

We need to examine other sources of evidence and use other methods – looking/thinking outside the factor analysis box





INTELLIGENCE 7, 107–127 (1983)

The Complexity Continuum in the Radex and Hierarchical Models of Intelligence*

Brachia Marshalek, David F. Lohman, and Richard E. Snow
Stanford University

One of the MDS classic articles

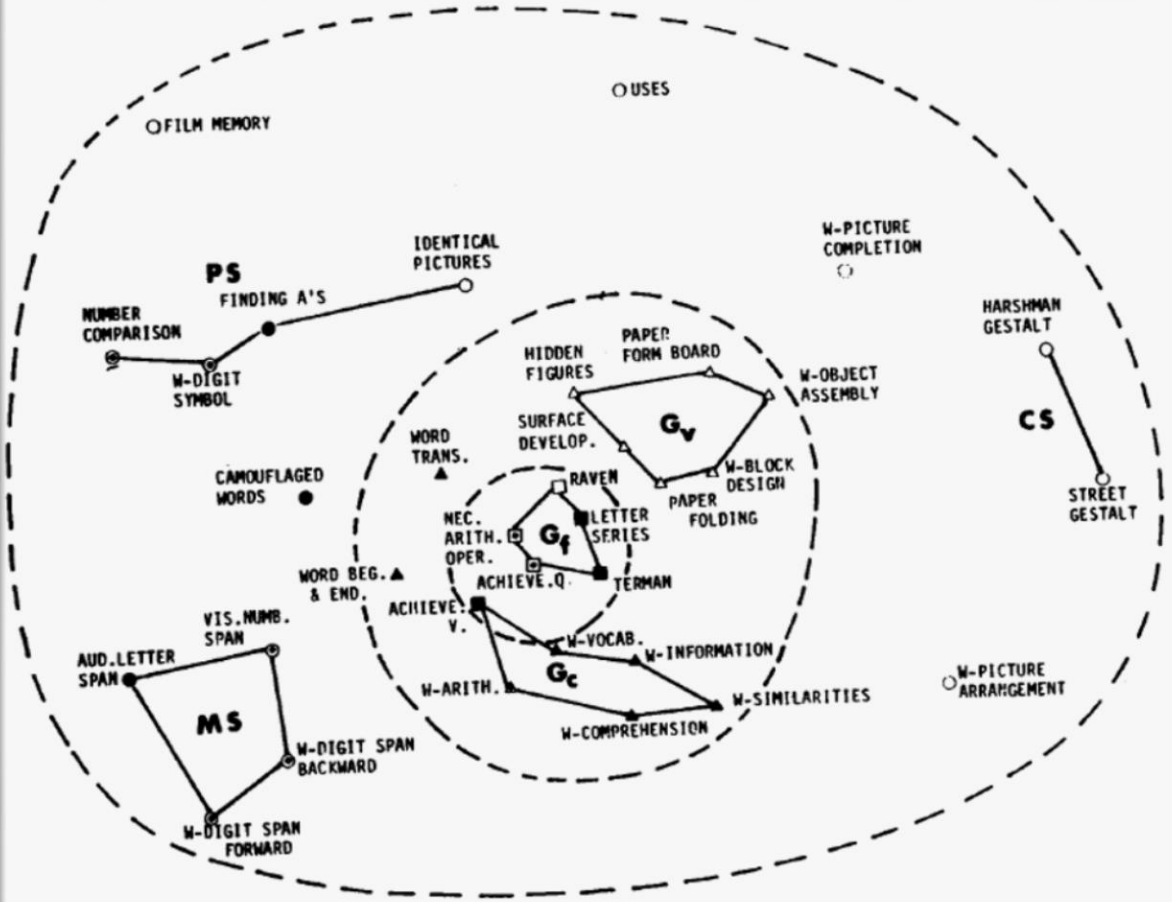
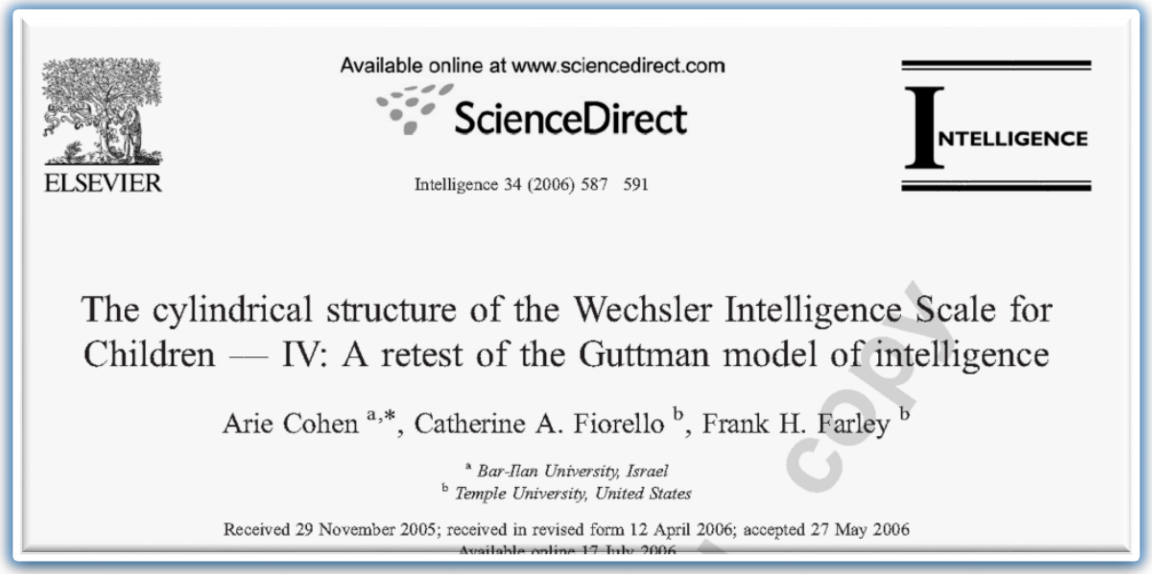


FIG. 3. A multidimensional scaling of the full test battery showing three levels of complexity and three content areas (high school sample, $N = 241$). Complex, intermediate, and simple tests are indicated as black (verbal), dotted (numerical), and white (figural-spatial) squares, triangles, and circles, respectively.



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INTELLIGENCE

Intelligence 34 (2006) 587 591

The cylindrical structure of the Wechsler Intelligence Scale for Children — IV: A retest of the Guttman model of intelligence

Arie Cohen [a,*], Catherine A. Fiorello [b], Frank H. Farley [b]

[a] Bar-Ilan University, Israel
[b] Temple University, United States

Received 29 November 2005; received in revised form 12 April 2006; accepted 27 May 2006

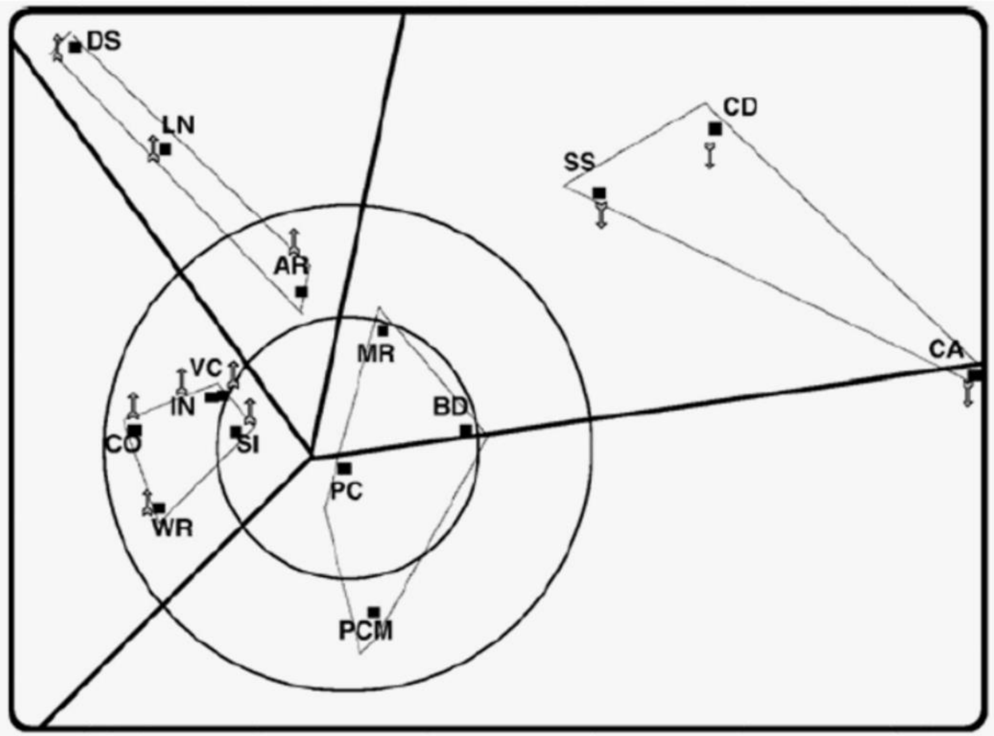


Fig. 1. Three-dimensional Guttmon model of the WISC-IV.

Another example of the usefulness of MDS method

International Journal of Behavioral Development
2009, 33 (3), 277–285
http://www.sagepublications.com

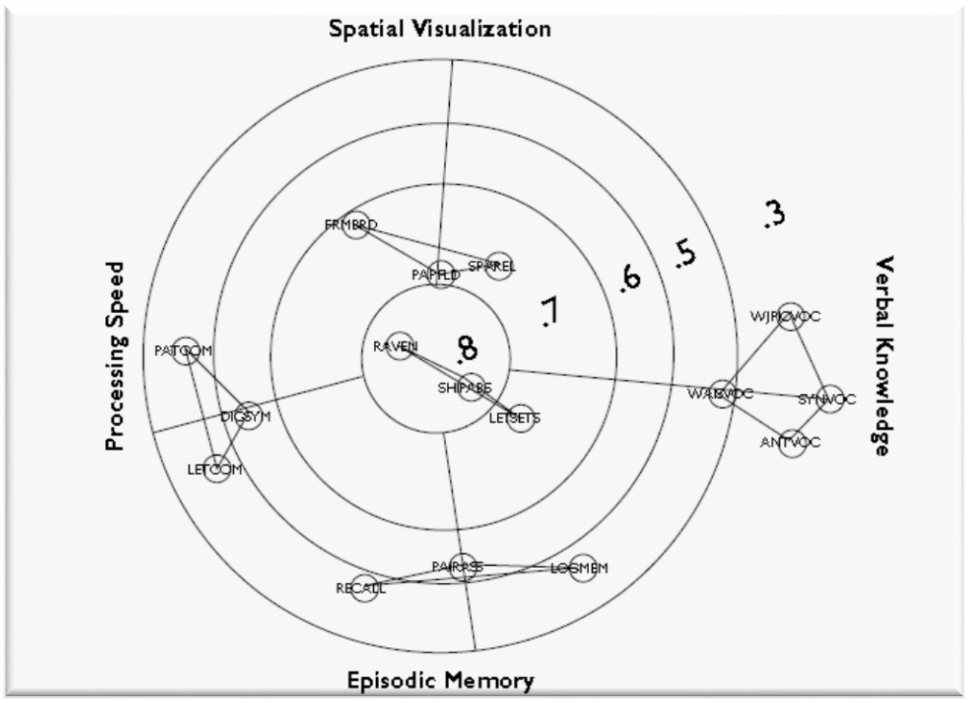
ijbd

DOI: 10.1177/0165025409104489

METHODS AND MEASURES

Confirmatory factor analysis and multidimensional scaling for construct validation of cognitive abilities

Elliot M. Tucker-Drob and Timothy A. Salthouse
University of Virginia, USA



A brilliant illustration of the complimentary use of CFA and MDS

Table 3
Standardized loadings from confirmatory factor analysis for total sample and (young group, middle-aged group, and old group)

Variable	*G*	*Memory*	*Space*	*Speed*	*Verbal*
Raven's	.88 (.83, .80, .78)				
Shipley abstraction	.87 (.83, .87, .85)				
Letter sets	.79 (.77, 78, .80)				
Logical memory	.56 (.57, .55, .53)	.44 (44, .44, .44)			
Free recall	.56 (.47, .41, .43)	.61 (.63, .68, .70)			
Paired associates	.61 (.58, .53, .41)	.42 (.41, .43, .47)			
Spatial relations	.78 (.84, .73, .60)		.50 (.40, .62, .59)		
Paper folding	.78 (.78, .70, .63)		.28 (.28, .29, .38)		
Form boards	.70 (.65, .58, .54)		.33 (.32, .37, .46)		
Digit symbol	.69 (.50, .54, .61)			.42 (.42, .37, .48)	
Letter comparison	.59 (.41, .49, .60)			.57 (.63, .64, .55)	
Pattern comparison	.59 (.42, .42, .54)			.54 (.56, .53, .50)	
WAIS vocabulary	.53 (.76, .76, .66)				.68 (.48, .43, .49)
WJ Picture vocabulary	.37 (.73, .71, .65)				.68 (.42, .37, .24)
Synonym vocabulary	.35 (.68, .70, .65)				.84 (.58, .58, .66)
Antonym vocabulary	.41 (.63, .70, .66)				.76 (.59, .53, .49)

Notes. Factors are uncorrelated. All loadings are significant at $p < .01$. Fit indices for total sample: $\chi^2 = 1470.5$, degrees of freedom = 91. CFI = .96. TLI = .95. RMSEA = .041.

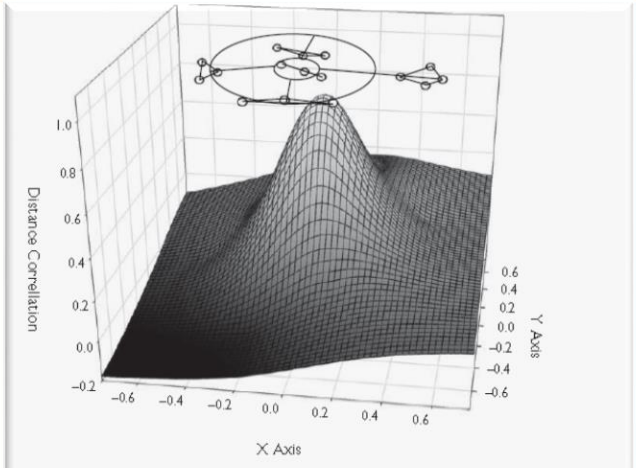
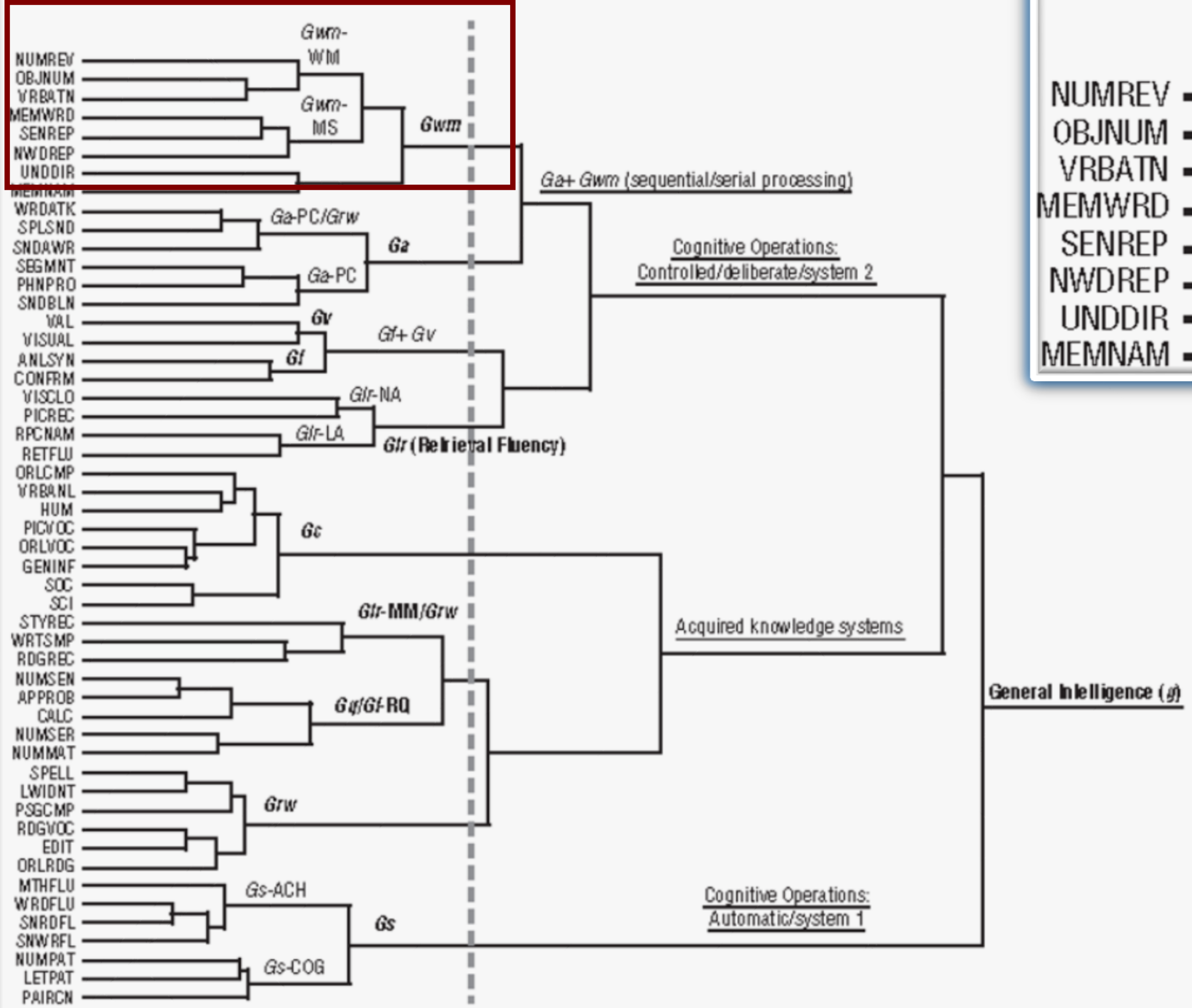
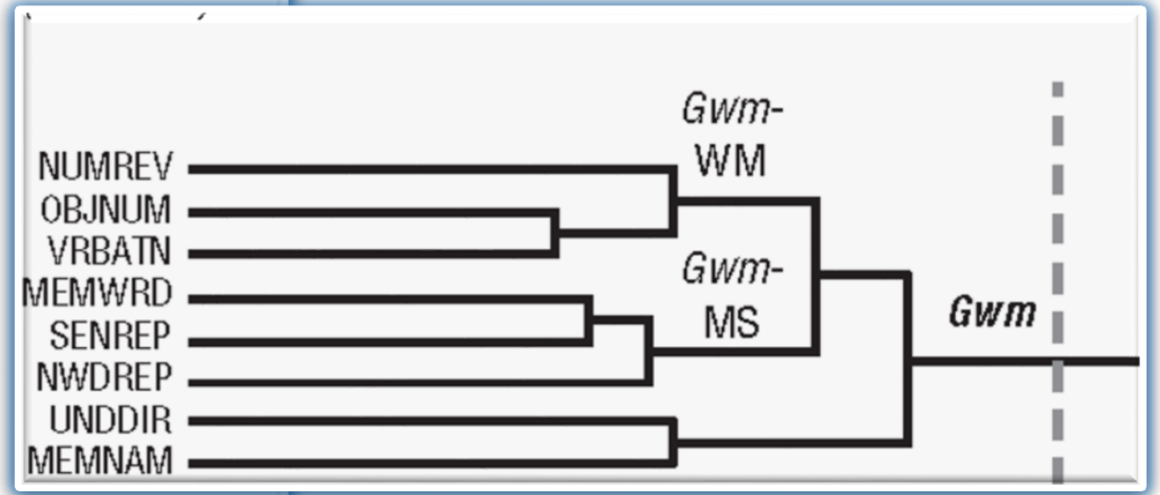


Figure 4. Example fit function: Reading Span. The reference radex space is superimposed.

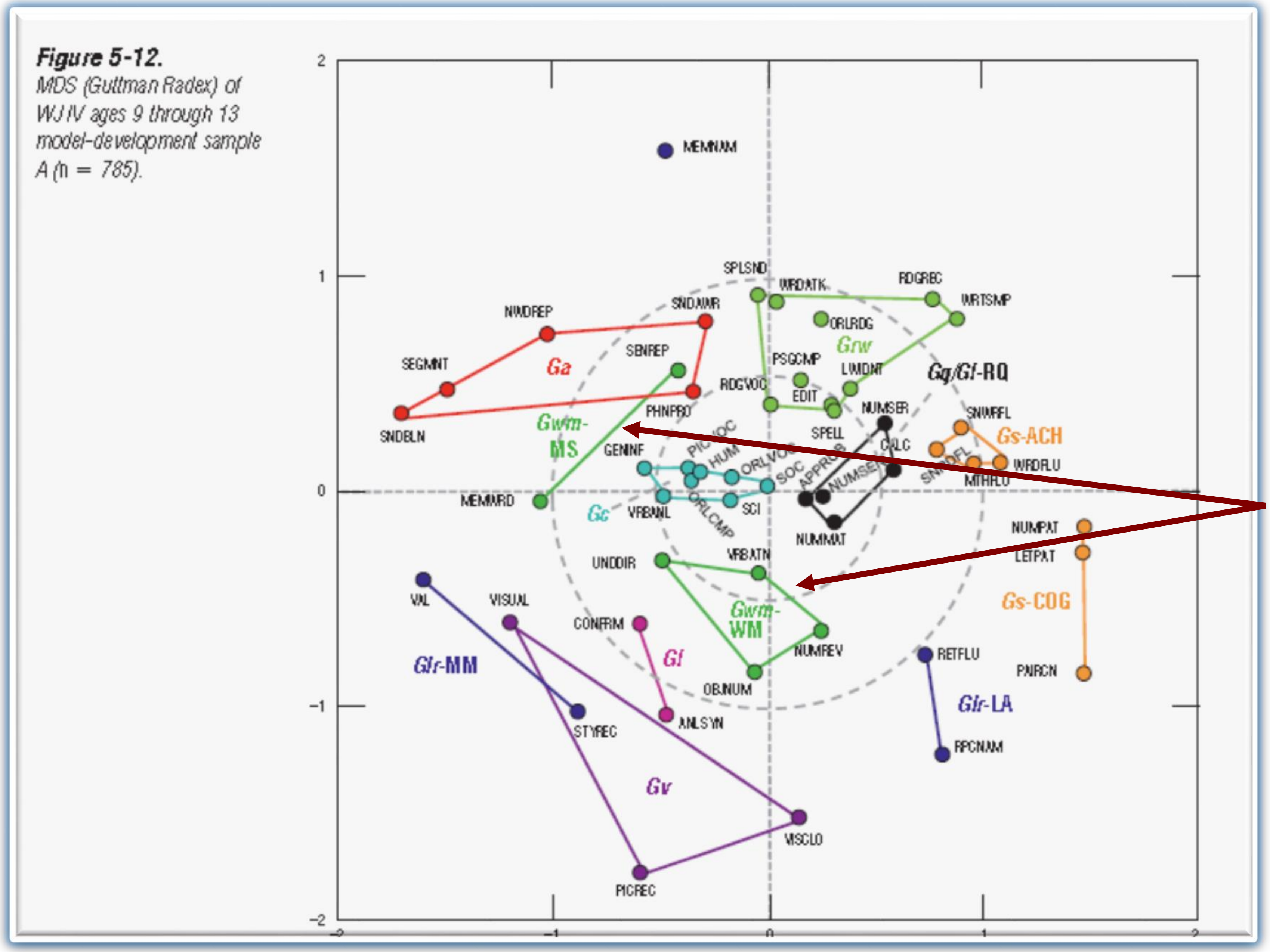
Figure 5-10.
Ward's cluster analysis of ages 9 through 13 model-development sample A (n = 785).



Note. Bold font = Broad or general CHC abilities. Underlined text = Possible intermediate level stratum dimensions. Groupings to the left of the vertical dashed line indicate they are interpreted as valid CHC abilities. Higher-order groupings to the left of the dashed line are potentially interesting hypothesized intermediate-ability dimensions.



Cluster analysis in same WJ IV model development sample (ages 9-13) suggested possibly two narrow *Gwm* dimensions (McGrew et al., 2014)



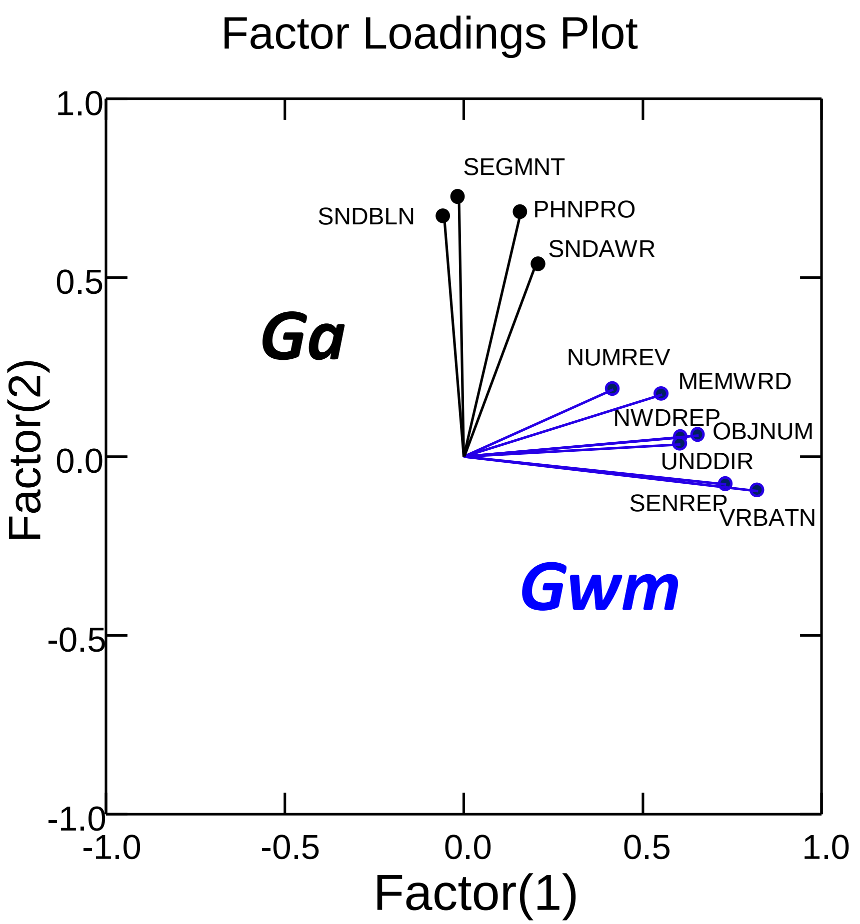
MDS in same model development sample also suggested possibly two narrow *Gwm* dimensions (McGrew et al., 2014)

In MDS the magnitude of the relationship between tests is represented by spatial proximity. Tests that are far apart or weakly correlated. Test that are close together are more highly correlated.

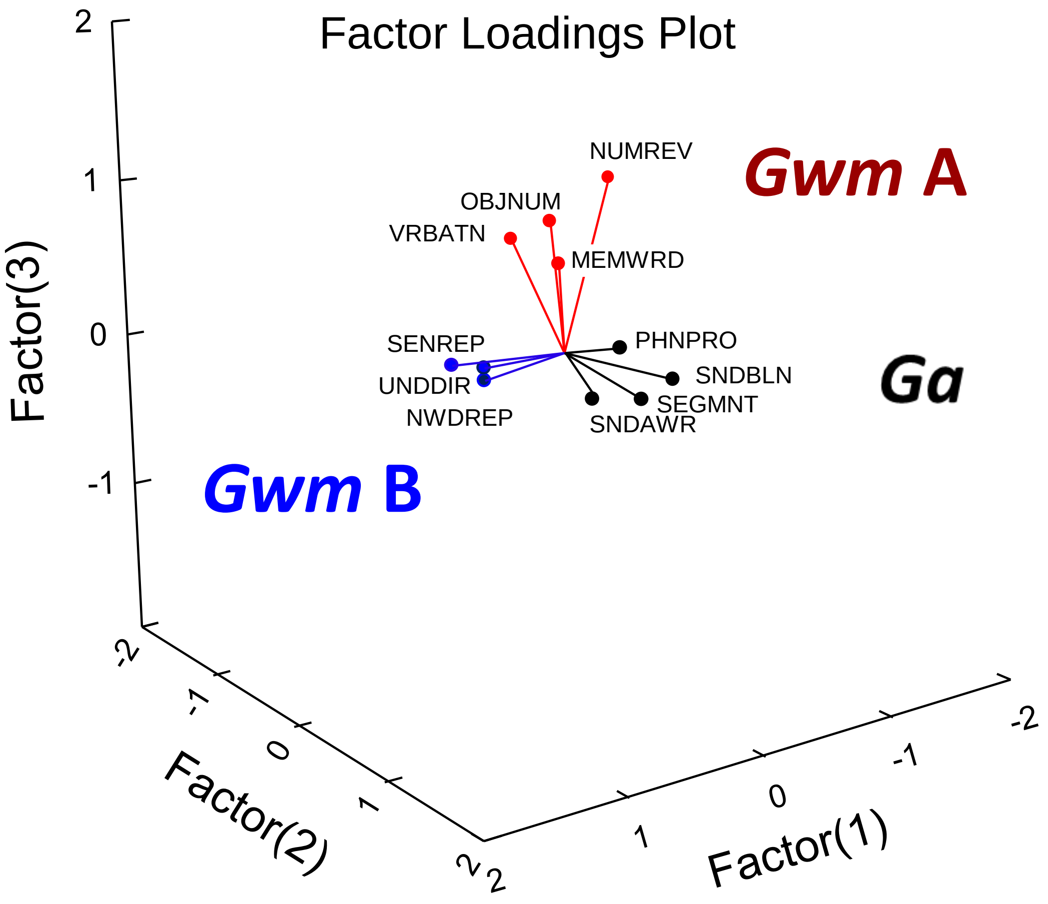
Kevin McGrew recently revisited the WJ IV norm data (ages 6-19) with EFA, CA and MDS exploratory methods and analyzed either all WJ IV tests together or subsets of tests

What follows are unpublished non-peer reviewed results

Exploratory factor analysis of WJ IV *Ga* and *Gwm* tests in norm subjects ages 6-19—two three factor solutions

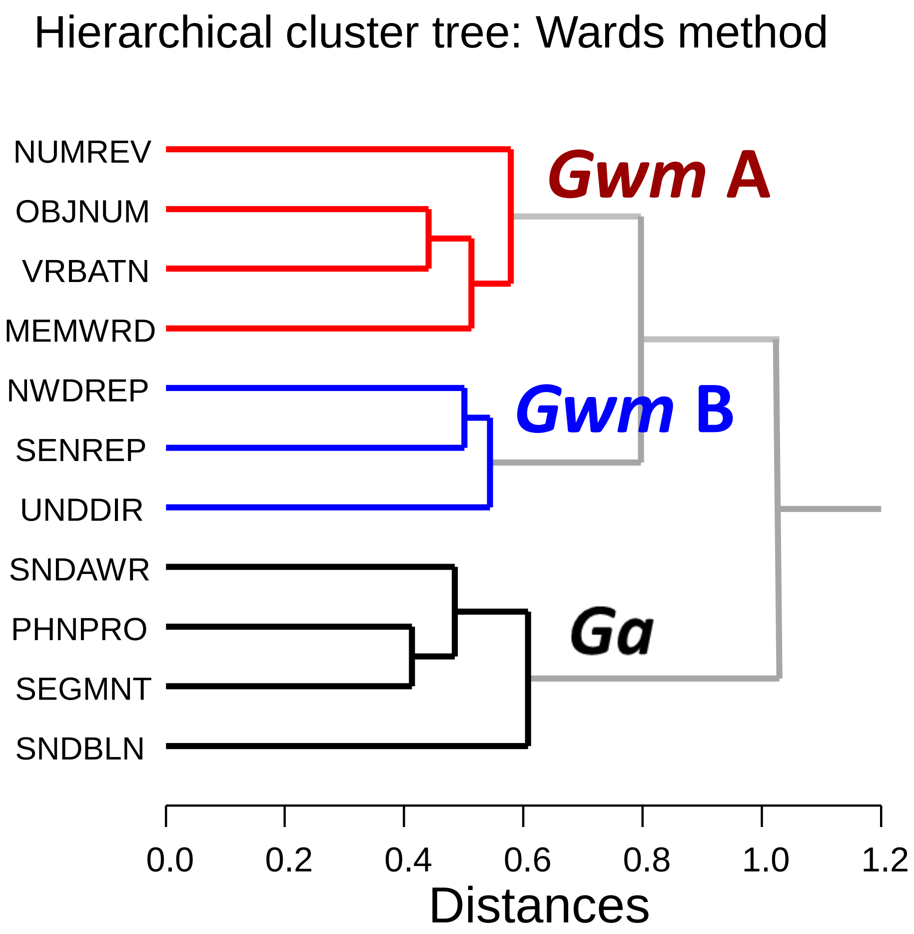


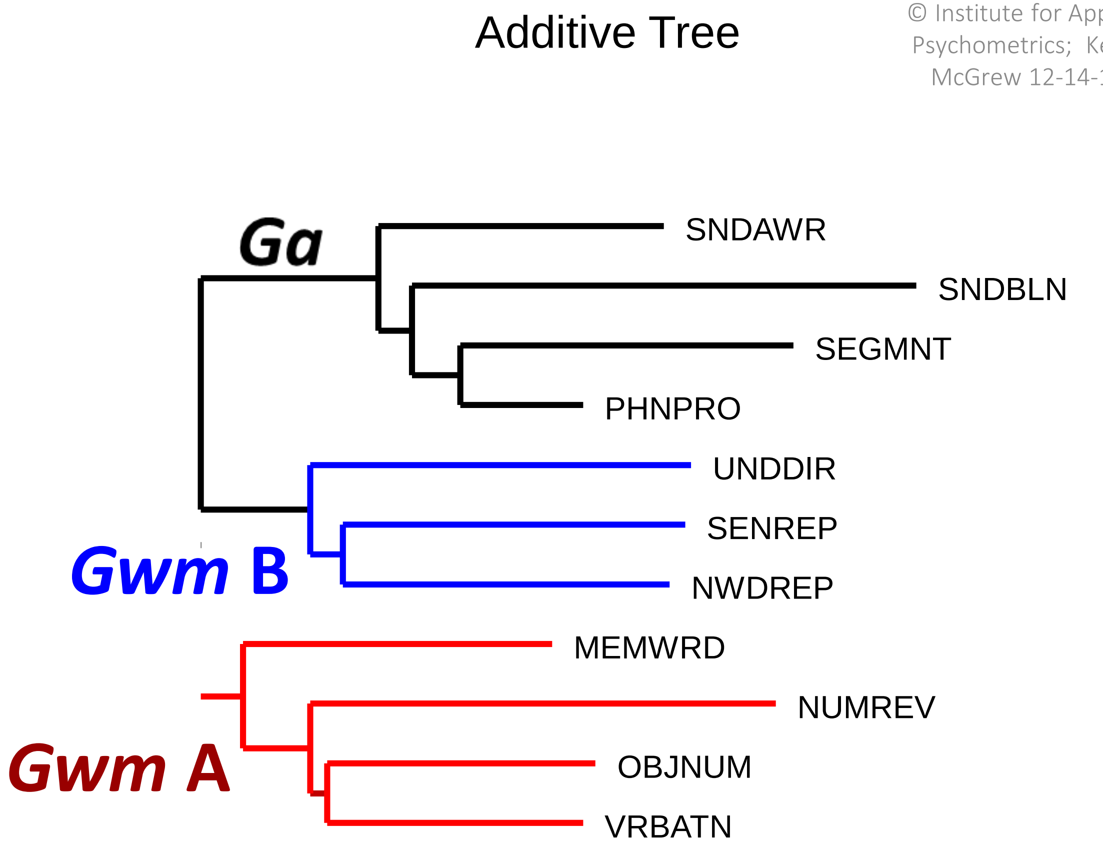
Oblique factor corr. = .54



Correlations Among Oblique Factors or Components	1	2	3
1	1.00		
2	**0.45**	1.00	
3	**0.61**	**0.64**	1.00

Exploratory cluster analysis of WJ IV *Ga* and *Gwm* tests—norm subjects ages 6-19

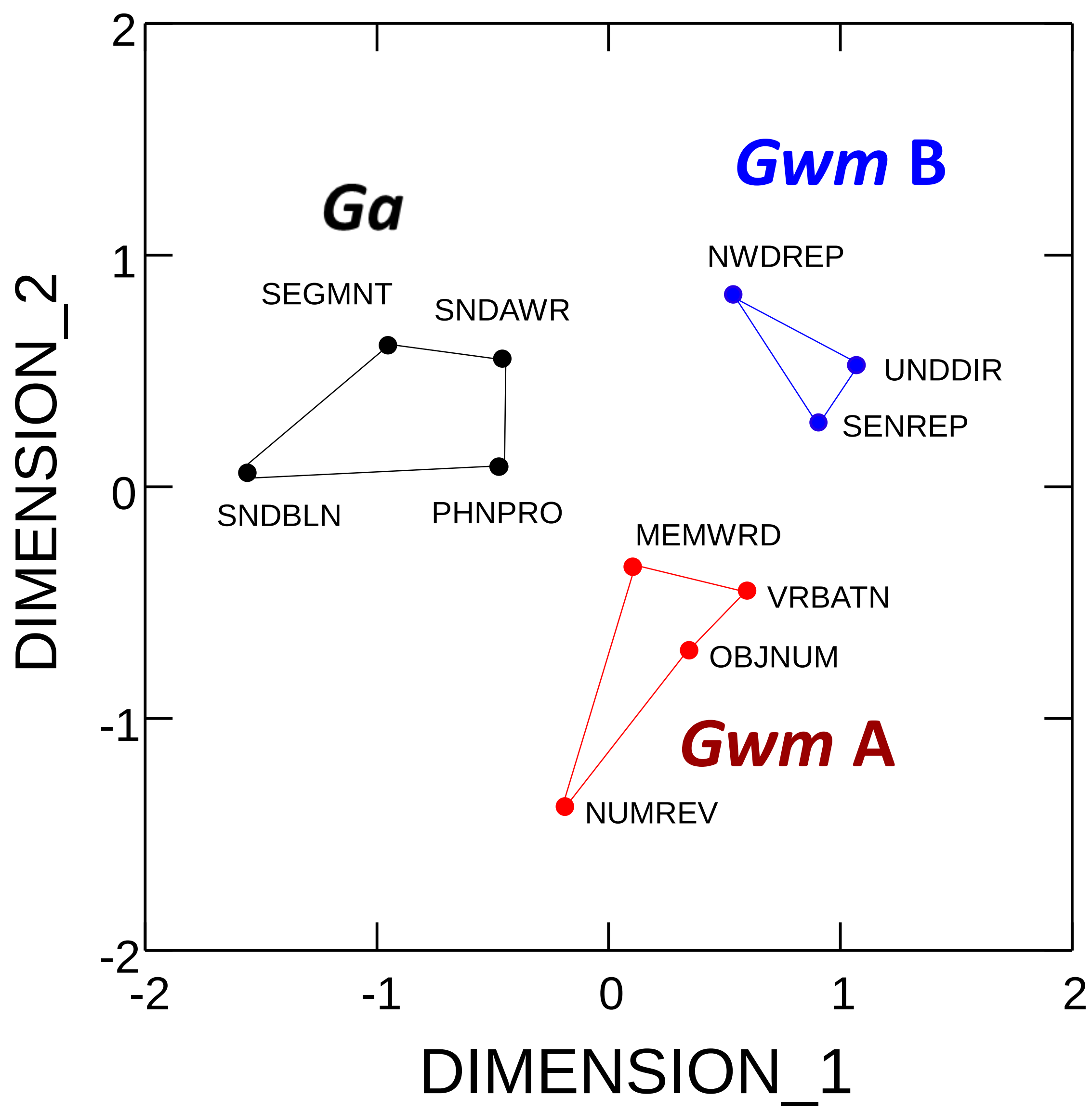


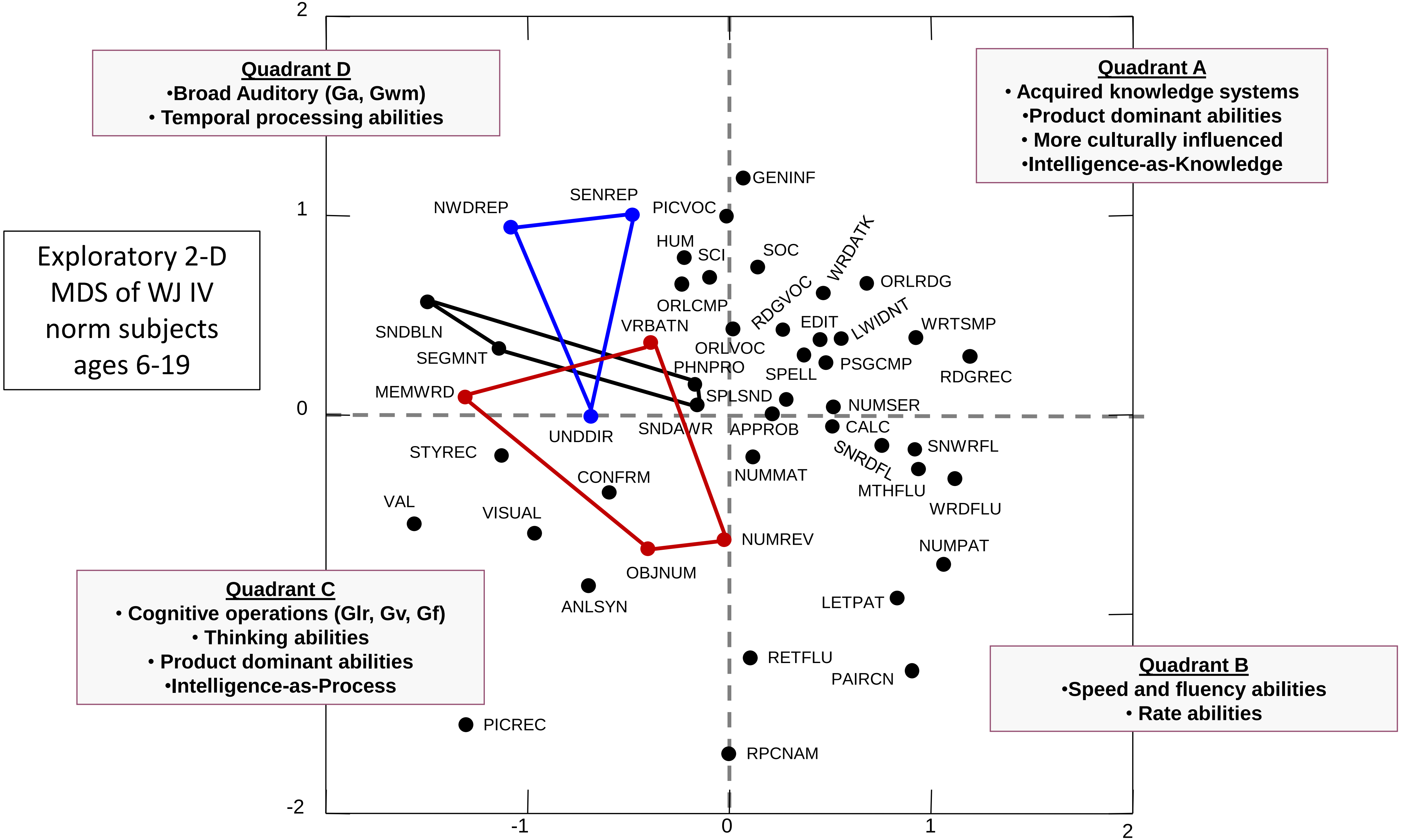


Note: When all WJ IV tests are in the cluster analyses, the same clusters appear—the only difference is that Word Attack and Spelling of Sounds cluster with the *Ga* tests

MDS Configuration – *Ga/Gwm* tests only

Exploratory 2-D MDS analysis of WJ IV norm subjects ages 6-19




Quadrant D
•Broad Auditory (Ga, Gwm)
• Temporal processing abilities
Quadrant A
• Acquired knowledge systems
•Product dominant abilities
• More culturally influenced
•Intelligence-as-Knowledge
Exploratory 2-D MDS of WJ IV norm subjects ages 6-19
Quadrant C
• Cognitive operations (Glr, Gv, Gf)
• Thinking abilities
• Product dominant abilities
•Intelligence-as-Process
Quadrant B
•Speed and fluency abilities
• Rate abilities
GENINF
NWDREP
SENREP
PICVOC
HUM
SCI
SOC
WRDATK
ORLRDG
ORLCMP
RDGVOC
VRBATN
EDIT
LWIDNT
WRTSMP
SNDBLN
SEGMNT
ORLVOC
PHNPRO
PSGCMP
SPELL
RDGREC
MEMWRD
SPLSND
NUMSER
UNDDIR
SNDAWR
APPROB
CALC
STYREC
SNWRFL
SNRDFL
CONFRM
NUMMAT
MTHFLU
WRDFLU
VAL
VISUAL
NUMREV
NUMPAT
OBJNUM
ANLSYN
LETPAT
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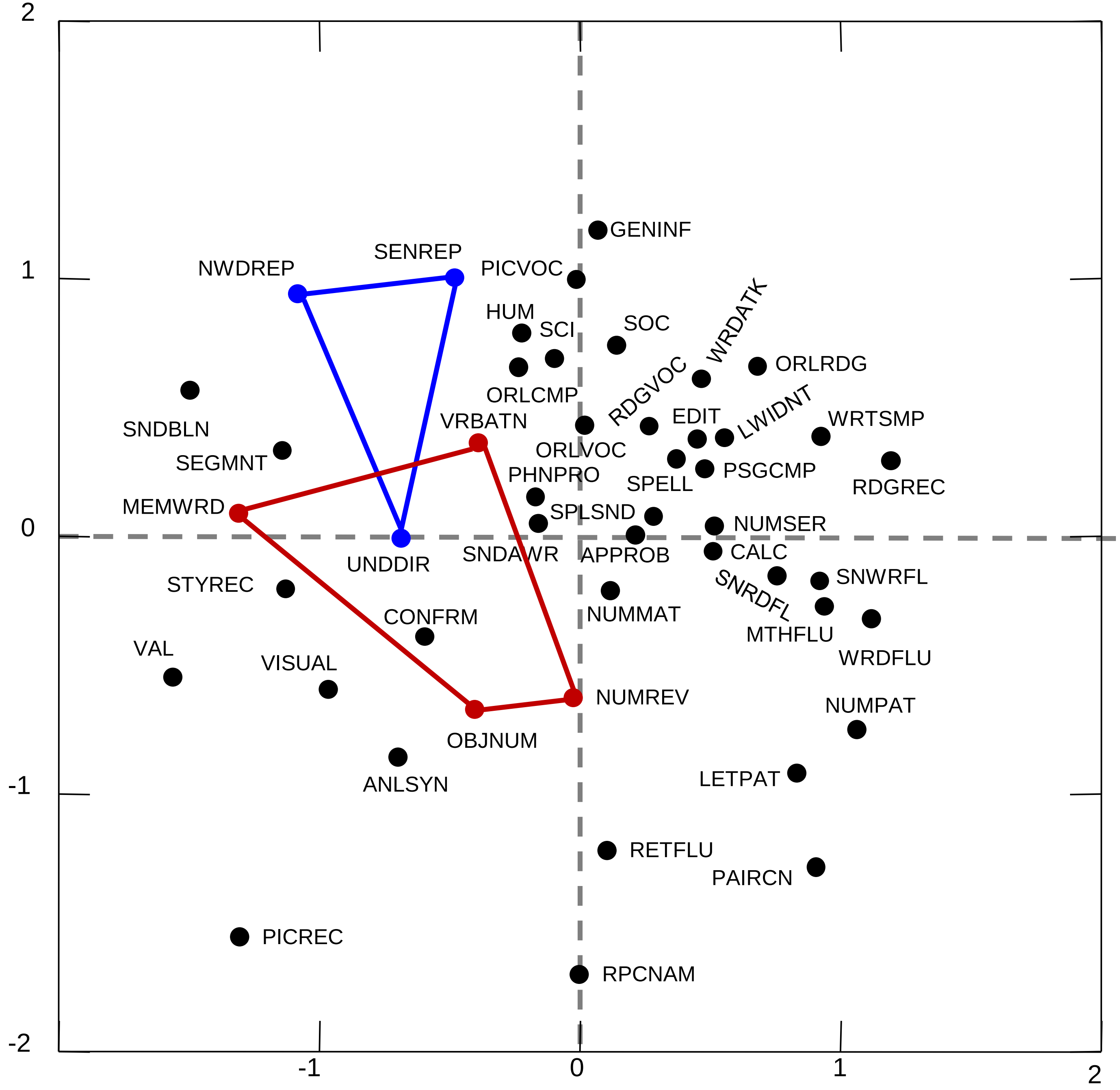
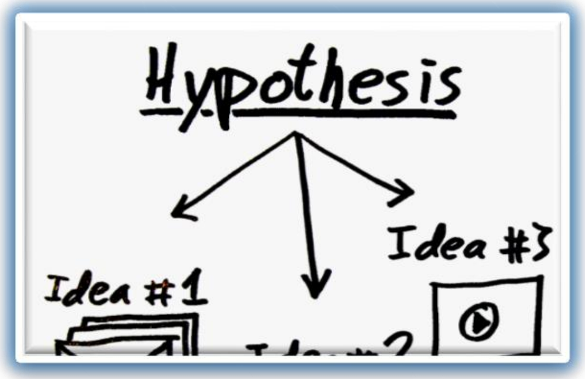
Exploratory MDS of WJ IV norm subjects ages 6-19



Ga grouping lines removed

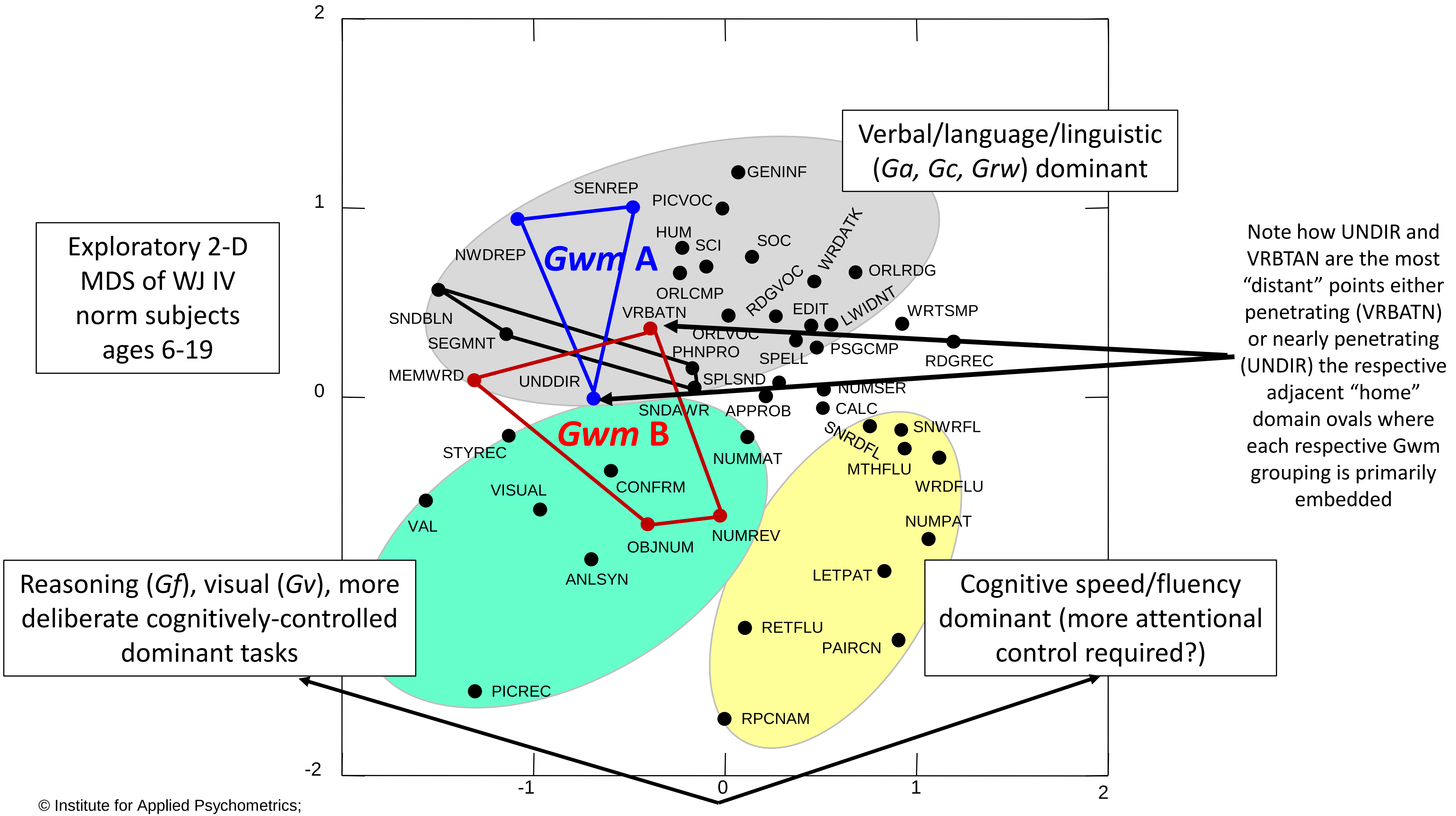


When one reviews these data and puts on one’s thinking cap, the following hypothesis is generated:

The WJ IV COG/OL battery may measure two components or mechanisms of working memory (*Gwm*)

What is the primary distinction?

Gwm A	*Gwm* B
Nonword Repetition	Verbal Attention
Sentence Repetition	Numbers Reversed
Understanding Directions	Object-Number Sequencing
	Memory for Words



More central executive-control network involvement?

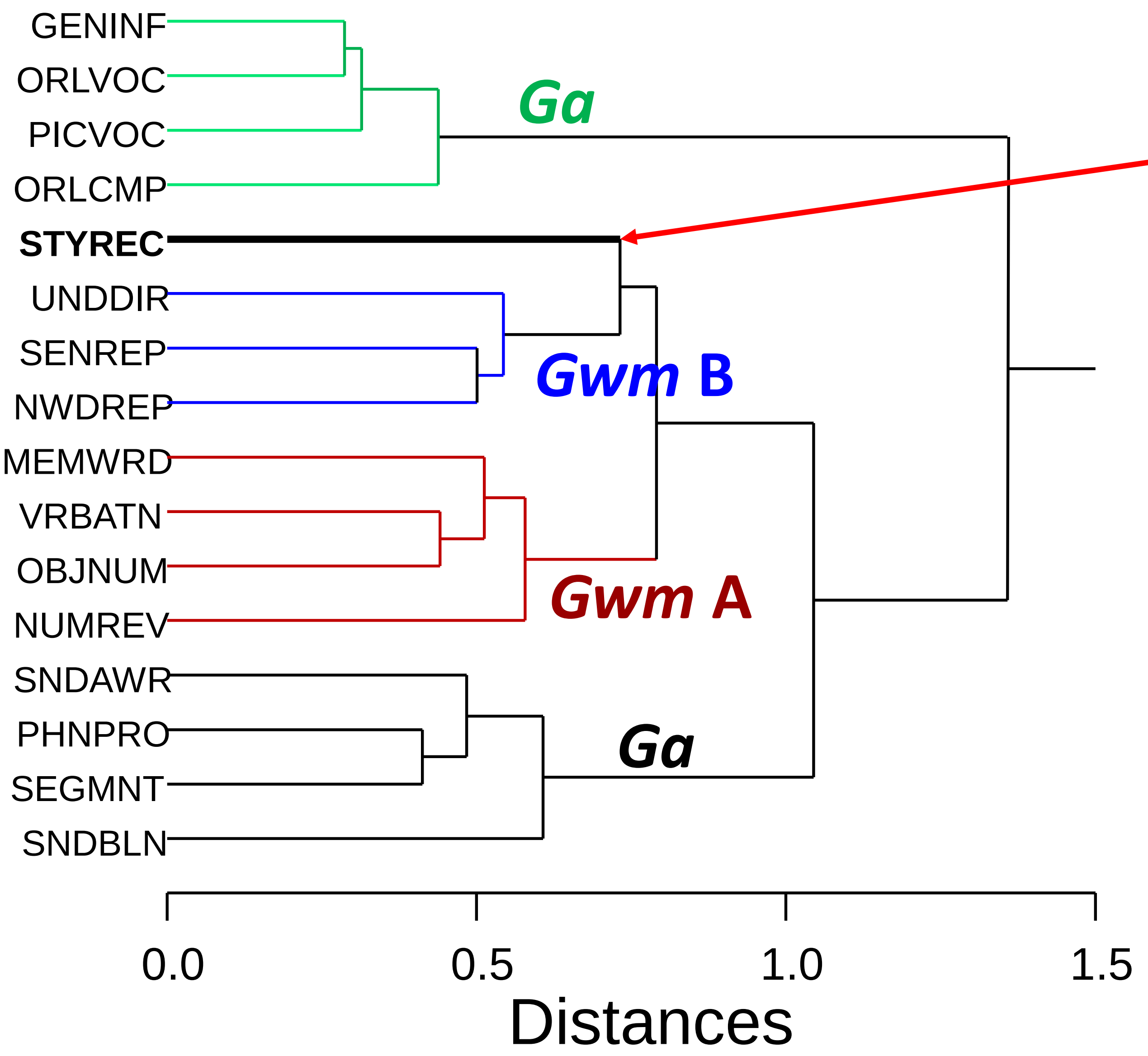
Correlations of *Gwm A* and *Gwm B* tests with 5 other independent CHC broad clusters and 3 broad achievement clusters (ages 6-19; n ≈ 4,100+)

	GF3	GC3	GS	GLR	GV	RDGBRD	MTHBRD	WRTBRD	Mdn
Gwm B									
VRBATN	0.45	0.43	0.31	0.33	0.23	0.43	0.44	0.51	0.43
OBJNUM	**0.51**	0.40	0.47	0.44	0.42	0.36	0.45	0.36	0.44
NUMREV	0.49	0.37	0.40	0.35	0.36	0.44	0.48	0.44	0.40
MEMWRD	0.41	0.33	0.23	0.39	0.36	0.32	0.27	0.33	0.33
Mdn	***0.47***	0.39	***0.36***	0.37	0.36	0.40	0.45	0.40	
Gwm A									
UNDDIR	**0.53**	0.40	0.32	0.44	0.43	0.44	0.43	0.40	0.43
SENREP	0.31	0.45	0.26	0.28	0.33	0.47	0.37	0.43	0.37
NWDREP	0.34	0.36	0.21	0.33	0.36	0.34	0.25	0.40	0.34
Mdn	***0.34***	0.40	***0.26***	0.33	0.36	0.44	0.37	0.40	

Mdn Diff	**0.13**	-0.02	**0.10**	0.04	0.00	-0.05	0.08	0.00

- ***Gwm B*** tests, on average, demonstrate differentially higher correlations (than *Gwm A* tests) with measures of *Gf* (associated with executive functions; executive control network) and *Gs* (speeded attention or speeded attentional control)
- Understanding Directions test shares similarities with ***Gwm B*** tests

Supplementary cluster analyses (Wards method) run to further explore *Gwm* tests (*Gc* tests included to check on possible *Gc* association for STYREC)



Note. STYREC is the last test to group with other tests—indicating that it has the least in common with all other tests in analyses (it had to go somewhere as per the logic of cluster analyses).

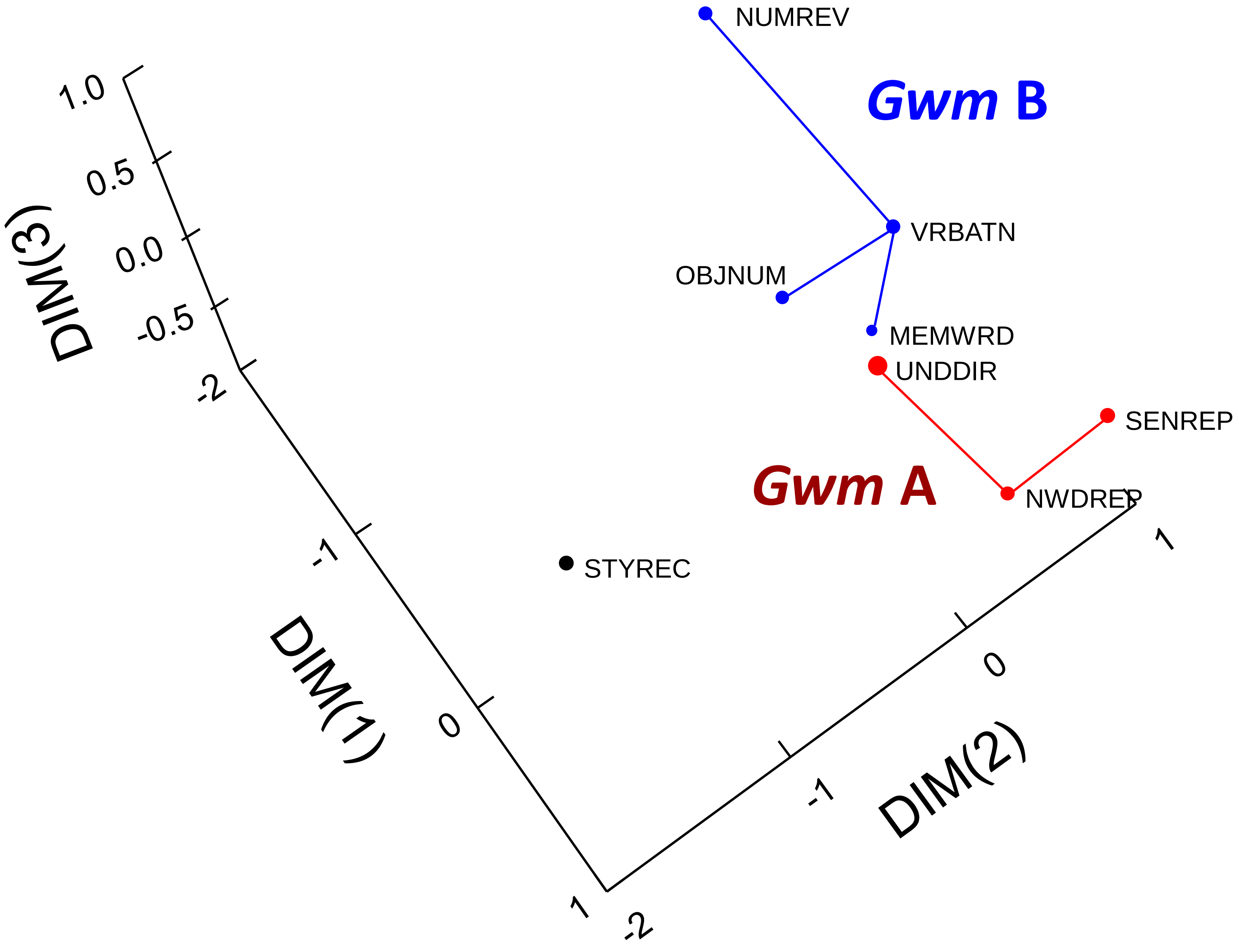
Ho – STYREC does not belong with *Gwm* tests. Is a *Glr* MM measure

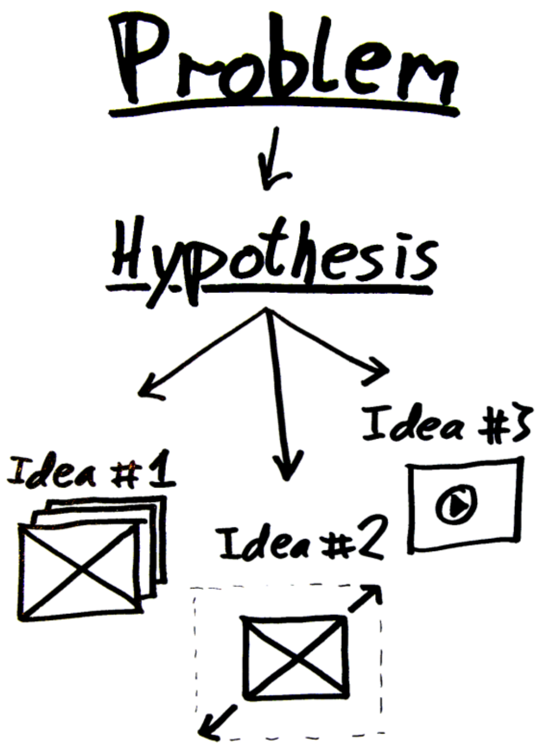
Supplemental 3D MDS model of *Gwm* tests.

<u>Note.</u> A 3-D MDS model with all WJ IV COG/OL/ACH tests was first run…and then all but the remaining tests were removed from the spatial map—to help focus only on the *Gwm* measures.

STYREC is far away from other *Gwm* tests. Confirms Ho that it is *Glr*-MM and does not belong with *Gwm* tests

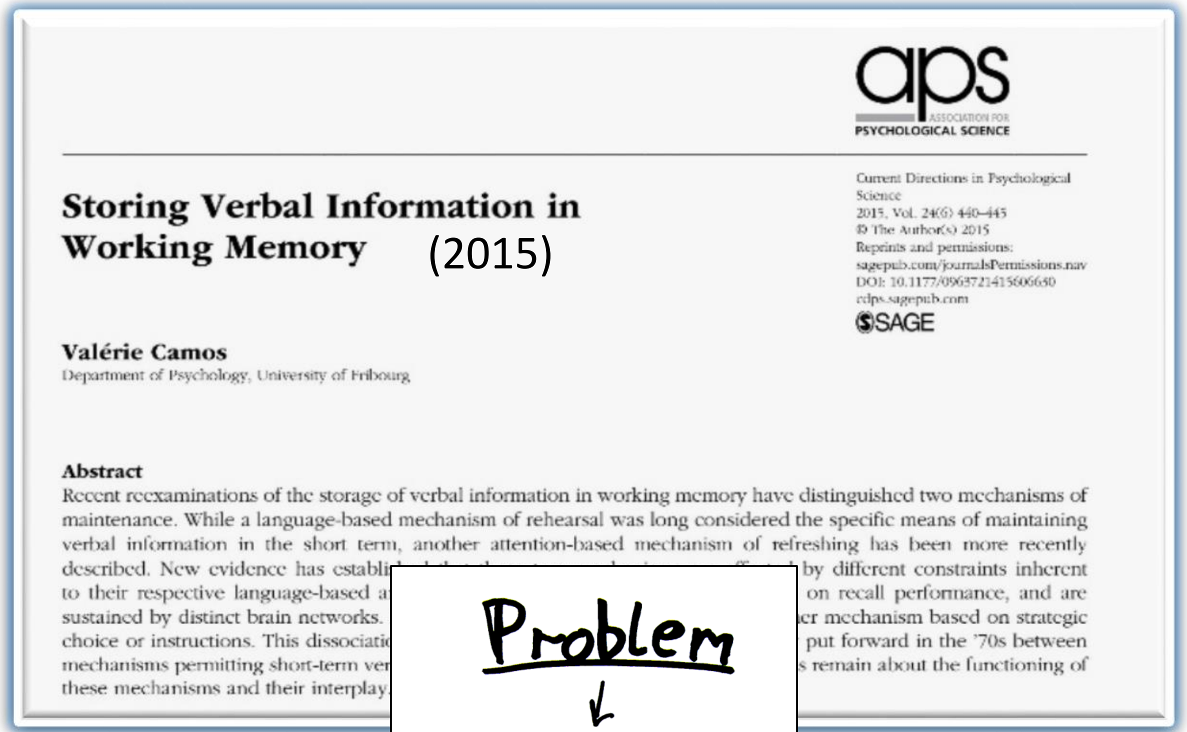
Based on theory and research literature, and exploratory EFA, CA, and MDS of joint *Ga/Gwm* tests, the final hypothesized *Gwm* groupings are suggested in this figure.





The working memory literature is extensive and there is no consensus model regarding the mechanisms of working memory. As a result, a number of viable hypotheses should be entertained when trying to explain test score differences on different working memory tests (*Gwm A* and *Gwm B* in WJ IV)

There may be two primary mechanisms of verbal working memory maintenance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Current Directions in Psychological Science
2015, Vol. 24(6) 440–445
DOI: 10.1177/0963721415606630
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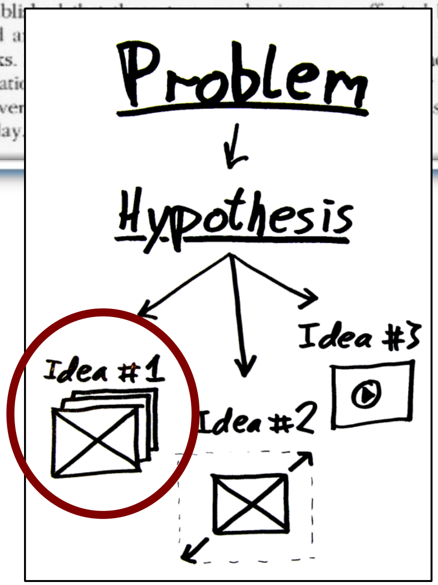
Storing Verbal Information in Working Memory (2015)

Valérie Camos
Department of Psychology, University of Fribourg

Abstract
Recent reexaminations of the storage of verbal information in working memory have distinguished two mechanisms of maintenance. While a language-based mechanism of rehearsal was long considered the specific means of maintaining verbal information in the short term, another attention-based mechanism of refreshing has been more recently described. New evidence has establi … by different constraints inherent to their respective language-based a … on recall performance, and are sustained by distinct brain networks. … er mechanism based on strategic choice or instructions. This dissociati … put forward in the '70s between mechanisms permitting short-term ver … s remain about the functioning of these mechanisms and their interplay.



Tasks that make greater use of the articulatory rehearsal maintenance mechanism

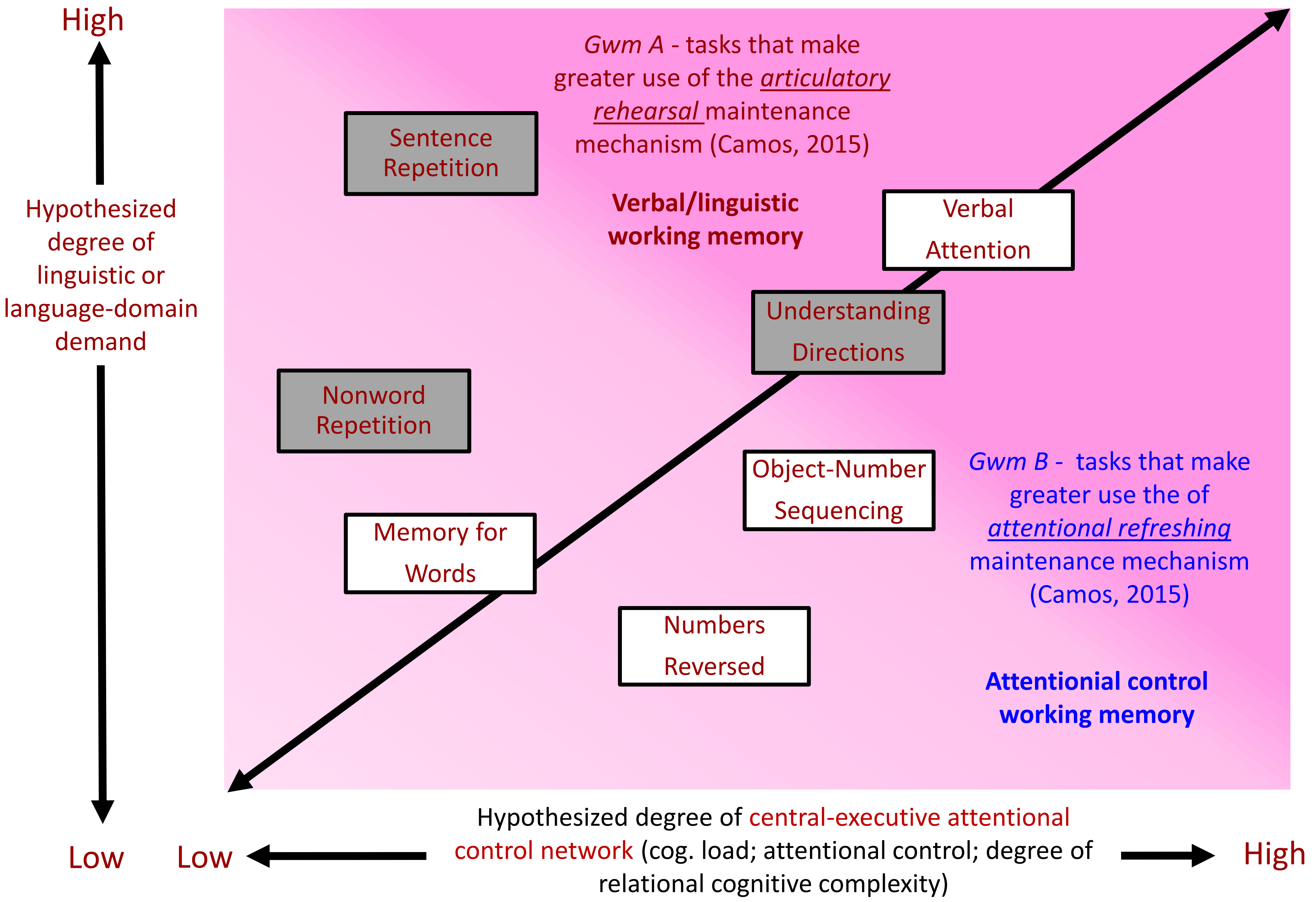
- A language production process mechanism
  - Phonological effects research
    - Covert/overt rehearsal

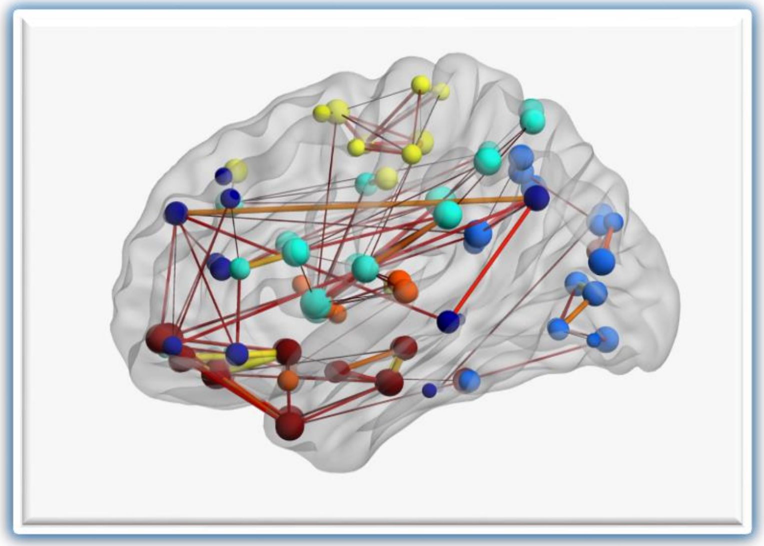
Tasks that make greater use the of attentional refreshing maintenance mechanism

- Reactivation memory trace mechanism across stimulus domains (lang, visual, spatial)
- Increasing focus and inhibiting distractions
- Controlling and directing focus of attention

Distances between tests intended to reflect relative hypothesized differences (not quantified) along two axis

Linguistic/language dimension classifications based on inspection of correlations with other WJ IV tests of *Gc* and *Ga* and Flanagan & Ortiz (2015) linguistic demand classifications

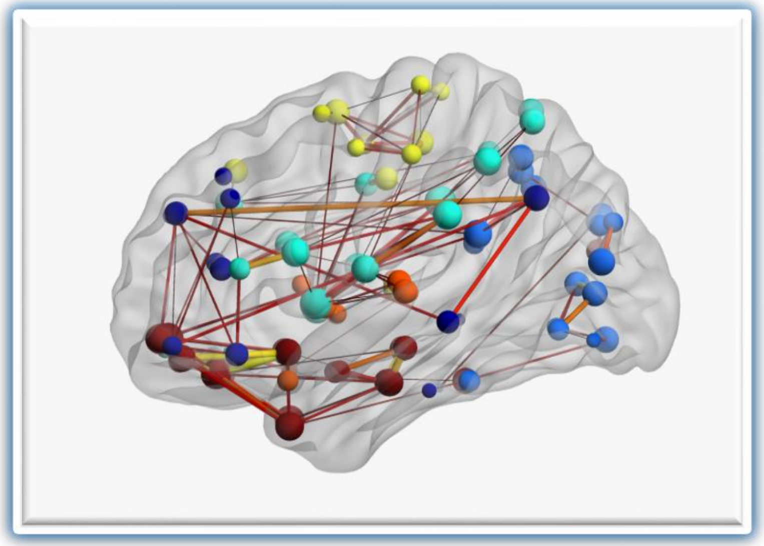




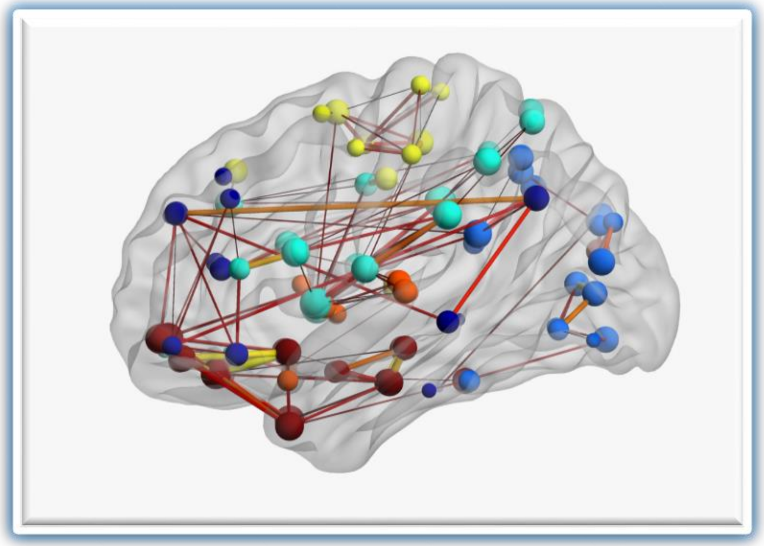
Contemporary brain network research, as well as some classic neuropsychological research, suggests that these two working memory mechanisms likely rely on different brain networks (Bressler & Menon, 2010; Camos, 2015).

Thus, the reason for unusual differences between some working memory tests may be due to different task demands placed on different brain network mechanisms

Verbal/linguistic rehearsal working memory network mechanism

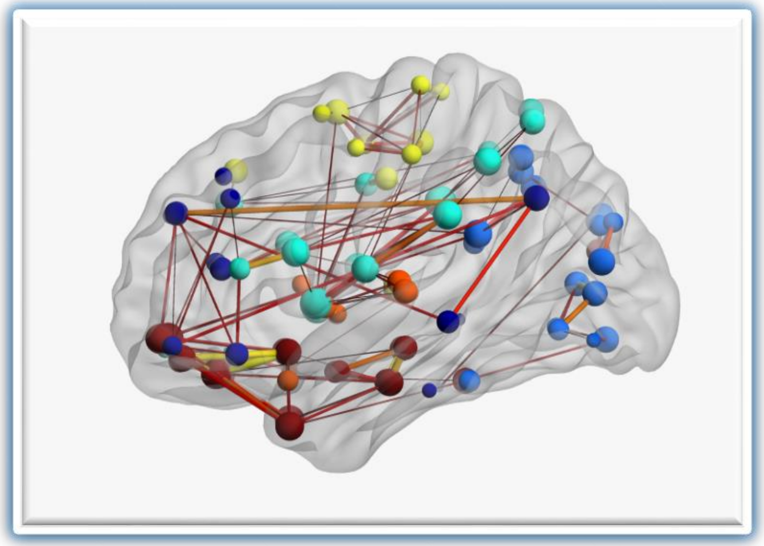


Broca's area, the left premotor cortex, the cortex along the left intraparietal sulcus, and the right cerebellum are active when verbal rehearsal is used. The entire "language network" (e.g., Broca and Wernicke's areas) may be involved (Bresslor & Menon, 2010; Camos, 2015)



Central-executive attentional control network mechanism

The prefrontal and parietal cortex's involved (Bresslor & Menon, 2010; Camos, 2010). Consistent with the Parietal-Frontal Integration (P-FIT) neuro-intelligence model (Cown, 1995; Jung, Haeir, Colom et al.)

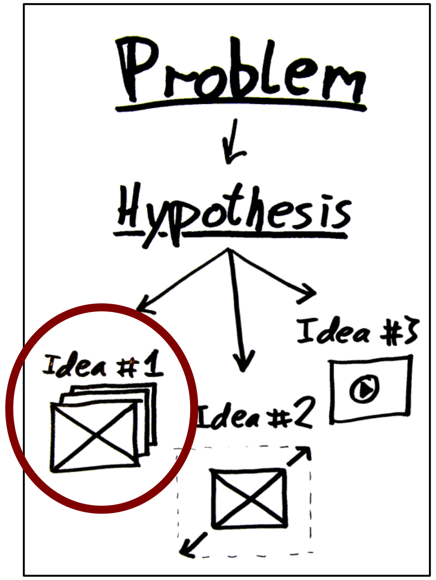


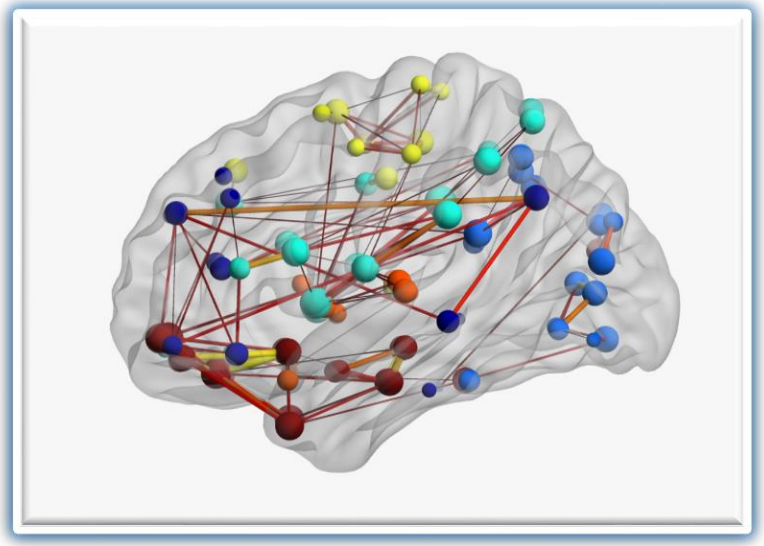
Central-executive attentional control network mechanism

+

Verbal/linguistic rehearsal network mechanism

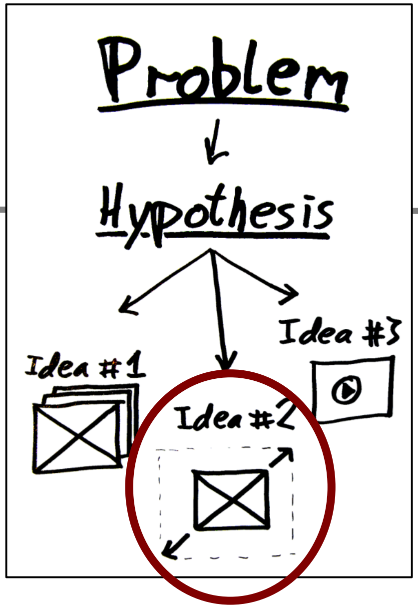
Research has shown that some individuals can be "adaptive" and switch between these working memory mechanisms based on task demands (Camos, 2015).





Unusual differences between some working memory tests may be due to the *Gwm* domain having a substructure where different maintenance mechanisms are required by different tests and these demands may recruit different brain network mechanisms.

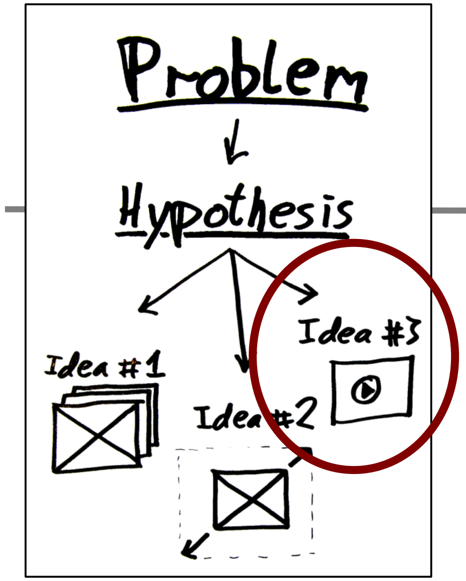
Anybody want a good dissertation topic? This seems like a good one.



Levels of processing differences in *Gwm* tasks

Early memory models (e.g., Craik & Lockart, 1972) proposed that the degree of transfer of information from immediate to long-term memory may depend on whether the material was processed at a surface or shallow level (Type 1) or, in contrast, at a deeper level (Type 2)

Unusual differences between some working memory tests may be due to the *Gwm* domain having a substructure where the level of required cognitive processing demands differ between the tests. It is possible these differential demands may recruit different brain network mechanisms.



Differences in the primary components of *Gwm* tasks

Unsworth and Engle (Unworth, in press; Unsworth & Engle, 2007) have proposed that *Gwm* consists of three major facets or components—primary memory (PM), attentional control (AC), and secondary memory (SM).

Individual differences as reflected by different *Gwm* test scores may "…arise from differences in the capacity of PM, differences in attention control processes that serve to maintain task-relevant information in PM, and differences in control processes that ensure that task-relevant information is properly encoded in and retrieved from SM."

Thus, it is unlikely that differences in *Gwm* test scores can be reduced to a single common cause

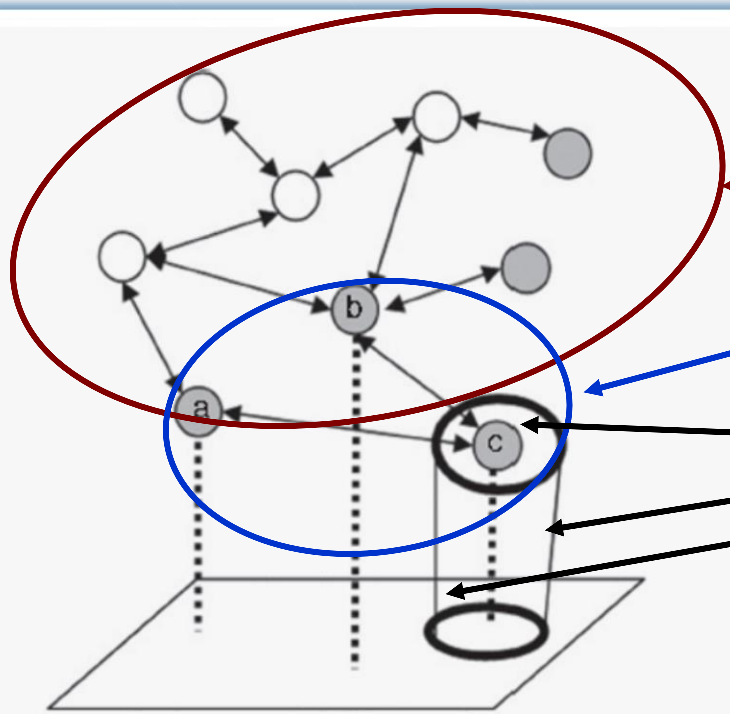


Fig. 1. An illustration of the three-embedded-component model of working memory. Within the network of representations in long-term memory, a subset is activated above baseline (depicted by gray circles). Of these representations, a small number (a, b, and c) are held in the region of direct access (or the broad focus). These items are directly accessible through temporary bindings (indicated by broken lines) that link them to locations in a mental space (e.g., to ordinal positions in a list or to spatial positions on the screen) that serve as cues. The narrow focus of attention (depicted by the bold circles) accesses a single item, using one location in mental space as a cue. Adapted from *Psychology of Learning and Motivation* (Vol. 51, p. 50), by B. H. Ross (Ed.), 2009, San Diego, CA: Academic Press. Copyright 2009, Elsevier. Adapted with permission.

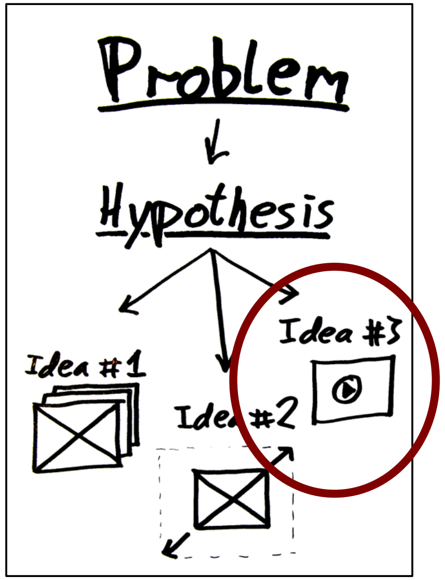
Unsworth's components or facets

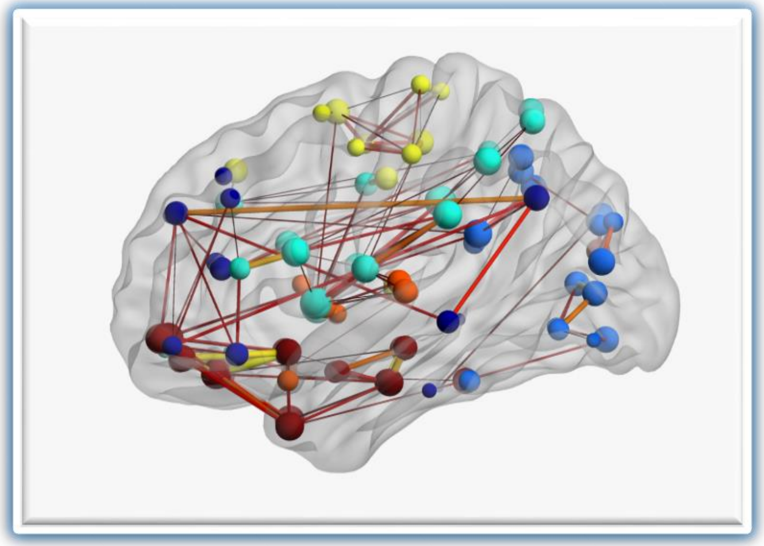
Secondary memory (SM)

Primary memory (PM; aka working memory capacity)

Attentional control (AC)

Oberauer's (2002, 2009) three-embedded-components model of working memory is similar to Unsworth's model



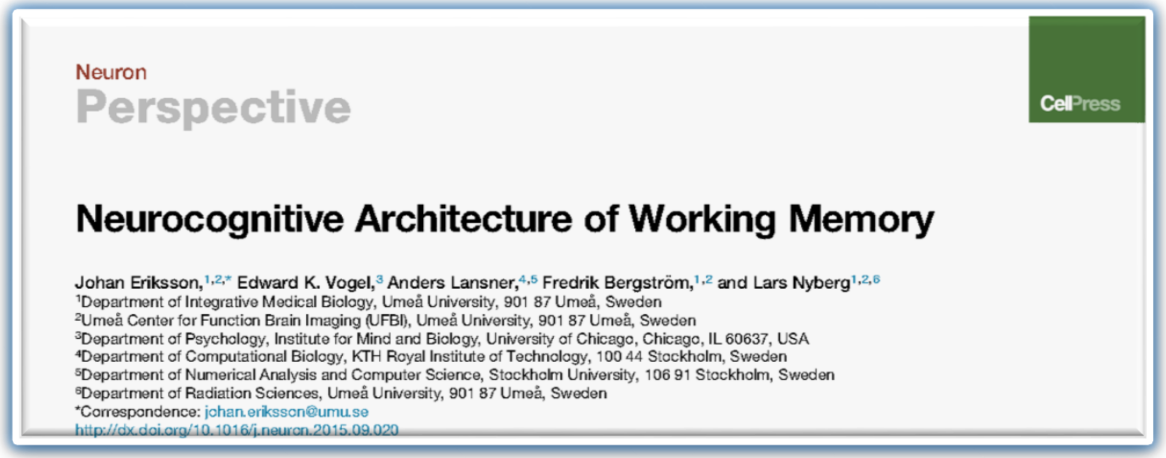


Primary Memory (PM; WMC) differences have been linked to activity in the intraparietal sulcus.

Attentional control (AC) differences have been linked to functioning of the locus coeruleus norepinephrine system (LC-NE). LC is a brain stem neuomodulatory nucleus that is responsible for most of the NE released in the brain, and has widespread projections throughout the necortex—particulary the prefrontal cortex, inferior frontal gyrus, and the anterior cingulate cortex.

Hippocampal activation has been linked to covert retrieval processes that bring items back into PM from SM. Retrieval from SM also associated with the medial temporal lobes.

(Unsworth, in press; Unsworth & Engle, 2007)



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Neurocognitive Architecture of Working Memory

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"Many brain regions interact during working memory and include 'executive' regions in the PFC, parietal cortex, and basal ganglia, as well as regions specialized for processing the particular representations to be maintained, such as the fusiform face area for maintaining face information."

"Persistent neural activity in various brain regions accompanies working memory and is functionally necessary for maintenance and integration of information in working memory."

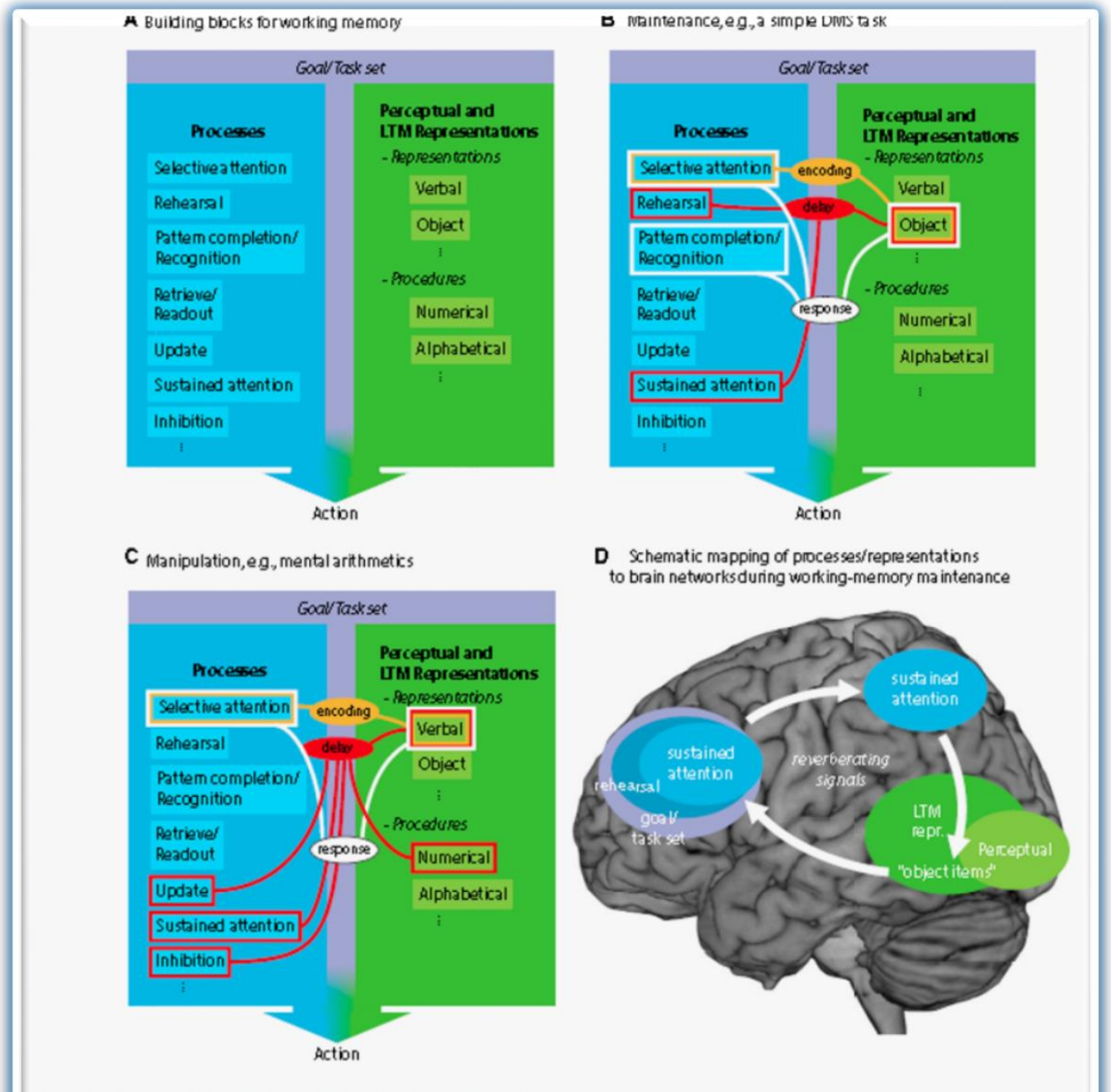
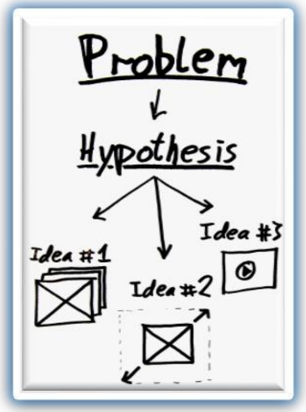
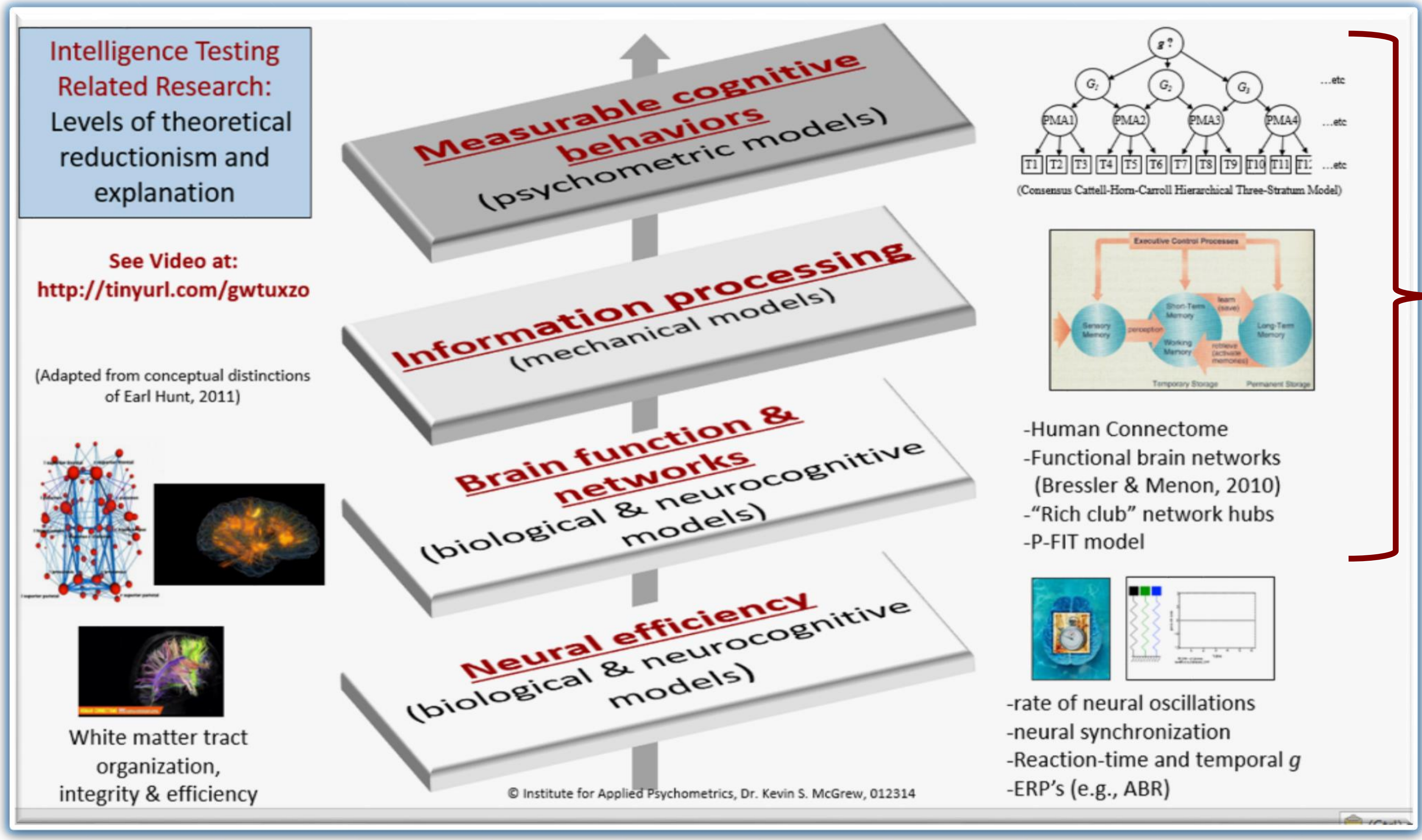


Figure 1. The Component Processes View of Working Memory



Significant score differences between different tests of *Gwm* are to be expected and may be due to numerous variables (content, format, etc.). In addition, when unusual differences occur, this may be due the reported findings that the CHC domain of *Gwm* may have a substructure (at least two measurable dimensions on the WJ IV) that reflects underlying task demands that recruit different brain networks and cognitive control processes.

Note. None of the material in this presentation should be used to make statements about a person's neurological integrity or functioning. This PPT module presents a set of working hypotheses that need further study.



These differential *Gwm* hypotheses are an attempt to integrate research from three primary levels of intelligence related research

For curious minds, recommended readings follow

See video link on this image for narrated explanation of this framework

The neuroscience of human intelligence differences

Ian J. Deary, Lars Penke and Wendy Johnson

Abstract | Neuroscience is contributing to an understanding of the biological bases of human intelligence differences. This work is principally being conducted along two empirical fronts: genetics — quantitative and molecular — and brain imaging. Quantitative genetic studies have established that there are additive genetic contributions to different aspects of cognitive ability — especially general intelligence — and how they change through the lifespan. Molecular genetic studies have yet to identify reliably reproducible contributions from individual genes. Structural and functional brain-imaging studies have identified differences in brain pathways, especially parieto-frontal pathways, that contribute to intelligence differences. There is also evidence that brain efficiency correlates positively with intelligence.

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Intelligence

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Understanding Human Intelligence by Imaging the Brain

Roberto Colom and Paul M. Thompson

The Wiley-Blackwell Handbook of Individual Differences

Edited by Tomas Chamorro-Premuzic, Sophie von Stumm, and Adrian Furnham

WILEY-BLACKWELL
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The Parieto-Frontal Integration Theory (P-FIT) of intelligence: Converging neuroimaging evidence

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Intelligence

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Gray matter correlates of fluid, crystallized, and spatial intelligence: Testing the P-FIT model

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MRI

ABSTRACT

The parieto-frontal integration theory (P-FIT) nominates several areas distributed throughout the brain as relevant for intelligence. This theory was derived from previously published studies using a variety of both imaging methods and tests of cognitive ability. Here we test this theory in a new sample of young healthy adults (N = 100) using a psychometric battery tapping fluid, crystallized, and spatial intelligence factors. High resolution structural MRI scans (3T) were obtained and analyzed with Voxel-based Morphometry (VBM). The main findings are consistent with the P-FIT, supporting the view that general intelligence (g) involves multiple cortical areas throughout the brain. Key regions include the dorsolateral prefrontal cortex, Broca's and Wernicke's areas, the somato-sensory association cortex, and the visual association cortex. Further, estimates of crystallized and spatial intelligence with g statistically removed, still share several brain areas with general intelligence, but also show some degree of uniqueness.

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ELSEVIER

Gray matter and intelligence factors: Is there a neuro-g?

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Structural efficiency within a parieto-frontal network and cognitive differences

CrossMark

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Attention to Information in Working Memory

Klaus Oberauer and Laura Hein
University of Zurich

Psychological Review
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The Nature of Individual Differences in Working Memory Capacity: Active Maintenance in Primary Memory and Controlled Search From Secondary Memory

Nash Unsworth and Randall W. Engle
Georgia Institute of Technology