



The What, When, and How of the Wechsler General Ability Index

Jianjun Zhu, PhD

Susan Engi Raiford, PhD

Diane Coalson, PhD

Discussant: Donald H. Saklofske, PhD



What is the GAI?

Jianjun Zhu, PhD



GAI=General Ability Index

- The GAI is an optional index score for the WISC-IV and the WAIS-IV.
- The GAI is derived from the core Verbal Comprehension and Perceptual Reasoning subtests.
- The GAI provides an estimate of general intellectual ability, with *reduced emphasis* on working memory and processing speed relative to the FSIQ.
- Theoretically, the GAI represents an individual's overall cognitive ability, if working memory and processing speed abilities were similar to verbal and non-verbal abilities.



CPI=Cognitive Proficiency Index

- The CPI is an optional index score for the WISC-IV and the WAIS-IV.
- The CPI is the counterpart to the GAI. It is derived from the core Working Memory and Processing Speed subtests.
- Theoretically, the CPI represents an individual's proficiency at cognitive processing.
- Efficient cognitive processing frees-up cognitive resources for more complex or higher-level tasks



Common GAI Myth #1

- The GAI is FSIQ without working memory and processing speed
 - Fact: GAI taps working memory and processing speed, but to a lesser degree than FSIQ
 - Fact: Cognitive abilities are interrelated
 - Fact: Even measures of “pure” domains are not pure (e.g., Coding more than graphomotor processing speed)



Intra-Index Correlations

		PRI	VCI
PSI	Direct r	.51 <.0001	.43 <.0001
	Partial r	.25 <.0001	.08 <.0004
WMI	Direct r	.62 <.0001	.64 <.0001
	Partial r	.30 <.0001	.40 <.0001

Kyllonen, P.C., & Christal, R.E. (1990). Reasoning ability is (little more than) working-memory capacity?! *Intelligence*, 14, 389-433.



Working Memory

A limited capacity system that facilitates a range of cognitive activities, such as reasoning, learning and comprehension (Baddeley, 2003)

Two slave systems:

Phonological loop & visual spatial sketch pad

Short-term maintenance of information

Central executive system:

Directs attention to relevant information

Suppresses irrelevant information and actions

Coordinates cognitive processes



Processing Speed

The brain requires time and capacity to process information.

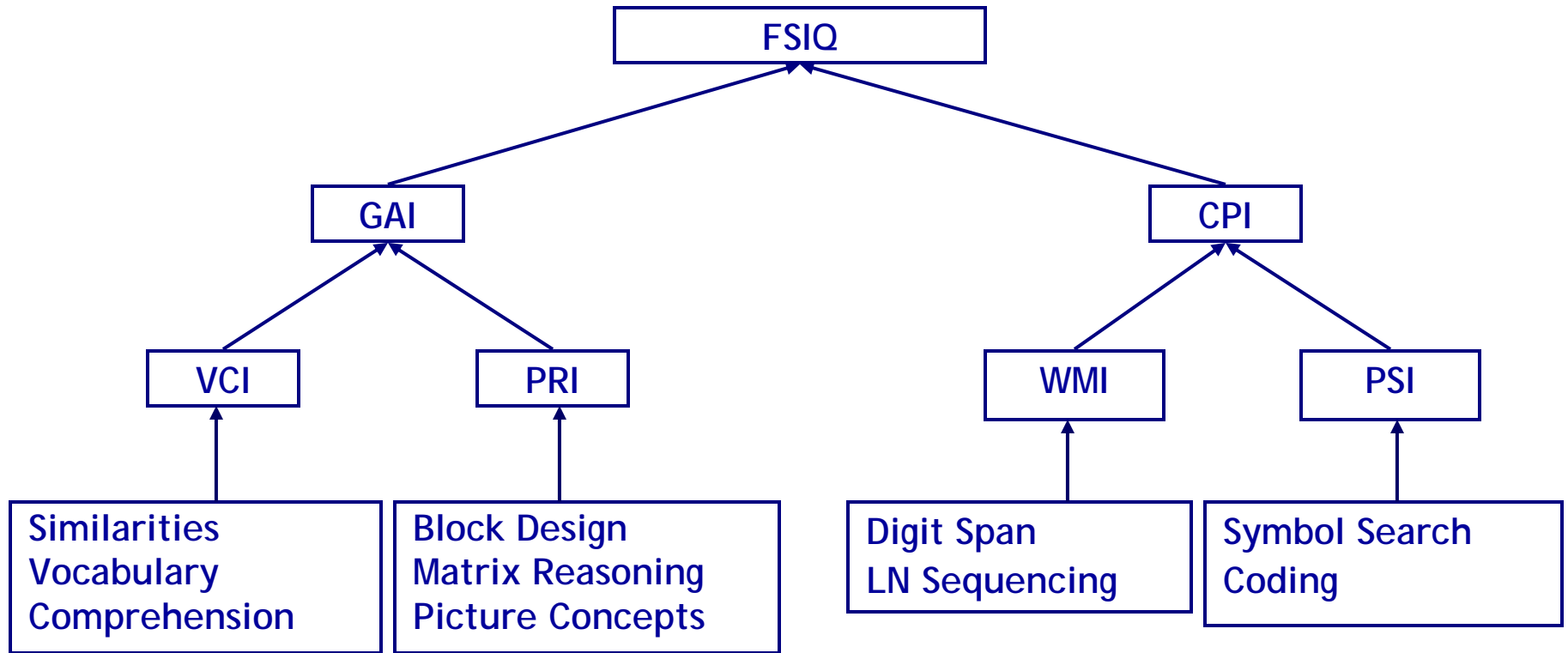
Recent research (Thompson, 2009) suggests that intelligence is strongly influenced by the quality of the brain's axons (the wiring that sends brain signals). The faster the signaling, the faster the brain processes information.

Performance on various tests of intelligence is correlated with reaction time - even a task as simple as hitting a button when it lights up.

Recent brain-mapping research indicates that processing speed is distributed throughout the noggin (Gläscher, et al. 2009).

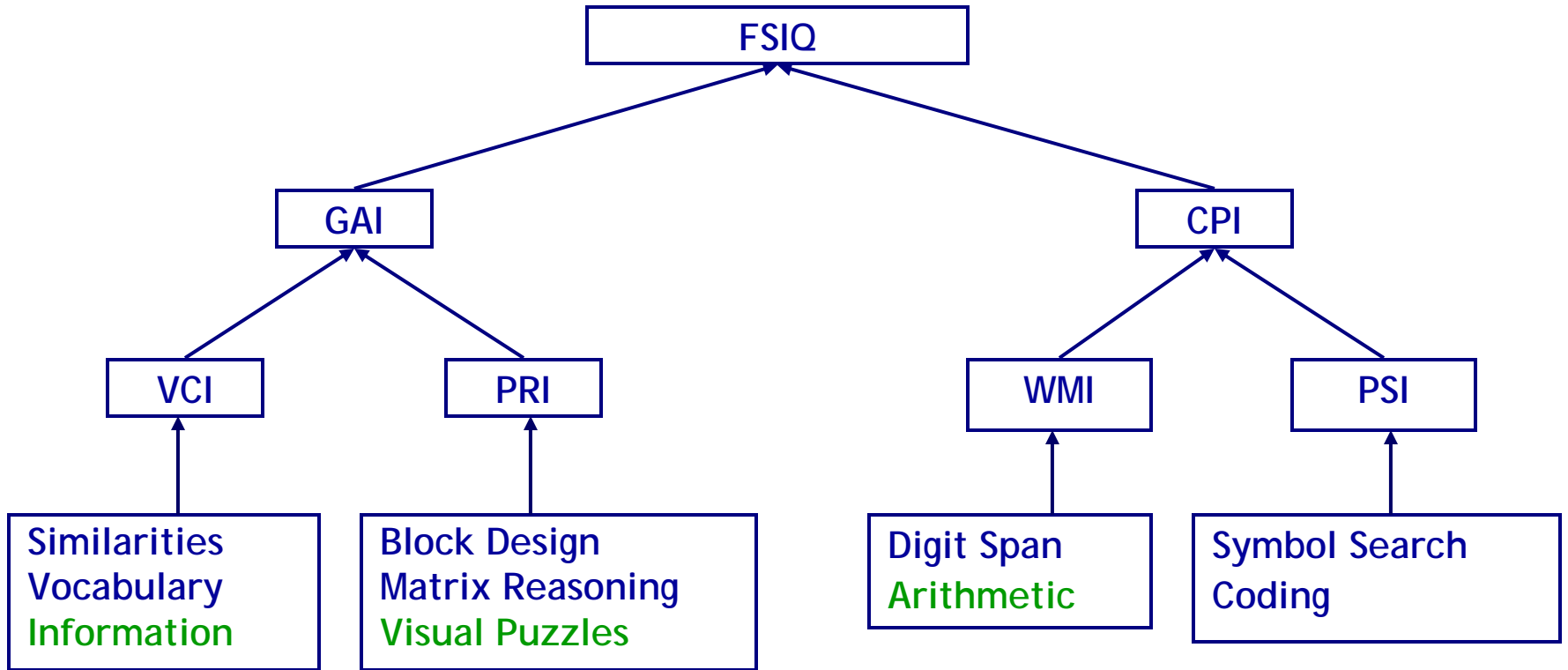


WISC-IV Structure With GAI & CPI



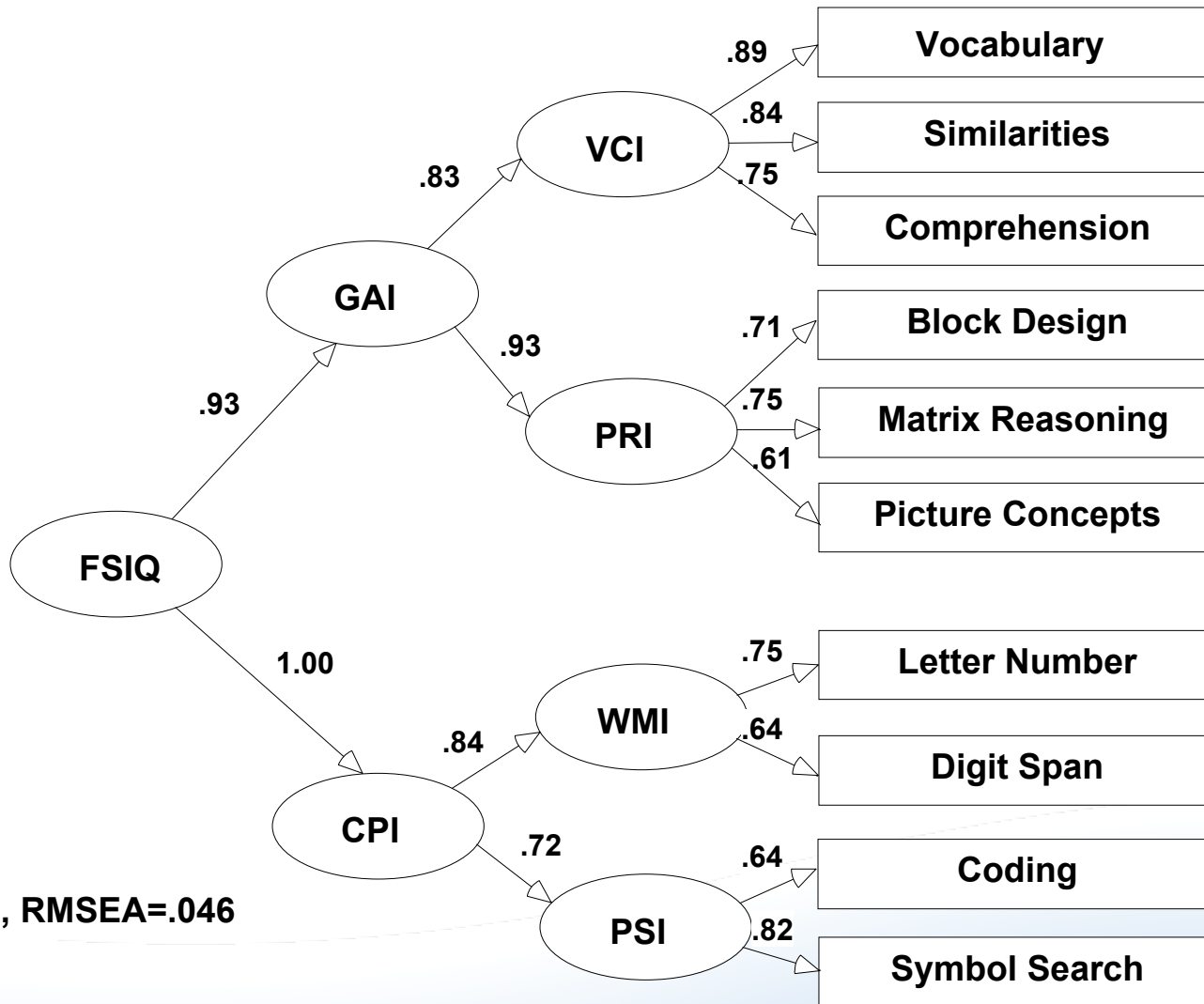


WAIS-IV Structure With GAI & CPI





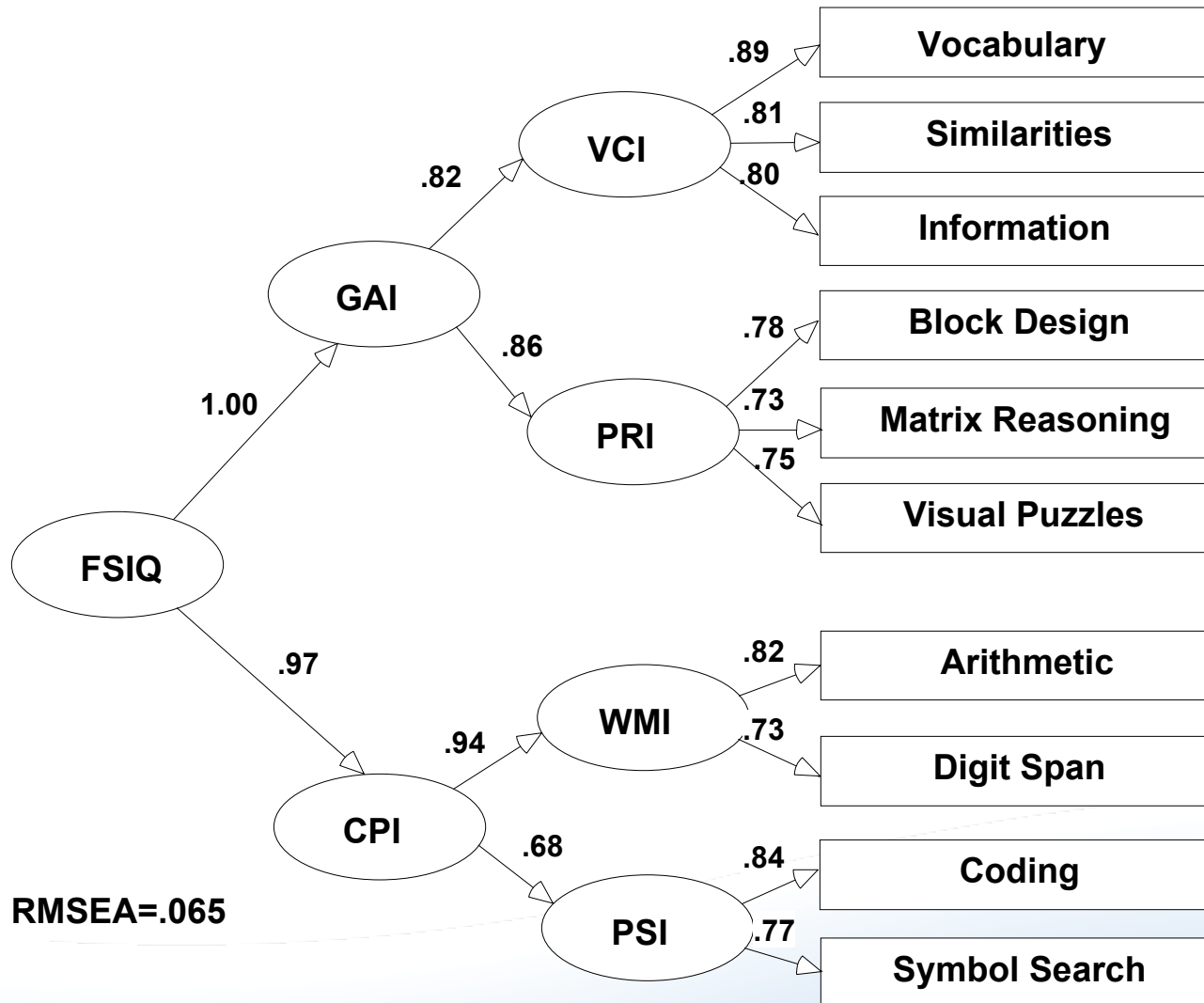
WISC-IV CFA With GAI & CPI



AGFI=.97, RMSEA=.046



WAIS-IV CFA With GAI & CPI



AGFI=.95, RMSEA=.065



Related Reading

Baddeley, A. (2003). Working memory: Looking back and looking forward. *Neuroscience*, 4, 829-839.

Chiang, M., et al. (2009). Genetics of brain fiber architecture and intellectual performance. *Journal of Neuroscience*, 29 (7): 2212-2224.

Gläscher, D. T., et al. (2009) Lesion mapping of cognitive abilities linked to intelligence. *Neuron*, 91 (5) 681-691.



When Should I Use the GAI?

Susan Engi Raiford, PhD



When GAI? Intrascale Comparisons

- Intrascale (within WISC-IV or WAIS-IV) comparisons desired at a higher level than Index score comparisons
 - Enrich clinical interpretation
 - Different theoretical perspective or cognitive model
 - General high level check
 - GAI vs. FSIQ
 - GAI vs. CPI



More Subtests Involved in Comparison
= Smaller Measurement Error

- Relative to comparisons involving the four traditional index scores, more subtests (all core subtests) involved in comparison
 - In general, smaller measurement error (see next slides)



WAIS-IV VCI, PRI, and GAI SEMs, by Age

Score	16-17	18-19	20-24	25-29	30-34	35-44	45-54
VCI	3.67	3.00	3.00	3.00	3.00	3.00	2.60
PRI	3.35	3.67	3.67	3.00	3.00	3.35	3.00
GAI	3.00	2.60	2.60	2.60	2.60	2.60	2.12



WAIS-IV VCI, PRI, and GAI SEMs, by Age

Score	55-64	65-69	70-74	75-79	80-84	85-90	All Ages
VCI	2.60	2.60	2.60	3.00	2.60	2.12	2.85
PRI	3.35	3.35	3.35	3.67	4.24	3.97	3.48
GAI	2.60	2.12	2.60	2.60	2.60	2.60	2.57



WAIS-IV WMI, PSI, and CPI SEMs, by Age

Score	16-17	18-19	20-24	25-29	30-34	35-44	45-54
WMI	3.97	3.67	4.24	3.35	3.35	3.35	3.35
PSI	5.20	4.74	4.74	4.74	5.41	5.41	5.41
CPI	3.97	3.67	3.67	3.35	3.67	3.67	3.67



WAIS-IV WMI, PSI, and CPI SEMs, by Age (cont'd)

Score	55-64	65-69	70-74	75-79	80-84	85-90	All Ages
WMI	3.67	3.67	3.97	3.35	3.67	3.97	3.67
PSI	4.50	4.50	4.50	4.24	4.24	4.24	4.78
CPI	3.35	3.35	3.35	3.00	3.35	3.35	3.50



More Subtests Involved in Comparisons
= Broader Perspective

- More subtests, so:
 - Broader construct coverage (but, less specific than the individual index scores)
 - Ability from a verbal and performance perspective
 - GAI and CPI both encompass subtests that sample verbal and performance, rather than mostly one or the other as on individual index scores
 - More varied presentation and response modalities within the GAI and CPI than within each index score
 - Verbal and Pictorial Stimuli
 - Verbal and Nonverbal Responses



Aggregating Clinically Sensitive Subtests (CPI) = More Powerful Picture of Strengths and Weaknesses

- Examples (see next slides)
 - Clinical vs. matched control studies, with GAI and CPI values
 - Comparison of GAI/CPI discrepancy baserates in WAIS-IV clinical groups and normative sample
 - (for illustration only; uses group mean data with baserate data designed to be used with individuals)



Learning Disorder: Reading

Composite	Clinical Mean	Control Mean	Mean Diff.	<i>p</i> value	Effect Size
VCI	89.5	98.6	9.06	<.01	.61
PRI	91.1	97.3	6.24	.04	.48
WMI	88.9	101.1	12.21	<.01	.90
PSI	94.5	97.1	2.59	.40	.22
GAI	89.2	97.5	8.35	<.01	.59
CPI	90.3	98.9	8.62	<.01	.73
FSIQ	88.7	97.9	9.18	<.01	.71

N=34

(avg age 18)



Learning Disorder: Reading

Composite	Clinical Mean	Control Mean	Mean Diff.	<i>p</i> value	Effect Size
VCI	91.9	100.9	9.00	<.01	.89
PRI	94.4	99.3	4.91	<.01	.48
WMI	87.0	99.8	12.81	<.01	1.10
PSI	92.5	98.6	6.16	.01	.53
GAI	92.9	100.7	7.84	<.01	.86
CPI	88.1	99.0	10.96	<.01	.96
FSIQ	89.1	99.9	10.79	<.01	1.08

N=56

(avg age 10)



Learning Disorder: Reading GAI/CPI Discrepancy Comparison

Scale	GAI Clinical Mean	CPI Clinical Mean	GAI/CPI Mean Diff.	Clinical Group Baserate	Normative Sample Baserate by FSIQ Ability
WAIS-IV (age 18)	89.2	90.3	-1.08	64.7	59.6
WISC-IV (age 10)	92.9	88.1	4.8	58.5	40.4



WAIS-IV ADHD

Composite	Clinical Mean	Control Mean	Mean Diff.	<i>p</i> value	Effect Size
VCI	100.9	102.8	1.93	.51	.12
PRI	98.6	103.4	4.82	.08	.34
WMI	94.7	100.6	5.91	.02	.43
PSI	94.0	100.4	6.36	.01	.49
GAI	99.8	103.5	3.68	.18	.24
CPI	93.6	100.5	6.93	<.01	.53
FSIQ	96.9	102.4	5.52	.02	.39

N=44

(avg age 23)



WISC-IV ADHD

Composite	Clinical Mean	Control Mean	Mean Diff.	<i>p</i> value	Effect Size
VCI	99.0	102.5	3.43	.07	.26
PRI	100.1	102.3	2.15	.22	.16
WMI	96.1	101.7	5.57	.01	.38
PSI	93.4	100.7	7.30	<.01	.59
GAI	100.3	103.3	2.96	.12	.22
CPI	94.0	101.2	7.21	<.01	.57
FSIQ	97.6	102.7	5.06	.01	.38

N=89

(avg age 11)



ADHD

GAI/CPI Discrepancy Comparison

Scale	GAI Clinical Mean	CPI Clinical Mean	GAI/CPI Mean Diff.	Clinical Group Baserate	Normative Sample Baserate by FSIQ Ability
WAIS-IV (age 23)	99.8	93.6	6.2	52.3	28.5
WISC-IV (age 11)	100.3	94.0	6.3	42.7	32.4



WAIS-IV

Asperger's Disorder

Composite	Clinical Mean	Control Mean	Mean Diff.	<i>p</i> value	Effect Size
VCI	104.5	105.9	1.35	.71	.08
PRI	100.0	103.7	3.70	.22	.25
WMI	96.0	105.1	9.13	<.01	.59
PSI	88.4	100.7	12.33	<.01	.91
GAI	102.5	105.5	3.05	.36	.19
CPI	90.9	103.2	12.33	<.01	.89
FSIQ	97.5	104.9	7.35	.02	.50

N=40

(avg age 23)



WISC-IV

Asperger's Disorder

Composite	Clinical Mean	Control Mean	Mean Diff.	<i>p</i> value	Effect Size
VCI	105.6	109.9	4.15	.28	.27
PRI	101.2	107.3	6.04	.15	.39
WMI	95.4	104.9	9.46	.08	.58
PSI	86.6	100.6	14.08	<.01	.94
GAI	104.7	110.2	5.54	.15	.36
CPI	89.7	103.5	13.85	<.01	.87
FSIQ	99.2	107.1	7.96	.06	.52

N=27

(avg age 13)



Asperger's Disorder GAI/CPI Discrepancy Comparison

Scale	GAI Clinical Mean	CPI Clinical Mean	GAI/CPI Mean Diff.	Clinical Group Baserate	Normative Sample Baserate by FSIQ Ability
WAIS-IV (age 23)	102.5	90.9	11.56	55.0	16.2
WISC-IV (age 13)	104.7	89.7	15.00	56.0	15.5



When GAI?

Comparison with Non-Ability Scores (cont'd)

- Some clinical conditions (e.g., Learning Disorders, memory issues)
 - Working Memory and/or Processing Speed subtest performance more likely to be lowered
 - Results:
 - lower FSIQ score
 - mask actual differences b/w cognitive ability and other scores
- Examples
 - FSIQ and WMS-IV scores
 - FSIQ and WIAT-III scores
- GAI comparison gives a different perspective, different results
 - Cognitive potential vs. memory or vs. achievement: how might this discrepancy be different if the clinical problem were treated successfully?



How do I interpret the GAI?

Diane Coalson, PhD



Section Goals

- Identify two more common GAI myths.
- Describe appropriate incorporation of GAI into interpretive reports.
- Provide a case study demonstrating the clinical utility of the GAI in an interpretive report.



Common GAI Myths #2 and #3

- The GAI can be used routinely as a substitute for the FSIQ
 - With rare exceptions (motor impairment, invalid FSIQ score), the GAI is not a substitute for the FSIQ
 - FSIQ more comprehensive; Working memory and processing speed are integral aspects of general intelligence
- The FSIQ is invalid if there are significant Index- Score differences, so use the GAI
 - FSIQ is invalid only if there are too few valid subtests to derive the score (even with substitution and proration)
 - Most of us (73.5% in WAIS-IV) have at least one Index Score that significantly differs from the mean of the Index Scores



GAI Comparisons

- Whenever possible, the GAI should be reported and interpreted in light of other scores; FSIQ, CPI, or Scores from other measures
 - **FSIQ vs. GAI** = comparison of two measures of general cognitive ability that differ in terms of emphasis on working memory and processing speed
 - **GAI vs. CPI** = comparison of a measure of current knowledge and reasoning ability to cognitive proficiency
 - **GAI vs. Achievement or Memory scores** = comparison of a measure of general cognitive ability to measures of achievement or memory



Case 1: Referral Question

- Evaluate for Memory Difficulties
 - Review medical, academic, work, social, and other relevant history
 - Individual and Spouse Interview
 - Administer WAIS-IV and WMS-IV



Case 1: Demographic Background

- Age: 63
- Sex: Female
- Race/Ethnicity: Caucasian
- Education Level: BA + 1 year grad school
- Region of Residence: Northeast



Case 1: Relevant Background

- Lives with spouse
- Retired English Teacher
- Volunteers at hospital 3 days/week
- Active, but admits to increasing difficulty recalling information (over ~1.5 years)
- Spouse also notes increased memory difficulties, missed appts, retelling stories
- Mother Dx w/Alzheimer's at age 74
- Current Medications: Prempro, Pravastatin



Case 1: Hypotheses

- Expect WMI and PSI to be lower than the VCI.
- Expect CPI to be lower than the GAI.
- Expect GAI to be higher than the FSIQ.
- Expect >1 WMS-IV memory scores to be lower than GAI



Case 1: Composite Scores

Sum of Scaled Scores to Composite Score Conversion

Scale	Sum of Scaled Scores	Composite Score	Percentile Rank	Confidence Interval*
				90% or 95%
Verbal Comprehension	40	VCI 118	88	112-123
Perceptual Reasoning	31	PRI 102	55	96 - 108
Working Memory	18	WMI 95	37	89-102
Processing Speed	17	PSI 92	30	84-101
Full Scale	106	FSIQ 104	61	100-108
General Ability	71	GAI 111	77	95 - 107
Cognitive Proficiency	35	CPI 93	32	87-100



Case 1: Composite Comparisons

Discrepancy Comparison					Critical Value	Significant Difference	Base Rate	MCI Clinical Base Rate
		Score 1	Score 2	Difference	.15 or .05			
Index Level	VCI – PRI	VCI 118	- PRI 102	= 16	8.31	Y or N	13.1	2.5
	VCI – WMI	VCI 118	- WMI 95	= 23	8.82	Y or N	4.1	5.0
	VCI – PSI	VCI 118	- PSI 92	= 26	10.19	Y or N	5.8	5.0
	PRI – WMI	PRI 102	- WMI 95	= 7	9.74	Y or N	29.4	35.8
	PRI – PSI	PRI 102	- PSI 92	= 10	11.00	Y or N	23.4	22.5
	WMI – PSI	WMI 95	- PSI 92	= 3	11.38	Y or N	42.1	40.0
	FSIQ – GAI	FSIQ 104	- GAI 111	= -7	3.51	Y or N	10.8	12.5
	GAI – CPI	GAI 111	- CPI 93	= 18	8.31	Y or N	12.8	22.5



Ability-Memory Comparison

Predicted-Difference Method

Ability-Memory Analysis

Discrepancy Analysis

WAIS-IV Ability Score Type GAI VCI PRI	Predicted-Difference Method			Simple-Difference Method			Significance Level .05 or .01						
	Index	Predicted WMS-IV Index Score	Actual WMS-IV Index Score	Difference	WAIS-IV Composite Score	WMS-IV Index Score	Difference	Critical Value	Significant Difference	Base Rate			
Auditory Memory	106	-	95	=	11	<input type="text"/>	-	<input type="text"/>	=	<input type="text"/>	8.95	Y or N	20
Visual Memory	106	-	92	=	14	<input type="text"/>	-	<input type="text"/>	=	<input type="text"/>	8.82	Y or N	10-15
Visual Working Memory	107	-	90	=	17	<input type="text"/>	-	<input type="text"/>	=	<input type="text"/>	11.60	Y or N	5-10
Immediate Memory	107	-	94	=	13	<input type="text"/>	-	<input type="text"/>	=	<input type="text"/>	10.99	Y or N	10-15
Delayed Memory	106	-	92	=	14	<input type="text"/>	-	<input type="text"/>	=	<input type="text"/>	11.44	Y or N	10-15

For discrepancy comparisons, refer to Tables B.1-B.15 of the Technical and Interpretive Manual.



Ability-Memory Contrast Scores

Contrast Scaled Scores

Score	WAIS-IV Composite	Score 1	WMS-IV Index	Score 2	Technical Manual Table	Contrast Scaled Score
General Ability Index vs. Auditory Memory Index	General Ability Index	111	Auditory Memory Index	95	C.1	8
General Ability Index vs. Visual Memory Index	General Ability Index	111	Visual Memory Index	92	C.2	6
General Ability Index vs. Visual Working Memory Index	General Ability Index	111	Visual Working Memory Index	90	C.3	6
General Ability Index vs. Immediate Memory Index	General Ability Index	111	Immediate Memory Index	94	C.4	6
General Ability Index vs. Delayed Memory Index	General Ability Index	111	Delayed Memory Index	92	C.5	7
Verbal Comprehension Index vs. Auditory Memory Index	Verbal Comprehension Index	118	Auditory Memory Index	95	C.6	7
Perceptual Reasoning Index vs. Visual Memory Index	Perceptual Reasoning Index	102	Visual Memory Index	92	C.7	8
Perceptual Reasoning Index vs. Visual Working Memory Index	Perceptual Reasoning Index	102	Visual Working Memory Index	90	C.8	7
Working Memory Index vs. Auditory Memory Index	Working Memory Index	95	Auditory Memory Index	95	C.9	9
Working Memory Index vs. Visual Working Memory Index	Working Memory Index	95	Visual Working Memory Index	90	C.10	8



Case 1: Summary and Conclusions

- Jane is currently functioning in the average range of overall intellectual functioning, as compared to her same-age peers.
- Relative to her high average verbal abilities, Jane performs in the average range on non-verbal, working memory, and processing speed tasks. It is likely that relative weaknesses in working memory and processing speed are adversely impacting Jane's overall cognitive functioning.
- Jane's memory complaints are consistent with test results which indicate that her performance on memory tasks is worse than one would expect of someone with her cognitive ability.



Case 1: Summary and Conclusions (cont'd)

- Although Jane is currently functioning in the average range of overall intellectual ability compared to her same-age peers, it is likely that this level of development represents a decline in her previous level of functioning.
- Recommend a neuropsychological evaluation for an in-depth assessment of memory and executive function. It is also recommended that the assessment include an estimate of premorbid function, based on Jane's previous educational and occupational performance.
- Jane will need to be seen for periodic neuropsychological re-evaluations to evaluate possible declines in her cognitive and memory abilities.



Case 1: Related Reading

- Luck T., Riedel-Heller, S.G., Kaduszkiewicz, H., Bickel, H., Jessen, F., Pentzek, M., et al. (2007). Mild cognitive impairment in general practice: Age-specific prevalence and correlate results from the German study on ageing, cognition and dementia in primary care patients. *Dementia And Geriatric Cognitive Disorders*, 24 (4), 307-16.
- Palmer, K., Bäckman L., Winblad B., Fratiglioni, L. (2008). Mild cognitive impairment in the general population: occurrence and progression to Alzheimer disease. *American Journal Of Geriatric Psychiatry*, 16 (7), 603-11.
- Schmitter-Edgecombe, M., Woo, E., & Greeley, D. R. (2009). Characterizing multiple memory deficits and their relation to everyday functioning in individuals with mild cognitive impairment. *Neuropsychology*, 23 (2), 168-177.
- Storandt, M., Grant, E. A., Miller, J. P., & Morris, J. C. (2006). Longitudinal course and neuropathologic outcomes in original vs revised MCI and in pre-MCI. *Neurology*, 67 (3), 467-473.
- Winblad, B., Palmer, K., Kivipelto, M., Jelic, V., Fratiglioni, L., Wahlund, L., et al. (2004). Mild cognitive impairment - beyond controversies, towards a consensus: Report of the International Working Group on Mild Cognitive Impairment. *Journal of Internal Medicine*, 256 (3), 240-246.
- Link to PowerPoint presentation on WMS-IV contrast scores:
<http://psychcorp.pearsonassessments.com/hai/images/products/wms-iv/WMS-IVContrastScaledScoresTraining.ppt>



Where do I find WAIS-IV GAI tables?

- WAIS-IV GAI norms: Appendix C of Technical and Interpretive Manual
- Critical values and non-clinical base rates for WAIS-IV FSIQ-GAI comparison: Appendix C of Technical and Interpretive Manual
- Clinical base rates for WAIS-IV FSIQ-GAI comparison: Appendix C of Technical and Interpretive Manual
- AAD tables for WAIS-IV FSIQ, VCI, and PRI vs. WIAT-II: Appendix B of WAIS-IV Technical and Interpretive Manual
- AAD tables for WAIS-IV GAI vs. WIAT-II: Appendix C of WAIS-IV Technical and Interpretive Manual
- AMD tables for WAIS-IV GAI, VCI, and PRI vs. WMS-IV: Appendix B of WMS-IV Technical and Interpretive Manual
- WAIS-IV CPI norms: Upcoming publication
- Critical values and non-clinical base rates for WAIS-IV GAI-CPI comparison: Upcoming publication
- Clinical base rates for WAIS-IV GAI-CPI comparison: Upcoming publication



Where do I find WISC-IV GAI tables?

- WISC-IV GAI norms: WISC-IV Technical Report #4
http://pearsonassess.com/NR/rdonlyres/1439CDFE-6980-435F-93DA-05888C7CC082/0/80720_WISCIV_Hr_r4.pdf
- Critical values and non-clinical base rates for WISC-IV FSIQ-GAI comparison: WISC-IV Technical Report #4
- Clinical base rates for WISC-IV FSIQ-GAI comparison: WISC-IV Technical Report #4
- AAD tables for WISC-IV FSIQ, VCI, and PRI vs. WIAT-II: Appendix B of Technical and Interpretive Manual
- AAD tables for WISC-IV GAI vs. WIAT-II: WISC-IV Technical Report #4
- WISC-IV CPI norms: Chapter 1 of Prifitera, Saklofske, & Weiss (2008) *WISC-IV Clinical Assessment and Intervention-Second Edition*
- Non-clinical base rates for WISC-IV GAI-CPI comparison: Chapter 1 of Prifitera, Saklofske, & Weiss (2008) *WISC-IV Clinical Assessment and Intervention-Second Edition*
- Critical values and clinical base rates for WISC-IV GAI-CPI comparison: Upcoming publication