Advances in Pediatric Neuropsychology Test Interpretation: Importance of Considering Normal Variability and Performance Variability

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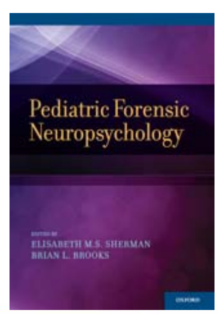
- I have financial relationships to disclose:

1. Co-author of two tests published by Psychological Assessment Resources, Inc.
   - I receive royalities for the sale of these products

ChAMP™ Child and Adolescent Memory Profile™

MVP Memory Validity Profile™

2. Co-editor of the book, *Pediatric Forensic Neuropsychology*, published by Oxford University Press
   - Brooks & Iverson chapter provides the basis for this talk
   - I receive royalities for the sale of this book



Objectives

1. Understand the difference between univariate and multivariate *clinical* interpretation.
2. Learn the 5 principles of multivariate base rates.
3. Appreciate how using multivariate base rates can reduce chances of over-interpreting isolated low scores.

Background

- Neuropsychology is well positioned to provide valuable information about whether a child's abilities have been negatively affected by a disease or injury, to quantify the change in functioning, and to communicate the impact on day-to-day functioning.
    1. What is impacted?
    2. How much is it impacted?
    3. How does this impact real-world?

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Background

National Academy of Neuropsychology

»And the winner is...

What does a NEUROPSYCHOLOGIST do?

It is time to announce the winner of the Social Media Committee's "what does a neuropsychologist do?" contest. It was a very hard decision for our committee.

First place: Neuropsychologists use their expertise in brain-behavior relationships to evaluate cognitive and emotional difficulties, educate clients and caregivers about what to expect, treat emotional symptoms and cognitive deficits, and advocate for broader understanding of neurological and psychological disorders. We work together with other healthcare providers, systems, and clients of all ages to create the best outcomes for individuals experiencing cognitive deficits and emotional turmoil. By: Dr. Beth Caillouet Arredondo.

Second place: Neuropsychologists use tools to assess individuals from a brain based perspective. The neuropsychologist is an expert in understanding how the brain informs function, behavior, and mood and can offer a unique perspective in treatment planning through differential diagnostics. By: Dr. Jennifer Maurer.

Third place: Neuropsychologists evaluate individuals with cognitive complaints like forgetfulness, inattention, or difficulty problem solving. We examine performance on cognitive and psychological testing in the context of their medical, psychiatric, educational, and occupational histories in order to understand their strengths and weaknesses, make a diagnosis, and recommend strategies to improve or adapt to their cognitive functioning. By Flannery Geier.

There's a common theme....

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Background

- No other specialty has developed, normed, and validated measures of cognitive abilities in the same manner as neuropsychology.
- The diligence of our field leads to lengthy assessments covering multiple cognitive domains and generating numerous scores

Background

- Clinical neuropsychological assessments are estimated between 4.4-6.5 hours
  - Sweet et al., 2002
- The average forensic neuropsychological assessment is estimated at 9.5 hours
  - Sweet et al., 2002
- Our assessments result in a large amount of data that are gathered and subsequently analyzed

Background

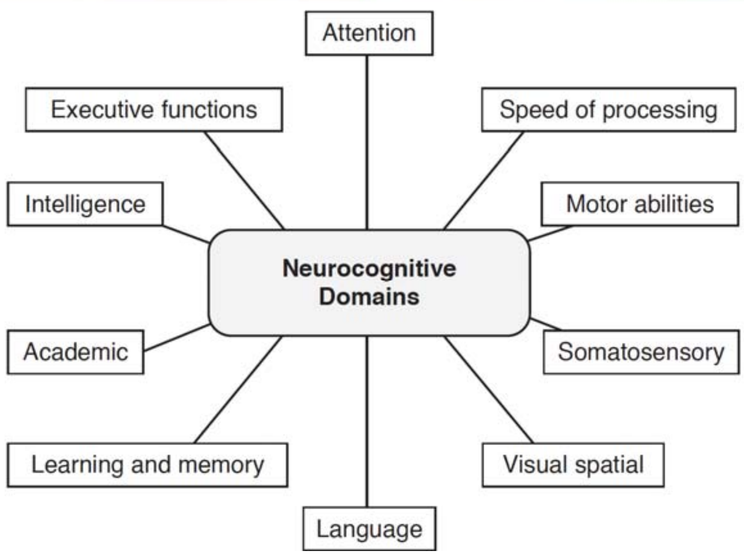

Figure 4.1; Brooks & Iverson, 2012

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24 scores

Verbal Knowledge and Expressive Language					
Following Multi-Step Instructions (NEPSY-II Comprehension of Instructions)			X		
Word Generation, Semantic Category Cue (NEPSY-II WG-Semantic)			X		
Word Generation, First Letter Cue (NEPSY-II WG- Letter)	X				
Phonological Decoding of Words (WJ-III Word Attack)	X[5]				
Attention and Concentration					
Sustained Visual Attention (TOVA Omission Errors)		X			
Information Processing Speed					
Visual-Motor Speed (CNS VS Processing Speed Composite)			X		
Response Speed During Sustained Attention (TOVA Response Time)			X		
Verbal-Motor Speed (NEPSY-II IN-Naming Combined Score)	X				
Motor Abilities					
Motor Speed in Right Hand (Right Hand; CNS VS Finger Tapping)			X		
Right Hand Motor Dexterity (Purdue Pegboard)		X			
Motor Speed in Left Hand (Left Hand; CNS VS Finger Tapping)			X		
Left Hand Motor Dexterity (Purdue Pegboard)			X		
Executive Functioning[6]					
Impulse Control – Verbal (NEPSY-II IN Errors)	X				
Impulse Control – Verbal (NEPSY-II IN Inhibition Combined Score)		X			
Visual Impulse Control (TOVA Commission Errors)	X				
Verbal Set Switching and Inhibition (NEPSY-II IN-Switching Combined Score)		X			
Fluid Design Production (MNI Design Fluency)			X		
Learning and Memory for Verbal Information					
Word List Learning (CVLT-C Trials 1-5)			X		
Rate of Learning (CVLT- C Slope Trials 1-5)			X		
Long Delay Free Recall of Word List (CVLT- C LDFR)			X		
Delayed Recognition of Word List (CVLT- C Recognition)			X		
Learning and Memory for Visual Information					
Delayed Visual Recognition (CVMT Delayed Recognition)			X		
Visual Recognition (CNS VS Visual Memory Composite)		X			
Spatial Abilities					
Visuo-Spatial Skills (NEPSY-II Geometric Puzzles)			X		

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33 scores

Intellectual Abilities					
General Intellectual Abilities (WAIS-IV^{CDN} GAI[1])			X		
Verbal Intellectual Abilities (WAIS-IV^{CDN} VCI)[2]			X		
Nonverbal Intellectual Abilities (WAIS-IV^{CDN} PRI)				X	
Verbal Knowledge and Expressive Language					
Vocabulary and Fund of Knowledge (WAIS-IV^{CDN} Vocabulary)			X		
Expressive Vocabulary (WJ-III Picture Vocabulary)			X		
Following Directions (WJ-III Understanding Directions)			X		
Word Generation, First Letter Cue (DKEFS Verbal Fluency-Letter)					X
Word Generation, Category Cue (DKEFS Verbal Fluency Category)			X		
Word Decoding (WRAT-IV Word Reading)			X		
Information Processing Speed					
Visual-Motor Processing Speed (WAIS-IV^{CDN} PSI)		X			
Visual-Motor Scanning Speed (WAIS-IV^{CDN} Symbol Search)		X			
Visual-Motor Scanning Speed (WAIS-IV^{CDN} Coding)			X		
Visual-Motor Reaction Time (CAT Reaction Time)					X
Motor Abilities					
Motor Speed (Right Hand; CNS VS Finger Tapping)		X			
Motor Speed (Left Hand; CNS VS Finger Tapping)			X		
Right Hand, Motor Dexterity (Purdue Pegboard)			X		
Left Hand, Motor Dexterity (Purdue Pegboard)			X		
Attention and Concentration					
Sustained Visual Attention (CAT Hits)			X		
Executive Functioning[3]					
Verbal Reasoning and Concept Formation (WAIS-IV^{CDN} Similarities)		X			
Nonverbal Reasoning (WAIS-IV^{CDN} Matrix Reasoning)			X		
Verbal Set Switching (DEKFS Verbal Fluency-Switching Accuracy)			X		
Cognitive Flexibility (CNS VS Cognitive Flexibility Index)			X		
Impulse Control – Verbal (CNS VS Stroop Commission Errors)			X		
Learning and Memory for Verbal Information					
Word List Learning (CVLT-II Trials 1-5)			X		
Rate of Learning (CVLT- II Slope Trials 1-5)			X		
Long Delay Free Recall of Word List (CVLT- II LDFR)			X		
Delayed Recognition of Word List (CVLT- II Recognition)		X			
Verbal Recognition (CNS VS Verbal Memory)	X				
Learning and Memory for Visual Information					
Visual Immediate Memory (CVMT Hits)					X
Visual Delayed Memory (CVMT Delayed Recognition)			X		
Visual Memory (CNS VS Visual Memory)			X		
Spatial Abilities					
Visuo-Spatial Construction (WAIS-IV^{CDN} Block Design)					X
Visuo-Spatial Integration (VMI)			X		

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42 scores

Intellectual Abilities					
Estimated Intellectual Abilities (WPPSI-III^{CDN} FSIQ)			X		
Verbal Intellectual Abilities (WPPSI-III^{CDN} VCI)			X		
Nonverbal Intellectual Abilities (WPPSI-III^{CDN} PRI)			X		
Verbal Knowledge and Expressive Language					
Vocabulary and Fund of Knowledge (WPPSI-III^{CDN} Vocabulary)			X		
Verbal Knowledge (WPPSI-III^{CDN} Information)			X		
Word Retrieval (NEPSY-II Word Generation Semantic Score)			X		
Information Processing Speed					
Visual-Motor Processing Speed (WPPSI-III^{CDN} PSI)			X		
Visual-Motor Scanning Speed (WPPSI-III^{CDN} Symbol Search)			X		
Visual-Motor Scanning Speed (WPPSI-III^{CDN} Coding)			X		
Response Speed During Sustained Attention (TOVA Response Time)				X	
Verbal-Motor Speed (NEPSY-II IN-Naming Completion Time)			X		
Motor Abilities					
Right Hand, Motor Dexterity (Purdue Pegboard)			X		
Left Hand, Motor Dexterity (Purdue Pegboard)			X		
Attention and Concentration					
Sustained Visual Attention (TOVA Omission Errors)			X		
Executive Functioning[a]					
Verbal Reasoning (WPPSI-III^{CDN} Word Reasoning)			X		
Nonverbal Reasoning and Concept Formation (WPPSI-III^{CDN} Pic Concepts)			X		
Nonverbal Abstract Reasoning (WPPSI-III^{CDN} Matrix Reasoning)			X		
Impulse Control – Visual (TOVA Commission Errors)			X		
-First Half Performance ("low arousal")			*X*		
-Second Half Performance ("high arousal")		*X*			
Impulse Control – Verbal (NEPSY-II IN Inhibition Completion Time)			X		
Impulse Control – Verbal (NEPSY-II IN Errors)			X		
Design Generation (MNI Design Fluency)			X		
Learning and Memory for Verbal Information					
Verbal Immediate Memory (CMS Verbal Immediate Index)			X		
Verbal Delayed Memory (CMS Verbal Delayed Index)				X	
Verbal Meaningful Immediate Memory (CMS Stories Immediate)			X		
Verbal Meaningful Delayed Memory (CMS Stories Delayed)			X		
Verbal Meaningful Recognition Memory (CMS Stories Recognition)			X		
Verbal Learning of Unrelated Information (CMS Word Pairs Total Score)			X		
Verbal Delayed Memory for Unrelated Info (CMS Word Pairs Long Delay)					X
Verbal Recognition Memory for Unrelated Info (CMS Word Pairs Recognition)				X	
Word List Learning (CVLT-C Trials 1-5)			X		
Rate of Learning (CVLT- C Slope Trials 1-5)			X		
Long Delay Free Recall of Word List (CVLT- C LDFR)			X		
Delayed Recognition of Word List (CVLT- C Recognition)			X		
Learning and Memory for Visual Information					
Visual Immediate Memory (CMS Visual Immediate Index)				X	
Visual Delayed Memory (CMS Visual Delayed Index)				X	
Visual Immediate Memory for Faces (CMS Faces Immediate)					X
Visual Delayed Memory for Faces (CMS Faces Delayed)				X	
Visual Learning of Locations (CMS Dot Locations Total)			X		
Visual Delayed Memory for Locations (CMS Dot Locations Delayed)				X	
Spatial Abilities					
Visuo-Spatial Construction (WPPSI-III^{CDN} Block Design)			X		

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Background

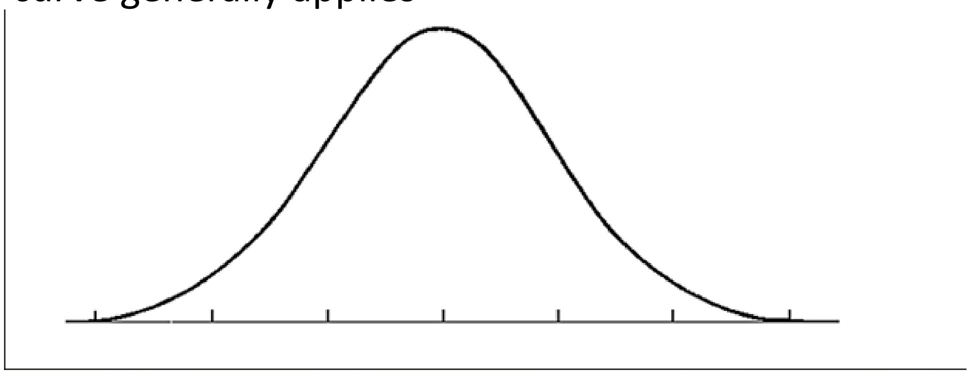
"Seeing the forest for the trees"

To discern an overall pattern from a mass of detail; to see the big picture, or the broader, more general situation

http://en.wiktionary.org/wiki/

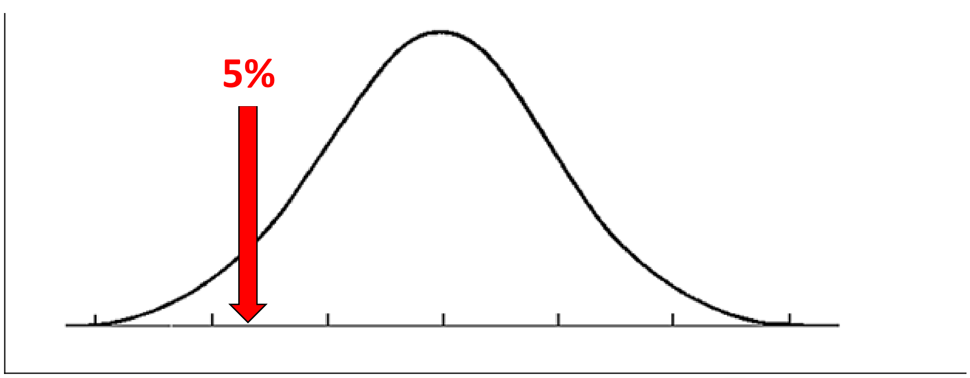
Univariate Test Interpretation

- Univariate analyses: consideration of a single test score in isolation
- Bell curve generally applies



Univariate Test Interpretation

- Assuming a normal distribution, what percent of the standardization sample obtains a score $\leq 5^{th}$ percentile?



Univariate Test Interpretation

- What about….?
  - If there are 2 scores?
  - If there are 5 scores?
  - If there are 50 scores?
  - If the person is low functioning?
  - If the person is high functioning?

Is it still 5% that will have a score ≤5th percentile?

  - Reliance on the bell curve when interpreting multiple test scores will lead us astray…

Multivariate Test Interpretation

- Univariate clinical analyses: consideration of a single test score in isolation
  - This is not really what we do in neuropsychology
- Multivariate clinical analyses: consideration of multiple test scores simultaneously
  - This is neuropsychology

Two case examples to consider regarding multivariate interpretation

Case Example #1

- Case Example #1:
  - 14-year-old previously healthy boy who sustained a concussion two years before assessment (slip and fall)
  - Although family report vague, appears to be functioning similar to before the injury; similar academic performance
  - Intellectual abilities estimated to be within the average range
  - Due to complaints about memory problems, administered the CMS as part of assessment

TABLE 4.2. Performance on the Children's Memory Scale (CMS) Indexes in a 14-Year-Old Boy Who Sustained a Concussion

	Standardized Performance and Descriptions		
CMS Index Scores	**Index Score**	**Percentile Rank**	**Classification**
Learning	103	58	Average
Visual Immediate	103	58	Average
Visual Delayed	84	14	Low Average
Verbal Immediate	115	84	High Average
Verbal Delayed	106	66	Average
Delayed Recognition	103	58	Average

Case Example #2

- Case Example #2:
  - 11-year-old previously healthy girl who sustained a severe TBI in a high-speed MVC
  - Lowest GCS 4/15, PTA and fluctuating orientation for 10 days, brain MR scan with diffuse and focal findings, numerous extra-cranial injuries
  - Assessment 1.5 years after injury
  - Patient was administered 17 subtests from the NEPSY-II as part of her assessment

8 scores ≤10th percentile
4 scores ≤5th percentile
2 scores ≤2nd percentile

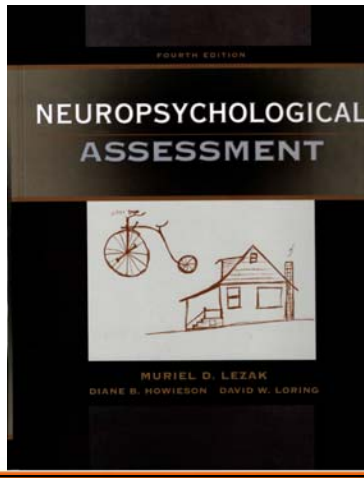
TABLE 4.3. Performance on Selected NEPSY-II Subtests in an 11-Year-Old Girl Who Sustained a Severe Traumatic Brain Injury

NEPSY-II Domains and Subtests	Standardized Performance and Descriptions: Scaled Score	Percentile	Classification
Attention and Executive Functioning			
Animal Sorting Total Correct Sorts	6	9	Borderline
Auditory Attention Total Correct	6	9	Borderline
Response Set Total Correct	5	5	Borderline
Inhibition: Naming Total Completion Time	6	9	Borderline
Inhibition: Inhibition Total Completion Time	4	2	Extremely Low
Inhibition: Switching Total Completion Time	2	<1	Extremely Low
Language			
Comprehension of Instructions Total	11	63	Average
Phonological Processing Total	9	37	Average
Speeded Naming Total Completion Time	7	16	Low Average
Memory and Learning			
Memory for Designs Total	9	37	Average
Memory for Designs Delayed Total	8	25	Average
Narrative Memory Free & Cued Recall Total	6	9	Borderline
Narrative Memory Free Recall Total	5	5	Borderline
Word List Interference Repetition Total	8	25	Average
Word List Interference Recall Total	7	16	Low Average
Visuospatial Processing			
Block Construction Total Score	10	50	Average
Geometric Puzzles Total Score	12	75	Average

How can multivariate interpretation help?
We will return to these examples later….

Multivariate Test Interpretation

- Historical context of multivariate test interpretation
  - Low scores/test-score scatter suggest something is wrong



PATTERN ANALYSIS

The basic element of test score analysis is a significant discrepancy between any two or more scores (Silverstein, 1982). Implicitly or explicitly, all score-based methods of neuropsychological assessment rest on the assumption that one cognitive performance level best represents each person's cognitive abilities generally (see pp. 97–98). Marked quantitative discrepancies in a person's performance—within responses to a test, between scores on different tests, and/or with respect to some expected level of performance—suggest that some abnormal condition is interfering with that person's overall ability to perform at their characteristic level of cognitive functioning. It then becomes the examiner's responsibility to determine the nature of that limitation.

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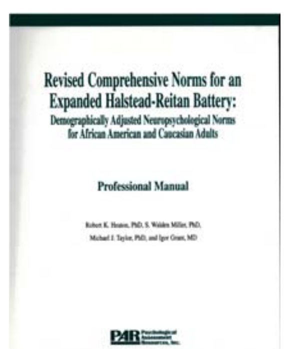
Multivariate Test Interpretation

- Are there empirical methods for interpreting multiple scores (multivariate clinical interpretation)?
  - Earliest work using the Halstead-Reitan Battery
    - Reitan & Wolfson, 1985, 1993;
    - Heaton et al., 1991, 1992, 2004



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Multivariate Test Interpretation

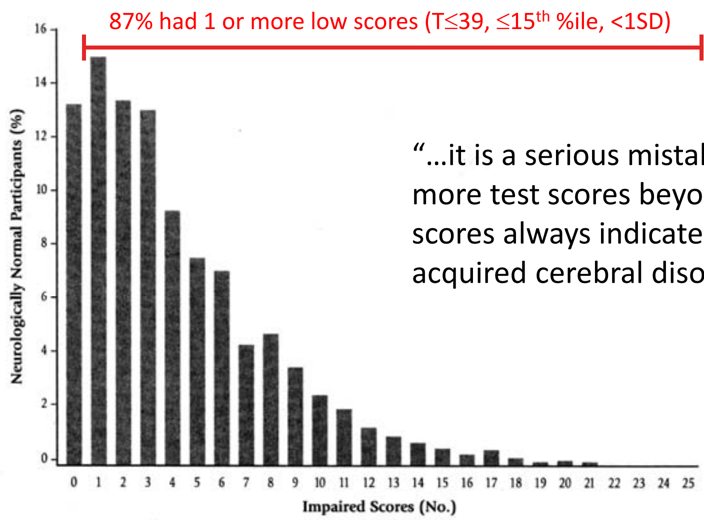

Figure 9. Frequency of "impaired" test scores (*T* scores ≤39) for 1,189 neurologically normal participants on 25 measures of the test battery.

"…it is a serious mistake to assume that one or more test scores beyond the acceptable cutoff scores always indicate the presence of an acquired cerebral disorder" (pp. 72-73).

Heaton et al., 2004

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Multivariate Test Interpretation

Five principles to understand
when interpreting multiple scores

Principles When Interpreting Multiple Scores

1. Test-score variability (scatter) is common
2. Having some low scores is common
3. The number of low scores is related to the cutoff score used
4. The number of low scores is related to the number of tests administered
5. The number of low scores varies by examinee characteristics

Principle 1

Test-score variability (scatter) is common

Also known as, an absence of variability or scatter in scores is uncommon (query pattern analysis)

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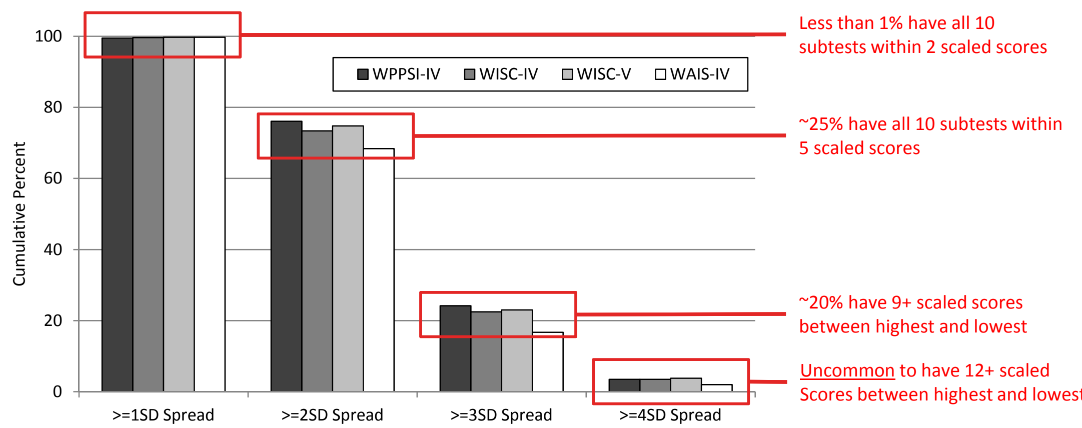
Principle 1

Percent with 1, 2, 3, or 4SD spread between highest and lowest subtest scores on Wechsler tests



Data derived from Table B.9 in WPPSI-IV and WISC-V, and Table B.6 in WISC-IV and WAIS-IV administration and scoring manuals

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Principle 1

- Scatter changes with level of functioning

The Clinical Neuropsychologist, 2013
Vol. 27, No. 6, 988–1003, http://dx.doi.org/10.1080/13854046.2013.797502
Routledge Taylor & Francis Group

Normal Variability of Children's Scaled Scores on Subtests of the Dutch Wechsler Preschool and Primary scale of Intelligence – Third Edition

P.P.M. Hurks[1], J.G.M. Hendriksen[2], J.E. Dek[3] and A.P. Kooij[3]
[1]Maastricht University, Maastricht, The Netherlands
[2]Kempenhaeghe Center for Neurological Learning Disabilities, Heeze, The Netherlands
[3]Pearson Test Publishers, Amsterdam, The Netherlands

Principle 1

- Scatter changes with level of functioning

that large differences between highest and lowest scaled subtest scores (or subtest scatter) were common in this sample. Furthermore, degree of subtest scatter was related to: (a) the magnitude of the highest scaled subtest score, i.e., more scatter was seen in children with the highest WPPSI-III-NL scaled subtest scores, (b) Full Scale IQ (FSIQ) scores, i.e., higher FSIQ scores were associated with an increase in subtest scatter, and (c) sex differences, with boys showing a tendency to display more scatter than girls. In conclusion, viewing subtest scatter as an index for abnormality in WPPSI-III-NL scores is an oversimplification as this fails to recognize disparate subtest heterogeneity that occurs within a population of healthy children aged 4:0–7:11 years.

Summary: More scatter if higher subtest scores, in higher FSIQ, and in boys

Principle 2

Low scores are common

Also known as, an absence of low scores is uncommon

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Principle 2

Percent with 1 or more scores at or below 5th percentile on different pediatric batteries

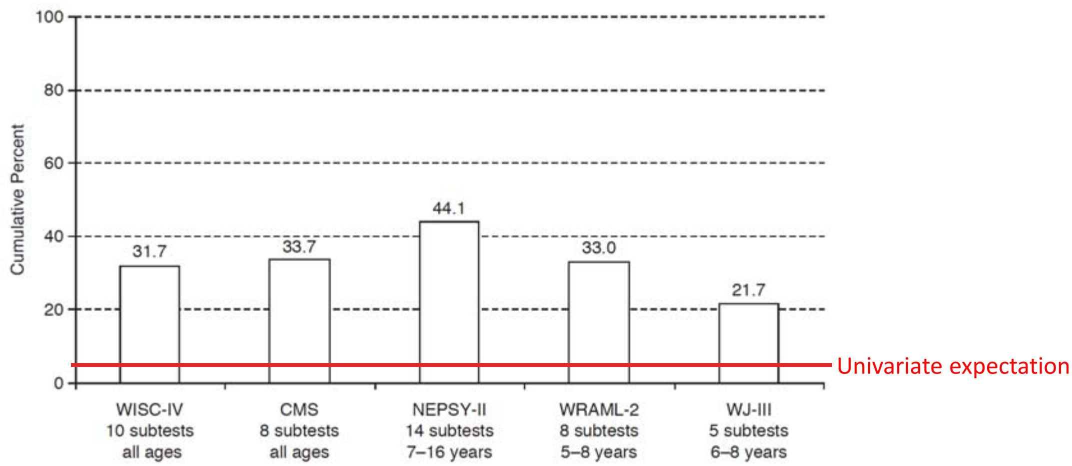

Figure 4.3; Brooks & Iverson, 2012

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Principle 3

The number of low scores depends on cutoff

Also known as, adjusting your cutoff score will adjust the number of low scores

Principle 3

Percent with 1 or more low scores across different cutoff scores on three pediatric memory batteries

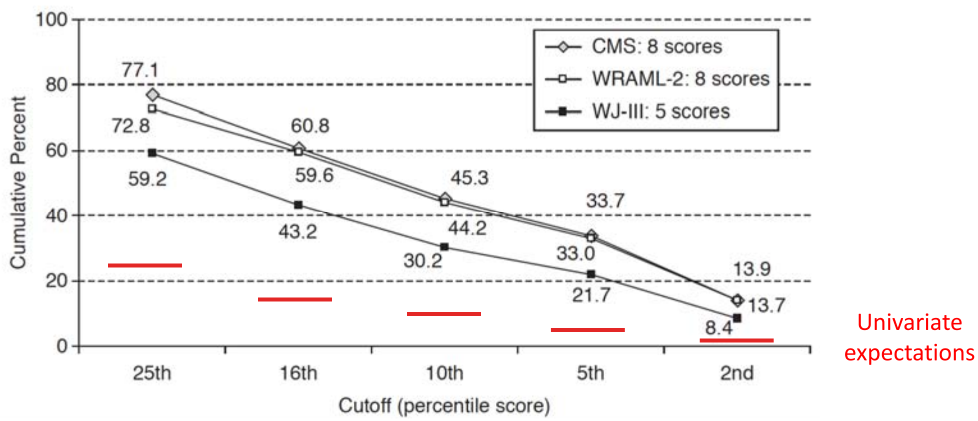


Figure 4.4; Brooks & Iverson, 2012

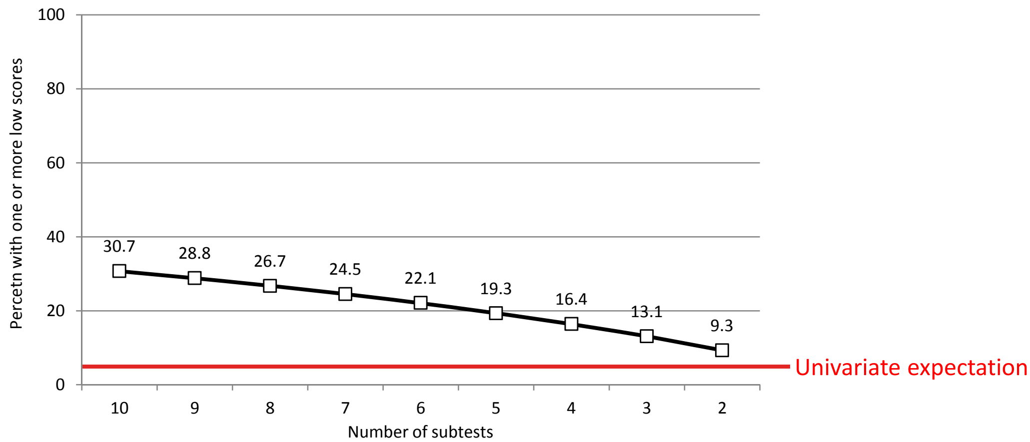
Principle 4

Number of low scores depends on number of tests

Also known as, give more tests and get more low scores

Principle 4

Estimated percent of people with at least one low subtest score (<5th percentile) when varying the length of a battery



Note: Percent of people with low scores was estimated using the Crawford et al. (2007) Monte Carlo program and an average inter-subtest correlation of 0.3.

Figure 2; From Donders, Brooks, Sherman, & Kirkwood, in press

Principle 4

Percent with 1 or more scores at or below 5th percentile

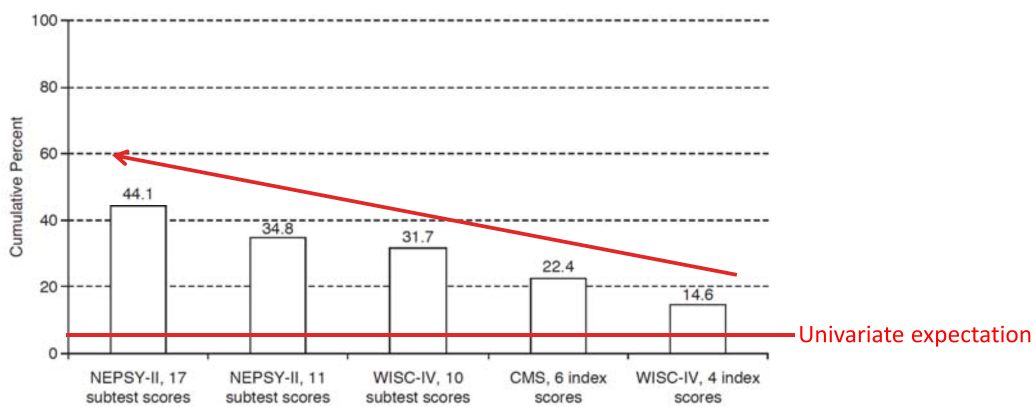


Figure 4.5; Brooks & Iverson, 2012

Principle 5

Number of low scores depends on examinee's characteristics

Also known as, examinee characteristics need to be considered

Principle 5

Percent with 1 or more WISC-IV subtest scores at or below 5th percentile by FSIQ categories

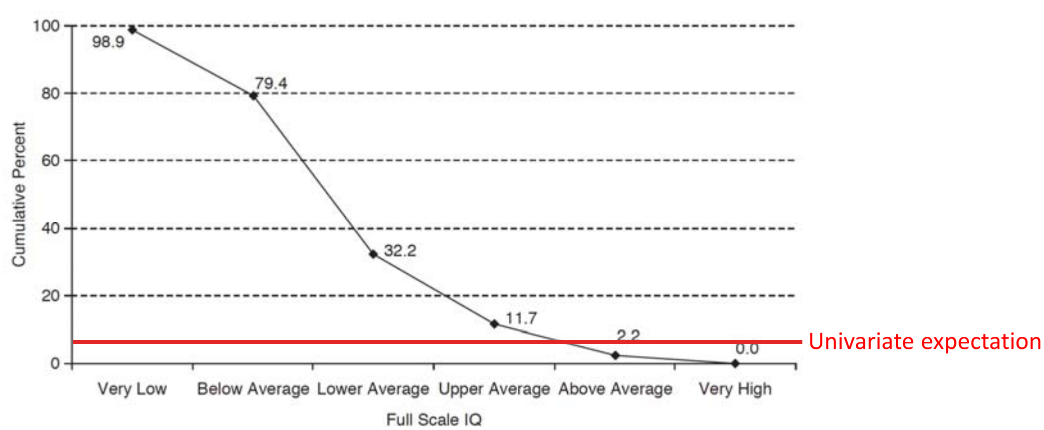


Figure 4.6; Brooks & Iverson, 2012

Percent with 1 or more Children's Memory Scale index scores at or below 5th percentile by WISC-IV FSIQ

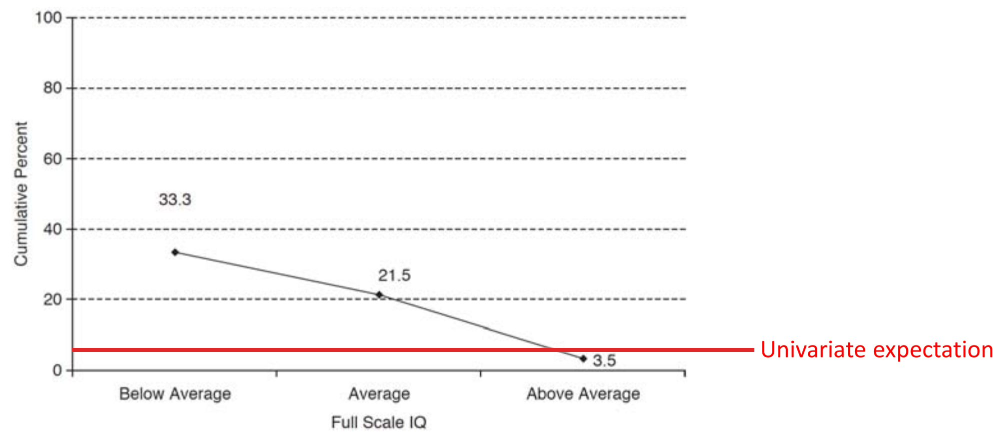


Figure 4.7; Brooks & Iverson, 2012

Principle 5

Percent with 1 or more scores at or below 5th percentile by parent education

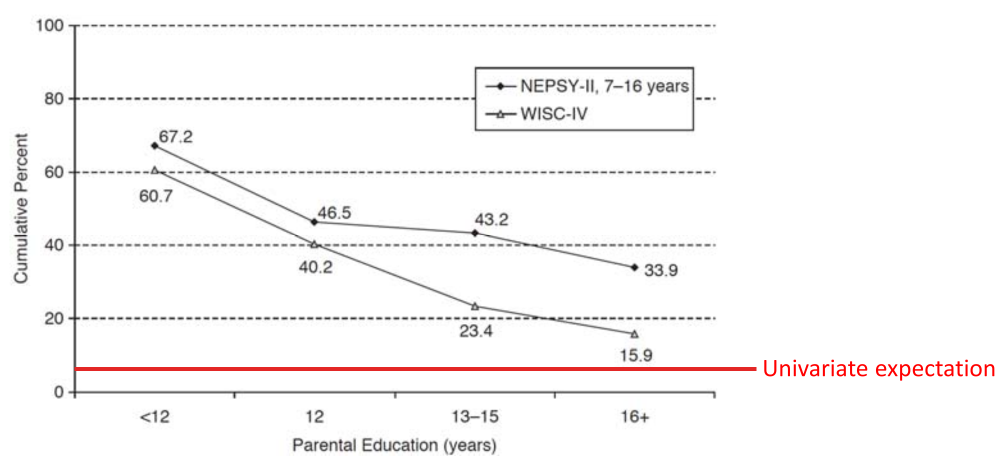


Figure 4.8; Brooks & Iverson, 2012

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What is a clinician to do?

Multivariate analyses in pediatric neuropsychological evaluations

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What is a clinician to do?

1. Knowledge is power
2. Use existing published tables (where available)
3. Compute your own multivariate base rates

What is a clinician to do?

- Knowing the prevalence of low scores can help to minimize the chance of misinterpretation of isolated low scores
  - Both *mis*diagnosis and *missed* diagnosis
- Multivariate analyses help determine if a certain number of low scores is uncommon

What is a clinician to do?

- Published tables with multivariate analyses are available for some pediatric neuropsychological tests
  - WISC-IV (Brooks, 2010; Brooks, 2011; Crawford et al., 2007)
  - Children's Memory Scale (Brooks et al., 2009)
  - NEPSY-II (Brooks et al., 2010)
  - Child and Adolescent Memory Profile (Sherman and Brooks, 2015)

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What is a clinician to do?

Brooks, 2010

Table 1
Base Rates of Low WISC-IV Subtest Scores by Impairment Cutoff, Level of Intelligence, and Parental Education

Number of low WISC-IV scores	Total sample	Level of intelligence (FSIQ): Very low (<80)	Below average (80–89)	Lower average (90–99)	Upper average (100–109)	Above average (110–119)	Very high (120+)	Parental education (years): ≤8	9–11	12	13–15	16+
≤5th percentile												
10 or more	0.5	5.9	—	—	—	—	—	—	0.5	0.8	0.3	0.5
9 or more	0.9	10.2	—	—	—	—	—	0.9	1.9	1.0	0.4	0.9
8 or more	1.3	15.1	—	—	—	—	—	1.9	3.8	1.3	0.7	0.9
7 or more	1.8	21.0	—	—	—	—	—	2.8	6.1	1.6	1.1	0.9
6 or more	2.2	26.3	—	—	—	—	—	3.7	8.0	2.1	1.4	0.9
5 or more	3.0	34.9	—	—	—	—	—	5.6	10.3	3.2	1.5	1.1
4 or more	4.7	53.8	0.9	—	—	—	—	9.3	13.6	5.7	2.8	1.6
3 or more	8.0	76.3	10.0	—	—	—	—	20.4	21.6	10.3	4.2	2.7
2 or more	14.2	93.5	34.4	3.5	0.2	0.3	—	33.3	35.2	17.9	8.6	5.5
1 or more	31.7	98.9	79.4	32.2	11.7	2.2	—	58.3	62.0	40.2	23.4	15.9
No low scores	68.3	1.1	20.6	67.8	88.3	97.8	100	41.7	38.0	59.8	76.6	84.1

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What is a clinician to do?

Sherman and Brooks, 2015

Table 10.1
Base Rates of Low Scores on the ChAMP

	Total Sample	Parent education level (years): <12	12	13-15	16+
Number of low subtest scores (SS ≤7 or ≤1 *SD*)					
8 low scores	1.4	.8	2.5	1.5	.6
7 or more	3.5	6.7	4.4	2.5	2.5
6 or more	6.7	11.5	6.0	6.4	6.3
5 or more	12.1	14.5	12.4	12.3	11.0
4 or more	18.6	19.0	17.7	21.5	16.8
3 or more	28.4	26.5	26.8	33.2	26.1
2 or more	41.0	40.2	39.9	47.8	38.3
1 or more	56.9	53.9	51.0	61.5	58.8
0 low scores	43.1	46.1	49.0	38.5	41.2
Number of extremely low subtest scores (SS ≤4 or ≤2 *SD*)					
8 low scores	.0	.0	.0	.0	.0
7 or more	.0	.0	.0	.0	.0
6 or more	.2	.0	.5	.0	.0
5 or more	.6	.3	.5	.8	.6
4 or more	1.5	2.3	1.5	1.1	1.7
3 or more	3.2	6.0	3.3	3.2	2.4
2 or more	9.1	9.5	10.6	9.5	7.3
1 or more	19.7	19.4	20.7	20.9	17.9
0 low scores	80.3	80.6	79.3	79.1	82.1

Note. N = 1,206. Analyses included scaled scores from Lists, Lists Delayed, Instructions, Instructions Delayed, Objects, Objects Delayed, Places, and Places Delayed. Lists Recognition and Instructions Recognition are not included in these analyses. Cumulative percentages are reported for all values except for "0 low scores," which is reported as an individual percentage.

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What is a clinician to do?

- Can compute multivariate base rates for any group of scores using a Monte Carlo program *if intercorrelations are known*
- Program publically available by Dr. John Crawford at http://homepages.abdn.ac.uk/j.crawford/pages/dept/psychom.htm

Webpage last accessed October 1, 2015

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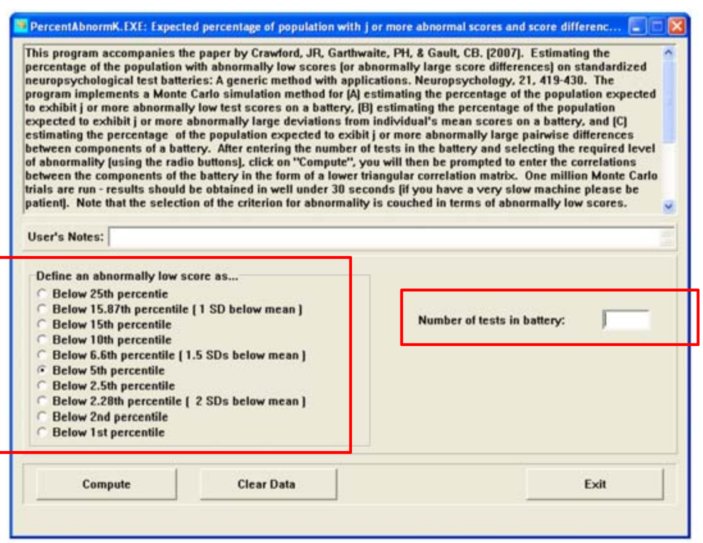
What is a clinician to do?



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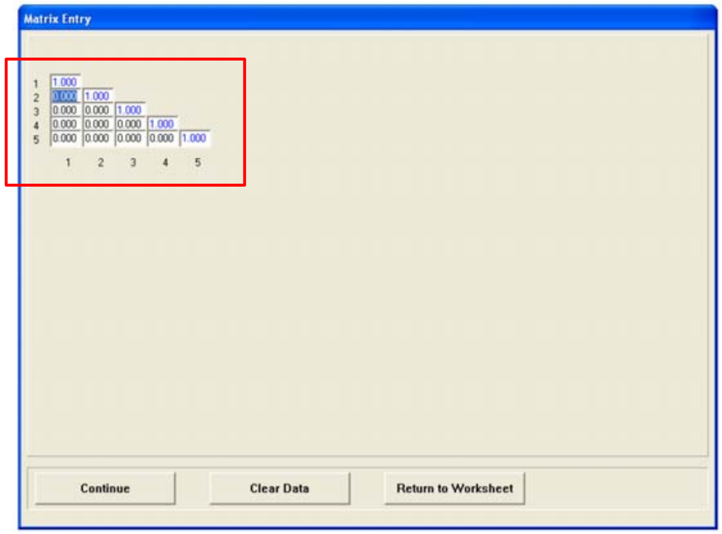
What is a clinician to do?



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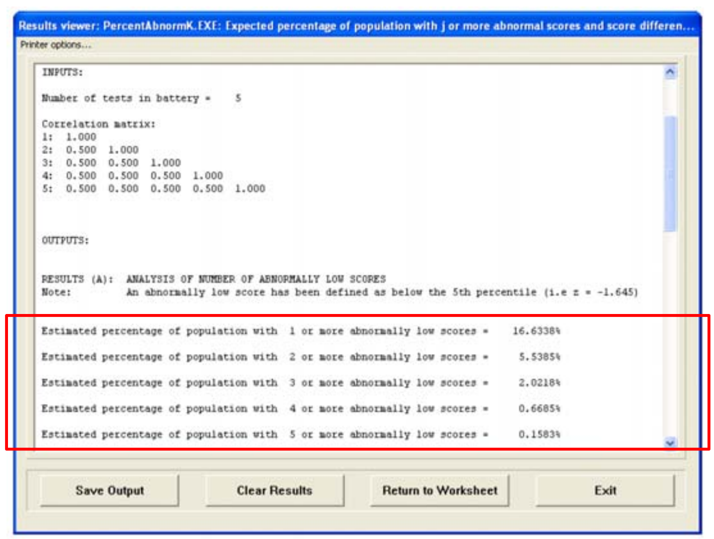
What is a clinician to do?



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What is a clinician to do?

OXFORD JOURNALS
OXFORD UNIVERSITY PRESS
Archives of Clinical Neuropsychology 25 (2010) 14–21
Archives of CLINICAL NEUROPSYCHOLOGY

Comparing Actual to Estimated Base Rates of "Abnormal" Scores on Neuropsychological Test Batteries: Implications for Interpretation

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Accepted 23 November 2009

- Monte Carlo estimation has good accuracy compared to actual base rates in standardization samples
- Caution with high or low functioning; subtest intercorrelations do not reflect

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Applications of Multivariate Interpretation

Journal of the International Neuropsychological Society (2015), **21**, 1–14.

doi:10.1017/S1355617715000636

Empirical Derivation and Validation of a Clinical Case Definition for Neuropsychological Impairment in Children and Adolescents

Miriam H. Beauchamp,[1,2] Brian L. Brooks,[3–6] Nick Barrowman[6] Mary Aglipay,[7] Michelle Keightley,[8–10] Peter Anderson[11,12] Keith O. Yeates,[5,6,13] Martin H. Osmond,[12,14] AND Roger Zemek[12,14]
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(Received September 25, 2014; Final Revision July 15, 2015; Accepted July 16, 2015)

Goal was to use the NIH pediatric sample to create a definition of "neuropsychological impairment" for future research comparisons

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Applications of Multivariate Interpretation

24% of healthy children in the NIH sample had 1 or more scores more than 1.5SDs below the mean

Thus, based on the frequency distributions presented in Table 6, the definition of neuropsychological impairment that best fits the NIHPD data and identifies approximately 95% of the population as "typically developing" is the following: *"A neuropsychological impairment is present when an individual performs 1.5 standard deviations below the mean on two or more measures."* Our derived NPI rule identifies 5.1% of the total sample as impaired on two or more of the eight subtests in the assessment battery, which covers six domains of neuropsychological functioning. Applying this rule to individual age groups identifies between 3.0 and 7.2% of the population as impaired, suggesting that the case definition is appropriate for children between the ages of 6 and 18 years.

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Applications of Multivariate Interpretation

Journal of the International Neuropsychological Society (2007), **13**, 490–500.

DOI: 10.1017/S1355617707070531

Substantial risk of "Accidental MCI" in healthy older adults: Base rates of low memory scores in neuropsychological assessment

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Journal of the International Neuropsychological Society (2008), **14**, 463–478.

doi: 10.1017/S1355617708080521

Potential for misclassification of mild cognitive impairment: A study of memory scores on the Wechsler Memory Scale-III in healthy older adults

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Dementia and Geriatric Cognitive Disorders

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DOI: 10.1159/000215390

Accepted: January 30, 2009
Published online: April 28, 2009

Minimizing Misdiagnosis: Psychometric Criteria for Possible or Probable Memory Impairment

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25-30% of healthy adults would meet psychometric criteria for memory impairment based on 1 or more scores being 1.5SDs below the mean

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Applications of Multivariate Interpretation

Table 3. Guidelines for determining memory impairment, based on level of functioning, when considering a cutoff of ≤5th percentile

	n	Memory scores below cutoff		
		broadly normal	possible memory impairment	probable memory impairment
Level of intelligence				
Unusually low (FSIQ ≤79)	40	0–3	4–5 (12.5%)	6+ (7.5%)
Low average (FSIQ = 80–89)	68	0–2	3 (11.8%)	4+ (4.4%)
Average (FSIQ = 90–109)	213	0	1 (18.8%)	2+ (5.6%)
High average (FSIQ = 110–119)	83	0	1 (14.5%)	2+ (7.2%)
Superior/very superior (FSIQ ≥120)	46	0	-	1+ (8.7%)
Level of estimated premorbid intelligence				
Unusually low (WTAR-FSIQ ≤79)	28	0–2	3 (25.0%)	4+ (7.1%)
Low average (WTAR-FSIQ = 80–89)	62	0–2	3 (11.3%)	4+ (4.8%)
Average (WTAR-FSIQ = 90–109)	255	0	1 (27.1%)	2+ (10.6%)
High average (WTAR-FSIQ = 110–119)	80	0	1 (11.3%)	2+ (5.0%)
Superior/very superior (WTAR-FSIQ ≥120)	16	0	–	1+ (6.3%)
Years of education				
8 years or less	101	0–1	2 (19.8%)	3+ (5.0%)
9–11 years	70	0–1	2 (22.9%)	3+ (12.9%)
12 years	151	0	1 (22.5%)	2+ (7.9%)
13–15 years	71	0	1 (22.5%)	2+ (11.3%)
16+ years	57	0	1 (14.0%)	2+ (7.0%)

≤5th percentile is a scaled score of 5 (mean = 10, SD = 3). The false-positive rates in healthy older adults, which are presented in parentheses, are presumed because the healthy community-dwelling adult sample was not followed longitudinally to determine if some of them were experiencing prodromal AD. Intelligence is based on FSIQ scores from the WAIS-III [22]. Intellectual abilities are estimated using the WTAR-demographics prediction method [32].

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Back to Our Case Examples

Case Example #1

- Case Example #1:
  - 14-year-old previously healthy boy who sustained a concussion two years before assessment (slip and fall)
  - Although family report vague, appears to be functioning similar to before the injury; similar academic performance
  - Intellectual abilities estimated to be within the average range
  - Due to complaints about memory problems, administered the CMS as part of assessment

TABLE 4.2. Performance on the Children's Memory Scale (CMS) Indexes in a 14-Year-Old Boy Who Sustained a Concussion

	Standardized Performance and Descriptions		
CMS Index Scores	**Index Score**	**Percentile Rank**	**Classification**
Learning	103	58	Average
Visual Immediate	103	58	Average
Visual Delayed	84	14	Low Average
Verbal Immediate	115	84	High Average
Verbal Delayed	106	66	Average
Delayed Recognition	103	58	Average

- Case #1 summary using multivariate:
  - Obtained 1 index score at 14th percentile on CMS
  - According to Brooks et al. (2009), having 1+ index scores ≤16th percentile is found in 37% of healthy children and adolescents
  - Considering only those with average intelligence, 1+ index scores ≤16th percentile is found in 36% of healthy children and adolescents
  - Number of low index scores on the CMS would be considered 'common'

Case Example #2

- Case Example #2:
  - 11-year-old previously healthy girl who sustained a severe TBI in a high-speed MVC
  - Lowest GCS 4/15, PTA and fluctuating orientation for 10 days, brain MR scan with diffuse and focal findings, numerous extra-cranial injuries
  - Assessment 1.5 years after injury
  - Patient was administered 17 subtests from the NEPSY-II as part of her assessment

TABLE 4.3. Performance on Selected NEPSY-II Subtests in an 11-Year-Old Girl Who Sustained a Severe Traumatic Brain Injury

NEPSY-II Domains and Subtests	Standardized Performance and Descriptions		
	Scaled Score	Percentile	Classification
Attention and Executive Functioning			
Animal Sorting Total Correct Sorts	6	9	Borderline
Auditory Attention Total Correct	6	9	Borderline
Response Set Total Correct	5	5	Borderline
Inhibition: Naming Total Completion Time	6	9	Borderline
Inhibition: Inhibition Total Completion Time	4	2	Extremely Low
Inhibition: Switching Total Completion Time	2	<1	Extremely Low
Language			
Comprehension of Instructions Total	11	63	Average
Phonological Processing Total	9	37	Average
Speeded Naming Total Completion Time	7	16	Low Average
Memory and Learning			
Memory for Designs Total	9	37	Average
Memory for Designs Delayed Total	8	25	Average
Narrative Memory Free & Cued Recall Total	6	9	Borderline
Narrative Memory Free Recall Total	5	5	Borderline
Word List Interference Repetition Total	8	25	Average
Word List Interference Recall Total	7	16	Low Average
Visuospatial Processing			
Block Construction Total Score	10	50	Average
Geometric Puzzles Total Score	12	75	Average

- Case #2 summary using multivariate:
  - Several low scores found on the NEPSY-II
    - 8 scores ≤10th percentile
    - 4 scores ≤5th percentile
    - 2 scores ≤2nd percentile
  - Having this many low scores is found in 0.9-5.2% of the standardization sample (range depends on cutoff selected) (Brooks et al., 2010)
  - Number of low scores on NEPSY-II is ‘uncommon’

Conclusions

- Interpretation of *multiple* test scores is different than interpretation of an isolated *single* test score
- Clinicians should appreciate the five principles of multivariate test interpretation

Conclusions

- Every test will have a "normal" amount of scatter and a "normal" amount of low scores that need to be accounted for when interpreting results
- Multivariate interpretation increases empirically-based conclusions on neuropsychological data
  - Provides empirical basis for "pattern analysis"

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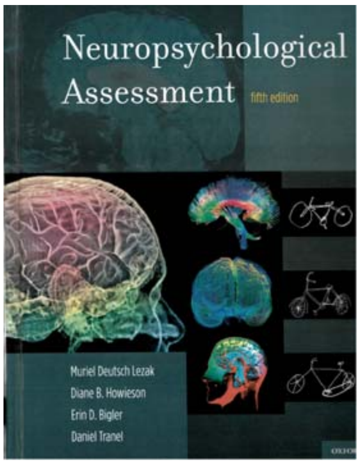
Multivariate Test Interpretation

- Has the field moved forward?



PATTERN ANALYSIS

A significant discrepancy between any two or more scores is the basic element of test score analysis (Silverstein, 1982). Any single discrepant score or response error can usually be disregarded as a chance deviation. A number of errors or test score deviations, may form a pattern. Marked quantitative discrepancies

If scatter is present within test performances, the challenge for the examiner is to assess whether the observed scatter in a given patient is beyond what would occur for the relevant reference group. As few intratest scat-

have the most difficulty. When the pattern of impaired functions or lowered test scores does not appear to be consistently associated with a known or neurologically meaningful pattern of cognitive dysfunction, discrepant scores may well be attributable to psychogenic, developmental, or chance deviations (L.M. Binder, Iverson, and Brooks, 2009).

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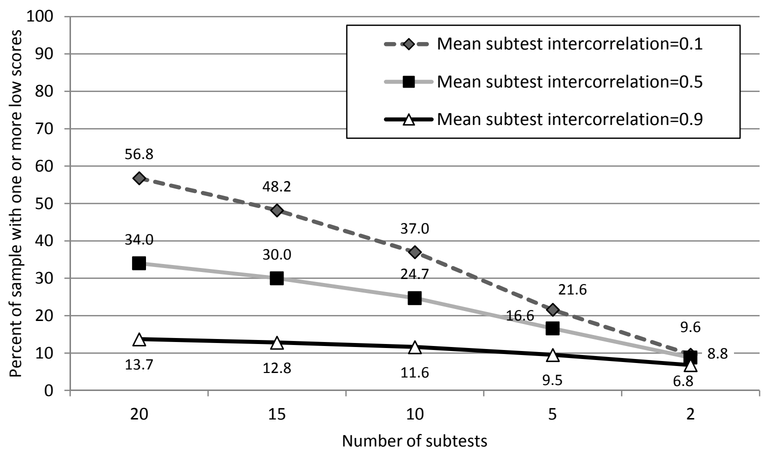
Cautions and Caveats

- Multivariate analyses *supplement, but do not replace,* clinical judgment
- Presence of more low scores than expected is not diagnostic
- Having a low score may not be 'uncommon', but could still impact functioning and merit accommodation
- Caution against substituting tests with existing tables
  - See next figure

Is substitution of scores problematic?

Estimated percent of healthy people who would obtain at least one subtest score <5th percentile across different subtest intercorrelations



Note: Percent of people with low scores was estimated using the Crawford et al. (2007) Monte Carlo program.

Figure 3; From Donders, Brooks, Sherman, & Kirkwood, in press

Collaborators

- Primary collaborators for multivariate base rate research:
  - Dr. Grant Iverson
  - Dr. James Holdnack, Pearson (now University of Delaware)
  - Dr. Elisabeth Sherman
  - Dr. Travis White, PAR Inc.
  - Dr. Larry Binder

- Primary reference:
  - Brooks, B.L. and Iverson, G.L. (2012). Improving accuracy when identifying cognitive impairment in pediatric neuropsychological assessments. In E.M.S. Sherman and B.L. Brooks (Eds.), *Pediatric Forensic Neuropsychology* (pp. 66-88). New York: Oxford University Press.