To Err is Human

Clinical and Forensic Implications of Normal Variability in Adults
Archives of Clinical Neuropsychology, 2009

L. Binder, B. Iverson, & B. Brooks
Focus of Presentation

- Neuropsychological diagnostic methods may err in the direction of lack of specificity (excessive false positive dx) or lack of sensitivity (false negatives). Focus on false positive dx from normal variability. Both error types, false negatives and false positives, are harmful.

- Adults

- Emphasis on published data

- Problems with sensitivity (false positives) of NP assessment is not a focus.
Abnormal is a statistical term, referring to some arbitrary degree of deviation such as > 1 S.D. or > 1.5 S.D. worse than the mean.

Abnormality is not the same as pathology or impairment.
Abnormalities Are Nonspecific

- Poor scores are not pathognomonic of brain injury in people with history of questionable causation, e.g. MTBI, possible neurotoxicity.

- Overdiagnosis of permanent brain injury

- Many causes of abnormality: normal variability, developmental LD, and poor motivation are common.
Normal Variability is Large: WAIS-R

- Jos. Matarazzo and David Herman: WAIS-R.
- 14% of sample had VIQ vs. PIQ absolute difference > 11
- Variability between highest and lowest subtest scores: mean 6.7, SD 2.2.
- 18% of sample had 9 points or more.
- Variability directly related to IQ.
Normal Variability is Directly Related to IQ (WAIS-R)

- WAIS-R normative sample, 287 with a high subtest score of 14:
  - mean lowest subtest score was 7.0 (mean diff = 7),
  - 41% had a lowest subtest score of 6 or below,
  - 20% had a low score of 5 or below.
- 85 standardization sample participants with a high subtest score of 9: mean lowest subtest score was 3.9 (diff ~ 5), 91% had a low score of 5 or below, and 13% had a low score of 2 or below

- Schinka, Vanderploeg, and Curtiss (1994)
Verbal Intellect vs. Memory

- Large discrepancies, favoring intellect, are common, esp. in higher VIQ normals.

- WAIS/WMS-III normative (n=1250)

- 16 or more years education, 21% had Verbal IQ – General Memory (delayed memory) discrepancies ≥ 15 points

- < 12 yrs educ, 11% had VIQ-GM ≥ 15 points

(Dori & Chelune 2004)
WAIS-IV

- More data will become available
- Processing Speed is the least reliable index score.
- Lower reliability of PSI compared with the other 3 indexes probably explains why frequencies of large discrepancies between pairs of index scores including PSI are higher than frequencies of pairs not including PSI.
Published findings parallel those of WAIS-III
WAIS IV Bidirectional Discrepancies

- IQs average range, 20 pts or more
- VCI vs. PSI 20.1%
- VCI vs. PRI 15.1%
- PRI vs. PSI 18.8%
WAIS IV Discrepancies Related to IQ

- Index score discrepancies are directly related to IQ: higher IQ associated with higher frequency of large discrepancies between index pairs.
- IQ > 119: PRI vs. PSI 20 points: 28.0%
- IQ average range: PRI vs. PSI 18.8%
Discrepancies and IQ

- VCI vs. PRI 20 points: 18.5% in Ss with IQ > 119, 15.0% in average range IQ Ss.
Table B.5 of the Manual indicates that several subtests can be significantly \( p < .05 \) different from the mean of 10 subtests and yet that difference occurred in \( > 15\% \) of the sample.

Table B.6: mean scatter for 10 subtests = 6.6 (SD 2.1).

Mean scatter for 15 subtests = 7.6 (SD 2.1)
WAIS-IV Relative Subtest Scatter

- The higher the maximum subtest score, the greater the normal variability. For 10 subtests: scatter and highest score, $r = .62$ (Binder, 2010, AACN).
- For participants with maximum subtest score > 15, almost 19% had lowest score less than 7, i.e. abnormal.
- For participants with max score < 13, majority had lowest score < 7.
Standardization data from the *Wechsler Adult Intelligence Scale*

*Fourth Edition (WAIS-IV).* Copyright © 2008 NCS Pearson, Inc. Used with permission.
WMS-IV and WAIS-IV: General Observations

- Intercorrelations are moderate, and so large discrepancies should be frequent.
- Memory tests are inherently less reliable than intelligence tests.
- WMS-IV offers contrast scaled scores. For example, Verbal Comprehension 100 and Aud Memory 84: contrast scaled score = 6. A 9-point difference is significant p < .05.
Higher IQs should be associated with higher frequencies of large discrepancies.
Variability: WAIS III

- FSIQ absolute differences with WMS-III
  Immediate Memory: 15% > 14 points
- FSIQ v. WIAT Numerical Operations: 15% > 20 points
- FSIQ v. WIAT Math (summary score): 15% > 15 points
- VCI and PSI, average FSIQ, absolute diff: 16% > 20 points
A Little Data On Kids

- **DKEFS and WASI Standardization** (Delis et al 2007 *J. of Educ Assess*)

- **VIQ and PIQ** compared with switching measures. (category, design fluency, trail making, color word inhibition)

- **17-23%** of normative sample had an IQ score in a higher ability category than one of the switching scores.

- **Study weakened** because small and large discrepancies lumped together
Normal Variability: HRB

- Halstead Reitan Battery Impairment Index: based on cutoffs on 7 measures, proportion of abnormal scores ranging from 0 (best) to 1.0 (worst). Scores reported to one decimal.
Normal College Students HRB

- **Percentage** of impaired scores using original HRB cutoff scores. Total of 7 measures.

- **Category:** 38%, TPT Time 8%, TPT Memory 7%, TPT Location 40%, SRT 37%, SSPT 4%, Tapping 56%

  Axelrod & Wall (2007)
HII > 0.4  10%
Mean HII 0.27 (SD 0.19)

Reitan & Wolfson Rating (0 high NL, 1 NL, 2 mild-mod imp. 3 severe imp. )
Rating >1 (impaired) 29% on 3 or more measures.

Mean AIR 0.86 (SD 0.44)  Axelrod & Wall (2007)
Some Abnormal Scores Are Expected

- Heaton, Grant, & Matthews (1991)
- 455 normative subjects
- Expanded HRB – 40 measures
- Demographic corrections
- Abnormal liberally defined as $T < 40$ (below 16th percentile)
Heaton et al 1991 Data

- Data from Fig. 6 of Manual
- 40 measures extended HRB
- Median of 4 abnormalities (10% of the measures)
- Only 10% of the sample had 0
- 27% of the sample had 8 or more
- 19% of the sample had 10 or more
Heaton, Miller, Taylor & Grant (2004)

- 1189 normal participants
- 25 measures
- “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” (p. 72-73, emphasis added)

- T < 40
- 25 measures
- Median of 3 abnormalities
- 13% had zero abnormalities
- 28% had 6 or more
- 10% had 10 or more

- $T < 35$
- Median of 1 abnormality.
- $59\% > 0$
- $15\%$ had 4 or more

- $T < 30$
- 28% had at least one abnormality
- 10% had 2 or more
Schretlen Findings

- Schretlen, using a different battery on a normative sample of 269 participants averaging age 52 and a mean IQ of 106, has data consistent with Heaton et al.

- 25 measures in battery. Demographically adjusted scores.
Schretlen Data

- T < 40: 53% of participants had 3 or more abnormalities
- T < 35: 16% of participants had 3 or more
- T < 30: 3% had 3 or more abnormalities

S. Marc Testa & David J. Schretlen, AACN Meeting, Philadelphia, 2006
Neuropsychological Assessment Battery and Low Score Base Rates

- Normative sample of 1448
- 24 tests, 5 domain based index scores: attention, language, memory, spatial, executive
- Demographic corrections
## NAB Base Rates Data

<table>
<thead>
<tr>
<th>No. of IndexScores</th>
<th>% of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>62.1</td>
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<tr>
<td>1</td>
<td>17.5</td>
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<tr>
<td>2</td>
<td>9.4</td>
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<tr>
<td>3</td>
<td>4.9</td>
</tr>
<tr>
<td>4</td>
<td>3.7</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
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</table>

*total 11% > 2*
T < 30: In a normal distribution, about 98% will not fall below this level on any single index score.

With multiple (5) measures, the probability of a single low score increases to 6.8%. 93.2% had 0 abnormalities.

Grant Iverson, Travis White, Brian Brooks
Abnormal Memory Scores

- 132 older normal adults, 5 memory tests, 10 scores.
- 39.4% > 0 abnormalities
- 16.7% > 1 abnormalities

Palmer, Boone, Lesser, & Wohl (1998)  ACN
Base Rate of Poor Memory: NAB

- “Accidental MCI”
- 742 participants Age 55-79 from normative sample
- 4 memory tests and 10 demographically corrected T scores

(Brooks, Iverson, & White, 2007, JINS)
Base Rate of Poor Memory: Results

- 10 measures, NAB, older normals
- $T < 40$: 55.5% had $> 0$ abnormalities, 18.5% had $> 2$.
- $T < 37$, < 10 percentile: 38.9% $> 0$, 18.6% $> 1$ abnormalities.
- $T < 30$: 16.4% $> 0$ abnormalities
Diagnostic Threat

- Some evidence that neuropsych testing more impaired if the examinee knows that bad scores imply the presence of something dreaded, like brain damage.

Julie Suhr and John Gunstad, JINS, 20005
Significance of Abnormalities: Heaton et al

Additional information needed for interpretation of abnormalities including school performance, vocational history, medical history, psych history, medications, behavior during testing, and knowledge of the patterns of strengths and deficits in various types of brain disorders
Significance of Abnormalities

- Describing patterns of strengths and weaknesses is less error-laden than inferring acquired deficits.

- An abnormality may not be an acquired deficit.
Suboptimal Motivation

Known external incentives for poor performance provide an obvious reason to assess motivation. External incentives include disability claims, potential for financial claims such as involvement in a MVA, WC claims, criminal allegations, opportunity to avoid military duty, qualifying for school accommodations, convincing one’s parents.
Frequency of Failed SVT in Group with No External Incentives

- High school athletes preseason cognitive baseline testing: 11% - Dot Counting (Hunt, Ferrara, Miller, Macciocchi, 2007, Archives of Clinical Neuropsychology)
Learning Disabilities

- In arithmetic impaired subjects with means of 12.5 years of educ, age 29, WAIS-R FSIQ of 87:
  - Trails A 39 sec, approx mean T 31
  - Trails B 101 sec, approx mean T 35
  - WCST 29 errors  WWNL
  - Rey Figure Copy 27/36, impaired

  (Greiffenstein & Baker, 2002, Neuropsychology)
Unpublished Data

- 12 VRD LD referrals
- HVLT-R Total Recall (sum of 3 learning trials)
  \[ T = 36 \]
Learning Disabilities - Prevalence

- 3-20% of adults in the general population
- 20-89% of adults in GED or adult basic educ programs
- Reading disability far more common than math

R.L Mapou presentation
Reading Disability and Neuropsychological Scores

- Poor sentence repetition, working memory, memory in general (McNamara & Wong, 2003, J Learning Dis; J.P. O’Donnell et al., 1988, J Gen Psychol; Minskoff et al 1989, JLD; Michaels et al JLD, 1997)

- 60 adults with mean IQ of 102 in a college support program with at least one WRAT score at least 15 points < IQ. 29/60 had HRB GNDS > 27 i.e. impaired. (Oestreicher & O’Donnell, 1995, Archives of Clinical Neuropsychology)
WMS-III

- 18 adults with reading LD and mean FSIQ 99
- Immed Mem 97.1
- General Mem 93.7
- Working Mem 91.7
- Auditory Process Retention Median percentile 22

## Lower IQ and Memory

- Memory scores on the NAB more frequently impaired in lower IQ, Reynolds Intellectual Screening Test, WAB normative data

<table>
<thead>
<tr>
<th>IQ</th>
<th>% &gt; 1 SD below mean, T &lt; 40</th>
</tr>
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<tbody>
<tr>
<td>80-89</td>
<td>44.7</td>
</tr>
<tr>
<td>90-109</td>
<td>13.1</td>
</tr>
<tr>
<td>110-119</td>
<td>4.8</td>
</tr>
<tr>
<td>120+</td>
<td>5.0 (Brooks, Iverson, &amp; White)</td>
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</tbody>
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IQ and Neuropsych Scores

- Index scores on NAB more frequently impaired in lower IQ normative Ss. Reynolds Intellectual Screening Test

IQ % > 1 SD below mean, > 1 index score

- 80-89: 63.8
- 90-109: 19.0
- 110-119: 6.9
- 120+: 7.4

(Iverson, White, & Brooks)
GPA Predicts Cognitive Scores

- Prolonged Postconcussive Syndrome, mean age 33, mean educ 11 yrs
- Correlation of GPA and scores on WAIS R, WMS R, HRB, others

FSIQ .55  RAVLT Total .41  VIQ .65
Trails B -.46  LM .33  SSPT -.49
VR I .56  BCT -.47

Significance of Abnormal Scores
Redux

Additional information needed for interpretation of abnormalities including school performance, vocational history, medical history, psych history, medications, behavior during testing, and knowledge of the patterns of strengths and deficits in various types of brain disorders.