BASELINE & POST-INJURY NEUROPSYCHOLOGICAL TESTING

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Disclosures: Has no relevant financial relationships to disclose.
HISTORICAL PERSPECTIVE

- High incidence of Football Injuries
- 1905 White House Meeting
  - President Theodore Roosevelt
- 1986 Jeffrey Barth, PhD at University of Virginia
  - Research Concussive Effects — Football
- 1993 Mark Lovell, PhD et al Pittsburgh Steelers
  - Traditional Neuropsychological Testing
- 1995 Kenneth Kutner, PhD et al New York Giants
  - Computerized Neuropsychological Testing

### Sideline Concussion Checklist (SCC)-B

<table>
<thead>
<tr>
<th>Player</th>
<th>Date</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LOC No</td>
<td>Yes</td>
<td>Length</td>
<td>Time of Injury</td>
</tr>
</tbody>
</table>

**Respiration:** Normal, Apnea, Irregular

**Trial**

<table>
<thead>
<tr>
<th></th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. **Unequal Pupils ≥ 2mm**
   - y
   - n
2. **Orientation:** *If on sidelines turn player away from field.*
   - Opponent
   - Current Date
   - Current Quart
   - Current Score
   - Play Injured
   - y
   - n
3. **Fine Motor:** Thumb to Fingertip Sequencing
   - Right
   - Left
   - y
   - n
4. **Vomiting:**
   - y
   - n
5. **Headache:**
   - y
   - n
   - 0 - None
   - 1 - Mild
   - 2 - Moderate
   - 3 - Severe
6. **Dizziness:**
   - y
   - n
7. **Dysmetria:** Examine player with eyes open. Have player touch examiner’s finger then his nose at right, left and midline. Player head/eyes are unfixed.
   - Right
   - Left
   - y
   - n
8. **Diplopia:** Examine with eyes open with central fixation. Have player count lines in left and right visual fields. Have players count lines or fingers.
   - y
   - n

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### Trail I

<table>
<thead>
<tr>
<th>Gait</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>H.T.</td>
<td>y</td>
<td>n</td>
<td>y</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Right</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Impair</td>
<td>Intact</td>
<td>Intact</td>
<td>Intact</td>
</tr>
<tr>
<td>Impair</td>
<td>Impair</td>
<td>Impair</td>
<td>Impair</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Left</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Impair</td>
<td>Intact</td>
<td>Intact</td>
<td>Intact</td>
</tr>
<tr>
<td>Impair</td>
<td>Impair</td>
<td>Impair</td>
<td>Impair</td>
</tr>
</tbody>
</table>

### Trail II

<table>
<thead>
<tr>
<th>Digit Span:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward</td>
</tr>
<tr>
<td>Backward</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oral Trails B:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternate numbers &amp; letters</td>
</tr>
<tr>
<td>1-A-2-B-3-C-4-D-5-E-6-F-7-G-8-H-9-I-10-J</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Remote Memory:</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Player Explains Coach Provided Play</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LT Memory:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shirt, Car, Apple</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other:</th>
</tr>
</thead>
<tbody>
<tr>
<td>i.e. Lethargy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Examination:</th>
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</thead>
</table>

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Head Injury Assessment

ATHLETE

TEAM PHYSICIAN

NEUROLOGICAL EXAMINATION

NEUROIMAGING CT/MRI

NEUROPSYCHOLOGICAL EVALUATION

EXPERIMENTAL BIOMARKERS (X2 SENSOR)

ATHLETIC TRAINER
NEUROPSYCHOLOGICAL TESTING IS AN INTEGRAL PART OF CONCUSSION MANAGEMENT

- American Academy of Neurology
  Sports Concussion Guidelines 2013

- American Medical Society for Medicine Position Statement:
  Concussion in Sports 2013

- Consensus Statement on Concussions in Sports:
  4th International Conference 2012

- National Athletic Trainers’ Association Position Statement:
  Management of Sports Concussion 2014

- NFL Brain & Spine Committee/Center for Disease Control
Neuropsychology is the study of brain-behavior relationships.

Clinical Neuropsychology is the clinical application of neuropsychology.

Includes evaluation and treatment of cognitive impairment.

Utilizes scientifically developed procedures to reliably and validly measure cognition.
NEUROPSYCHOLOGICAL EXAM

- Attention/Concentration
- Reasoning
  - Verbal/Nonverbal
- Intelligence
- Memory
  - Short Term/Long Term
  - Working Memory
  - Verbal & Visual
- Speed of Information Processing
- Language
  - Expressive
  - Receptive
- Visuo-Spatial
- Academic
- Pre Accident Psychological Hx
  - Learning Disabilities
  - ADHD
  - Depression/Anxiety/Panic

Tests of Effort/Malingering

*Practice Parameters (1997) TCN/AACN*
**NEUROPSYCHOLOGICAL TESTING**

*** Two Critical Issues ***

RELIABILITY & VALIDITY

Reliability is consistency of measurement. Repeated administrations of a test reveal consistent findings. Tests must be reliable.

- .60 - .69 Marginal
- .70 - .79 Adequate
- .80 - .89 High
- .90 + Very High

Validity reflects how well a test assesses what it is supposed to be measuring. Tests can be reliable but not valid. Does a test actually measures cognitive impairment.

![Validity vs. Reliability](image)
Greater incidence of invalid test performances in group administration

- Determine athletes understand purpose and nature of baseline testing
- Ensure athletes understand the test directions
- Encourage good effort on part of the athlete
- Reduce and control for distractions
  - Comfortable seating, separation between athletes, limit extraneous sounds, limit interruptions, limit athletes talking, functional computers and mouse
- Have administrator present at all times, baseline and post-injury administration
NY Giants 2014 Baseline Examinations
Neuropsychological Testing may be most valuable when the athlete is at or is approaching being symptom free.

Research is not clear
Initial 48-72 hours
Subsequent Exams 7-10 days
<table>
<thead>
<tr>
<th>TRADITIONAL 1:1</th>
<th>COMPUTERIZED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation better assessed</td>
<td>Reaction time better measured</td>
</tr>
<tr>
<td>Understand Task Directions better</td>
<td>Automatic scoring</td>
</tr>
<tr>
<td>Neurobehavioral status assessed</td>
<td>Less Expensive</td>
</tr>
<tr>
<td>Better control of environment</td>
<td>Multiple athletes run at same time</td>
</tr>
<tr>
<td>More global and detailed exam</td>
<td>Test in Multiple Languages</td>
</tr>
</tbody>
</table>
1. Practice Effects: Test-Retest Effect

2. Motivation: More Motivated to Score Higher

3. Individuals who score at the bottom 10% on baseline can score higher due to regression to the mean.

4. Computerized tests need to repeat a subset of subtests within the same testing i.e. ANAM.
** Utilizing > 1.5 SD below mean for impairment.
  Impact Test results are not normally distributed.
  15% of non-injured score > 1 SD below mean for 1 Composite
  40% of non-injured score > 1 SD below mean for 4 Composites
  Schatz, P & Iverson, G (2014)

** Reliable change indicator (RCI) for ImPACT.
  Single positive RCI score may but usually does not = impairment.
  Two positive RCI scores suspicious for but may not = impairment
  Three positive RCI scores = impairment

** Recommend use of Base Rate Analysis

** Neuropsychologists are in the best position to interpret ImPACT and other cognitive test scores, i.e. NFL
Baseline to post-injury evaluation is often years (4 in NFL)

305 Players, Mean age 25.61 ± 4.87, Mean Education 12.63 ± 2.21 years, mult language
Mean time between testing 373.35 ± 13.86 days

<table>
<thead>
<tr>
<th>Composite</th>
<th>Mean$_1$</th>
<th>Mean$_2$</th>
<th>.70 RCI</th>
<th>.80 RCI</th>
<th>.90 RCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Memory</td>
<td>87.92</td>
<td>88.71</td>
<td>10.19</td>
<td>12.60</td>
<td>16.15</td>
</tr>
<tr>
<td>Visual Memory</td>
<td>77.81</td>
<td>77.92</td>
<td>11.52</td>
<td>14.23</td>
<td>18.23</td>
</tr>
<tr>
<td>Reaction Time</td>
<td>0.57</td>
<td>0.57</td>
<td>0.07</td>
<td>0.09</td>
<td>0.11</td>
</tr>
<tr>
<td>Visual Motor</td>
<td>41.42</td>
<td>41.76</td>
<td>4.31</td>
<td>5.33</td>
<td>6.82</td>
</tr>
</tbody>
</table>

**Study found mixed support for use of Visual Motor and Reaction Time Composites

**Rest-retest reliabilities for the Verbal and Visual Memory Composites were low, suggesting low sensitivity to memory change

**Supplement ImPACT testing with 1:1 for memory assessment
1. Standard Scores for Individual Subtests

2. Percentiles for Individual Subtests

3. Implementation of Two-Factor Theory
   Increased Sensitivity (89%) & Specificity (70%)
   Resulted in Improved Reliability
   Memory (Verbal & Visual)
   1 month .88  1 year .85  2 years .76
   Speed (Visual Motor Speed & Reaction Time)
   1 month .81  1 year .75  2 years .74

POST INJURY ImPACT WITHOUT BASELINE

- Increase chance of making Type I & II Error

- 90% of non-injured population score low on at least 1/10 tests

- Athletes with Learning Disability, ADHD, or history of substance use score lower on baseline in absence of injury

- Utilizing CogSport/Axon baseline method resulted in higher specificity and classification rates than normative method

FUTURE DIRECTIONS

1. Head-to-head testing will determine which computerized test has best reliability & validity.

2. College and possibly high school testing will incorporate hybrid testing format.

3. Normative data for specialized groups (LD & ADHD) will be developed and utilized.

4. Improved Baseline Validity Measures (Reduce Sandbagging)
   i.e. ANAM PVI: Performance Validity Index