Cognitive Rehabilitation After Traumatic Brain Injury

Daniel C. Krawczyk, Ph.D.

Center for BrainHealth®
School of Behavioral and Brain Sciences
The University of Texas at Dallas
&
Department of Psychiatry
UT Southwestern Medical Center
Traumatic Brain Injury (TBI)

- TBI is the leading cause of death and disability in Americans under age 45
- Symptoms include difficulties with memory, attention, and reasoning
- Involves damage to the cortex and to the connections within the brain
Blast injuries, Falls, Vehicle Accidents are prevalent

15% of returning soldiers meet criteria for mild TBI

Mild TBI represents > 90% of military TBI cases

New treatments for TBI symptoms can have a large impact on quality of life for many service members and veterans
Common Challenges Associated with Traumatic Brain Injuries

- Headaches
- Chronic Pain
- Sleep disruption

- Motor deficits
- Balance & coordination difficulties

- Post-traumatic Stress symptoms
- Depression
- Emotional dysregulation
- Substance Abuse
Common Challenges Associated with Traumatic Brain Injuries

• Daily Living Challenges
  – Difficulty focusing attention
  – Challenges with complex tasks
  – Problems managing time and money
  – Difficulties with scheduling
  – Challenges at home, work, or school

Role for Cognitive Rehabilitation
Common Cognitive Symptoms Associated with TBI

- Executive Function Deficits
  - Working memory problems
  - Planning difficulties
  - Reasoning problems
  - Reduced Speed of Processing
Mild Traumatic Brain Injury

- **Difficult to Diagnose**
  - May not involve significant loss of consciousness
  - May not show evidence in neuroimaging
  - Effects may accrue over numerous injuries
  - Effects may be occasional and inconsistent across people
  - Often co-occurs with other issues
    - Sleep disturbance
    - Depression
    - PTSD
    - Pain
Chronic Phase TBI

• *Lasting effects three months or more after TBI*

– Common Cognitive Problems

  • Sustaining attention
  
  • Focusing attention
  
  • Blocking distraction

→ Challenges with memory
Addressing TBI Cognitive Challenges

- Cognitive Interventions
  - Frequently conducted in-person
  - May be run in groups
  - Last 1-2 months in duration
  - Session numbers vary (12-20 sessions)
  - May include domain-specific training
  - May include strategies for tasks of daily living
SMART Trial: Study Overview

- Addressing cognitive challenges in mild-to-moderate TBI
- Chronic phase individuals (3 months or more past TBI)

Pre Testing:
- Neuropsych
- MRI
- Surveys

Strategy Training (SMART)

Post Testing:
- Neuropsych
- MRI
- Surveys

Information Training (BHW)

Follow up Testing 3 months later:
- Neuropsych
- MRI
- Surveys
- 67 civilians and 47 veterans
- 43% of the participants were between 1 and 10 years post TBI
- Chronic stages of recovery (> 1yr. post TBI)
- Blast; Blunt force trauma(s); Fall(s); vehicle accidents; Sports injuries; Multiple Injuries (e.g., vehicle and sports accidents)
- 61% were males, 75% were white
- BHW: 44 completed; SMART: 43 completed
## Study Background/Rationale

### Strategic Memory Advanced Reasoning Training (SMART) Overview

<table>
<thead>
<tr>
<th>Cognitive Function</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>STRATEGIC ATTENTION</strong></td>
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<tr>
<td>1. Filter</td>
<td>Delete unimportant details so main ideas emerge</td>
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<td><strong>INTEGRATION (WM)</strong></td>
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<tr>
<td>2. Focus</td>
<td>Bind important material together into information chunks</td>
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<td>3. Link</td>
<td>Link information chunks to world knowledge</td>
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<td><strong>INNOVATION (LTM)</strong></td>
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<td>4. Zoom</td>
<td>Zoom in/out to place information in broader context</td>
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<td>5. Depth</td>
<td>Discover the deeper meanings and interpretations from multiple perspectives</td>
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Brain Health Workshop (BHW) Overview

- Developed by Dr. Gary Turner (Rotman Research Institute, Toronto)
- Sessions provide fact-based information about the brain.
- Participants find the BHW training to be as equally engaging as SMART
- Critically, BHW does not train cognitive strategies
TBI Cognitive Assessments

Neuroimaging     Neuropsychological Profile     Surveys of Daily Living
Design/Methodology

NEUROPSYCHOLOGICAL ASSESSMENT PLAN

Participant Characterization Measures
- Intellectual capacity
- Processing speed
- Sustained attention

Outcome Measure / Dependent Variable
- Gist-based Reasoning

Predictor Variables / Independent Variables
- Working memory
- Inhibition
- Mental set-shifting
- Recall memory
- Verbal fluency

Functional Outcome Measures
- Glasgow Outcome Scale – Extended (GOSE)
- Functional Status Examination (FSE)
Results - Trail Making Letter-number Sequencing

Significant interaction p<.05
Results - Trail Making Letter-number switching motor speed correction

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<th>Pre</th>
<th>Post</th>
<th>3-mo.</th>
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<td>BHW</td>
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<td>SMART</td>
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Significant interaction $p < .05$
Results - Connectivity Changes for SMART

Cingulo-Opercular Network
Results: Activities of Daily Living

Significant interaction p < .05
MRI-based Cortical Thickness Change In Training Groups

- Occurred in Regions strongly linked to reasoning abilities
- Cortical Dynamics linked to network modularity
Interim Summary

- Short-term intensive cognitive interventions show promise for military TBI populations

- State-of-the-art neuroimaging and cognitive assessments may provide new insights about TBI and evaluating treatment outcomes

- Treatment shows effectiveness at both cognitive, brain, and daily life levels
Other observations...

- Recruitment challenge for military / veterans
  - Establishing trust
  - Framing the training appropriately

- Tele-medicine approaches are needed
  - Reaching more underserved individuals
  - Overcome scheduling and transport challenges

- Outcome measures are key
  - Must align with clinical needs
  - Performance-based challenges must be addressed
Addressing Measurement Gaps in TBI
The Challenges of Measurements for chronic TBI

• Neuropsychological assessments may not fully capture the real world deficits in chronic TBI
  – Tests are performed under idealized conditions

• Questionnaire data on community integration may not connect to cognitive assessments
  – Limitations of administration exist
  – Participant biases may influence results
An Emerging Approach: VR Simulations of Daily Life Cognition

Virtual Reality Functional Cognitive Assessment Tool (VRFCAT)

Kitchen Task              Bus stop Task              Shopping Task              Purchasing Task
(evaluate ingredients)    (catch bus and pay)    (select correct items)    (pay correctly)

* All settings provide numerous performance metrics
Translating Cognition into Daily Living Tasks: Adaptations to VRFCAT for TBI

- Memory Load Manipulation
- Distraction Manipulation
VRFCAT TBI Adaptations

Memory Load Manipulation

Distraction Manipulation

Memory Load × Distraction


Neuro:COG
VRFCAT Results:

• Evidence of a strong practice effect as conditions got more demanding

• *Time to Complete Tasks in VRFCAT*: trial number.
  Total Time on Trial 1 is was statistic significantly different than all other trials
The Potential for Interventions Addressing Activities of Daily Living
Game-based Tools for Training

Virtual Reality Functional Capacity Tool (VRFCAT)

“Evidence-based Gaming”

EXPEDITION:
Upcoming Project funded by U.S. Department of Defense
Advantages of Virtual Reality Environments

• Approximate daily life conditions while allowing experimental control

• Greater potential for sensitive metrics (response times)

• Test for interactions among cognitive challenges

• Can understand life challenges in the context of traditional assessments:
  – neuropsychological testing data
  – neuroimaging markers
  – Community integration instruments

• Opportunity to evaluate assessments aimed at daily life cognition:
  – Virtual Multiple Errands Test (VMET) (Cipresso et al., 2011)
  – Goal Processing Scale (GPS) (Novakovic-Agopian et al., 2014)
Conclusions

• Cognitive Interventions are one avenue for treatment for TBI
• Strategies and cognitive skills can yield gains
• Measurements at multiple levels are needed
• Tele-medicine approaches hold promise
  ➢ Individual differences and needs are key when considering appropriate course of treatment
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