VIRTUAL DRIVING

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Disclosures

• studies funded by NIH, ARRA and The Council on Brain Injury

• collaboration with Digital MediaWorks (DMW)

• editor “Handbook for the assessment of driving capacity”
“Driving is one of the most complex activities of daily living”
DRIVING AFTER NEUROLOGICAL COMPROMISE

Applied Neurotechnologies Lab
Expertise: Clinical Neuropsychology, Physical Medicine and Rehabilitation, Engineering

- Defining driving after TBI (NIH: R01)
- Driving after multiple sclerosis (NMSS)
- Driving after concussion (NIH: ARRA)
- Novice drivers (CDC)
- Driving and veterans with TBI/PTSD (Council on Brain Injury)

OVERARCHING OBJECTIVES

- Develop an integrated model of driving behavior that cuts across spectrum of impairment
- Identify new methods for assessment of driving capacity with and without neurological compromise
- Identify interventions for targeting individualized driver re-training needs
Defining the demands of driving

- Attention
- Visual Spatial
- Executive Function
- Information Processing
- Working Memory
- Vision
- Strength
- Proprioception
- Motor Control

- Physical/Sensory
- Cognitive
- Behavior
- Road Knowledge

- Frequency
- Self-Limiting
- Dual-tasks
- Risk Taking
Defining the demands of driving

- Society
- Environment
- State

Diagram:
- Physical/Sensory
- Cognitive
- Behavior
- Road Knowledge
Measures of Driving

- Paper and pencil cognitive tests
- Self-reporting questionnaires
- Motor vehicle driving reports
- On-road driving evaluations
The VR-Driver Simulation (VRDS)

Clinically usable
- Affordable to clinicians
- Not require large space
- Not require specialized personnel
- Low-tech/ non-intimidating
DREXEL-DMW VR DRIVING SIMULATOR
Driving Challenges
Established VRDS measures

- Speed
  - Average speed in a specific section (i.e., curves)
  - Approaching speed (i.e., stops)
  - Speed control (i.e., variability)

- Lane positioning
  - Lane management (i.e., maintaining position)
  - Lane busts to left or right

- Stopping behaviors
  - How far stop from stop sign?
  - How long wait at stop sign?
  - Did they come to “full stop” or “rolling stop”

- Pedals & Steering wheel
  - Pedal pressure
  - Steering behaviors (i.e., overcorrections)

- Driving Challenges
  - Scenarios that may not happen on road
    - Detours
    - Complex intersections
    - Abrupt events (i.e., pedestrian, car doors)

- Integrated Behavioral Recording
SIMULATED DRIVING AND TBI

What have we learned?

- Cognitive impairment is primary contributor to driving difficulties after TBI
  - Impaired attention (all types)
  - Slowed information processing speed
  - Impaired self-awareness
- Severity of impairment important factor
  - Many mild TBI are successful drivers
SIMULATED DRIVING AND TBI

What have we learned?

- What are the driving errors?
  - Variability
    - Speed, lane positioning
  - Susceptibility to overload
    - Performance decrement during basic tasks

- Other factors are important
  - Previous driving experience
    - Self-limiting behaviors
  - Driving frequency
    - Longer discontinuation
ARE THE QUESTIONS THE SAME FOR TBI & PTSD?
TBI and PTSD

- Traumatic Brain Injury
- Cognitive impairment
- Depression
- Fatigue
- Disinhibition
- Post Traumatic Stress Disorder
- Anxiety
- Sleep disruption
- Re-experiencing symptoms
- Fatigue

Cognition, Emotion, Behavior
PTSD and TBI and Driving

- Self report PTSD and risk taking behaviors
- Aggressive driving behaviors commonly reported
  
  Kuhn et al, 2010; Strom et al, 2012

- Higher self-reported aggressive driving in Iraq and Afghanistan veterans
  
  Kuhn et al, 2010
PTSD and TBI and Driving

- OIF Veterans reported that they sometimes or always fell into combat driving behaviors in civilian settings:
  - 25% drove through stop signs
  - 23% drove in the middle of the road or into oncoming traffic
  - 35% made lane changes or turns without signaling

- 20% reported to be anxious when driving at any time, with larger percentages in situations that mimic combat exposure:
  - 30% when driving near roadside debris
  - 41% in slowed or stopped traffic
  - 31% when passed by other cars
  - 49% when another car approached quickly or boxed them in
PTSD/TBI Simulated Driving

- PTSD/TBI veterans (n=18) compared to healthy controls (n=20)
- Drove 15 min route with intersections
- Driving errors recorded by CDRS:
  - Vehicle position
  - Visual scanning
  - Speed regulation
  - Lane maintenance
  - Signaling
  - Adjustment to stimuli
  - Gap acceptance

Classen et al, 2011
PTSD/TBI Simulated Driving

Main findings: Classen et al, 2011

- Veterans made more over-speeding errors
- Veterans made more adjustment to stimuli errors
- Controls made more signaling errors
PTSD/TBI – driving is different

• Questions about driving in PTSD/TBI are different

• Not only examine the driving errors – but more importantly what contributes to those errors?
PTSD/TBI – driving is different

• Not only examine impact of “traditional” factors contributing to driving but also other contributors
  • Emotionality
  • “Triggers”
  • Interaction of these with cognitive impairment

• Different approach- define difficulties and create individualized simulated driving
ACKNOWLEDGEMENTS:

The Council on Brain Injury

Philadelphia veterans affairs medical center
VETERAN DRIVING QUESTIONNAIRE

- Existing questionnaires are not specific enough for this unique population
  - Need to determine what driving errors veterans are making and what situations are most high-risk

- Steps of development
  - Literature review & clinician feedback
  - Focus groups
  - Pilot data
QUESTIONNAIRE DEVELOPMENT

• Literature review generated three categories:

  • Anxiety provoking situations

  27. When I drive near or next to roadside debris.

<table>
<thead>
<tr>
<th>Never Anxious</th>
<th>Sometimes</th>
<th>Always</th>
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  • High and low-risk behaviors

  62. Swerve or change lanes before driving under an overpass, or before coming out the other side.

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Very Often</th>
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  • Common affective states

  83. I feel aggressive while driving.

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• All ratings on 5-point Likert scale
Focus Groups

• Procedure
  • 2 focus groups, 4 total participants
  • Began with discussion, open-ended questions
  • Gave each participant the VDQ draft, elicited feedback on individual items

• Outcome
  • Added missing items
  • Reworded questions
  • Removed non-pertinent items
### VDQ PILOT DATA: SAMPLE OVERVIEW

<table>
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<tr>
<th></th>
<th>TBI/PTSD</th>
<th>Control</th>
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<tbody>
<tr>
<td><strong>Age</strong></td>
<td>$M = 32.41$, $SD = 7.25$ (Range = 23 – 48 years)</td>
<td>$M = 28.67$, $SD = 5.99$ (Range = 22 – 38 years)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>21 male, 1 female</td>
<td>6 male, 0 female</td>
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<tr>
<td><strong>Race</strong></td>
<td>7 African-American, 1 Asian, 11 Caucasian, 3 Other</td>
<td>3 African-American, 3 Caucasian</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td>3 Divorced, 12 Married/Partnered, 7 Single</td>
<td>1 Divorced, 2 Married/Partnered, 3 Single</td>
</tr>
<tr>
<td><strong>Branch of Military</strong></td>
<td>2 Air Force, 13 Army, 2 National Guard, 2 Navy, 3 Marines</td>
<td>4 Army, 1 Navy, 1 Marines</td>
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<tr>
<td><strong>Education</strong></td>
<td>$M = 14.68$ years, $SD = 1.84$ (Range = 12 – 18 years)</td>
<td>13 years, $SD = 2.45$ (Range = 12 – 18 years)</td>
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Pilot Study: Procedure

- Background and demographics
  - Time spent driving or in convoy during deployment
  - Years since deployment
- Sensation Seeking Scale-Version V (Zucherman, 2007)
  - Premorbid personality factors
- Driver's Angry Thoughts Questionnaire (Deffenbacher et al., 2003)
  - Cognitive component of driving
- DMV records
- VDQ
INITIAL FINDINGS: ANXIETY PROVOKING SITUATIONS

Boxed In
Approached
Debris
Tight Lanes
Potholes
Traffic

TBI/PTSD
Control
INITIAL FINDINGS: BEHAVIORS

- Careful Eye
- Speeding
- Seatbelt
- Forgetting
- Full Stop
- D.U.I.

TBI/PTSD vs. Control
INITIAL FINDINGS: AFFECTIVE STATES

- Very vigilant
- Confident
- In Control
- Aggressive
- Impatient
- Anxious
- Irritated

TBI/PTSD vs Control

Legend:
- Red: TBI/PTSD
- Blue: Control
DISCUSSION POINTS

• Biggest group differences found in ratings of anxiety provoking situations
  • VR implications
  • Exposure therapy
  • Habit training

• High-risk versus protective behaviors

• Qualitative reports
Virtual Driving

- Create specific scenarios related to driving that “trigger” PTSD or compromising behavior:
  - “being crowded in by other vehicles”
  - “seeing debris along road side”
Virtual Driving

• Integrate use of these systems with current interventions
  • Anxiety management
  • Anger management
  • Cognitive processing therapy
• Coupled with neuropsychological assessment
The road to success is still under construction!!!
SIMULATION SICKNESS

Simulation Sickness

Yes

No

HC  TBI  CVA
**significant difference btw. HC and CVA**
WHAT PREDICTS USER FEEDBACK?

User Feedback
Total Score

Age
Education
Cognition
Gender

Age .048*
STRENGTH: YOU CAN MEASURE EVERYTHING

Weakness: You can measure everything
DATA MANAGEMENT?

- 4 primary driving variables
- Every 50 milliseconds (total time = 30 min.)
- 9 different zones
- 7 different challenge triggers
- 70 participants
Simulation vs. Real?

- Research offers many new driving measures

- Few studies have done direct validation with “real world driving”
  - None with TBI

- Without evidence how will clinician use confidently?
Simulation versus Real

Distance (feet)

Intercept

-4 -2 0 2 4 6

0 500 1000 1500 2000 2500 3000

Distance (feet)
Closing thoughts.....

• Virtual driving can offer new opportunities for safe return to driving for veterans with TBI/PTSD
• Driving is different for TBI/PTSD veterans
• Defining the best use of driving simulators will help to improve:
  • Evaluation of driving difficulties
  • Identifying new interventions
## Acknowledgments

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<tr>
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Thank You!

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