THE RELATIONSHIP BETWEEN REAL-TIME EEG ENGAGEMENT, DISTRACTION AND WORKLOAD ESTIMATES AND SIMULATOR-BASED DRIVING PERFORMANCE

Introduction

Objective: To determine the feasibility, and preliminary validity, of adapting a wireless EEG system and cognitive state algorithms (engagement, distraction, workload) for use in the wild – in a driving simulator – with both healthy and neurologically compromised drivers (individuals with HIV-associated neurocognitive disorders (HAND)).

- Despite significant advances in neuroscience research, little is known regarding the cognitive mechanisms of real world functioning (Burges et al., 2006).
- Most studies collect neuropsychological data in a setting where distractions are minimized and individuals complete one task at a time with support from the examiner, and then try to predict real world functioning (a chaotic environment with conflicting priorities, time pressures, and opportunities for engagement to wane) (Marcotte et al., 2009).
- One recent approach, the application of EEG-based cognitive state algorithms to capture neuropsychological states during various activities, has thus far had two critical limitations: 1) the inability to handle dynamic real world conditions, and 2) a focus only on non-neurologic populations.
- HAND is an important population because 1) HIV is now a chronic condition, initially affecting individuals in young/middle age; 2) HAND remains prevalent and affects everyday functioning (Heaton et al., 2004), including automobile driving (Marcotte et al., 1999; Marcotte et al., 2006; Marcotte et al., 2004), and 3) as with other conditions, clinic-based NP assessments only modestly predict who will, or will not, fail real world tasks (Marcotte & Scott, 2009; Reger et al., 2004).
- Driving provides a rich environment for evaluating real-world cognition using EEG algorithms – it is characterized by monotony contrasted with elevated workload, overlearned behaviors and novel responses, multi-tasking, risk-assessment, and time pressure, with salient and immediate consequences (e.g., crash or ticket).

Methods

Participants

<table>
<thead>
<tr>
<th>Sample</th>
<th>Age (M, SD)</th>
<th>Education (M)</th>
<th>Gender (%M)</th>
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<tbody>
<tr>
<td>HIV+</td>
<td>10</td>
<td>49.1 +/- 11.3</td>
<td>14.9</td>
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<tr>
<td>HIV-</td>
<td>14</td>
<td>52.6 +/- 18.8</td>
<td>14.1</td>
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Procedures

SIMULATED DRIVING: STISIM PC-Based consisting of a PC computer, steering wheel, and accelerator/brake pedals, auditory feedback (e.g., engine noise), with the driving environment (roadway, cars, buildings, pedestrians) displayed on a 52” plasma screen.

Participants then completed a 30 min driving simulation. Participants were instructed to get to a location as soon as possible, but to follow traffic laws. The simulation included monotonous, uneventful and low-load driving scenarios, as well as highly demanding events (e.g., intersections, crash avoidance, freeway merges). Participants also needed to respond to occasional divided attention tasks in the corner of the screen.

EEG: B-Alert, Portable, Wireless X10 system

- Participants completed a benchmark set of neurocognitive tasks required to individualize the B-Alert drowsiness/attention and workload algorithms. This consisted of an auditory psycho-vigilance task, a visual psycho-vigilance task, and a 20-min three-choice vigilance task.
- Previously validated EEG-based algorithms for engagement, workload, and distraction, as well individual data from three tasks to adjust centroids, enabling both individualization (required due to the complexity of individual variability in EEG) and generalization (required to apply the algorithm across subjects and tasks) (Berka et al., 2007; Johnson et al., 2011). These algorithms have proven robust in multiple real world validation studies (Burges et al., 2007; 2005; Stevens, Gallaway, & Berka, 2006; Stevens, Gallaway, & Berka, 2007a; Stevens, Gallaway, & Berka, 2007b).
- Engagement: active attention/vigilance constructs
- Distraction: inability to maintain passive attention
- Workload: primarily working memory load and processing.

Results

Figure 3. Crash analysis included all crashes, across 21 of the 24 participants. Random non-crash periods were selected from all 24 participants for the control comparison. A total of 57 crashes and 57 control periods were compared.

Conclusions

- EEG Based Distraction is higher in HIV+ participants as well as in poor drivers, throughout the 30 minute drive, regardless of task.
- EEG based Distraction is elevated 7-14 sec prior to a crash, while EEG based workload dips from 10-16 seconds prior to the crash.
- HIV+ participants are more vulnerable to distraction associated crashes than the HIV- controls.

Future Directions

- Confirm findings using larger sample sizes.
- Determine whether EEG provides incremental improvement beyond cognitive testing in identifying at-risk drivers
- Apply to real-world, on-road driving

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