Examining Young Driver Behaviors Using Driving Simulation and Neuroimaging

Anuj K. Pradhan, PhD
University of Michigan
  • Dr. C. Raymond Bingham
  • Dr. Lisa Buckley
  • Dr. Chris Monk

Toyota CSRC
  • Dr. Tina Sayer

NICHD
  • Dr. Bruce G. Simons-Morton
Overview

- Background & Introduction
  - Young Drivers
  - Teen Passengers

- Measuring behaviors
  - Driving Simulation
  - Eye movements
  - Neuroimaging

- Ongoing study: fNIRS & Driving Simulation
  - fNIRS
  - Brain regions
  - Experimental protocols
Motor Vehicle Crashes are the leading cause of death for teenagers in the United States.

- Youth 15-20 years old
  - 9% of U.S. population (2007)
  - 6% of driving population
  - But, 19% of fatalities in US in 2007 related to young drivers

- Annual cost for Teen injuries = $ 14 billion (CDC, 2010)
Background & Introduction

Young Drivers + Peer Passengers

• Peer passenger presence is a risk factor for teen drivers
  • Especially male drivers
  • Especially multiple peer passengers

• Naturalistic studies have shown that teens drive worse when with passengers

• Epidemiological studies have shown higher crashes and higher fatalities when peer passengers are present

• Why??
Measuring driver behavior

• Approaches
  • Naturalistic
    • Instrumented vehicles
  • Experimental
    • Driving Simulators

• Measures
  • Driving simulation/vehicle kinematic measures
  • Eye movements
  • Neuroimaging
    • (teenage brain’s activity is different from that of adults)
Background & Introduction
Past simulator study

- Driving simulator study
  - Teen drivers with confederate passengers

- Simulator measures (driving risks)
  - Teen drivers took more risks in the presence of a passenger

- Eye movement measures
  - Teen drivers scanned less widely in the presence of passengers
  - Scanning patterns resembled those of cognitively loaded drivers
fNIRS & Driving Simulation

Neuroimaging

- Functional Magnetic Resonance Imaging (fMRI)
  - High resolution
  - Deep brain scanning
  - Experimental limitations
  - Costs
Functional Near Infra Red Spectroscopy (fNIRS)
- a non-invasive optical brain imaging
- in vivo measurements of oxygenated and deoxygenated hemoglobin in cortical tissue
- to study regions in the prefrontal cortex of drivers performing an ecologically valid driving simulation task.

TechEN CW6 equipment
- continuous wave approach
- up to 32 lasers and detectors.
Brain activity is fueled by glucose metabolism

Increased neural activity results in increased glucose & Oxygen consumption

Increases local cerebral blood flow to active brain areas

Oxygen is transported by Oxygenated Hemoglobin (O2Hb) in the blood

As oxygen is withdrawn for metabolism there is an increase in Deoxygenated Hemoglobin (HHb)
• O2Hb and HHb have optical properties in the near-infrared light range (700 to 900 nm)

• This makes it possible to measure change in their concentration using optical measures such as fNIRS
fNIRS & Driving Simulation

fNIRS

- Optodes are used to shine near-infrared light into regions of interest
- Emitters shine light into the skull
  - The light penetrates the scalp in a banana shape
- Reflected light is measured by receivers
- The amount of absorbed light relate to when and where the brain is active
# fNIRS & Driving Simulation

## Neuroimaging

<table>
<thead>
<tr>
<th></th>
<th>fMRI</th>
<th>fNIRS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spatial Resolution</strong></td>
<td>8-27 mm³</td>
<td>1-10 cm³</td>
</tr>
<tr>
<td><strong>Temporal Resolution</strong></td>
<td>Slow (1-2 sec)</td>
<td>Fast (50 Hz)</td>
</tr>
<tr>
<td><strong>Measurement Parameter</strong></td>
<td>Mix of blood volume, blood flow, and O₂ metabolism</td>
<td>[Hb] and [HbO]</td>
</tr>
</tbody>
</table>
fNIRS & Driving Simulation

The Study

• Driving simulation study
  • Teen drivers, with confederate peer passengers
  • Driving simulation will introduce and latent risks

• Driving Simulator
  • Realtime Technologies Incorporated (RTI) desktop version.

• Brain regions of interest
  • Response inhibition, Incentive processing, cognitive control
  • Ventrolateral Prefrontal Cortex, Dorsolateral Prefrontal Cortex, Orbitofrontal Cortex.
fNIRS & Driving Simulation

The Study

Hypotheses:

1. There will be a significant interaction of age group by passenger condition, such that teenage drivers demonstrate higher risky driving behavior in a simulator when driving with a peer passenger compared with driving alone.

2. Age group by passenger condition comparisons will demonstrate differential neural activation in selected PFC regions between groups and conditions resulting in a significant age group by passenger condition interaction.
fNIRS & Driving Simulation

The Study

• Status:
  • Interface of driving simulator and fNIRS
  • Identification of brain region, fNIRS optodes & head regions
  • Simulator drives
  • Recruitment ongoing
  • Data collection is imminent
  • Results?
Thank you

Questions?

anujkp@umich.edu

Twitter: @DriverScience