Assessment of driving performance of drivers with brain pathologies in urban roads, using a driving simulator

Dimosthenis Pavlou, Eleonora Papadimitriou, Sophia Vardaki, Constantinos Antoniou, Panagiotis Papantoniou, George Yannis, John Golias, Ion Beratis, Alexandra Economou, Sokratis Papageorgiou
Outline

• Background
  • Cerebral diseases and driving performance
  • Driving in urban areas
• Objectives
• Driving simulator experiment
  • Overview of the experiment
  • Driving at the simulator
• Results
• Conclusions and discussion
Background

- Cerebral diseases and driving performance
  - Cognitive skills needed while driving:
    - concentration and attention
    - adequate visual and perceptual skills
    - Insight and judgment
    - memory
  - Brain pathologies cause motor, visual, cognitive and perceptual deficits

- Driving in urban areas,
  requires several tasks performed simultaneously due to:
  - increased traffic
  - presence of bicyclists and pedestrians
  - traffic signs and frequent junctions

German Federal Highway Research Institute (BAST), Bergisch-Gladbach, Germany, 27-28.11.2014
Objectives

Analyze the driving performance in urban roads of drivers with cerebral diseases by means of a driving simulator

- Cerebral diseases examined:
  - Mild Cognitive Impairment (MCI)
  - Alzheimer’s Disease (AD)
  - Parkinson’s Disease (PD)

- Driving performance measures:
  - mean speed
  - lateral position
  - space headway
  - reaction time and accident probability at unexpected incidents
Driving simulator experiment

• Distract and DriverBrain research projects

• An interdisciplinary research team
  • Dpt. of Transportation Planning and Engineering NTUA
  • Dpt. of Neurology of the University of Athens (NKUA)
    Medical School, ATTIKON Hospital, Athens
  • Dpt. of Psychology, UoA School of Philosophy,
    Pedagogy and Psychology

• A large simulator experiment
  • Medical/neurological assessment
  • Neuropsychological assessment
  • Driving at the simulator
Driving at the simulator

- 1 driving simulator
  - Foerst Driving Simulator FPF (1/4 cab)
- 1 road environment
  - Urban: divided urban arterial
- 2 traffic scenarios
  - $Q_L$: Low traffic volume
  - $Q_H$: High traffic volume
- 2 unexpected incidents at each trial
  - Child crossing the road
  - Sudden appearance of a car
Sampling scheme

- 97 participants
  - 62 healthy controls
  - 35 impaired

Age distribution of the sample
Results 1/5

- Control drivers drove at 17% higher speed than impaired ones
- Large variability in PD drivers’ mean speed
Results 2/5

- Impaired drivers keep larger headways than controls (7% in Q_L and 27% in Q_H)
- Large variability of mean space headways for PD drivers in high traffic volume
Results 3/5

- Impaired drivers drive approximately 40cm to the right compared to the control group
- Control drivers show somewhat increased variability in lateral position

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>AD</th>
<th>MCI</th>
<th>PD</th>
</tr>
</thead>
<tbody>
<tr>
<td>QL aver+stdev</td>
<td>3.54</td>
<td>3.96</td>
<td>4.07</td>
<td>3.88</td>
</tr>
<tr>
<td>QL aver-stdev</td>
<td>2.31</td>
<td>2.51</td>
<td>2.68</td>
<td>2.83</td>
</tr>
<tr>
<td>QL aver</td>
<td>2.93</td>
<td>3.23</td>
<td>3.38</td>
<td>3.36</td>
</tr>
<tr>
<td>QH aver+stdev</td>
<td>3.66</td>
<td>3.80</td>
<td>4.15</td>
<td>3.87</td>
</tr>
<tr>
<td>QH aver-stdev</td>
<td>2.40</td>
<td>3.26</td>
<td>2.81</td>
<td>2.69</td>
</tr>
<tr>
<td>QH aver</td>
<td>3.03</td>
<td>3.53</td>
<td>3.48</td>
<td>3.28</td>
</tr>
</tbody>
</table>
• Impaired drivers have worse reaction times than the control ones (0.25 sec worse overall)
• AD drivers have the worst reaction times
Results 5/5

- Impaired drivers have higher accident probability than the control group (12% higher at low traffic, 18.1% at high traffic and 15% overall)
- It seems that high traffic volume has an effect on the accident probability at all drivers
- PD and AD drivers seem to be affected from the more difficult driving environment
Conclusions 1/2

- Ongoing experiment
- Sample size needs improvement
- Cerebral diseases appear to have considerable impact on longitudinal driving performance measures (mean speed, headways) but less identifiable impact on lateral driving performance measures (lateral position)
- Impaired group has worse reaction times and higher accident probability in an unexpected incident
Conclusions 2/2

- AD and PD drivers seems to have the worse driving behaviour:
  - very low speeds
  - very large space headways
  - don’t adjust to the traffic environment
  - bad reaction times
  - very high accident probability
  - difficulties in high traffic conditions
  - Promising results
  - Further statistical analyses
Assessment of driving performance of drivers with brain pathologies in urban roads, using a driving simulator

Dimosthenis Pavlou, Eleonora Papadimitriou, Sophia Vardaki, Constantinos Antoniou, Panagiotis Papantoniou, George Yannis, John Golias, Ion Beratis, Alexandra Economou, Sokratis Papageorgiou