A large driving simulator experiment on driver distraction of older drivers

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Outline

• Background
• Objectives
• Key research variables
• Overview of the experiment
• Medical assessment
• Neuropsychological assessment
• Driving simulator experiment
• Preliminary results
• Discussion
Background

• The **Distract** research project  
  **distrACT**  
  [www.nrso.ntua.gr/distract](http://www.nrso.ntua.gr/distract)  
  “Analysis of causes and impacts of driver distraction”  
  Causes: engodenous & exogenous, Impacts: driver behaviour & safety  
  Drivers from the general population, as well as drivers with altered cognition due to cerebral diseases with high prevalence: e.g. Mild Cognitive Impairment (MCI), mild Alzheimer’s Disease.

• The **DriverBrain** research project  
  **driverBRAIN**  
  [www.nrso.ntua.gr/driverbrain](http://www.nrso.ntua.gr/driverbrain)  
  “Analysis of the performance of drivers with cerebral diseases” altering cognition  
  Alzheimer’s Disease, Parkinson’s disease, Cerebrovasular disease - both in their MCI (pre-dementia) stages, but also in their mild dementia stages.

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

• A **common simulator experiment**
Objectives

• To present the design and preliminary results of a simulator experiment which:

• Has a twofold objective
  • Impacts of driver distraction
  • Performance of drivers

• Targets two groups of drivers
  • Drivers from the general population
  • Drivers with a mild pathological condition
Key research variables

• Diseases & conditions targeted
  • Parkinson’s (PD), Alzheimer’s (AD), (patients must be still able to drive)
  • Mild Cognitive Impairment (MCI), mainly pre-dementia stage of AD
  • In terms of driving performance, but also as ‘endogenous’ causes of distraction

• Exogenous distraction causes
  • Use of mobile phone (hand-held)
  • Conversation with passenger

• Road and traffic variables
  • Area type (urban / rural)
  • Traffic volume (moderate, high)
Sample design & characteristics

• Healthy drivers & impaired drivers: oversampling of ages >55 years

<table>
<thead>
<tr>
<th>Age</th>
<th>Impaired</th>
<th>Healthy</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 55</td>
<td>125</td>
<td>75</td>
<td>200</td>
</tr>
<tr>
<td>&lt; 55</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>175</td>
<td>125</td>
<td>300</td>
</tr>
</tbody>
</table>

• Duration: 3 years
  Fall 2012 – Fall 2015 (incl. analysis)
Phases of the experiment

• Part 1. Medical, Clinical & Neurological evaluation
  Attikon General Hospital, (~1,5 hours)

• Part 2. Neuropsychological Assessment
  Attikon General Hospital, (~2 hours)

• Questionnaire on driving habits
  At home (~20 minutes)

• Part 3. Driving simulation experiment
  NTUA Driving Simulator (~1,5 hour)

• Part 1B. Medical evaluation, Part 2B. Neuropsychological Assessment
  Attikon General Hospital, (~1 hours)
Medical/neurological assessment

- **Comprehensive Clinical Evaluation** (general medical and neurological)
  - Present & past history, pharmacological treatment, life habits (alcohol consumption, smoking, etc)
  - Detailed neurological examination (neurological signs: markers for a disease)
  - Psychiatric assessment for depression, anxiety, behavioral disturbances
  - Ophthalmological evaluation: visual acuity, visual fields, fundoscopy
- **Motor ability-tests in Fitness to Drive**: Specific clinical tests examining motor control, balance, visual fields etc. related to driving skills
Neuropsychological assessment

- Comprehensive Neuropsychological Evaluation
- Tests covering a large spectrum of Cognitive Functions:
  - Visuo-spatial, verbal episodic and working memory
  - General, selective and divided attention
  - Reaction time
  - Processing speed, psychomotor speed

- Associated with fitness to drive:
  - MMSE: General Cognitive State
  - Clock Drawing Test
  - Hopkins Verbal Learning Test
  - Trail Making Test
  - Useful Field of View
Driving simulator experiment (1/2)

- 2 blocks with up to 6 trials each
- 1.7 km for each urban trial - 2.0 km for each rural trial (3.0 - 3.5 minutes on average)
- Randomized between and within block-trials
- Incidents at fixed points

<table>
<thead>
<tr>
<th>Block</th>
<th>Trial</th>
<th>Area type</th>
<th>Traffic</th>
<th>Distractor</th>
<th>Length (km)</th>
<th>Duration (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Urban</td>
<td>Moderate</td>
<td>None</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>Urban</td>
<td>High</td>
<td>None</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>Urban</td>
<td>Moderate</td>
<td>Cell phone</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>Urban</td>
<td>High</td>
<td>Cell phone</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>Urban</td>
<td>Moderate</td>
<td>Passenger conversation</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>Urban</td>
<td>High</td>
<td>Passenger conversation</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Rural</td>
<td>Moderate</td>
<td>None</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Rural</td>
<td>High</td>
<td>None</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Rural</td>
<td>Moderate</td>
<td>Cell phone</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>Rural</td>
<td>High</td>
<td>Cell phone</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>Rural</td>
<td>Moderate</td>
<td>Passenger conversation</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>Rural</td>
<td>High</td>
<td>Passenger conversation</td>
<td>2.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Total Length: 22.2 km, Total Duration: 39.0 min
Driving simulator experiment (2/2)

• Traffic scenarios
  • **Input:** Vehicle headways drawn from a Gamma distribution with a given mean and variance
  • **Output:** The specific traffic volume experienced per trial for each participant

• Quantitative indicators - Trial specific (automatically recorded)
  • Reaction time
  • Speed (& difference from mean)
  • Lateral position (& difference from mean)
  • Steering angle (& difference from mean)
  • Accident probability at specific incident
    • Urban drive: parked car enters the road, a child with a ball crosses the road
    • Rural drive: sudden appearance of animal
Preliminary results (1/5)

• Basic facts
  • Participants so far: 31 [aver. 63.6 years old (stdev 13.1), 22 males]
  • Impaired: 20 (9 MCI, 4 AD, 7 PD)
  • Control: 11
  • Duration: 15 weeks

• Simulator driving: (completed by)
  • No distraction drive: 31/31 rural area, 27/31 urban area
  • Distraction: Conversation with passenger: 30/31 rural area, 24/31 urban area
  • Distraction: Mobile phone: 9/31 rural area, 8/31 urban area (6 controls)

• Questionnaires:
  • Driving behaviour questionnaire (filled in at home)
  • Self-assessment and memory questionnaire (filled in after the experiment)
Preliminary results (2/5)

- Simulator sickness
  - Simulator sickness: 11/31 (5PD, 1AD, 3 MCI, 2 Control)
  - Soft symptoms: 5/31
  - Intense symptoms: 6/31
  - Would like to continue the driving despite the symptoms: 3/31
  - Completed only 1 or 2 trials: 4/31 (3PD, 1AD)
  - Drop out: only 1 (Intense symptoms and stop from the beginning)
Preliminary results (3/5)

Mean speed profile along the route in the rural area

(Low traffic volume, No distraction)
## Preliminary results (4/5)

**Reaction time** at unexpected incident in **Rural area** and with **Low traffic volume**

<table>
<thead>
<tr>
<th>Reaction Time (sec)</th>
<th>Participants</th>
<th>Events</th>
<th>No distraction</th>
<th>Distraction*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy drivers</td>
<td>11</td>
<td>52</td>
<td>1,73</td>
<td>1,52</td>
</tr>
<tr>
<td>Impaired drivers</td>
<td>20</td>
<td>71</td>
<td>2,02</td>
<td>2,06</td>
</tr>
<tr>
<td>MCI</td>
<td>9</td>
<td>36</td>
<td>1,94</td>
<td>1,60</td>
</tr>
<tr>
<td>AD</td>
<td>4</td>
<td>13</td>
<td>2,32</td>
<td>3,04</td>
</tr>
<tr>
<td>PD</td>
<td>7</td>
<td>22</td>
<td>2,00</td>
<td>2,46</td>
</tr>
</tbody>
</table>

* Conversation with passenger

## Mean Speed in **Rural area** and with **Low traffic volume**

<table>
<thead>
<tr>
<th>Mean Speed (km/h)</th>
<th>Participants</th>
<th>Trials completed</th>
<th>No distraction</th>
<th>Distraction*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy drivers</td>
<td>11</td>
<td>25</td>
<td>49,01</td>
<td>50,71</td>
</tr>
<tr>
<td>Impaired drivers</td>
<td>20</td>
<td>35</td>
<td>41,13</td>
<td>41,29</td>
</tr>
<tr>
<td>MCI</td>
<td>9</td>
<td>17</td>
<td>44,53</td>
<td>39,77</td>
</tr>
<tr>
<td>AD</td>
<td>4</td>
<td>7</td>
<td>37,63</td>
<td>39,31</td>
</tr>
<tr>
<td>PD</td>
<td>7</td>
<td>11</td>
<td>39,34</td>
<td>47,29</td>
</tr>
</tbody>
</table>

* Conversation with passenger
**Preliminary results (5/5)**

Average Lateral Position in **Rural area** and with **Low traffic volume**

<table>
<thead>
<tr>
<th>Lateral Position* (km/h)</th>
<th>Participants</th>
<th>Trials completed</th>
<th>No distraction</th>
<th>Distraction**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy drivers</td>
<td>11</td>
<td>25</td>
<td>0.77</td>
<td>0.81</td>
</tr>
<tr>
<td>Impaired drivers</td>
<td>20</td>
<td>35</td>
<td>0.82</td>
<td>0.89</td>
</tr>
<tr>
<td>MCI</td>
<td>9</td>
<td>17</td>
<td>0.82</td>
<td>0.90</td>
</tr>
<tr>
<td>AD</td>
<td>4</td>
<td>7</td>
<td>0.72</td>
<td>0.86</td>
</tr>
<tr>
<td>PD</td>
<td>7</td>
<td>11</td>
<td>0.87</td>
<td>0.89</td>
</tr>
</tbody>
</table>

* Distance from the right road board  ** Conversation with passenger
Conclusions

• An interdisciplinary approach by engineers, doctors and psychologists allows for better insight on driver behaviour.

• The fundamental research challenge is the separation of the age effect from the cerebral disease effect to older driver behaviour.

• Analysis of behaviour of several driver sub-groups requires a large sample, with identical experiment conditions. The optimum number of parameters to examine should be defined.

• Analysis results from driving simulator experiments do not always represent real driving behaviour, however the relative behaviour between the different sub-groups examined can be well demonstrated.
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