Design of a dedicated driving simulator experiment on driving behaviour

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Athens, 26 June 2015
Background

- The DISTRACT research project
  - “Analysis of causes and impacts of driver distraction”
  - Causes: endogenous & 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, Cerebrovascular disease (stroke).

- The DriverBrain research project
  - “Analysis of the performance of drivers with cerebral diseases” altering cognition
  - Alzheimer’s Disease, Parkinson’s disease, Cerebrovascular 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, UoA School of Philosophy, Pedagogy and Psychology

- A common simulator experiment
Objectives

Objective

Design of a dedicated driving simulator experiment to assess the driving performance of older drivers in terms of both traffic and safety parameters with emphasis on driver distraction

- The experiment has a twofold objective
  - assessment of driving performance
  - impacts of driver distraction

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

- Medical and neurological parameters
- Neuropsychological parameters
- Road type and traffic parameters
- Driver behaviour and safety parameters
Overview of the experiment

**Designed sample size**

<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>
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</tbody>
</table>

**Phases of the Experiment**

- **Phase 1.** Medical / Neurological Assessment
- **Phase 2.** Neuropsychological Assessment
  - Questionnaire on driving habits
- **Phase 3.** Driving at the simulator
  - Rural and urban driving sessions
  - Motorway driving session
Phase 1: Medical / neurological assessment

Comprehensive clinical evaluation

- 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

- **Phase 1A** - pre-simulator with up to 14 exams
- **Phase 1B** - post-simulator with up to 2 exams
Phase 2: Neuropsychological assessment

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

- **Phase 1A** - pre-simulator with up to 13 tests
- **Phase 1B** - post-simulator with up to 6 tests
Phase 3: Driving at the simulator

Urban and rural driving sessions

**Objective:** investigate the driving performance of healthy versus impaired subjects at typical driving conditions, with different road, traffic and distraction characteristics.

Motorway driving session

**Objective:** determine whether varying levels of operational and tactical task demands would differentially affect healthy versus impaired subjects in recall of traffic safety messages.
Urban and rural driving sessions (1/2)

- Full factorial within-subject design
- 1 driving simulator
  - Foerst Driving Simulator FPF (1/4 cab)
- 2 road environments
  - Rural: undivided two-lane rural road
  - Urban: divided urban arterial
- 3 distraction conditions
  - No distraction
  - Conversation with passenger
  - Mobile phone use
- 2 traffic scenarios
  - Low to moderate traffic conditions ($v/c \approx 0.50-0.70$)
  - Moderate to high traffic conditions ($v/c \approx 0.70-0.85$)
- 2 unexpected incidents at each trial
  - Deer or donkey at rural area
  - Child crossing the road or sudden appearance of a car at urban area
Urban and rural driving sessions (2/2)

- 2 driving sessions with up to 6 trials each
- 1.7 km for each urban trial - 2.1 km for each rural trial (3.5 minutes on average)
- Counterbalanced between and within session-trials
- Incidents at fixed points

<table>
<thead>
<tr>
<th>Session</th>
<th>Area Type</th>
<th>Trial</th>
<th>Traffic</th>
<th>Distractor</th>
<th>~ Length (Km)</th>
<th>~ Duration (Min)</th>
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<td>1</td>
<td>Urban</td>
<td>1</td>
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<td>None</td>
<td>1.7</td>
<td>3:30</td>
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<td>2</td>
<td>High</td>
<td>None</td>
<td>1.7</td>
<td>3:30</td>
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<td></td>
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<td>3:30</td>
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<td></td>
<td>4</td>
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<td>5</td>
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<td>Conversation</td>
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<td>8</td>
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<td>3:30</td>
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<td>9</td>
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<td></td>
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<td></td>
<td>Total</td>
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<td>22.8</td>
<td>42:00</td>
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</table>
Motorway driving session

- 3 trials (6 minutes each)

- **Memory task** involving a cued recall of important safety information presented (8sec)
  - Three signs to recall:
    - a) a type of situation ahead (icy road)
    - b) a distance (4 km ahead)
    - c) a driver action required (use of snow chains)

- **Different levels of task demand** (100sec each)
  - **Low demand trial**: minimal steering input, lead vehicles at safe distance ahead
  - **Moderate demand trial**: after an initial low-demand driving the driver makes a double lane change (roadworks section)
  - **High demand trial**: same steering requirements in addition drivers are required to execute a lane change in response to a discriminative stimulus (activation of brakes of the lead vehicle).
Discussion

**Contribution of the research**

- Interdisciplinary approach
- Large sample size
- Focus on impaired drivers
- Endogenous and exogenous effects on driver performance
- Detailed effects of traffic

**Challenges in the experiment design**

- Combine and balance the objectives & targets
- Selection of key variables (medical, neuropsychological, traffic)
- Individual assessment and population analysis
- Efficiency: rigorous design yet manageable size
- Effects of simulator sickness and unfamiliar technological environment
## Experiment characteristics

<table>
<thead>
<tr>
<th>Total participants</th>
<th>Total progress 30 April 2015</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase A Pre-Simulator</td>
<td>307 completed (192 impaired)</td>
<td>9 drop outs</td>
</tr>
<tr>
<td>Driving at the Simulator</td>
<td>226 completed (133 impaired)</td>
<td>49 sim. sick. drop outs</td>
</tr>
<tr>
<td>Phase B Post-Simulator</td>
<td>209 completed</td>
<td>107 drop outs</td>
</tr>
</tbody>
</table>

**209 participants completed all phases (127 impaired)**
Key figures of the experiment (2/2)

Sample characteristics

Sample Scheme
(209 participants through all phases)

Age Distribution
(209 participants through all phases)

Mental Condition Distribution
(209 participants through all phases)
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