Design of a dedicated driving simulator experiment on driving behaviour

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Background

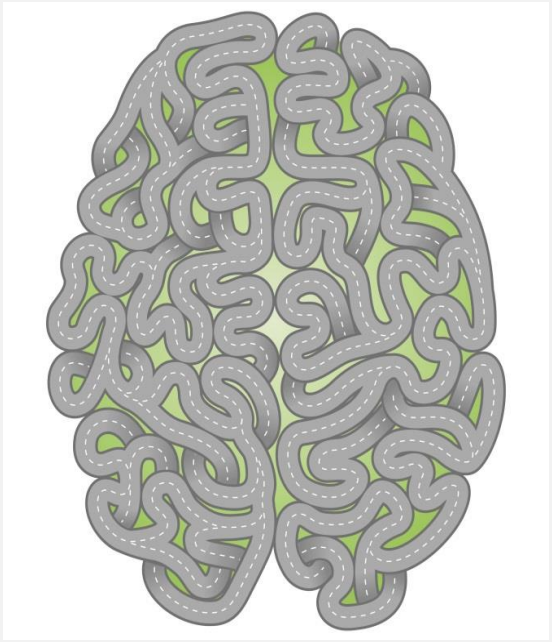
- **The DISTRACT research project**
  - "Analysis of causes and impacts of driver distraction"
  - Causes: engodenous & exogenous, Impacts: driver behaviour & safety
  - Drivers from the general population, as well as drivers with altered cognition due to cerebral diseases with high prevalence: e.g. Mild Cognitive Impairment (MCI), mild Alzheimer's Disease, Cerebrovascular disease (stroke).
- **The DriverBrain research project**
  - "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, UoA School of Philosophy, Pedagogy and Psychology
- **A common simulator experiment**

Objectives

Objective

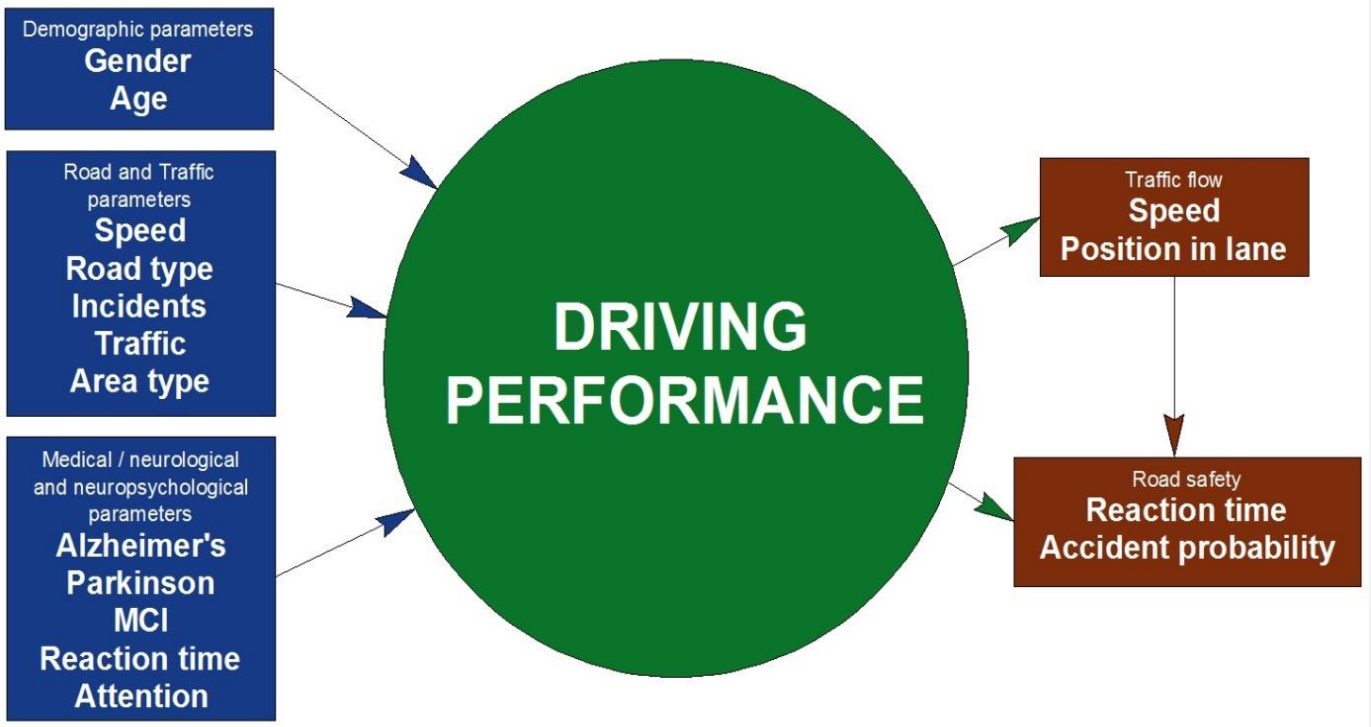
Design of a dedicated driving simulator experiment
to assess the driving performance of older drivers
in terms of both traffic and safety parameters
with emphasis on driver distraction

- **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

Age	Impaired	Healthy	Total
> 55	125	75	200
< 55	50	50	100
Total	175	125	300

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 acquity, 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 Gognitive 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 ~ 0.50-0.70)
  - Moderate to high traffic conditions (v/c ~ 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

Session	Area Type	Trial	Traffic	Distractor	~ Length (Km)	~ Duration(Min)
1	Urban	1	Moderate	None	1,7	3:30
		2	High	None	1,7	3:30
		3	Moderate	Cell Phone	1,7	3:30
		4	High	Cell Phone	1,7	3:30
		5	Moderate	Conversation	1,7	3:30
		6	High	Conversation	1,7	3:30
2	Rural	7	Moderate	None	2,1	3:30
		8	High	None	2,1	3:30
		9	Moderate	Cell Phone	2,1	3:30
		10	High	Cell Phone	2,1	3:30
		11	Moderate	Conversation	2,1	3:30
		12	High	Conversation	2,1	3:30
				Total	22,8	42:00

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

Key figures of the experiment (1/2)

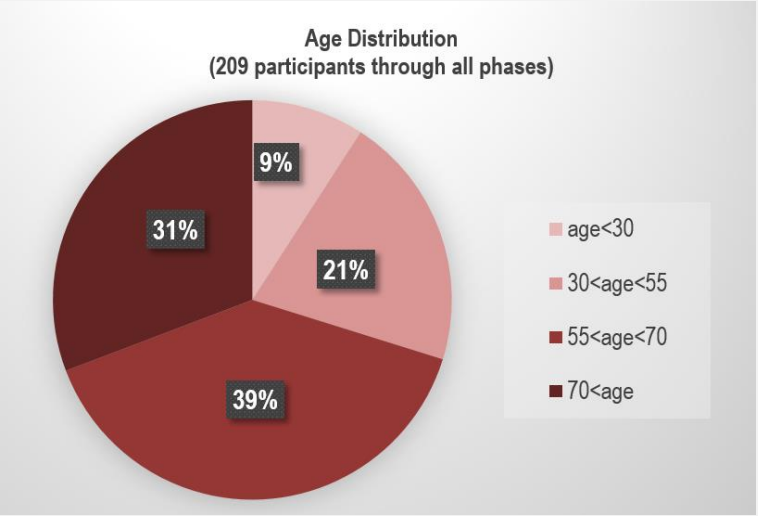
Experiment characteristics

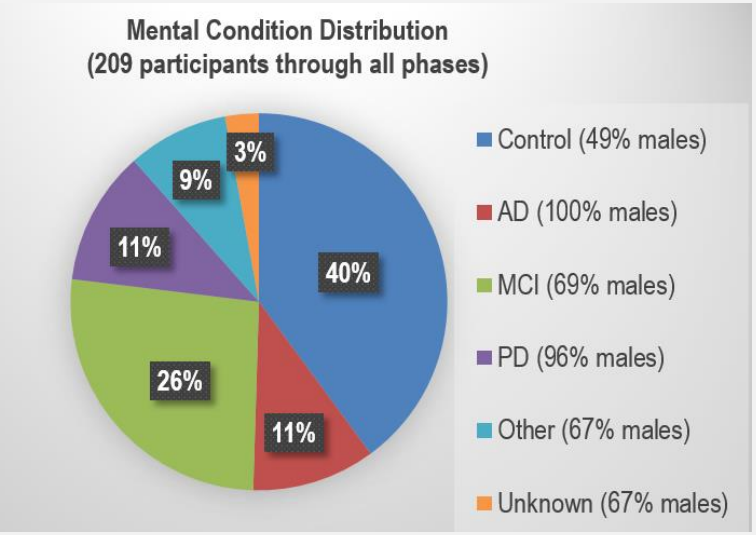
TOTAL PROGRESS 30 April 2015			Total
Total paricipants	**316** (192 impaired)		316
Phase A Pre-Simulator	**307** completed (192 impaired)	**9 drop outs**	316
Driving at the Simulator	**226** completed (133 impaired) **(25AD, 59MCI, 25PD, 22other, 5unknown)**	**49** sim. sick. drop outs **41** drop outs	316
Phase B Post-Simulator	**209** completed	**107** drop outs	316

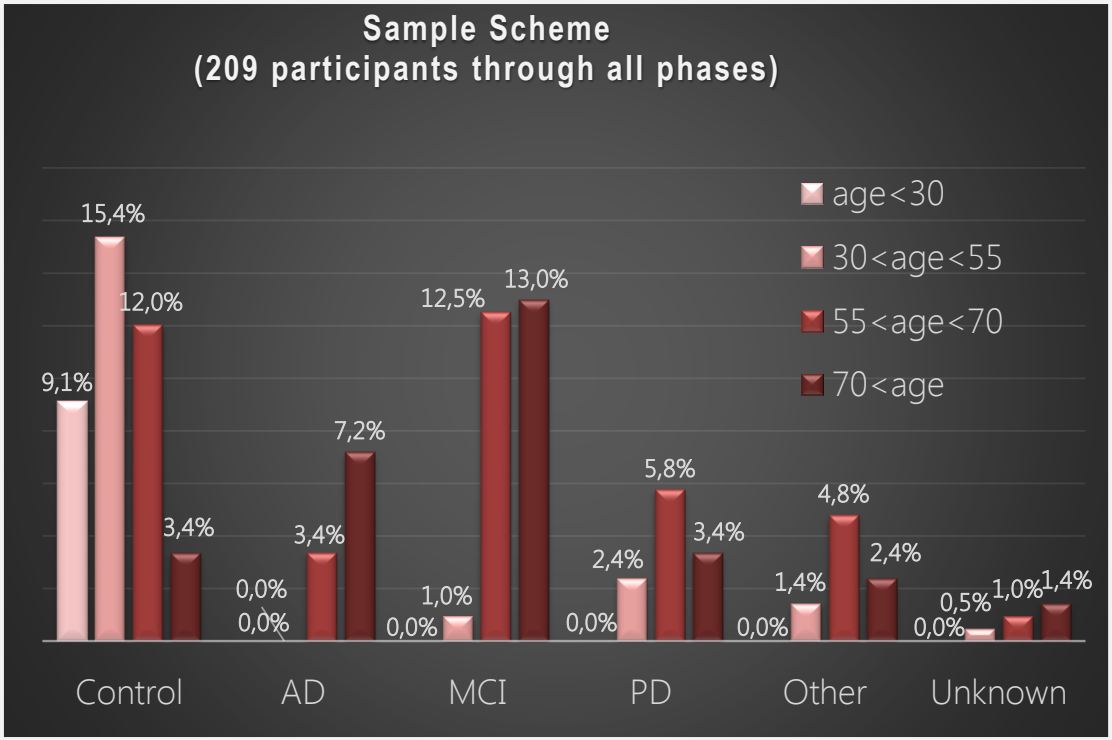
209 participants completed all phases (127 impaired)

Key figures of the experiment (2/2)

Sample characteristics







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