



Driving simulator experiment design for the effects of driver distraction and the assessment of driver skills



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■ 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



- To present our approach for the design of a driving simulator experiment which:
 - Has a twofold objective
 - impacts of driver distraction
 - assessment of driver performance and skills
 - 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), Cerebrovascular (CVD) in their Pre-Dementia or the very Mild Dementia Stages
 - MCI due to various causes (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 (low, moderate, high)

Overview of the experiment

- Sample design & characteristics:
 - Healthy drivers & impaired drivers: oversampling of ages >55 years

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

- Duration: 2 years
- Questionnaire on driving habits
- Medical, clinical & neurological evaluation
- Neuropsychological assessment
- Driving simulation experiment
 - Familiarisation with the simulator
 - Phase 1: Distracted driving experiment
 - Phase 2: Assessment of driver skills at operational level



Medical 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

Simulator experiment phase 1

- **Distracted driving and performance assessment experiment**
- Full factorial within-subject design
- 3 distraction conditions: none / cell-phone / conversation with passenger
- 2 road environments: divided urban arterial / undivided two-lane rural road
- 2 traffic scenarios
 - Q_M : moderate traffic conditions
(vehicle arrivals drawn from a Gamma distribution with $m=12$ sec, $\sigma^2=6$ sec $\sim Q=300$ veh/h)
 - Q_H : high traffic conditions
(vehicle arrivals drawn from a Gamma distribution with $m=6$ sec, $\sigma^2=3$ sec $\sim Q=600$ veh/h)

Distraction sources	Road and traffic conditions			
	Urban area		Rural area	
	Q_M	Q_H	Q_M	Q_H
No distraction	√	√	√	√
Cell phone	√	√	√	√
Conversation with passenger	√	√	√	√



Simulator experiment phase 1

- **Distracted driving and performance assessment experiment**
- Summary of participant trials
 - 2 blocks with 6 trials each
 - Randomized between and within block-trials
 - Incidents at fixed points

Block	Trial	Area type	Time	Traffic	Distractor	~Length (Km)	~Duration (min)
1	1	Urban	Day	Moderate	None	1.7	3.0
1	2	Urban	Day	High	None	1.7	3.0
1	3	Urban	Day	Moderate	Cell phone	1.7	3.0
1	4	Urban	Day	High	Cell phone	1.7	3.0
1	5	Urban	Day	Moderate	Passenger conversation	1.7	3.0
1	6	Urban	Day	High	Passenger conversation	1.7	3.0
2	7	Rural	Day	Moderate	None	2.0	3.0
2	8	Rural	Day	High	None	2.0	3.0
2	9	Rural	Day	Moderate	Cell phone	2.0	3.0
2	10	Rural	Day	High	Cell phone	2.0	3.0
2	11	Rural	Day	Moderate	Passenger conversation	2.0	3.0
2	12	Rural	Day	High	Passenger conversation	2.0	3.0
					Total	22.2	36



Simulator experiment phase 1

- **Distracted driving and performance assessment experiment**
- 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: parked car door opening, sudden appearance of child
 - Rural: sudden appearance of animal



- **Assessment of driver skills at operational level**
- Control tasks and a working memory task that involves information presented on road signs
- Scenarios enabling assessment of drivers' performance on control tasks and a working memory task
- 3 drives
 - Duration of experiment (phase2): ~ 12 minutes
 - Conditions of varying level of task demand:
 - Low demand
 - Moderate demand
 - High demand



- **Assessment of driver skills at operational level**
- Driving tasks
 - Car following
 - Lane changes (driving between traffic cones)
 - Decision task
- Quantitative indicators
 - Speed
 - Lateral position
 - Collisions
- Qualitative indicators
 - Recall of safety information
 - Compliance to instructions



- 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
 - Need for extensive pilot-testing (in progress)



