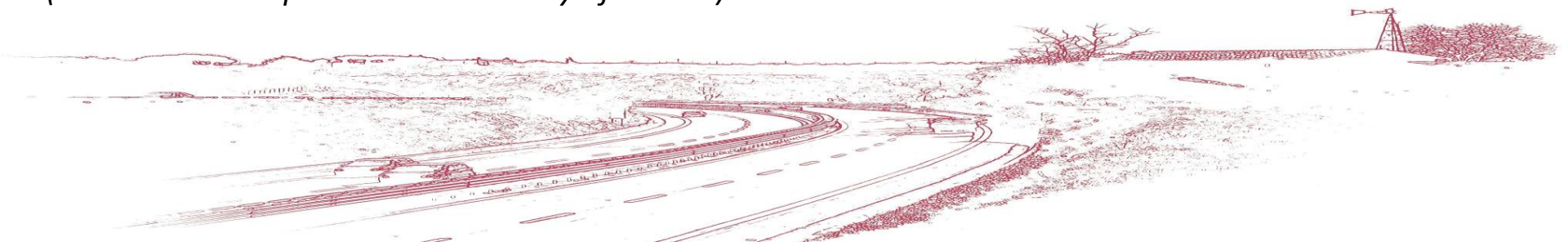
4th International Conference on Road Safety and Simulation RSS 2013

23rd-25th October 2013
Rome, Italy

Design of a Large Driving Simulator Experiment on Performance of Drivers with Cerebral Diseases

G. Yannis, J. Golias, C. Antoniou, E. Papadimitriou, S. Vardaki, P. Papantoniou, D. Pavlou
(Dpt of Transportation Planning and Engineering, National Technical University of Athens)

S. Papageorgiou, N. Andronas, I. Papatriantafyllou, A. Liozidou, I. Beratis, D. Kontaxopoulou, S. Fragkiadaki
(Dpt of Neurology, Psychiatry and Social Medicine)
A. Economou (Dpt of Psychology)
(National and Kapodistrian University of Athens)



Objectives – Research Hypotheses

- A large driving simulator experiment aiming to assess the driving performance of drivers with cerebral diseases, in terms of both traffic and safety parameters.
  - Do cerebral diseases affect driving performance and especially at unexpected incidents?
  - Do cerebral diseases interact with the other medical, neuropsychological, demographic characteristics of the drivers and road - traffic parameters, and do they lead to downgrade of driving performance?

Interdisciplinary research

RSS 2013

- The "**Distract**" research project: "Analysis of causes and impacts of driver distraction".
- The "**DriverBrain**" research project: "Analysis of the performance of drivers with cerebral diseases".
- An interdisciplinary research team, of traffic engineers, neurologists and neuropsychologists, co-funded by the Greek Research Secretariat and the European Commission.

Department of Transportation Planning and Engineering, NTUA

Department of Neurology, Psychiatry and Social Medicine, UoA
Department of Psychology, UoA

European Union
European Social Fund

OPERATIONAL PROGRAMME
EDUCATION AND LIFELONG LEARNING
investing in knowledge society
MINISTRY OF EDUCATION, LIFELONG LEARNING AND RELIGIOUS AFFAIRS
MANAGING AUTHORITY

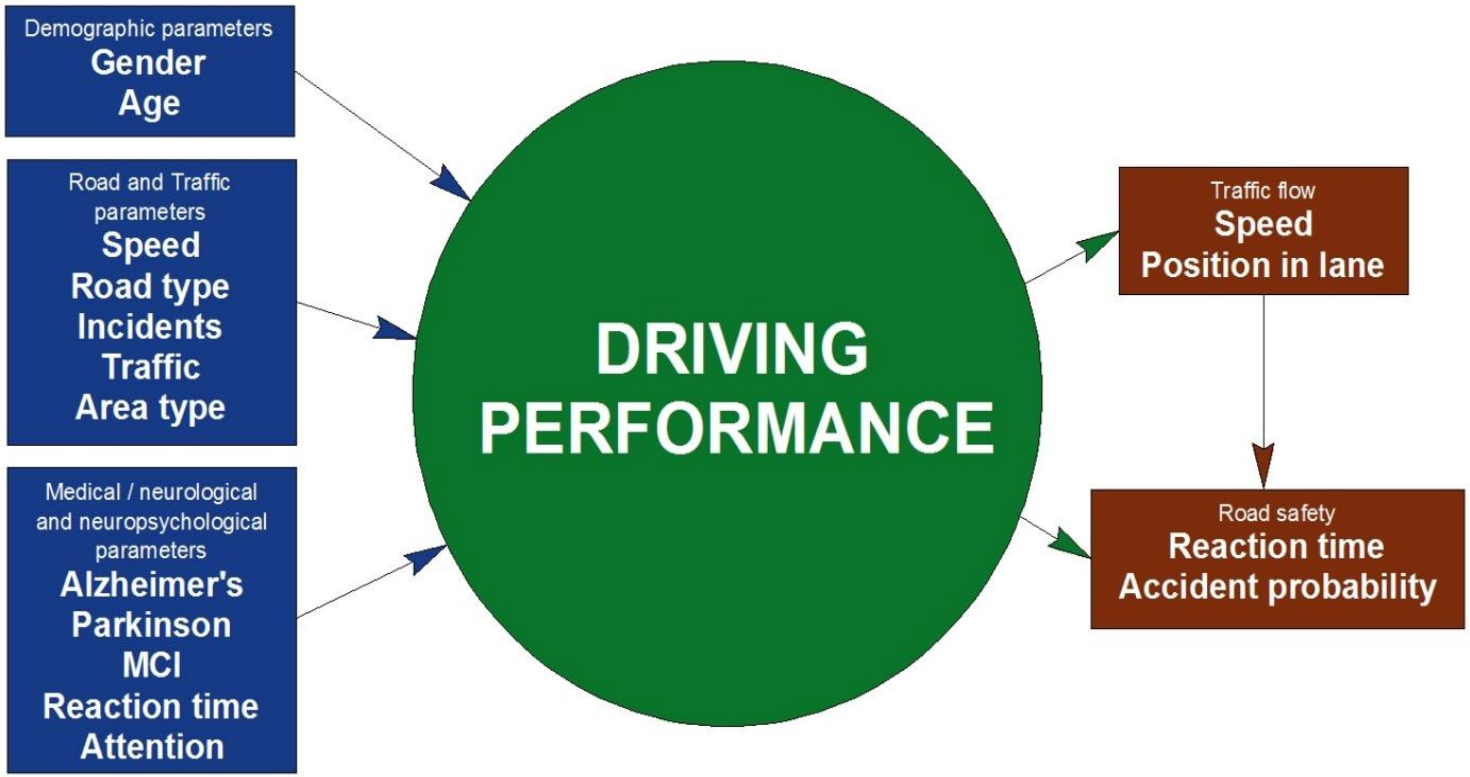
NSRF 2007-2013
EUROPEAN SOCIAL FUND

Co- financed by Greece and the European Union

Key research parameters

RSS 2013

- Medical and neurological parameters
- Neuropsychological parameters
- Road type and traffic parameters
- Driver behaviour and safety parameters

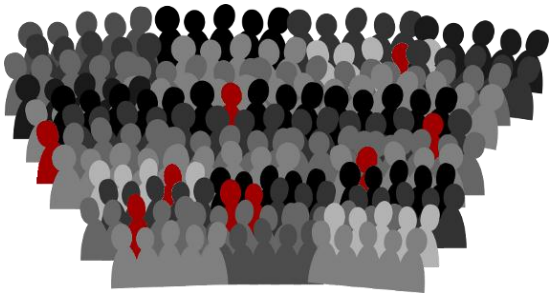


Experiment design

RSS 2013

- Designed sample size

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



Cerebral diseases examined: Mild Cognitive Impairment (MCI), Alzheimer's Disease (AD), Parkinson's Disease (PD).

- Overview 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

Phases 1 and 2

RSS 2013

- **Medical - neurological assessment**
  - Phase 1A - pre-simulator with up to 14 exams
  - Phase 1B - post-simulator with up to 2 exams
    - present & past history
    - detailed neurological examination
    - psychiatric assessment for behavioural disturbances
    - ophthalmological evaluation
    - motor ability-tests in Fitness to Drive

- **Neuropsychological assessment**
  - Phase 2A - pre-simulator with up to 13 tests
  - Phase 2B - post-simulator with up to 6 tests
    - visuospatial, verbal episodic and working memory
    - general selective and divided attention
    - reaction time
    - processing speed
    - psychomotor speed etc.

Phase 3 - Driving at the simulator

- **Urban and rural driving sessions**
  (Main driving sessions of ~ 42+ minutes)
  - Objective: investigate the driving performance of healthy versus impaired subjects at typical driving conditions, with different road, traffic and distraction characteristics.

- **Motorway driving session**
  (Additional drive of ~ 6 minutes)
  - 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

RSS 2013

- 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
  - Q_M: Moderate traffic conditions
  - Q_H: High traffic conditions
- 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

RSS 2013

- 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

RSS 2013

- **3 trials** (a total of 6 minutes)
- **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).

Preliminary results 1/4

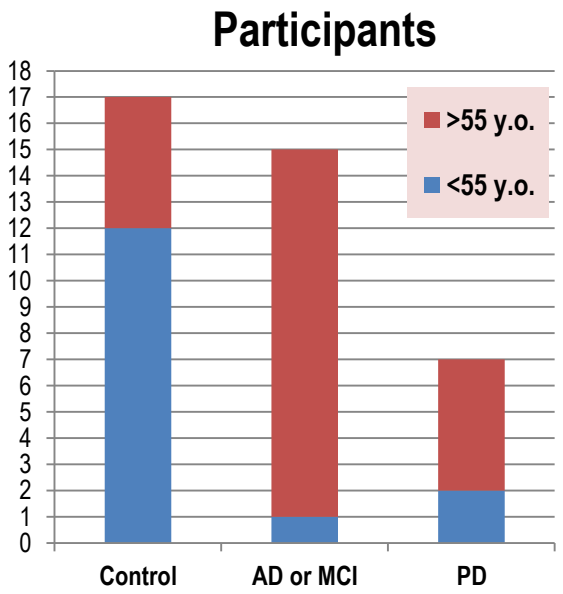
RSS 2013

Basic facts

Participants so far: **39**

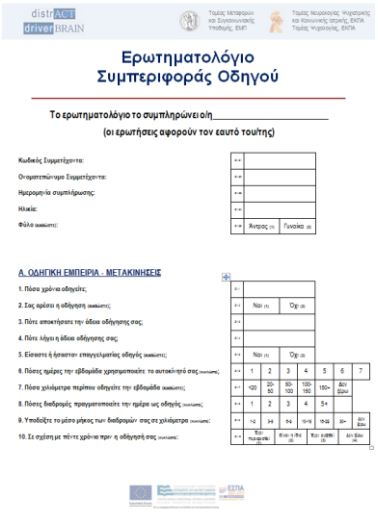
Impaired: **22** (15 AD or MCI, 7 PD)
completed 2-4 trials out of 6

Control group: **17**
completed 4-6 trials out of 6

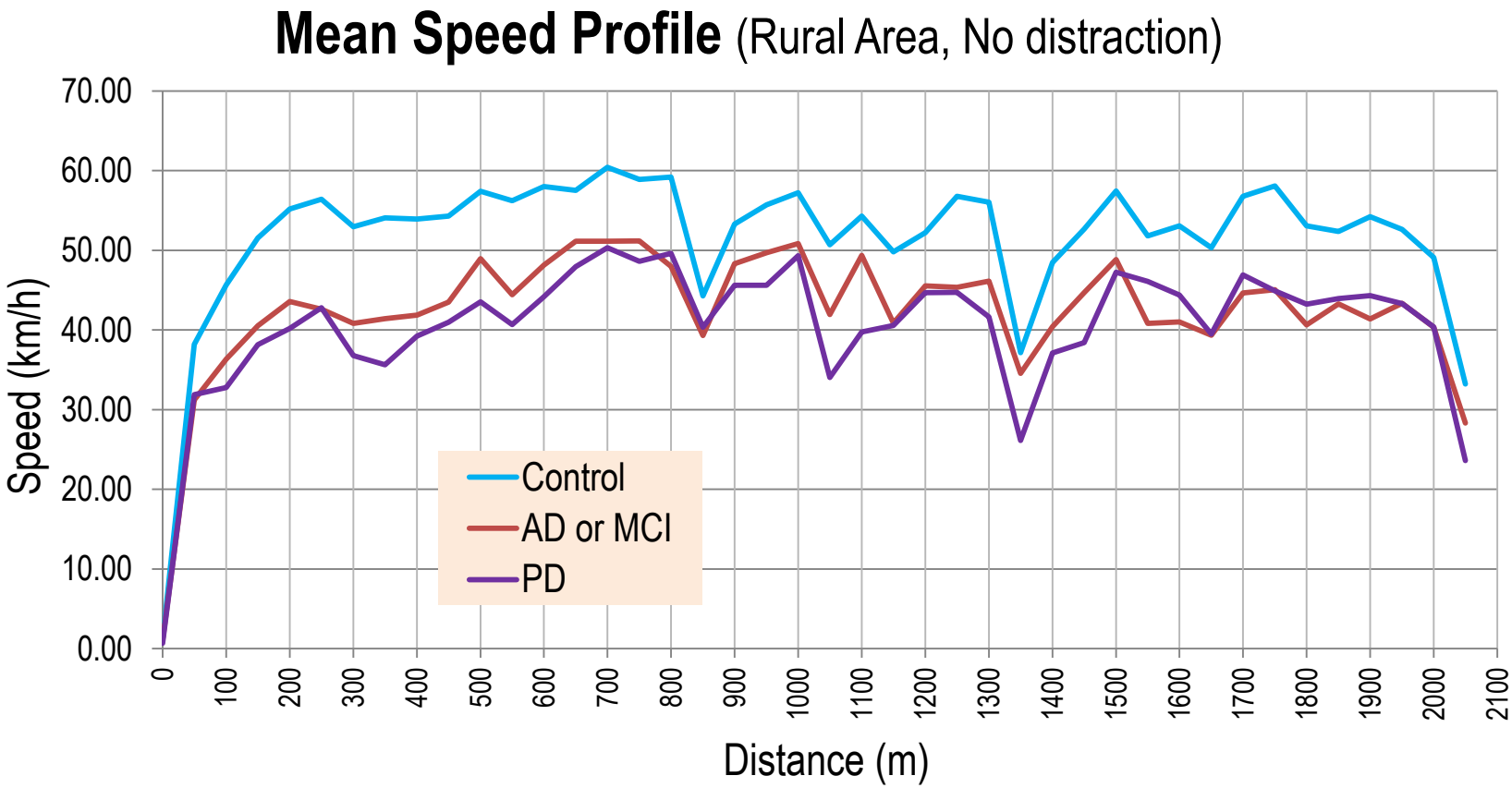


Questionnaires

- Driving behaviour questionnaire (filled in at home)
- Self-assessment and memory questionnaire (filled in after the experiment)

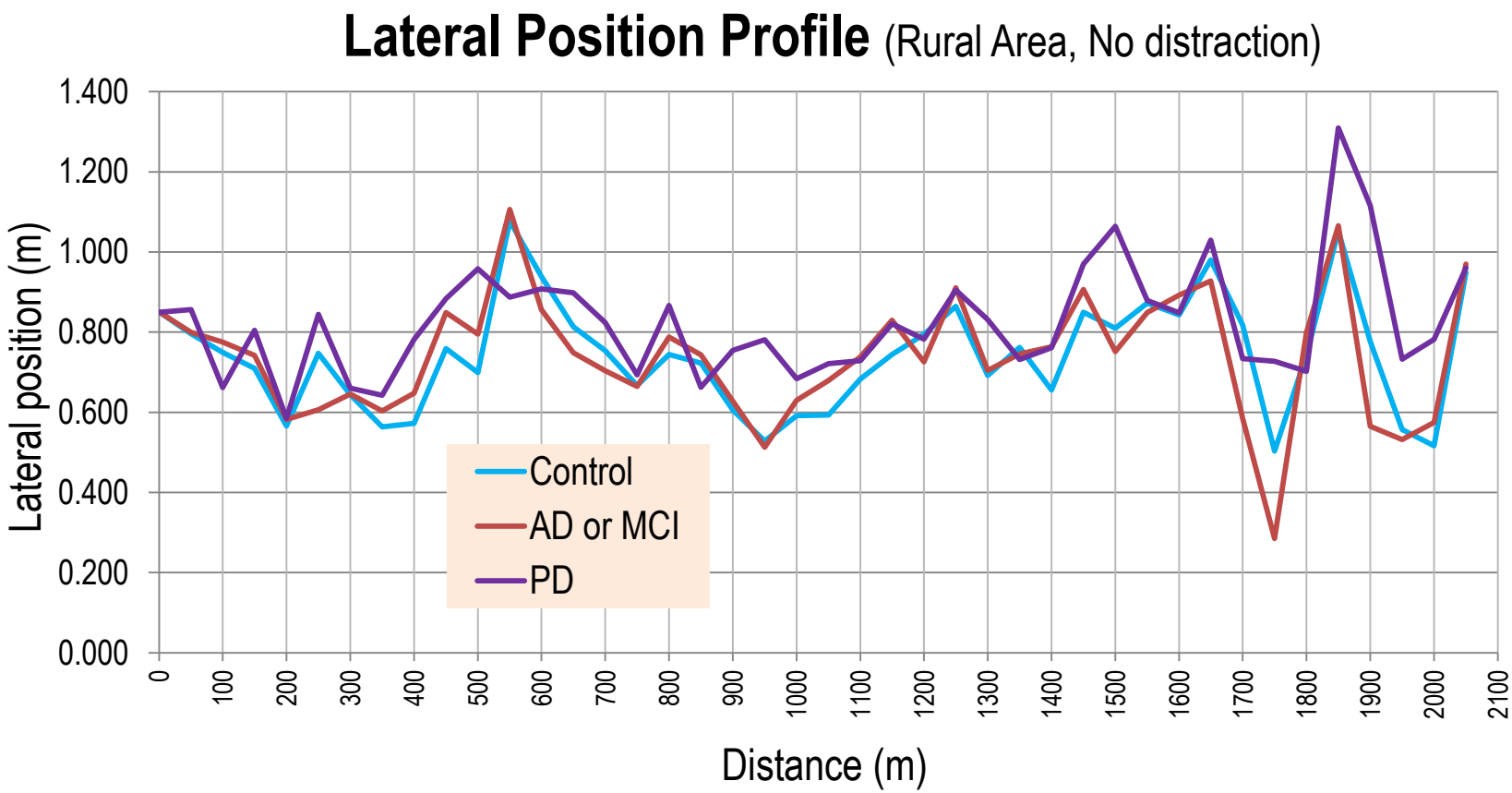

Ερωτηματολόγιο
Συμπεριφοράς Οδηγού

Preliminary results 2/4



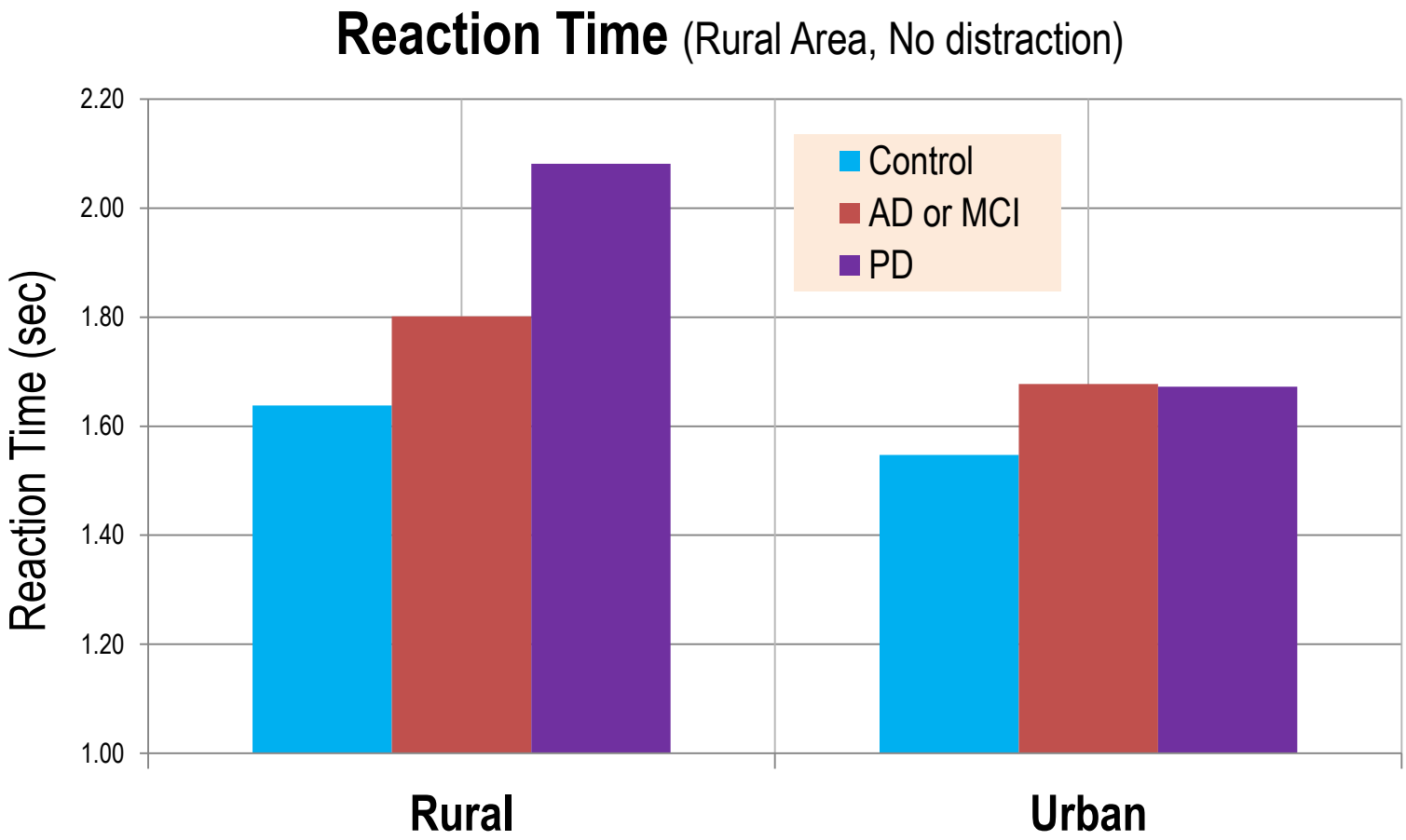
- Control group drive at higher speeds than the impaired
- PD patients drive at slightly lower speeds than AD or MCI patients
- Similar speed profiles in terms of general shape
- Incidents at 850m and 1350m

Preliminary results 3/4



- Lateral position reflects the distance from the right road border
- Similarities in terms of overall shape
- PD patients appear to have difficulty in positioning the vehicle (at specific points along the route)

Preliminary results 4/4



- Higher reaction times in rural area
- Impaired group have higher reaction times than healthy drivers
- PD patients have higher reaction times than AD or MCI patients in rural areas

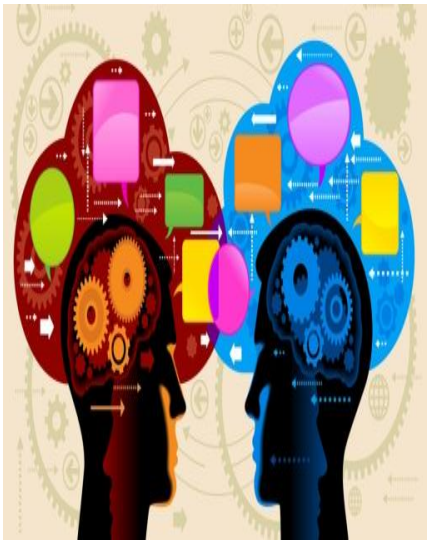
Summary of preliminary findings

- Cerebral diseases appear to affect driving performance both in terms of longitudinal and lateral control.
- Impaired drivers appear to drive at lower speeds and have higher reaction times at unexpected incidents, especially at rural areas.
- Some differences between different pathologies have already emerged from this first small sample of drivers:
  - Increased impairment of PD patients compared to mild AD or MCI pathologies (procedural learning deficits of PD, motor deficiencies)
  - PD patients appear to have difficulty in positioning the vehicle on the lane at specific point along the route

Conclusions

- The combined effect of medical, neurological, neuropsychological, road type and traffic, external distraction and individual characteristics on driving performance has not been adequately examined in the literature.

- This experiment design was challenging in several ways:
  - Combine and balance the objectives & targets
  - Selection of key variables
  - Efficiency: rigorous design yet manageable size



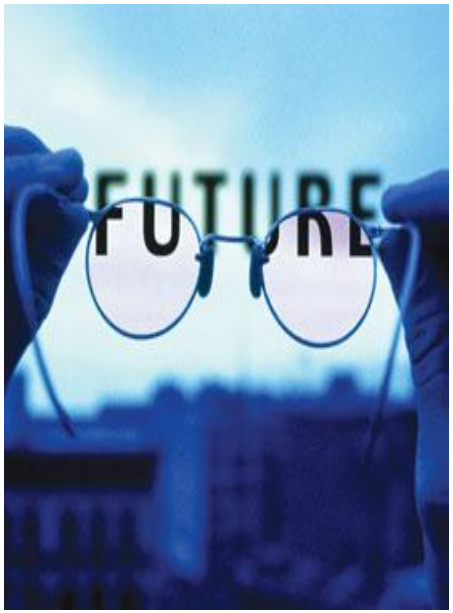
- The first results suggest that the specific methodology and design confirm the initial hypotheses and may reveal important specific differences between healthy and impaired drivers.

Discussion and next steps

- The application of appropriate statistical techniques on the larger sample may shed some light on the mechanisms of impaired driving due to cerebral diseases.

- The results of this study can be eventually exploited in the development of measures for addressing impaired driving due to cerebral diseases.

- The methodological framework proposed in the present study can be extended to other related interdisciplinary research areas on road safety (driver drowsiness or fatigue, driving under the influence of alcohol or drugs, etc.) and thus broaden the research perspective in the field.



4th International Conference on Road Safety and Simulation RSS 2013

23rd-25th October 2013
Rome, Italy

Design of a Large Driving Simulator Experiment on Performance of Drivers with Cerebral Diseases

G. Yannis, J. Golias, C. Antoniou, E. Papadimitriou, S. Vardaki, P. Papantoniou, D. Pavlou
(Dpt of Transportation Planning and Engineering, National Technical University of Athens)

S. Papageorgiou, N. Andronas, I. Papatriantafyllou, A. Liozidou, I. Beratis, D. Kontaxopoulou, S. Fragkiadaki
(Dpt of Neurology, Psychiatry and Social Medicine)
A. Economou (Dpt of Psychology)
(National and Kapodistrian University of Athens)