Effects of cerebral diseases on driver distraction

D. Pavlou, E. Papadimitriou, P. Papantoniou, G. Yannis,
National Technical University of Athens, Greece

I. Beratis, A. Liozidou, N. Andronas, A. Economou, S.G. Papageorgiou
National and Kapodistrian University of Athens, Greece

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The framework

- A **large driving simulator experiment** on driver distraction including drivers with cerebral diseases
- By an **interdisciplinary research team,** co-funded by the Greek Research Secretariat and the European Commission

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- **Phases of the Experiment** (Fall 2012 – Fall 2015)

- Part 1. Medical, Clinical & Neurological evaluation (~2 hours)
- Part 2. Neuropsychological Assessment (~2,5 hours)
- Questionnaire on driving habits (~20 minutes)
- Part 3. Driving simulation experiment (~1,5 hour)

- **Sample size**

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

Review Objectives

- Analyse the **combined effect** of cerebral diseases (MCI, PD, AD) and driver distraction on driver performance

- **Literature review** of studies on cerebral diseases, driving and driver distraction:

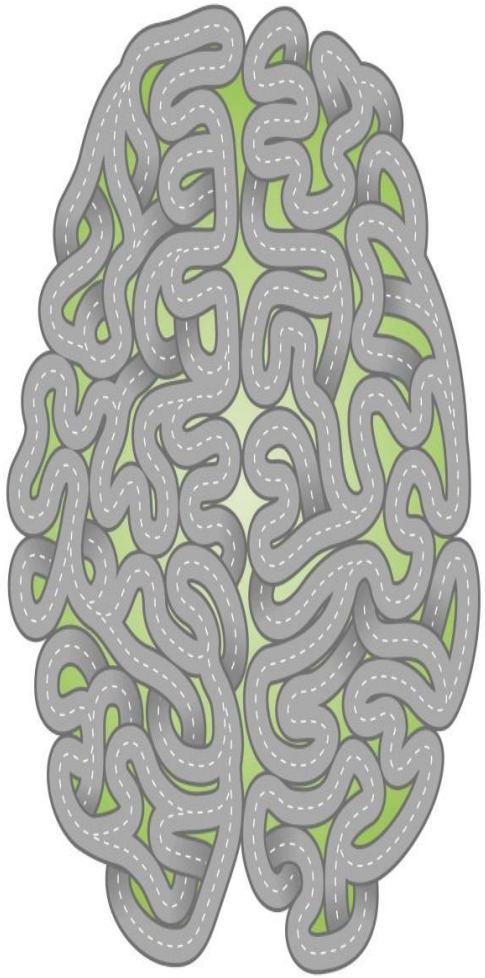
  - Review of **cognitive functions** critical for safe driving

  - **Effects of cerebral diseases** on critical driving tasks (more than 20 studies)

  - **Interaction** between cerebral diseases and distraction (only 8 studies)

A complex phenomenon with plenty of interactions

- Basic parameters
  - **Driving** – complex activity
  - **Older drivers** – more likely to get involved in a road accident
  - **Diseases affecting brain** (cerebral diseases) – impair driving performance
  - **Driver distraction** (exogenous or endogenous) – increased risk for road accident



- Interaction of cerebral diseases and driver distraction
  - possibly critical risk factor especially for older drivers
  - has received little attention in the literature

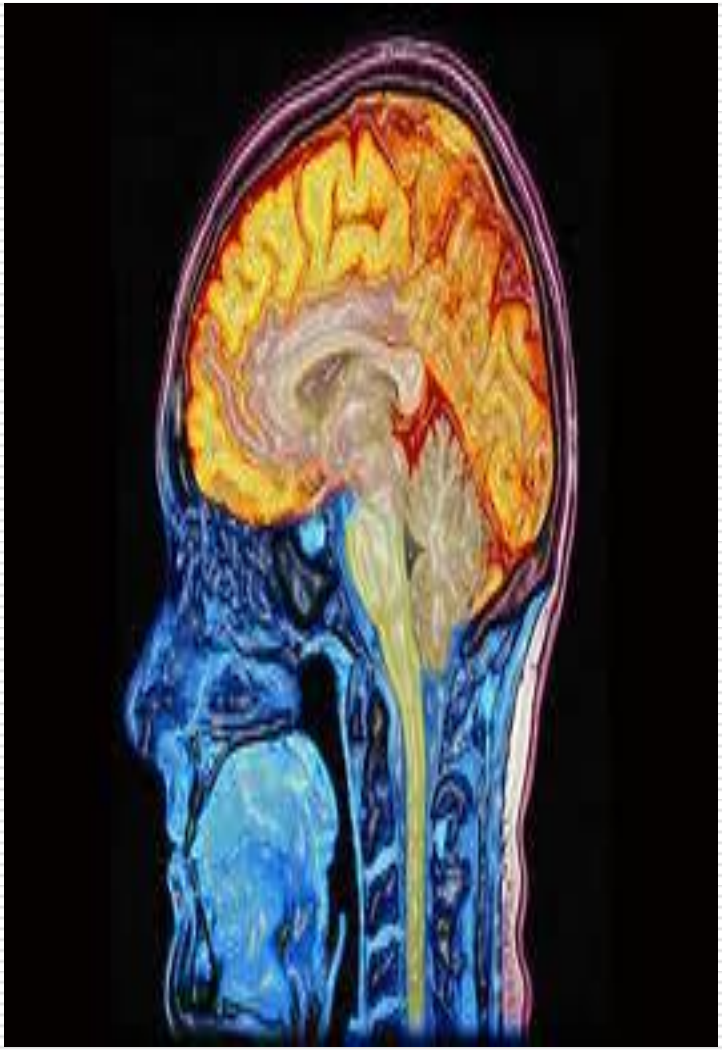
Cognitive functions related to driving

- Driving requires sufficient cognitive, visual and motor skills

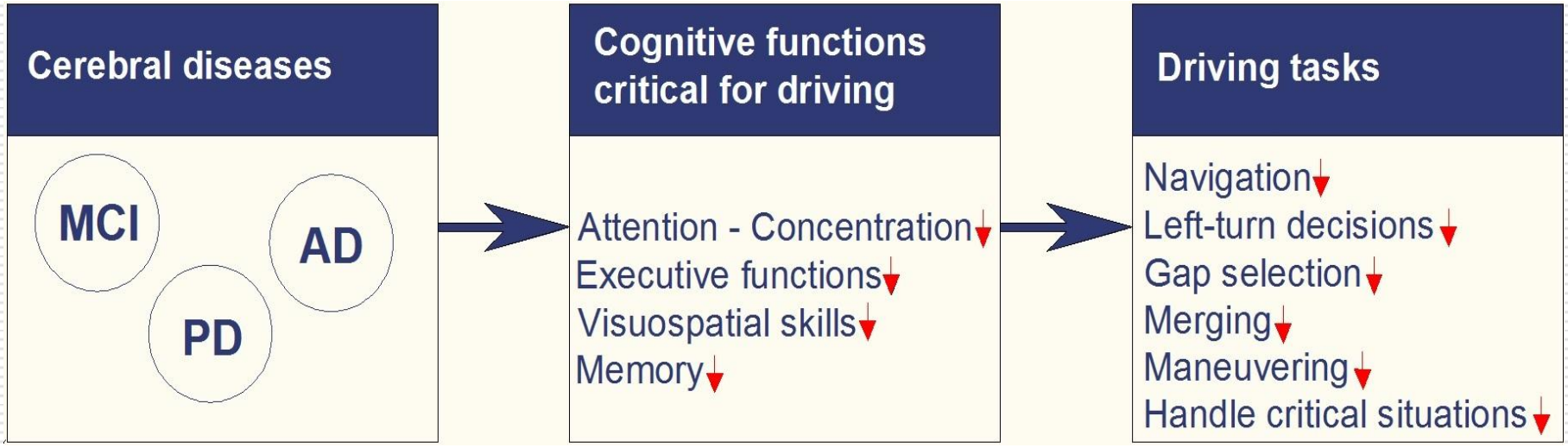
- Cognitive functions related to driving may be categorized into the following **neuropsychological domains** (Reger et al. 2004):
  - mental status - general cognition
  - attention - concentration
  - executive functions
  - visuospatial skills
  - memory

Cognitive functions critical for safe driving

- **Attention**
  - quick perception of the environment
- **Executive functions**
  - process multiple simultaneous environmental cues
  - make rapid, accurate and safe decisions
- **Visuo-spatial skills**
  - position the car accurately on the road
  - manoeuvre the vehicle correctly
  - judging distances and predicting the development of traffic situations
- **Memory**
  - journey planning
  - adapting behaviour



Cerebral diseases and driving



- Cerebral diseases examined
  - Mild Cognitive Impairment (MCI)
  - Alzheimer's disease (AD)
  - Parkinson's disease (PD)

Downgrade the main cognitive functions critical for safe driving and affect driving tasks

Cerebral diseases and driving

- MCI drivers seem to have **statistically significant driving behaviour deviation** (maintaining speed, wheel stability, lateral control) from the control driving population (Wadley et al. 2009)
- AD drivers (especially the elderly) are making many **more safety errors** (the most common error is lane violation) (Dawson et al. 2009)
- The risk of causing accidents is **significantly increased** for patients who were moderately impaired by PD (Meindorfner et al. 2005)

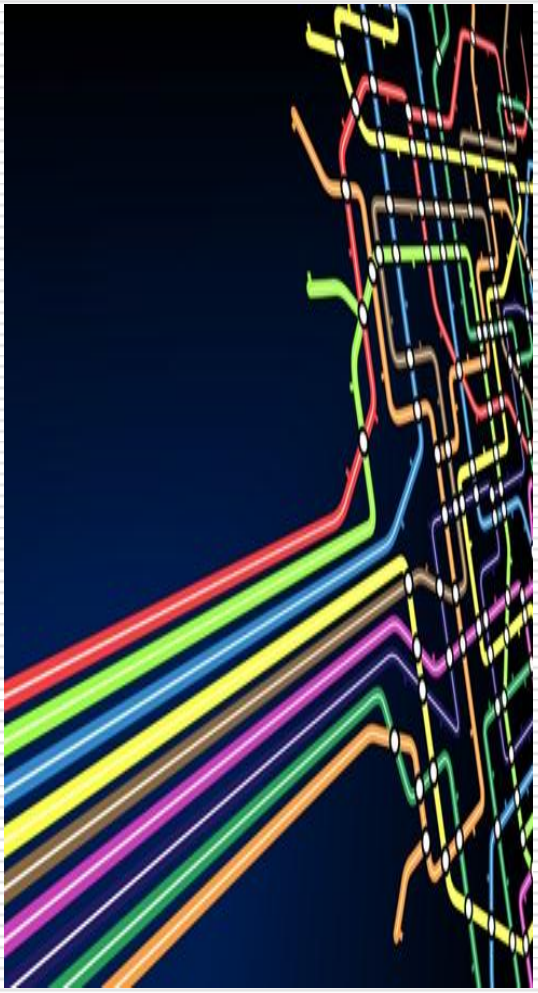
Driver distraction

- Human factors in total are the basic causes in 65-95% of road accidents (Sabey & Taylor 1980, Salmon et al. 2011).
- Driver impairment or distraction factors appear to account for 12% of all road accident contributory factors, while in-vehicle distraction factors account for 2/3 of the total distraction factors (Department for Transport 2008).
- Driver distraction is therefore estimated to be an important cause of vehicle accidents.

Driver distraction and MCI or AD

- **Harvey et al. (1995)**
  Performance of patients with dementia on driving simulator
  - Patients with dementia can retain their ability to perform a driving task.
  - Loss of this ability is associated with progression of the dementia.

- **Duchek et al. (1998)**
  Relationship between visual attention and driving performance in healthy older adults and individuals with very mild and mild dementia of the Alzheimer type (DAT).
  - Best predictors of driving performance: error rate and reaction time during visual search.



Driver distraction and MCI or AD

- **Frank-Garcia et al. (2009)**

  Analysis of AD, MCI patients, and control volunteers.
  MCI patients showed changes in driving:
  - lane departures doubt
  - distraction with external auditory stimuli
  - inadequate responses to unexpected situations
  - increased irritability

  possible predictor for future dementia

- **Parasuraman et al. (1991)**

  Many attentional functions and particularly the switching of visual selective attention are impaired in the early stages of DAT and thus may contribute to increased accident risk.

- **Anderson et al. (2007)**

  Memory impairment does not impair most aspects of driving performance, but may increase safety risk under some challenging circumstances, such as some kind of distraction.

Driver distraction and Parkinson's disease

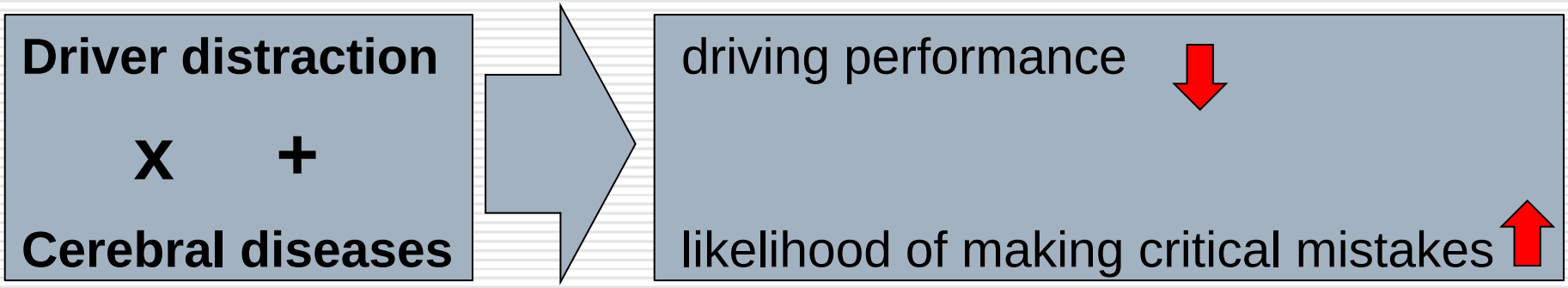
- **Uitti (2009)**
  77 patients with mild-moderate PD utilized an instrumented vehicle in real road conditions and:
  - took longer to finish the route than control drivers,
  - made more incorrect turns, got lost, or committed safety errors than controls,
  - had more difficulty identifying specific landmarks and traffic signs,
  - had more errors due to distraction.

- **Uc et al. (2006)**
  Memory resources were examined and mimic actual conditions of distraction (conversation while driving) were analyzed. PD drivers:
  - committed more errors than controls during both baseline and distracted driving,
  - drove slower with higher speed variability during distraction.

Driver distraction and Parkinson's disease

- **Uc et al. (2008)**
  Although both control driving population and PD drivers were similarly affected by the concurrent task on most driving measures, participants with PD were disproportionately affected on operational level driving behaviour, as manifested by closer deceleration points in PD drivers before traffic signals with distraction, despite sacrificing concurrent task performance to maintain driving performance.

Conclusions



- Limited literature review
- At early stages of cerebral diseases, driving seems safe
- At more advanced stages of diseases, driving ability is downgraded

Discussion

Open issues for further research

- How far distraction is **a symptom** of the cerebral disease?
- How far drivers with cerebral diseases **self-regulate** and use **coping strategies?**
- Which **other parameters** are interacting (demographic, medical, neuro-psychological characteristics, etc)?
- Which **countermeasures** best fit drivers with cerebral diseases?

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