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Driving performance profiles of drivers with brain pathologies in rural roads

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Introduction

- Despite the fact that road traffic casualties presented **a constantly decreasing trend** during the last years, the number of fatalities in road accidents in several countries in Europe and in Greece in particular **is still unacceptable** and illustrates the need for even greater efforts with respect to better driving performance and increased road safety
- Older drivers generally exhibit **a higher risk** of involvement in a road accident
- A number of **brain pathologies** may affect driving performance in the general population and particularly in the elderly. More specifically, diseases affecting a person's brain functioning (e.g. presence of specific brain pathology due to cerebral diseases such as Mild Cognitive Impairment (MCI), Alzheimer's disease (AD), Parkinson's disease (PD), **may significantly impair** the person's driving performance, especially **when unexpected incidents occur**

Objectives

- present and analyze the driving performance profiles of drivers with some brain pathology in rural driving environment, by means of a simulator experiment
  - ✓ brain pathologies examined are AD, PD, MCI and some others
  - ✓ driving performance measures examined: mean speed, lateral position, steering angle, time headway, reaction time at unexpected events
  - ✓ the driving performance of drivers impaired by the brain pathologies is compared to that of healthy controls by means of descriptive statistics

Driving simulator experiment

- Distract and DriverBrain research projects
  - ✓ **Medical/neurological assessment** (full clinical medical, ophthalmological and neurological evaluation)
  - ✓ **Neuropsychological assessment** (a series of neuropsychological tests and psychological-behavioural questionnaires)
  - ✓ **Driving at the simulator** (concerns the driving behaviour by means of programming of a set of driving tasks into a driving simulator for different driving scenarios)

"Driving at the simulator" assessment

- **quarter-cab driving simulator** manufactured by the FOERST Company (3 LCD wide screens 42", full HD, total field of view 170 degrees, validated against a real world environment)
- At first, **one practice drive** (usually 10-15 minutes)
- Afterwards, the participant drives **one rural session** (2.1 km long, single carriageway, zero gradient, mild horizontal curves, approximately 15 minutes)
- **Two traffic scenarios** examined:
  - ✓ **Low traffic conditions** (Q=300 vehicles/hour)
  - ✓ **High traffic conditions** (Q=600 vehicles/hour)
- Consequently, each participant drives 2 trials of the simulated route
- During each trial, **2 unexpected incidents** are scheduled to occur:
  - ✓ sudden appearance of an animal (deer or donkey) on the roadway (photo)

Analysis data and methods

- Descriptive statistics
- 190 participants have participated in the experiment
- 36 eliminated due to simulator sickness issues
- 40 participants of age <55 years old eliminated too for age representativity reasons
- The analysis is thus based on **114 participants**:
  - ✓ **34 are controls** (66.0 y.o.±8.6, 17 males)
  - ✓ **80 are impaired** (69.0 y.o.±9.1, 55 males)
    - ✓ **17 AD patients** (74.4 y.o.±5.2)
    - ✓ **35 MCI patients** (70.1 y.o.±5.0)
    - ✓ **16 PD patients** (66.1 y.o.±7.6)
    - ✓ **12 patients of other brain pathologies** (66.2 y.o.±6.4)
- Driving performance measures examined:
  - ✓ Longitudinal control measures: **Mean speed, Time headway, Reaction time**
  - ✓ Lateral control measures: **Lateral position and Steering angle**

Results (longitudinal control measures)

Mean Speed

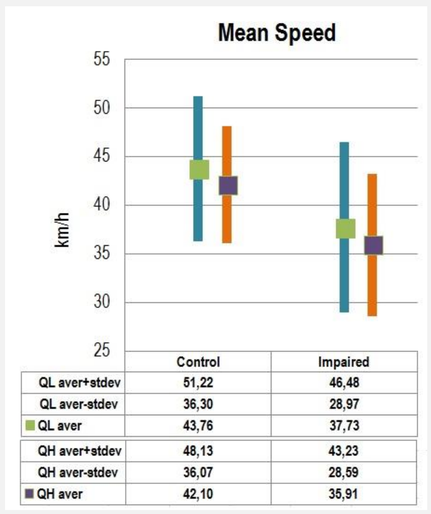
- Control drivers drove the trial road section at approximately 16% higher speed than impaired drivers in both low and high traffic volumes
- Mean speed is lower in high traffic volume conditions, as expected
- Finally, the variability of speed is lower in high traffic volume as expected

Time headway

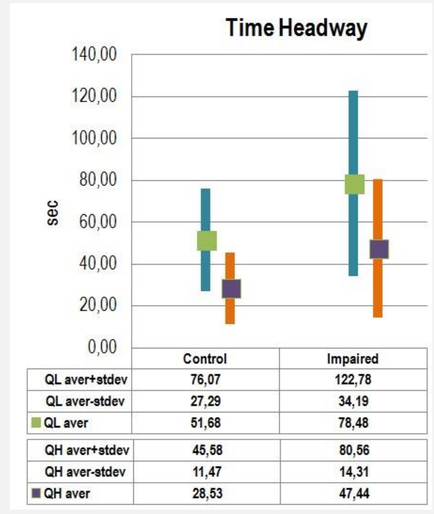
- Impaired drivers keep larger headways from the vehicle ahead compared to the control group (52% in low traffic volume and 66% in high traffic volume)
- It's worth noticing the large variability of mean space headways for impaired drivers in both traffic volumes compared with the variability of the control group headways

Reaction time

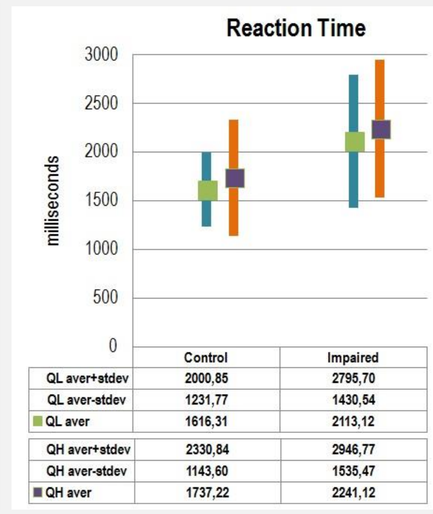
- Impaired drivers had worse reaction times than the control ones (30% worse overall)
- Finally, traffic volume appears to affect the reaction time of all drivers



	Control	Impaired
QL aver+stdev	51,22	46,48
QL aver-stdev	36,30	28,97
QL aver	43,76	37,73
QH aver+stdev	48,13	43,23
QH aver-stdev	36,07	28,59
QH aver	42,10	35,91



	Control	Impaired
QL aver+stdev	76,07	122,78
QL aver-stdev	27,29	34,19
QL aver	51,68	78,48
QH aver+stdev	45,58	80,56
QH aver-stdev	11,47	14,31
QH aver	28,53	47,44



	Control	Impaired
QL aver+stdev	2000,85	2795,70
QL aver-stdev	1231,77	1430,54
QL aver	1616,31	2113,12
QH aver+stdev	2330,84	2946,77
QH aver-stdev	1143,60	1535,47
QH aver	1737,22	2241,12

Results (lateral control measures)

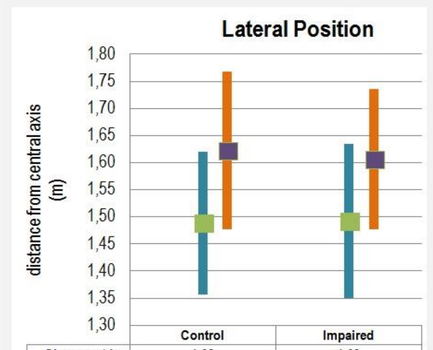
Lateral Position

- Lateral position profiles of both examined groups don't seem to have any significant differences
- In high traffic volume both control and impaired drivers drive approximately 10% more closely to the right border of the road

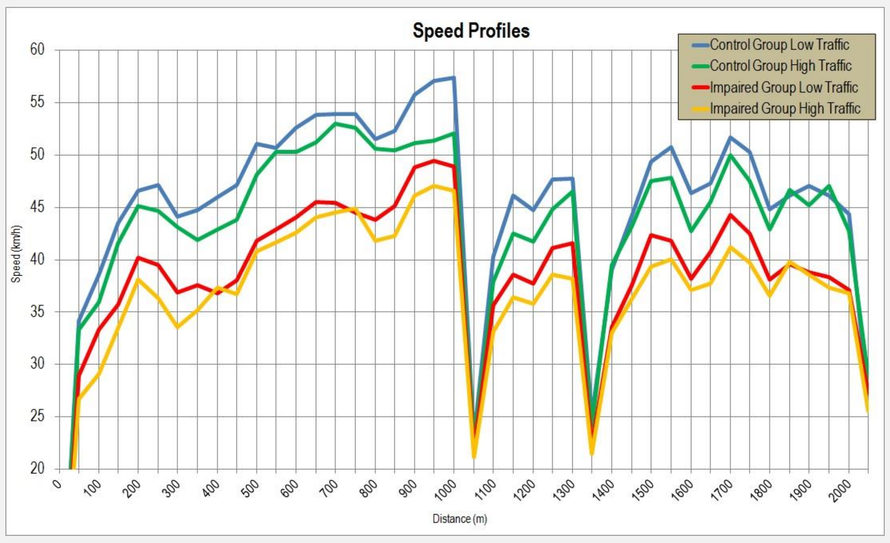
Steering Angle*

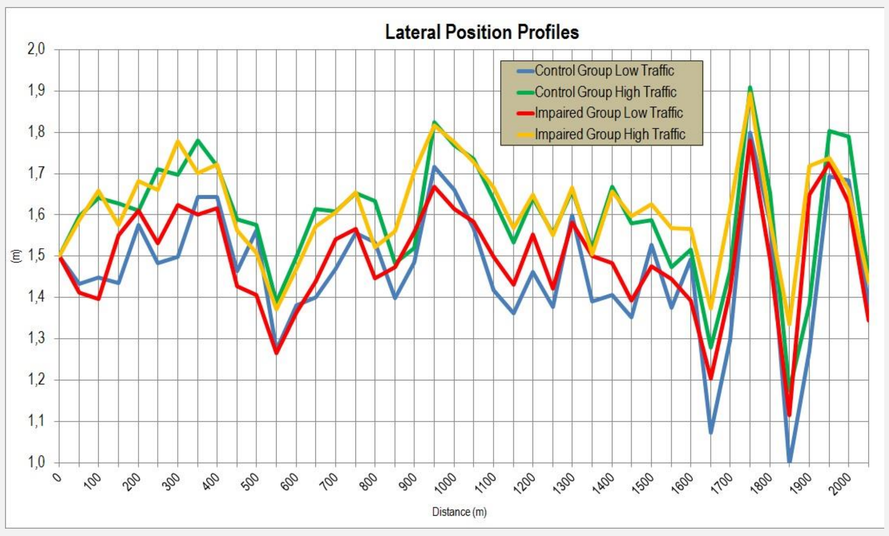
- No significant differences are presented between control and impaired group
- In high traffic volumes all participants tend to drive at the right border of the road

*the steering angle figure is not presented because of no significant differences



	Control	Impaired
QL aver+stdev	1,62	1,63
QL aver-stdev	1,36	1,35
QL aver	1,49	1,49
QH aver+stdev	1,77	1,74
QH aver-stdev	1,48	1,48
QH aver	1,62	1,61





Speed profiles

- All drivers present very similar speed profiles in terms of general shape
- incidents at around Km 1.05 and Km 1.35
- Healthy drivers drove the trial road section at higher speeds than impaired drivers
- It is also observed that the difference between the two traffic volumes is obvious in both examined groups

Lateral Position Profiles

- Lateral position profiles between healthy drivers and impaired drivers exhibit more similarities in terms of overall shape of the profile and magnitude of the examined measure
- It seems that high traffic conditions lead drivers to drive to the right border of the road

Conclusions and discussion

- Control drivers drove at approximately **16% higher speed** than impaired drivers in both low and high traffic volumes and have lower variability in their speed
- Impaired drivers keep **much larger headways** than control ones (more than 50% larger)
- Impaired drivers have **very large variability in headways** along the driving route. This means that they cannot adjust their speed and have difficulties in keeping constant and safe headways
- The lateral position profiles presented **a large variability in impaired drivers' lateral position** along the route, which means difficulties in positioning the vehicle properly in the lane
- **The higher the traffic is**, the more variability in steering angle the control drivers have, whereas **the lower traffic volume is**, the more variability in wheeling angle the impaired drivers have
- A possible explanation is that in high traffic volumes healthy drivers may **try to overtake the vehicle ahead** and thus they have variability in wheeling angle, whereas impaired drivers (who drive at lower speeds) may use the vehicle ahead as a "guide" and **just drive behind them** conservatively. In every case, this finding is very interesting and will be examined in the future in a larger sample
- Finally, drivers suffering from brain pathology **have significantly larger reaction times in both traffic environments** compared to the control group (**almost 30% worse reaction times**)
- All above results are quite promising and **confirm the initial hypotheses** of the research that brain pathologies may deteriorate driving performance in several ways
- Finally, the results are to be considered within the limiting context of driving simulator studies - driving performance is known to be more accurately and reliably estimated by means of on-road studies

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