Driving behaviour of drivers with Mild Cognitive Impairment and Alzheimer’s Disease: A Driving Simulator Study

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Introduction - Background
The task of driving requires the ability to receive sensory information, process the information, and to make proper timely judgments and responses. Various motor, visual, cognitive and peripheral functions can affect the ability to drive and to lead to reduced driver fitness and increased crash risk. Moreover, specifically, driving performance can be affected by the presence of specific brain pathology due to neurological diseases as Alzheimer’s disease may significantly impair the performance of driving tasks.

Neuropsychological parameters associated with driving performance are reaction time, visual attention, speed of perception and processing, and general cognitive and executive functions. These parameters show considerable decline with age or at the presence of cognitive impairments and are associated with various accidents involved.

Main objective:
- Analyze the driving performance of drivers with Mild Cognitive Impairment (MCI) and Alzheimer’s Disease (AD) and their impact on road safety.

Methodology:
- Various driving performance measures are examined in both rural and urban environment and the differences in driving performance of drivers impaired by the above pathologies are compared to that of healthy controls by means of Repeated Measures Linear Mixed Modeling (REML).

Research questions:
- How MCI and AD affect various measures of driving performance?
- How these diseases interact with road and traffic parameters?

Driving simulator experiment
- Distinct research project
- Distract - Meditative assessment:
  - The first assessment concerns the administration of a full clinical ophthalmological and neurological evaluation, in order to well document the characteristics of each of them.
  - Neuropsychologists - Neuropsychological assessment:
    - The second assessment consists in a series of neuropsychological tests and psychological - behavioral scales, covering a wide spectrum of Cognitive Functions; visuospatial and executive functions, and general selective and divided attention, reaction time, processing speed, working memory.
    - Transportation Engineers - Driving at the simulator:
    - The third assessment concerns the driving behaviour by means of programmed scenarios of driving tasks into a driving simulator for different driving scenarios.

Results - Analysis of variance (Table 1)
- Traffic volume has a significant effect on mean speed, mean headway and lateral position in all tested scenarios, whereas lateral position variability and steering angle variability only on rural road.
- The presence of a cerebral disease affect mean speed and reaction time in both road conditions.
- The presence of a cerebral disease affect mean headway, lateral position variability and steering angle variability only in rural roads and lateral position only in urban road environment.

Results - Repeated measures GML - Lateral control measures (Table 3):
- There are no significant differences in lateral position except for high traffic volume in urban area where impaired groups drive at longer distance from the central road axis.
- MCI drivers in rural area and AD drivers in high traffic volume in urban road have a significant increase in the variability of the lateral position.
- Statistically significant differences are not observed for mean steering angle or for the lateral control variability in the rural road for both groups of impaired drivers.

Conclusions - Discussion
- Summarizing the results, AD and MCI drivers were found to drive at significantly lower speeds compared to the healthy control group drivers in every examined condition.
- AD drivers in rural environment have even lower mean speeds compared to the MCI drivers, but in urban roads their speed is approximately the same.
- This reduced speed results under given ambient traffic conditions in increased headways. In rural roads, however, urban environment there is not any significant differences in mean headways only for MCI drivers in high traffic volume.
- MCI and AD drivers have significantly longer reaction times in rural road in both traffic volumes compared to the controls.
- In urban area, they have longer reaction times, but only in low traffic volume this is significant.
- MCI drivers have slightly better reaction times than the AD group in most cases.
- MCI drivers behave more closely to the right border of the road in urban area and this can be explained by the lower traffic volume in this area.
- A significantly higher variability of the lateral position is highlighted for AD drivers only.
- The more complex is the driving environment the more the AD drivers have difficulty in maintaining the position of the vehicle on the lane.
- It is also found that they have low steering variability in high traffic volume that is a result of their conservative driving.
- The age and gender distributions of the populations examined at the present time, however, should be considered at the new steps of the ongoing experiment, in order to determine the differences in the driving behaviour are a result of age distribution.

Acknowledgement
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TABLE 1: Tests of within and between subjects in rural and urban road environment

| | Rural Road | Urban Road |
|---------------------------|---------------------------|
| | Mean (σ) | Mean (σ) | Mean (σ) | Mean (σ) |
| | | | | |
| | | | | |

TABLE 2: Parameter estimates of the repeated measures GML - Lateral control measures

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