Can driving at the simulator “diagnose” cognitive impairments?
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Background
• Numerous studies associate cognitive impairments in the elderly with driving performance
• Particular focus has been placed on Alzheimer’s disease (AD), and Mild Cognitive Impairment (MCI)
• Main purpose: to assess the potential to diagnose and classify driving performance deficits and risks due to the disease and the related cognitive impairments

Objectives
• In this paper, the question is reversed: Can driving at the simulator assist in the screening for cognitive impairments, towards their diagnosis?
• In order to address this question, the simulated driving performance of 86 older drivers (healthy controls, MCI patients and AD patients) was associated with their clinical diagnosis, in order to attempt to classify the drivers into healthy or cognitively impaired groups on the basis of their driving performance.

Literature Review
• Cognitive and driving impairments are strongly interrelated, with critical impact on the mobility and quality of life of older individuals
• Results clearly establish that older drivers with cognitive impairments (MCI and AD) may: drive at very low speeds, have difficulty in positioning the vehicle on the lane and maintaining position, have slower reaction time at unexpected events, be more vulnerable to complex driving environments and be affected by in-vehicle or external distraction, conduct more driving errors and unintentional traffic violations etc.
• However, they are often capable of self-regulating, and their driving impairments are partly balanced by their reduced exposure.

• There is strong need for identifying sensitive tools to measure cognitive and functional changes in the early stages of the disease.
• A driving simulation test, although often criticized for lack of fidelity, might provide more detailed information on the types and impact of driving errors and could be repeated in other settings with other samples.

Sampling frame
• 86 individuals ≥55 years old: 
  • 47 healthy controls
  • 38 MCI patients
  • 21 AD patients
• 59 males and 25 females.
• The mean age of the control group was 65 years, while for the MCI and the AD groups the mean age was 70 and 75 years respectively.
• Females had slightly lower mean age in all groups, with the same general trend of increasing age with the presence of pathology (Fig. 1).

Data Collection
• This research was implemented by an interdisciplinary team including transportation engineers, neurologists and neuropsychologists.
• The study was approved by the Ethics Committee of the “ATTIKON” University General Hospital.
• All participants were recruited among patients of the 2nd Department of Neurology of the University of Athens Medical School at the “ATTIKON” General University Hospital, Greece.

Driving simulator assessment
• Quarter-cab driving simulator manufactured by the FOERST Company
• 1 practice drive (usually 10–15 minutes)
• Afterwards, the participant drives two sessions (approximately 15 minutes each)
  • Each session corresponds to a different road environment:
  - a rural road (2.1 km long), single carriageway, zero gradient, mild horizontal curves
  - an urban road (1.7km long), dual carriageway, separated by guardrails. Two traffic controlled junctions, one stop-controlled junction and one roundabout along the route.
• 2 traffic scenarios examined:
  • Low traffic conditions (Q=300 vehicles/hour)
  • High traffic conditions (Q=600 vehicles/hour)
• 3 distraction conditions for each route:
  • Undistracted driving
  • Driving while conversing with a passenger
  • Driving while conversing on a hand-held mobile phone

During each trial, 2 unexpected incidents are scheduled to occur:
• sudden appearance of an animal (deer or donkey) on the roadway, and
• sudden appearance of a child chasing a ball on the roadway.

Results
• The medical diagnosis was used as the dependent variable and the simulator driving measures were used as independent variables.

Results (cont.)
Table 2 presents the discriminant functions coefficients and the respective structure matrix, interpreted in the same way that factor loadings are interpreted in a factor analysis: age, average speed, gearbox position, reaction time and accident occurrence at incidents are strongly correlated with discriminant function 1, mean headway and lateral position variability are strongly correlated with discriminant function 2.

Classification results are presented in Table 3.

Discussion - Conclusions
• The results of the discriminant analysis did not support the conservative hypothesis.
• The more ambitious analysis attempting to discriminate between MCI and AD pathologies surprisingly resulted in more robust models and satisfactory classification of individuals.
• The classification results are encouraging (correctly “diagnosed” nearly 65% of the cases), but they lead to returning to the conservative hypothesis.
• The misclassification occurs almost exclusively between “neighboring” groups (MCI classified as AD, healthy classified as MCI).

The model may be most useful for a general classification in cognitively impaired or not, with an indication of specific pathology.

There is promising indication that the simulator may be used as a “neuropsychological tool” revealing the presence of cognitive impairments and might have a two-fold added value:
• To assist clinicians in the screening and examination process
• To assist clinicians in the provision of more targeted and substantiated advice as regards driving.

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