Compensatory driving behaviour of older drivers with Parkinson’s disease. Is it sufficient to counterbalance their driving difficulties?

D. Pavlou\textsuperscript{a}, E. Papadimitriou\textsuperscript{b}, P. Papantoniou\textsuperscript{c}, G. Yannis\textsuperscript{d}, S.G. Papageorgiou\textsuperscript{e}

\textsuperscript{a} PhD, Researcher, National Technical University of Athens, Greece
\textsuperscript{b} PhD, Researcher, National Technical University of Athens, Greece
\textsuperscript{c} PhD, Researcher, National Technical University of Athens, Greece
\textsuperscript{d} Professor, National Technical University of Athens, Greece
\textsuperscript{e} Associate Professor, National and Kapodistrian University of Athens, Greece
Background

- Parkinson’s Disease (PD) is a slowly progressive, degenerative disease of the basal ganglia, **with motor dysfunction as a cardinal feature**
- An area of functioning that is commonly influenced in a **negative way by the multimodal clinical picture of PD**, is the driving fitness of individuals belonging to the specific clinical group.
- Various motor, visual, cognitive and perceptual deficits can affect the ability to drive and lead to **reduced fitness-to-drive and increased accident risk**
Objectives

- The analysis of driving and safety behaviour of PD drivers
- The identification of possible compensatory strategies that these drivers follow

Research questions:
- Do PD patients try to develop a compensatory driving behaviour?
- Do they follow a more conservative driving pattern in order to counterbalance their driving difficulties?
- Is this strategy successful or not?
Experiment Design

- **Medical/neurological assessment:**
  - full clinical medical, ophthalmological and neurological evaluation

- **Neuropsychological assessment:**
  - a battery of neuropsychological tests and a set of psychological - behavioural questionnaires, which cover a large spectrum of Cognitive Functions

- **Driving at the simulator**

A multidisciplinary research team of neurologists, neuropsychologists, and transportation engineers
NTUA Driving simulator

- A dynamic quarter-cab manufactured by the FOERST Company
- 3 LCD wide screens 42” (full HD: 1920x1080 pixels) - total F.O.V. 170 degrees
- Validated against a real world environment (relative validity for age, gender, area type and traffic volume)
Driving at the simulator assessment

• 1 practice drive (usually 15-20 minutes)
• 1 rural route
• 1 urban route
• Moderate traffic conditions (Q=300 vehicles/hour)

• 2 unexpected incidents during each trial:
  • Sudden appearance of an animal on the roadway
  • Sudden appearance of a child chasing a ball on the roadway or of a car suddenly getting out of a parking position.
Sample scheme and analysis method

- 34 healthy “controls” (65.4 years of age on average)
- 20 PD patients (63.3 years of age on average)
- Generalized linear models (GLM)
- Driving parameters examined
  - Mean speed
  - Time Headway
  - Lateral position (vehicle distance from the central road axis in meters)
  - Steering angle variability
  - Reaction time at unexpected incidents
  - Accident Probability
PD has a **significant effect on mean speed**.

The PD participants drove slower than controls possibly as a compensatory mechanism to counterbalance their driving difficulties.
Results: Mean Headway

PD has a significant effect on mean headway.

This is intuitive, as lower speeds result in larger headways, for a given distribution of ambient traffic on the virtual road network.
Results: Lateral position

PD has a **significant effect** on lateral position but only in rural areas.

PD participants show a more conservative driving patterns with smaller distance from the right edgeline.
Results: Steering angle variability

PD has a significant effect on the variability of the steering angle but only in rural areas.

PD exhibit a smoother use of the steering wheel with less variability.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rural Area</th>
<th>Urban Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>(Intercept)</td>
<td>17.55</td>
<td>11.44</td>
</tr>
<tr>
<td>Parkinson's Disease</td>
<td>-1.389</td>
<td>2.255</td>
</tr>
<tr>
<td>Controls</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>(Scale)</td>
<td>-3.614</td>
<td>2.643</td>
</tr>
</tbody>
</table>

Dependent Variable: StdWheelAverage
Model: (Intercept), Disease
a. Set to zero because this parameter is redundant.
b. Maximum likelihood estimate.
Both in rural and urban areas, participants with PD had significantly slower reaction times at unexpected incidents than the healthy controls.

- approximately 0.7 sec slower in rural area
- 0.38 sec slower in urban area
Both in rural and urban areas, participants with PD had significantly higher accident probability at incidents than the healthy controls.

- 9% higher accident probability in rural area
- 19% higher accident probability in urban area
Conclusions (1/2)

- PD patients, as compared to their healthy control counterparts of similar demographics:
  - drove at slower speeds,
  - kept larger headways,
  - drove more closely to the right border of the road,
  - had lower variability on their steering angle,

but on the other hand they had:
  - significantly slower reaction times and
  - higher accident probability at an unexpected incident.
PD drivers seem to be aware of their driving difficulties. They try to compensate their “impaired” driving behavior by following a more conservative and careful driving pattern. However, the results of this study clearly suggest that this compensatory driving pattern is not adequate for safe driving.

Implications of practical importance:
- development of policies that aim at reducing accident risk and at improving aspects of driving performance in this sensitive group of drivers
- restrictive measures, training and licensing
- medical and neuropsychological monitoring
- Information, education and support of patients and caregivers