VIENNA 2018 TRA TRANSPORT RESEARCH ARENA

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

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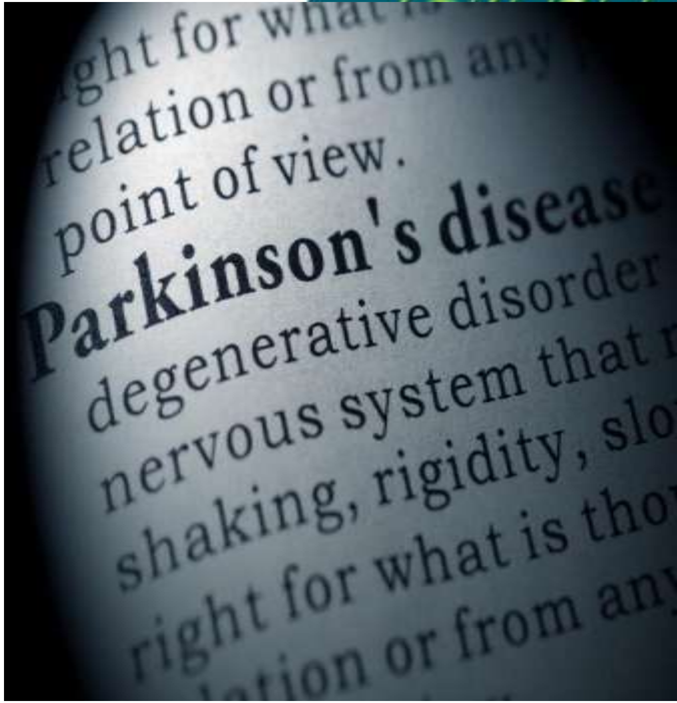
Background

- **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: 1920x1080pixels) - 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

Results: Mean Speed

	Rural Area							Urban Area						
			Confidence Interval		Hypothesis Test					Confidence Interval		Hypothesis Test		
Parameter Estimates	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	**44.04**	.4865	43.085	44.992	8194.986	1	**0.000**	**29.770**	.3897	29.006	30.534	5835.150	1	**0.000**
Parkinson's Disease	**-8.846**	.9503	-10.708	-6.983	86.638	1	**0.000**	**-3.316**	.8133	-4.910	-1.722	16.620	1	**.000**
Controls	0[a]							0[a]						
(Scale)	65.318[b]	4.7765	56.596	75.384				31.592[b]	2.7190	26.688	37.397			

Dependent Variable: AverageSpeed
Model: (Intercept), Disease
a. Set to zero because this parameter is redundant.
b. Maximum likelihood estimate.

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

	Rural Area							Urban Area						
			Confidence Interval		Hypothesis Test					Confidence Interval		Hypothesis Test		
Parameter	**B**	Std. Error	Lower	Upper	Wald Chi-Square	df	**Sig.**	**B**	Std. Error	Lower	Upper	Wald Chi-Square	df	**Sig.**
(Intercept)	**326.03**	11.0167	304.434	347.619	875.793	1	**0.000**	**90.172**	2.4620	85.347	94.998	1341.436	1	**0.000**
Parkinson's Disease	**161.899**	21.5216	119.718	204.081	56.590	1	**0.000**	**7.399**	1.1378	3.671	10.469	2.074	1	**.049**
Controls	0[a]							0[a]						
(Scale)	33497.509[b]	2449.58	29024.62	38659.70				1260.786[b]	108.51	1065.08	1492.45			

Dependent Variable: HWayAverage
Model: (Intercept), Disease
a. Set to zero because this parameter is redundant.
b. Maximum likelihood estimate.

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

Parameter	Rural Area							Urban Area						
			Confidence Interval		Hypothesis Test					Confidence Interval		Hypothesis Test		
	B	Std. Error	Lower	Upper	Wald Chi-Square	df	**Sig.**	**B**	Std. Error	Lower	Upper	Wald Chi-Square	df	**Sig.**
(Intercept)	**1.54**	.0091	1.521	1.557	28594.391	1	**0.000**	**3.177**	.0438	3.091	3.263	5253.687	1	**0.000**
Parkinson's Disease	**-0.045**	.0178	-0.080	-0.010	6.494	1	**0.011**	**0.107**	.0915	-0.072	0.287	1.381	1	**.240**
Controls	0[a]							0[a]						
(Scale)	.023[b]	.0017	.020	.026				.400[b]	.0344	.338	.473			

Dependent Variable: LateralPositionAverage

Model: (Intercept), Disease

a. Set to zero because this parameter is redundant.

b. Maximum likelihood estimate.

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

	Rural Area							Urban Area						
			Confidence Interval		Hypothesis Test					Confidence Interval		Hypothesis Test		
Parameter	**B**	Std. Error	Lower	Upper	Wald Chi-Square	df	**Sig.**	**B**	Std. Error	Lower	Upper	Wald Chi-Square	df	**Sig.**
(Intercept)	**17.55**	.1144	17.328	17.777	23531.024	1	**0.000**	**22.402**	.3536	21.709	23.095	4014.771	1	**0.000**
Parkinson's Disease	**-1.389**	.2235	-1.827	-0.950	38.588	1	**0.000**	**-0.133**	.7378	-1.579	1.313	0.032	1	**.857**
Controls	0[a]							0[a]						
(Scale)	3.614[b]	.2643	3.131	4.171				26.000[b]	2.2377	21.964	30.778			

Dependent Variable: StdWheelAverage
Model: (Intercept), Disease
a. Set to zero because this parameter is redundant.
b. Maximum likelihood estimate.

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.

Results: Reaction Time

	Rural Area							Urban Area						
			Confidence Interval		Hypothesis Test					Confidence Interval		Hypothesis Test		
Parameter	**B**	Std. Error	Lower	Upper	Wald Chi-Square	df	**Sig.**	**B**	Std. Error	Lower	Upper	Wald Chi-Square	df	**Sig.**
(Intercept)	**1656.60**	42.7497	1572.810	1740.386	1501.651	1	**0.000**	**1396.348**	35.0490	1327.653	1465.043	1587.216	1	**0.000**
Parkinson's Disease	**691.828**	84.3668	526.472	857.184	67.244	1	**0.000**	**375.452**	74.1245	230.170	520.733	25.656	1	**.000**
Controls	0[a]							0[a]						
(Scale)	502571.766[b]	36949.80	435127.47	580469.85				234630.630[b]	21155.90	196623.06	279985.13			

Dependent Variable: ReactionTime
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

Results: Accident probability

Parameter	Rural Area							Urban Area						
			Confidence Interval		Hypothesis Test					Confidence Interval		Hypothesis Test		
	B	Std. Error	Lower	Upper	Wald Chi-Square	df	**Sig.**	**B**	Std. Error	Lower	Upper	Wald Chi-Square	df	**Sig.**
(Intercept)	**0.15**	.0228	0.108	0.197	44.766	1	**0.000**	**0.116**	.0259	0.065	0.167	20.026	1	**0.000**
Parkinson's Disease	**0.089**	.0450	0.001	0.178	3.936	1	**0.047**	**0.188**	.0542	0.081	0.294	11.990	1	**.001**
Controls	0[a]							0[a]						
(Scale)	.143[b]	.0105	.124	.165				.127[b]	.0115	.107	.152			

Dependent Variable: AccidentProbability
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 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.

Conclusions (2/2)

- 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

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