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DRIVING PERFORMANCE PROFILES OF DRIVERS WITH PARKINSON'S DISEASE

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OVERVIEW

- Background
- Objectives
- Experiment Design
- Data and analysis methods
- Results
- Conclusions - Discussion

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BACKGROUND 1/2

- Driving requires the ability to receive sensory information, process the information, and to make proper, timely judgments and responses
- Various motor, visual, cognitive and perceptual deficits can affect the ability to drive and lead to reduced driver fitness and increased crash risk
- More specifically, diseases affecting a person's brain functioning (e.g. Parkinson's disease) may significantly impair the person's driving ability

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BACKGROUND 2/2

- 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 and especially at the presence of Parkinson's disease lead to deterioration in driving performance and are associated with the increased probability of accident involvement

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OBJECTIVE OF THE RESEARCH

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The objective of this research is to present and analyze the driving performance profiles of drivers with Parkinson's disease (PD), on the basis of a driving simulator experiment, in which healthy and PD participants drive in different driving scenarios

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EXPERIMENT DESIGN

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- Distract research project

http://www.nrso.ntua.gr/distract/

- Neurologists - Medical/neurological assessment:
  - administration of a full clinical medical, ophthalmological and neurological evaluation
- Neuropsychologists - Neuropsychological assessment:
  - administration of a series of neuropsychological tests and psychological - behavioural questionnaires to the participants which cover a large spectrum of Cognitive Functions
- Transportation Engineers - Driving at the simulator

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"DRIVING AT THE SIMULATOR"

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- Concerns the assessment of driving behaviour by means of programming of a set of driving tasks for different driving scenarios
- Quarter-cab driving simulator manufactured by the FOERST Company
- 3 LCD wide screens 42" (full HD: 1920x1080pixels) - total field of view 170 degrees
- Validated against a real world environment
- At first, one practice drive (usually 10-15 minutes)

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RURAL SESSION

- 2.1 km long, single carriageway, 3m lane width, zero gradient, mild horizontal curves
- 2 traffic scenarios examined:
  - Low traffic conditions (Q_L=300 vehicles/hour)
  - High traffic conditions (Q_H=600 vehicles/hour)
- 2 unexpected incidents are scheduled to occur:
  - sudden appearance of an animal (deer or donkey) on the roadway
- Analyzed by Generalized Linear Model (GLM)

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MOTORWAY SESSION

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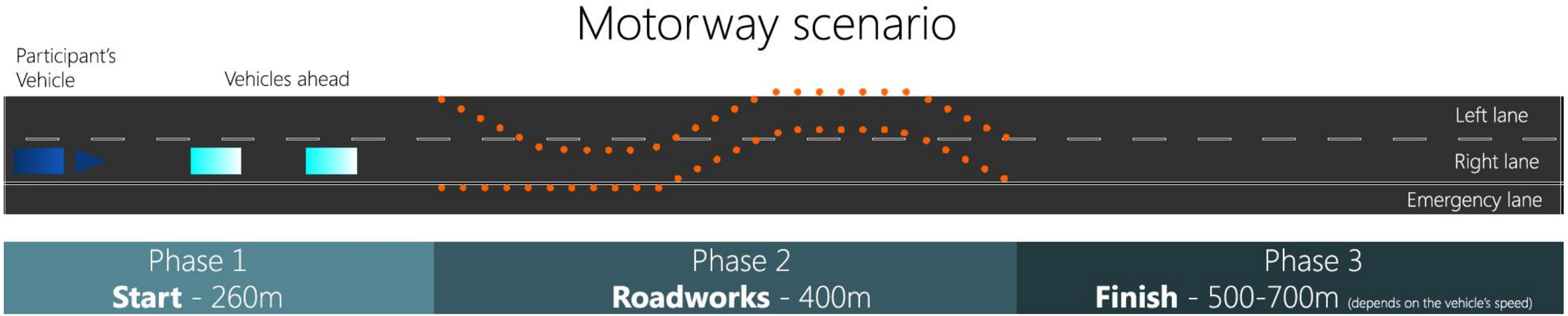

- Firstly a period of low-demand driving (right lane, straight ahead)
- Afterwards, the subject is negotiating the road work segment
  - All drivers made a double lane change that involved driving through a road work section containing large blocks (barriers) on each side of the road, causing the road to progressively narrow (1:20 taper ratio; lane width 3m)

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DATA AND ANALYSIS METHODS

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Sample size

- 62 participants (36 males)
- 41 “healthy controls” (64.1y.o.±8.1)
- 21 PD patients (65.3y.o.±6.9)

Driving performance measures

- Mean speed
- Time Headway
- Lateral position (+variability)
- Wheel steering angle (+variability)
- Reaction time at unexpected incident
- Accident probability (inside the work segment)

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RESULTS - SPEED AND HEADWAY

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Parameter Estimates	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	42,78	1,05	40,71	44,84	1651,68	1	0,000
PD Q_L	-6,36	2,05	-10,38	-2,35	9,64	1	0,002
PD Q_H	-8,72	2,05	-12,74	-4,71	18,12	1	0,000
Controls Q_L	2,61	1,52	-0,37	5,59	2,95	1	0,086
Controls Q_H	0[a]						
(Scale)	58,72[b]	7,02	46,45	74,22			

Dependent Variable: Speed
Model: (Intercept), ID

a. Set to zero because this parameter is redundant. b. Maximum likelihood estimate.

Parameter Estimates	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	28,58	3,86	21,02	36,15	54,87	1	0,000
PD Q_L	72,01	7,51	57,29	86,73	91,89	1	0,000
PD Q_H	26,72	7,51	12,00	41,45	12,66	1	0,000
Controls Q_L	20,75	5,57	9,84	31,67	13,90	1	0,000
Controls Q_H	0[a]						
(Scale)	789,2[b]	94,3279	624,38	997,53			

Dependent Variable: Time Headway
Model: (Intercept), ID

a. Set to zero because this parameter is redundant. b. Maximum likelihood estimate.

- PD drivers drive at significant slower speeds (20% lower speed overall)
- The traffic volume seems to have the same effect on all participants

- PD drivers keep statistically significant larger time headways
- The higher traffic volume seems to affect more the PD group

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RESULTS - LATERAL POSITION

Parameter Estimates	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1,60	0,02	1,56	1,64	7637,80	1	0,000
PD Q_L	-0,16	0,04	-0,23	-0,09	19,24	1	0,000
PD Q_H	-0,06	0,04	-0,13	0,01	2,91	1	0,088
Controls Q_L	-0,11	0,03	-0,17	-0,06	18,34	1	0,000
Controls Q_H	0[a]						
(Scale)	0,018[b]	0,002	0,014	0,022			

Dependent Variable: Lateral Position
Model: (Intercept), ID

a. Set to zero because this parameter is redundant. b. Maximum likelihood estimate.

- PD drivers tend to drive "to the left" at low traffic volume
- High traffic volume leads to more conservative driving

Parameter Estimates	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	0,26	0,01	0,24	0,27	949,44	1	0,000
PD Q_L	0,05	0,02	0,01	0,08	8,06	1	0,005
PD Q_H	0,00	0,02	-0,03	0,04	0,18	1	0,673
Controls Q_L	0,03	0,01	0,01	0,05	5,48	1	0,019
Controls Q_H	0[a]						
(Scale)	0,004[b]	0,0004	0,003	0,005			

Dependent Variable: Lateral Position Variability
Model: (Intercept), ID

a. Set to zero because this parameter is redundant. b. Maximum likelihood estimate.

- PD drivers have difficulty in positioning the vehicle inside the lane in low traffic volume

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RESULTS - STEERING ANGLE

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Parameter Estimates	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-2,03	0,09	-2,21	-1,85	498,58	1	0,000
PD Q_L	0,48	0,18	0,13	0,83	7,36	1	0,007
PD Q_H	0,18	0,18	-0,16	0,53	1,07	1	0,300
Controls Q_L	0,22	0,13	-0,04	0,48	2,77	1	0,096
Controls Q_H	0[a]						
(Scale)	0,44[b]	0,05	0,35	0,55			

Dependent Variable: Steering Angle
Model: (Intercept), ID

a. Set to zero because this parameter is redundant. b. Maximum likelihood estimate.

Parameter Estimates	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	17,02	0,250	16,53	17,51	4619,81	1	0,000
PD Q_L	1,41	0,487	0,46	2,37	8,39	1	0,004
PD Q_H	0,92	0,487	0,04	1,87	3,53	1	0,050
Controls Q_L	0,40	0,361	-0,31	1,10	1,19	1	0,275
Controls Q_H	0[a]				-1,87		
(Scale)	3,32[b]	,397	2,63	4,20			

Dependent Variable: Steering Angle Variability
Model: (Intercept), ID

a. Set to zero because this parameter is redundant. b. Maximum likelihood estimate.

- PD participants in low traffic volume tend to turn the wheel "to the left" compared with the control group
- PD participants have higher variability in wheeling angle compared with the control group in both traffic volumes

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RESULTS - REACTION TIME

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Parameter Estimates	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1719,90	76,17	1570,61	1869,19	509,85	1	0,000
PD Q_L	349,58	151,28	53,08	646,08	5,34	1	,021
PD Q_H	641,47	151,28	344,97	937,96	17,98	1	,000
Controls Q_L	-130,45	109,90	-345,84	84,95	1,41	1	0,235
Controls Q_H	0[a]						
(Scale)	307497,66[b]	37018,37	242867,38	389326,92			
Dependent Variable: Reaction Time Model: (Intercept), ID							
a. Set to zero because this parameter is redundant. b. Maximum likelihood estimate.							

- PD drivers have statistically worse reaction times in all traffic environments (30% worse reaction times overall)
- The higher is the traffic volume the worse is the reaction time for PD participants
- Traffic volume does not affect reaction time of the control group

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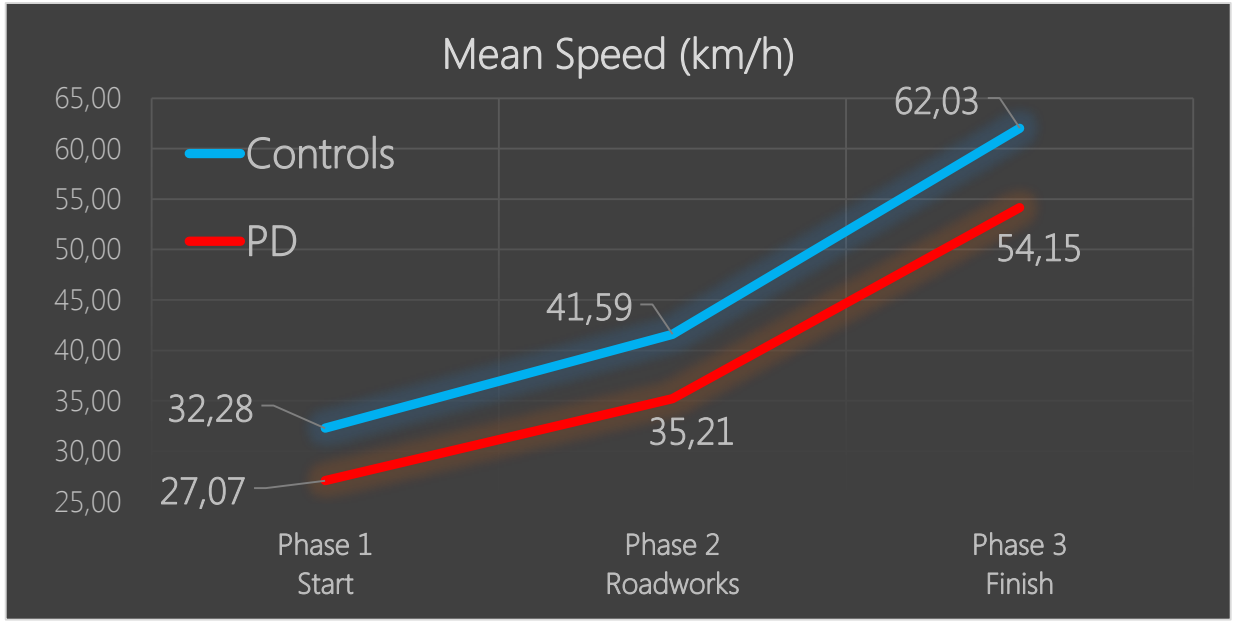
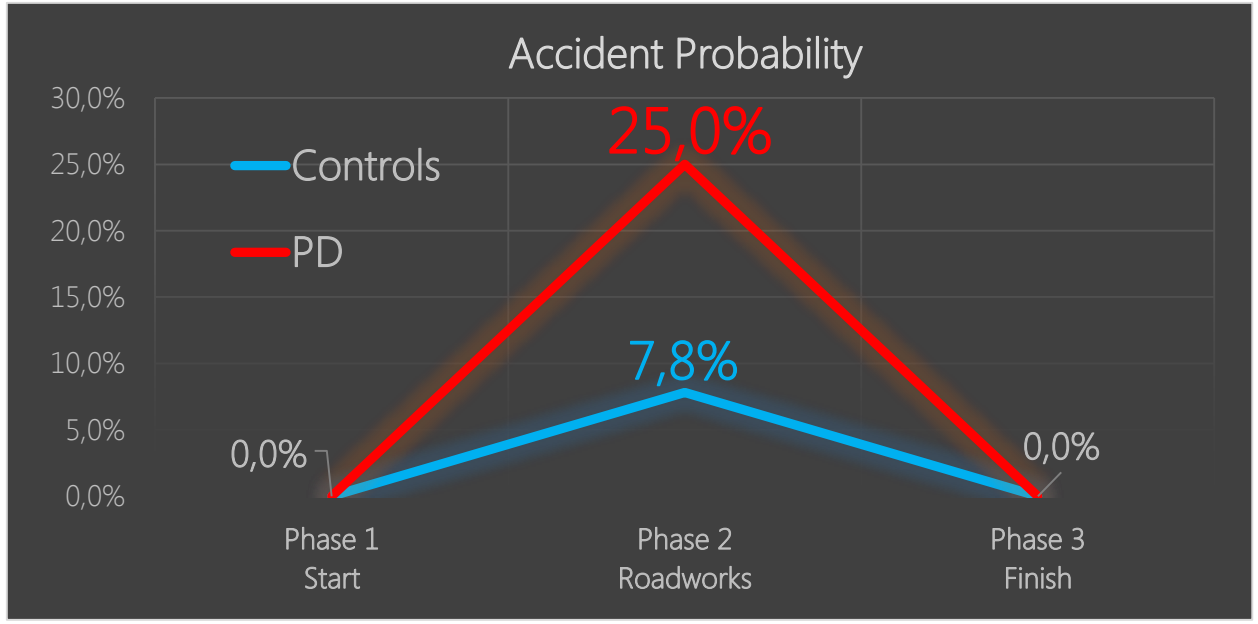
RESULTS - MOTORWAY SESSION





- Inside the work segment, although PD patients drive 15% lower than control group, their accident probability is 3 times higher

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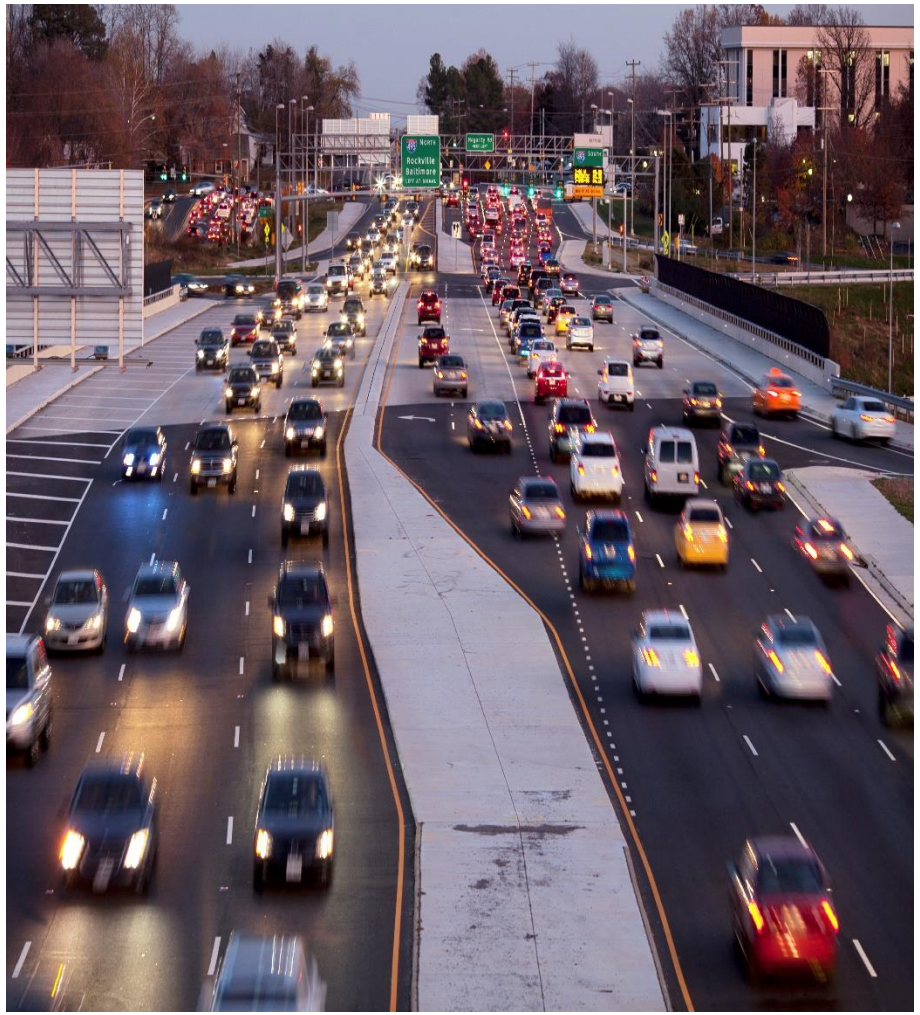
CONCLUSIONS - DISCUSSION 1/2

PD drivers (compared to the control group) were found to:

- drive at significantly lower speeds
- keep large headways
- have significantly worse reaction times (even worse if the driving environment difficulty level increases)
- have difficulties in positioning the vehicle inside the lane
- tend to drive to the left double borderline
- have 3 times higher accident probability inside a work-zone segment that demands a simple manoeuvre



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CONCLUSIONS - DISCUSSION 2/2

- Overall, the deterioration of the driving performance of PD patients is confirmed and analyzed with mathematical models by the present study
- The results are to be considered within the limited context of driving simulator studies - driving performance is known to be more accurately and reliably estimated by means of on-road studies
- However, the relative effects of patients vs healthy drivers are known to be quite identifiable in simulator studies

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