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In-vehicle distraction and brain pathologies: Effects on reaction time and accident probability

Dimosthenis Pavlou[1], Panagiotis Papantoniou[1], Eleonora Papadimitriou[1], Sophia Vardaki[1], George Yannis[1], Constantinos Antoniou[1], John Golias[1] and Sokratis G. Papageorgiou[2]

[1]Department of Transportation Planning and Engineering, National Technical University of Athens, Athens, Greece
[2]University of Athens, 2nd Department of Neurology, "Attikon" University General Hospital, Athens, Greece

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Outline

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

Background 1/2

- Driving requires the ability to receive sensory information, process the information, and to make proper, timely judgments and responses

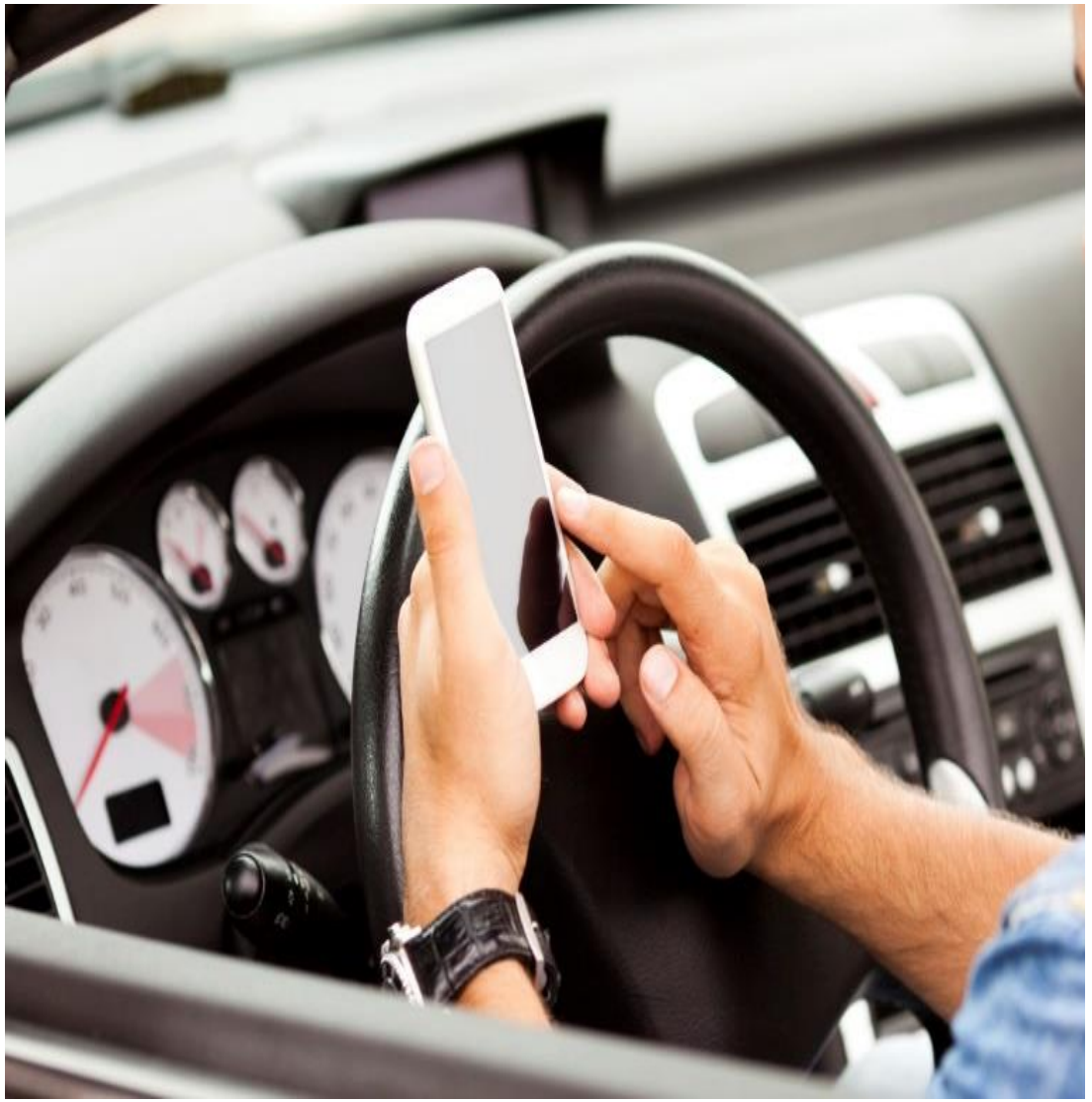
- Various motor, visual, cognitive and perceptual deficits can affect the ability to drive and lead to reduced driver fitness and increased accident probability

- More specifically, diseases affecting a person's brain functioning may significantly impair the person's driving performance

Background 2/2

- Parameters associated with driving performance are reaction time, visual attention, speed of perception and processing, and general cognitive and executive functions

- Driver distraction is estimated to be an important cause of vehicle accidents, and when combined with a brain pathology it can lead to significant deterioration in driving performance

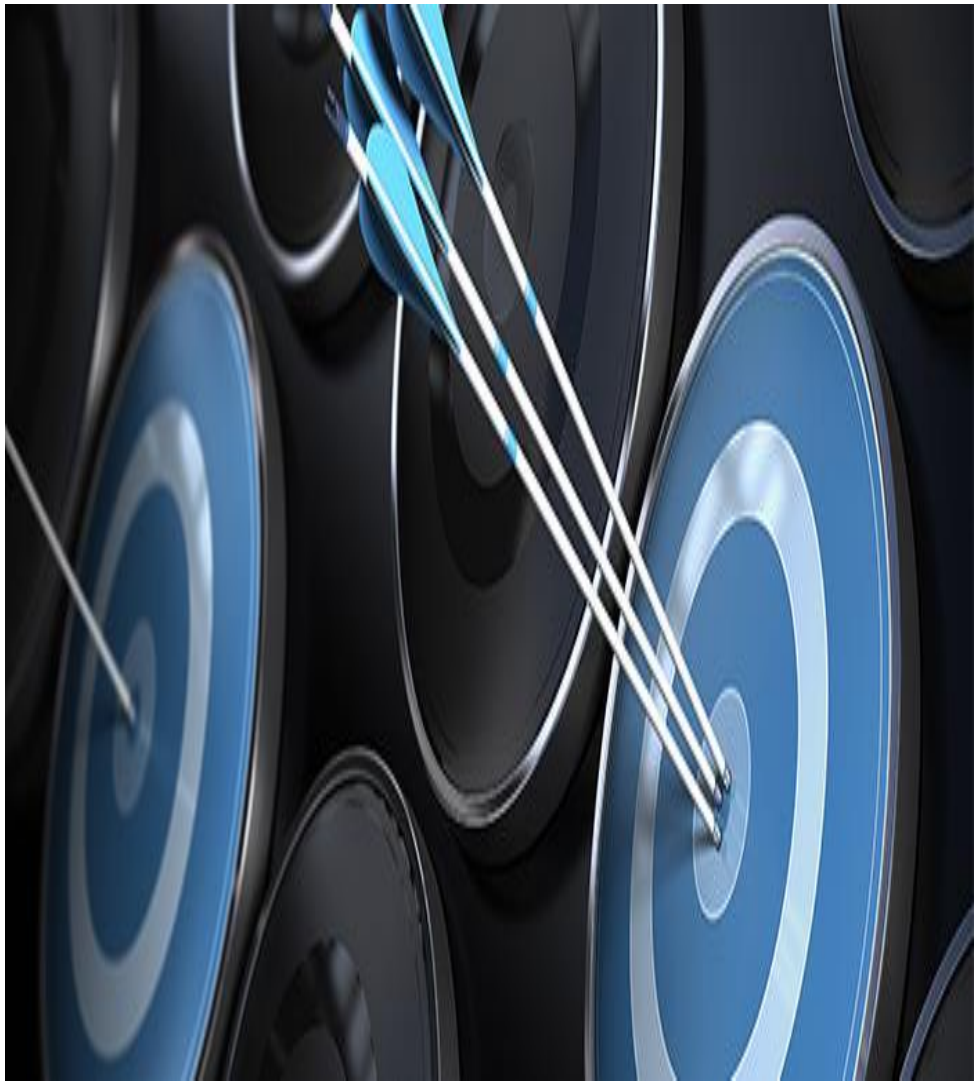


Objective

- The analysis of reaction time and accident probability of drivers with brain pathologies, in combination with in-vehicle distraction, using a driving simulator

- The brain pathologies examined include early Alzheimer's disease (AD), early Parkinson's disease (PD), and Mild Cognitive Impairment (MCI)

- Groups of patients are compared with a control group with no brain pathologies of similar age, driving experience and education



Panagiotis Papantoniou, National Technical University of Athens, Greece, ppapant@central.ntua.gr

Experiment Design

- Distract research project

distrACT

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

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- 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 simulator

- 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

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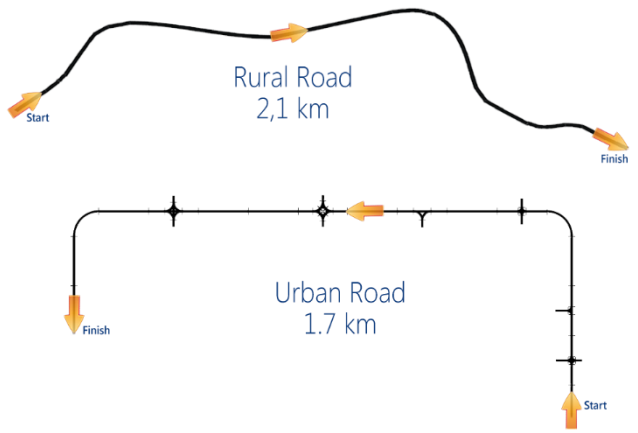
"Driving at the simulator assessment"

- 1 practice drive (usually 15-20 minutes)
- 1 rural route (2,1km long, single carriageway, 3m lane width)
- 1 urban route (1,7km long, at its bigger part dual carriageway, 3.5m lane width)
- 2 traffic scenarios for each route:
  - Q_L: Moderate traffic conditions (Q=300 vehicles/hour)
  - Q_H: 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
  - Sudden appearance of a child chasing a ball on the roadway or of a car suddenly getting out of a parking position.



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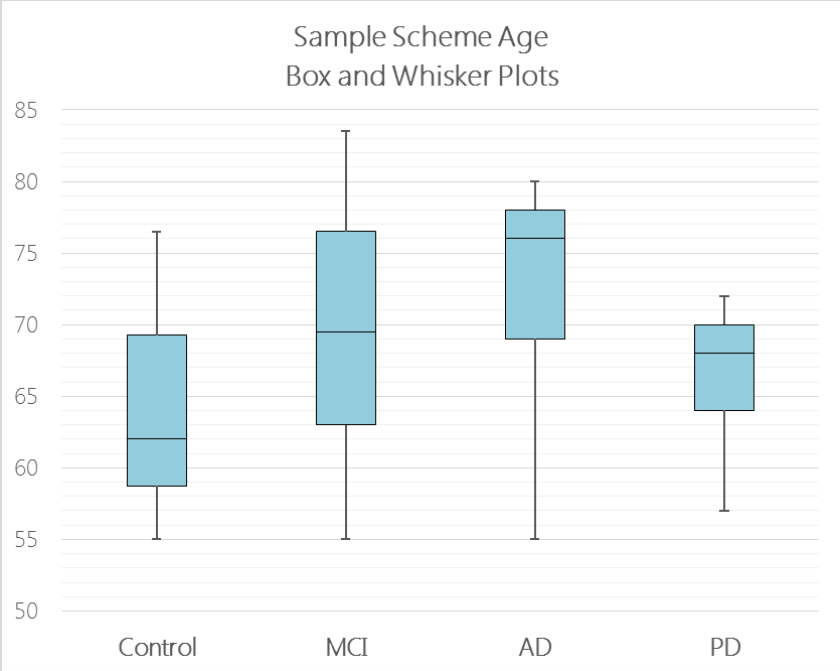
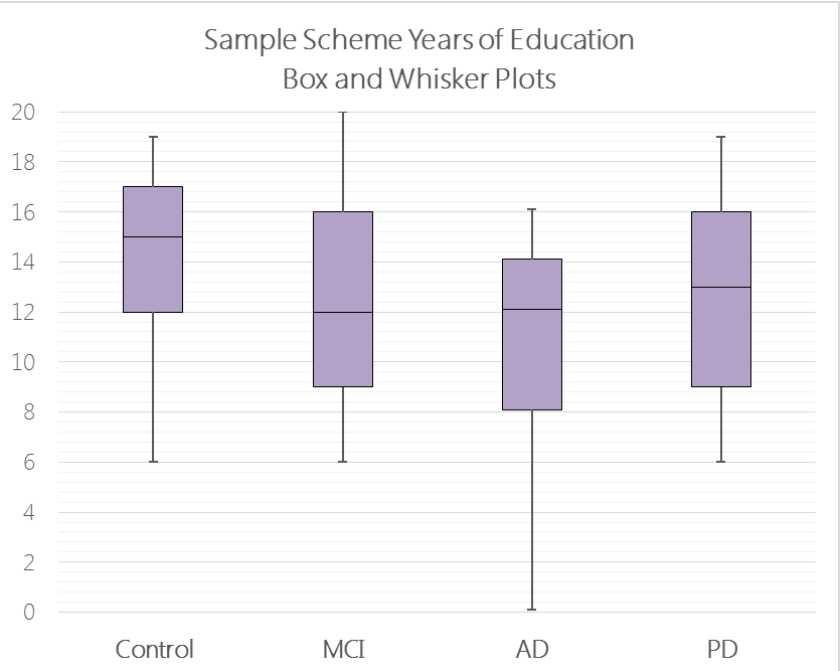
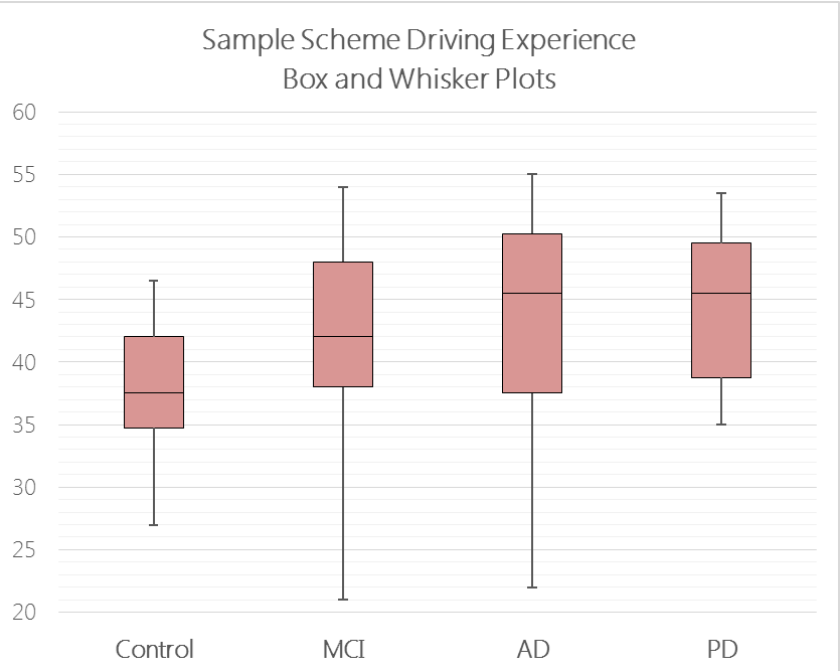
Sample Scheme







140 participants (all more than 55 years of age and of similar demographic characteristics):

- 31 Healthy Controls (aver. 64.5 y.o., 20 males)
- 109 Patients (aver. 69.0 y.o., 80 males):
  - 59 MCI patients (aver. 70.1 y.o.)
  - 25 AD patients (aver. 75.4 y.o.)
  - 25 PD patients (aver. 66.1 y.o.)

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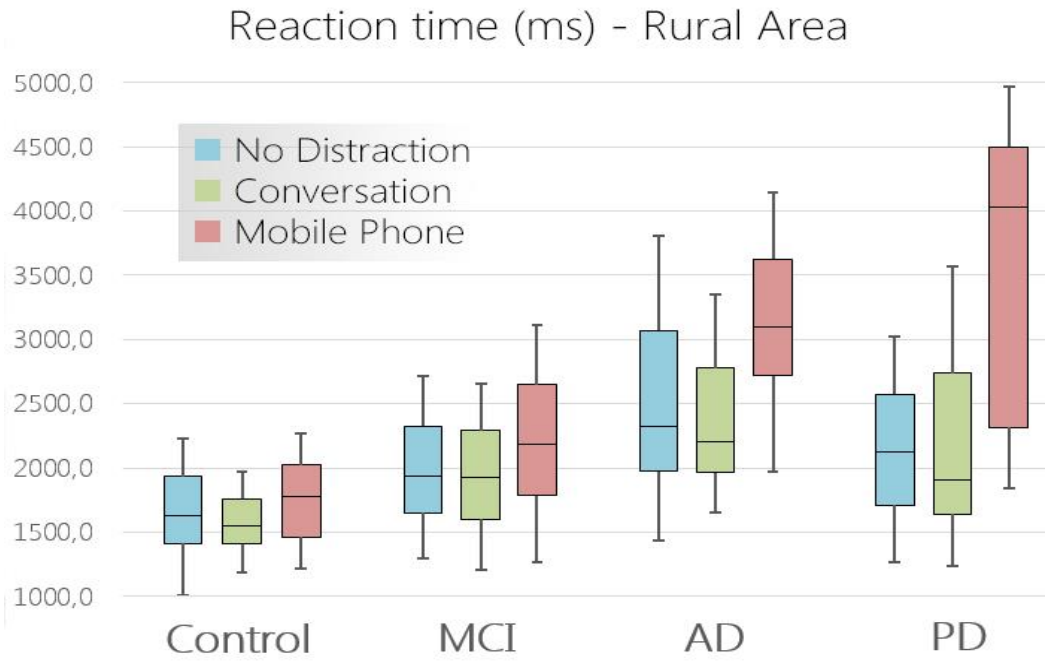
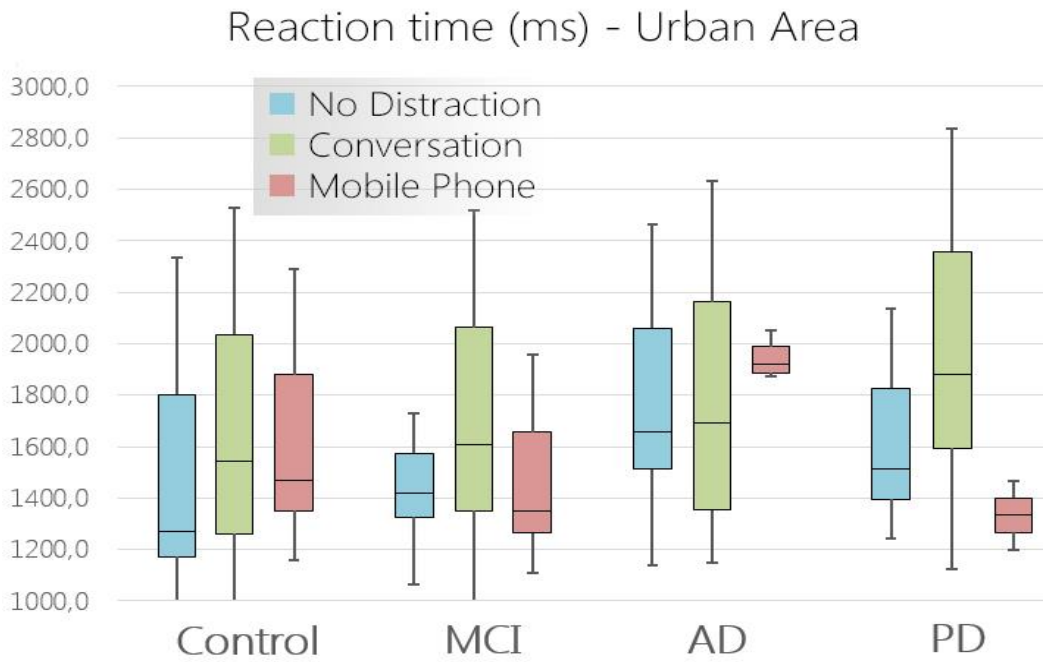
Results - Overview

- We examined and compared the:
  - 4 examined groups (Controls vs MCI vs AD vs PD)
  - 3 examined distraction conditions (No distraction vs Conversation with passenger vs Mobile phone use)
  - 2 examined driving areas (Rural vs Urban)
- But more importantly the interaction between the disease and the distractor was examined and significant results carried out.
- The statistical analysis method selected is the mixed generalized linear model (GLM)

Results - Reaction time 1/2





- In rural area AD and PD groups had the worst reaction times (more than 40% worse reaction times than the control group)
- Mobile phone use seemed to have a significant effect on reaction time for AD and especially PD groups
- AD and PD sample in mobile phone use in urban areas was very small, thus the mobile phone use results for these two groups were not significant
- Conversing with passenger didn't seem to have an important effect on reaction time in all examined groups

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Results - Reaction time 2/2

Parameter Estimates

	Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			
				Lower	Upper	Wald Chi-Square	df	Sig.	
Disease	(Intercept)	1679,1	71,3	1539,3	1819,0	554,1	1	,000	
	MCI	**372,8**	100,4	176,1	569,5	13,8	1	**,000**	**
	AD	**884,4**	129,8	630,0	1138,7	46,4	1	**,000**	**
	PD	**575,9**	134,5	312,4	839,5	18,3	1	**,000**	**
	Control	**0[a]**							
Disease*Distractor	**MCI Mobile Phone**	**338,4**	135,4	73,1	603,8	6,2	1	**,012**	**
	MCI Conversation	-46,1	100,1	-242,4	150,1	0,2	1	,645	
	MCI No distraction	**0[a]**							
	AD Mobile Phone	**1171,8**	332,4	520,4	1823,2	12,4	1	**,000**	**
	AD Conversation	-74,5	154,2	-376,9	227,8	0,2	1	,629	
	AD No distraction	**0[a]**							
	PD Mobile Phone	**1014,1**	240,5	542,6	1485,6	17,8	1	**,000**	**
	PD Conversation	108,8	164,6	-213,8	431,4	0,4	1	,509	
	PD No distraction	**0[a]**							
	Control Mobile Phone	91,6	122,3	-148,1	331,3	0,6	1	,454	
	Control Conversation	-109,3	103,4	-312,0	93,4	1,1	1	,291	
	Control No distraction	**0[a]**							
	(Scale)	493591,96[b]	27571,1	442406,6	550699,3				

Dependent Variable: Reaction Time (ms) (Rural area)
Model: (Intercept), Disease, Disease * Distraction

Parameter Estimates

	Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			
				Lower	Upper	Wald Chi-Square	df	Sig.	
Disease	(Intercept)	1341,9	52,8	1238,4	1445,3	646,5	1	,000	
	MCI	130,6	73,6	-13,6	274,8	3,2	1	,076	*
	AD	**463,4**	94,4	278,4	648,5	24,1	1	**,000**	**
	PD	**262,2**	100,7	64,9	459,6	6,8	1	**,009**	**
	Control	**0[a]**							
Disease*Distractor	MCI Mobile Phone	55,8	110,9	-161,6	273,1	0,3	1	,615	
	MCI Conversation	**247,5**	74,2	102,1	392,8	11,1	1	**,001**	**
	MCI No distract	**0[a]**							
	AD Mobile Phone	141,0	191,7	-234,8	516,8	0,5	1	,462	
	AD Conversation	4,6	127,8	-246,0	255,1	0,0	1	,971	
	AD No distraction	0[a]							
	PD Mobile Phone	-257,6	230,9	-710,1	194,9	1,2	1	,265	
	PD Conversation	**438,0**	128,6	185,9	690,1	11,6	1	**,001**	**
	PD No distraction	**0[a]**							
	Control Mobile Phone	147,9	96,7	-41,7	337,4	2,3	1	,126	
	Ctrl Conversation	**160,2**	76,5	10,3	310,0	4,4	1	**,036**	**
	Ctrl No distract	**0[a]**							
	(Scale)	183824,602[b]	12838,9	160307,2	210792,0				

Dependent Variable: Reaction Time (ms) (Urban area)
Model: (Intercept), Disease, Disease * Distraction

- Rural area: Although conversing with a passenger didn't seem to affect reaction time, the use of the mobile phone had significant effect on all groups of patients
- Urban area: all participants (except for the MCI group) were affected by the "conversation with passenger" task, and their reaction time was significantly deteriorated; even the control group

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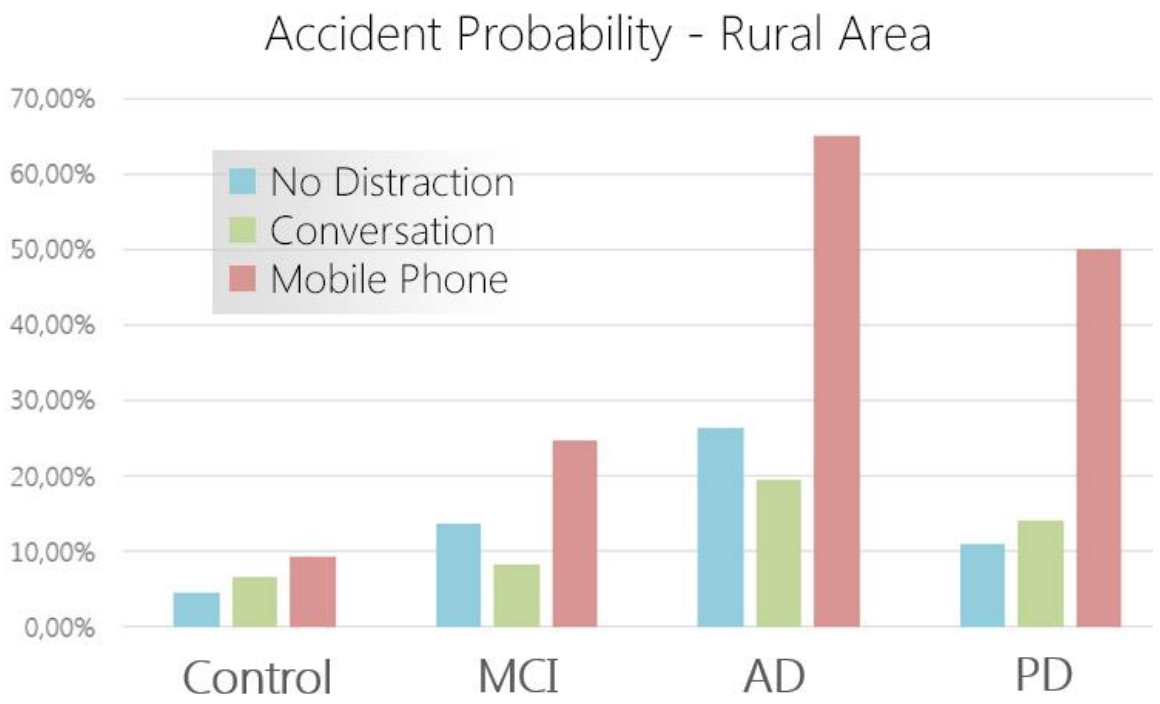
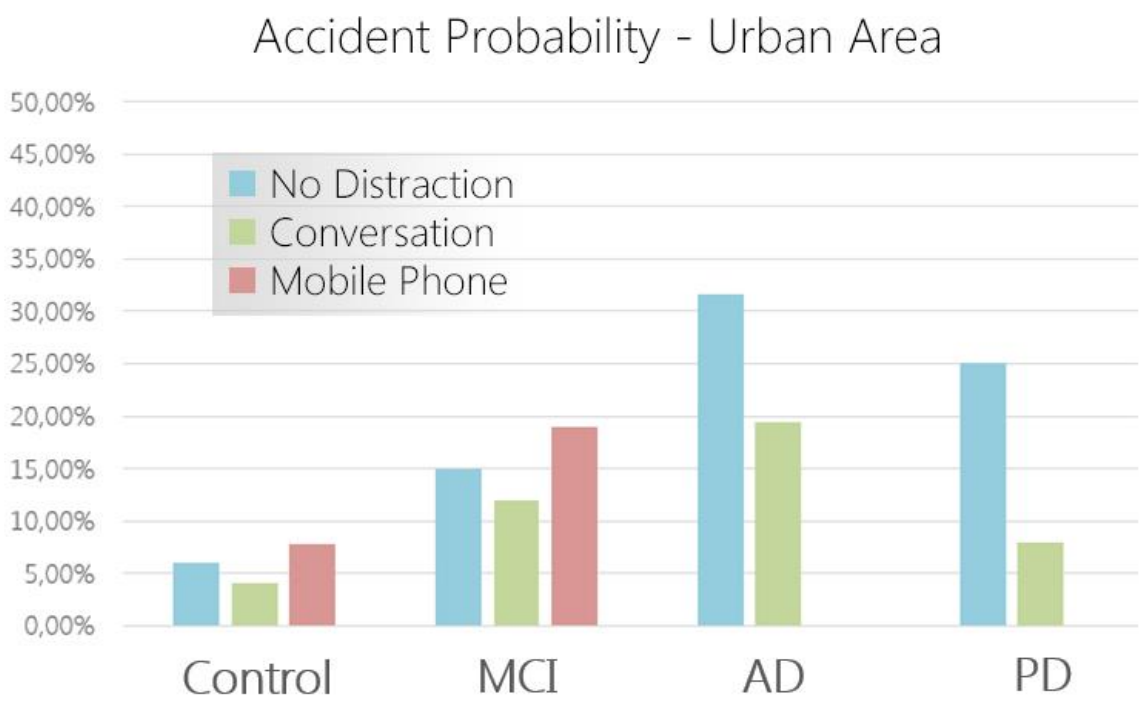
Results - Accident Probability 1/2





- AD drivers had in all conditions the higher accident probability, and especially when conversing on the mobile phone (more than 60%)
- PD participants had also a significant negative effect in accident probability when using the mobile phone
- Conversation with passenger didn't increase the possibility of causing an accident
- In urban area the differences between the groups were approximately the same with the rural area

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Results – Accident Probability 2/2

Parameter Estimates

	Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			
				Lower	Upper	Wald Chi-Square	df	Sig.	
Disease	(Intercept)	0,077	0,026	0,026	0,128	8,82	1	,003	
	MCI	**0,068**	0,027	0,016	0,120	6,61	1	**,010**	**
	AD	**0,185**	0,047	0,092	0,277	15,19	1	**,000**	**
	PD	0,015	0,049	-0,081	0,111	0,09	1	,763	
	Control	**0[a]**							
Disease*Distractor	**MCI Mobile Phone**	**0,125**	0,049	0,029	0,222	6,45	1	**,011**	**
	MCI Conversation	-0,055	0,037	-0,126	0,017	2,25	1	,134	
	MCI No distract	**0[a]**							
	AD Mobile Phone	**0,438**	0,121	0,200	0,676	13,04	1	**,000**	**
	AD Conversation	-0,067	0,056	-0,177	0,044	1,41	1	,236	
	AD No distraction	**0[a]**							
	PD Mobile Phone	**0,362**	0,088	0,190	0,535	17,04	1	**,000**	**
	PD Conversation	0,051	0,060	-0,067	0,168	0,71	1	,398	
	PD No distraction	**0[a]**							
	Control Mobile Phone	0,051	0,060	-0,067	0,168	0,71	1	,398	
	Control Conversation	0,025	0,038	-0,049	0,099	0,44	1	,509	
	Control No distraction	0[a]							
	(Scale)	,066[b]	0,0	0,1	0,1				

Dependent Variable: Accident probability (Rural area)
Model: (Intercept), Disease, Disease * Distraction

Parameter Estimates

	Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			
				Lower	Upper	Wald Chi-Square	df	Sig.	
Disease	(Intercept)	0,068	0,027	0,016	0,120	6,61	1	,010	
	MCI	**0,182**	0,037	0,109	0,254	24,18	1	**,000**	**
	AD	**0,248**	0,047	0,155	0,341	27,42	1	**,000**	**
	PD	**0,172**	0,051	0,073	0,271	11,53	1	**,001**	**
	Control	**0[a]**							
Disease*Distractor	**MCI Mobile Phone**	**-0,197**	0,056	-0,307	-0,088	12,54	1	**,000**	**
	MCI Conversation	**-0,219**	0,037	-0,292	-0,146	34,45	1	**,000**	**
	MCI No distract	**0[a]**							
	AD Mobile Phone	-0,150	0,096	-0,339	0,039	2,423	1	,120	
	AD Conversation	-0,094	0,064	-0,220	0,031	2,16	1	,142	
	AD No distraction	0[a]							
	PD Mobile Phone	-0,115	0,116	-0,342	0,112	0,98	1	,322	
	PD Conversation	**-0,140**	0,065	-0,267	-0,013	4,69	1	**,030**	**
	PD No distraction	**0[a]**							
	Control Mobile Phone	-0,015	0,049	-0,110	0,081	0,09	1	,764	
	Control Conversation	-0,035	0,038	-0,110	0,040	0,82	1	,365	
	Ctrl No distract	0a							
	(Scale)	,046[b]	0,0	0,0	0,1				

Dependent Variable: Accident probability (Urban area)
Model: (Intercept), Disease, Disease * Distraction

- Mobile phone use had a significant effect in increasing the accident probability in the MCI and the PD groups in rural driving environment
- In urban area, the effect of the presence of distraction was not significant, probably because of the small sample size of the impaired participant who use mobile phone in such an environment

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Conclusions - Discussion 1/2

- All findings suggest difficulties in safe driving of the group of patients in both reaction time and accident probability
- AD group had the worst reaction times compared to all other groups
- Distraction through mobile phone use deteriorated the reaction time of patients with AD or PD by at least 1 second
- The accident probability for the group of patients was significantly higher than the control drivers
- Distraction through mobile phone use increased the accident probability for the MCI and PD groups in rural area

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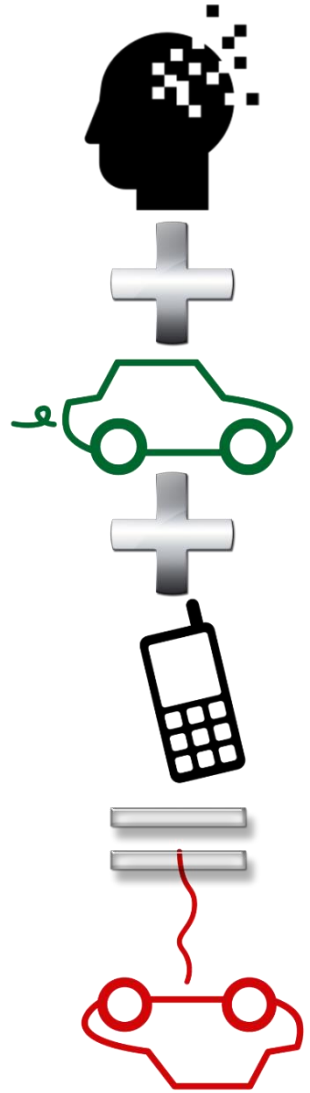
Conclusions - Discussion 2/2

- AD and PD drivers had the worst driving performance overall;
  - very large reaction times
  - even with in-vehicle no distraction
  - higher accident probability even with no distraction
- When using the mobile phone, their driving performance was even more deteriorated (reaction times over 3 seconds and accident probability approximately 50%)
- Control group didn't seem to be affected by the distraction conditions regarding either reaction time or accident probability
- All above results are quite promising and confirm the initial hypotheses



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