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"Expert Symposium on Accident Research"

The impact of cognitive impairments on accident risk

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Outline

- Introduction
- Objectives
- Methodology
- 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

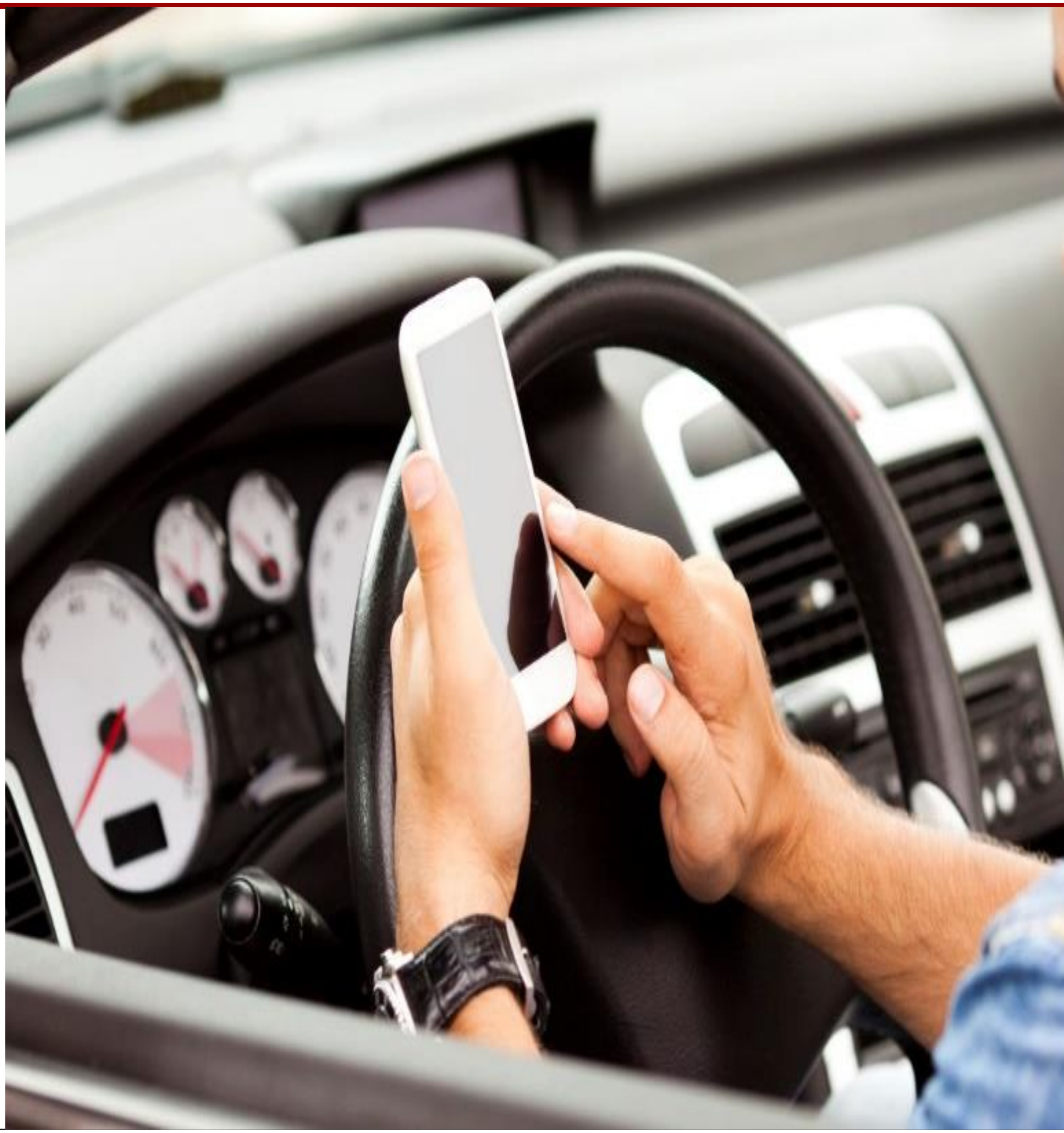
- Various motor, visual, cognitive and perceptual deficits can affect the ability to drive and lead to reduced driver fitness and increased accident risk

- 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



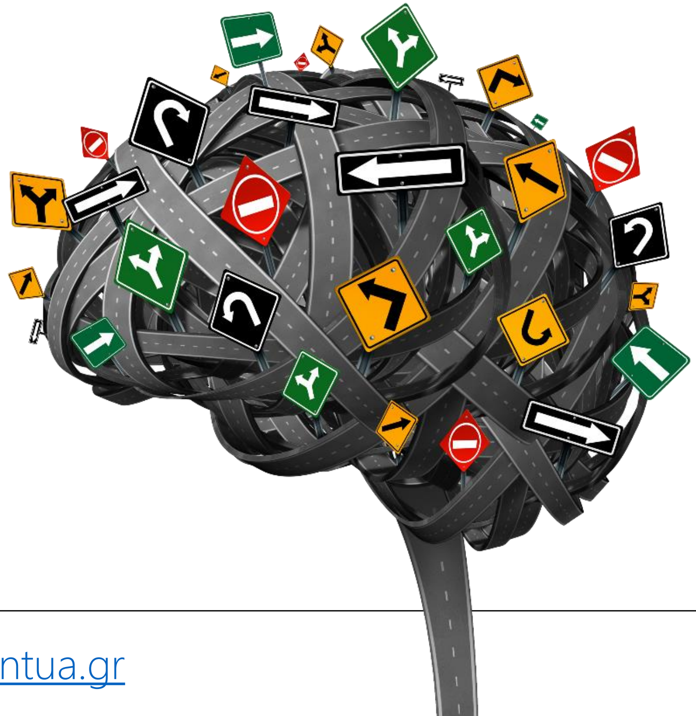
Objectives

- The analysis of the accident risk of drivers with cognitive impairments due to brain pathologies, through a large driving simulator experiment and
- The investigation of the impact of driver distraction on the accident risk
- 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 to a control group with no brain pathologies of similar age, driving experience and education

Experiment Design

- Distract and DriverBRAIN research projects
- 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

distrACT http://www.nrso.ntua.gr/distract/
driverBRAIN http://www.nrso.ntua.gr/driverbrain/



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 F.O.V. 170 degrees
- Validated against a real world environment

“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
- 2 unexpected incidents occur 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.

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Sample Scheme

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

- 34 Healthy Controls (aver. 64.1 y.o., 25 males)
- 91 Patients (aver. 71.2 y.o., 59 males):
  - 43 MCI patients (aver. 70.1 y.o.)
  - 28 AD patients (aver. 75.4 y.o.)
  - 20 PD patients (aver. 66.1 y.o.)

	"MCI, AD, PD Patients" group	"Control" group	P-values
Age, y, mean±SD	71.2±7.2	64.1±6.6	0.122
N, M/F (Gender)	91, 59/32	34, 25/9	0.141
Driving experience, y, mean±SD	41.3±5.8	38.7±2.8	0.271
Days/week, median (range)	4 (2-7)	5 (2-7)	0.359
Kilometers driven/week[a], median (range)	3 (2-5)	3 (2-5)	0.416
Accidents (2 years) - reported, median (range)	0 (0-0)	0 (0-0)	1.000
Education, y, mean±SD	12.1±3.5	13.5±2.2	0.812
Simulator sickness[b] - reported, median (range)	0.23 (0-3)	0.18 (0-3)	0.726

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Results - Overview

- We examined and compared the accident risk of:
  - 4 examined groups
    (Controls vs MCI vs AD vs PD)
  - in 2 driving areas
    (Rural vs urban)
  - in 2 traffic volumes
    (Moderate vs high traffic)
  - in undistracted condition at first
  - and then in 3 distraction conditions
    (No distraction vs Conversation with passenger vs Mobile phone use)
- Regression analysis by generalized linear modeling (GLM) techniques

Results - Accident risk GLMs

- AD participants in all 4 driving conditions had significantly higher accident risk by more than 15% compared to healthy controls of similar demographics
- PD participants had significantly higher accident risk than the controls only in urban area in high traffic volume (the most complex driving environment of all four)
- MCI patients didn't have significant differences with the control group in rural road, but on the other hand they had higher accident risk in urban driving environment.

Parameter Estimates of the GLM

Dependent variable: Accident Probability

Model: (Intercept), Disease, No distraction Condition

Rural Area

Parameter	Low Traffic B	Std. Error	Hypothesis Test: Wald Chi-Square	df	Sig.	High Traffic B	Std. Error	Hypothesis Test: Wald Chi-Square	df	Sig.
(Intercept)	0,13	0,0	11,2	1	0,001	0,04	0,0	1,4	1	0,238
MCI	-0,01	0,1	0,0	1	,916	0,09	0,0	3,2	1	,072
AD	0,15	0,1	5,4	1	,020	0,19	0,1	11,6	1	,001
PD	-0,03	0,1	0,2	1	,691	0,04	0,1	0,4	1	,521
Controls	0[a]					0[a]				
(Scale)	,068[b]	0,0				,055[b]	0,0			

Urban Area

Parameter	Low Traffic B	Std. Error	Hypothesis Test: Wald Chi-Square	df	Sig.	High Traffic B	Std. Error	Hypothesis Test: Wald Chi-Square	df	Sig.
(Intercept)	0,07	0,0	2,8	1	0,095	0,10	0,0	4,7	1	0,030
MCI	0,16	0,1	6,2	1	,013	0,15	0,1	4,4	1	,037
AD	0,23	0,1	9,6	1	,002	0,20	0,1	5,3	1	,021
PD	0,12	0,1	2,0	1	,156	0,19	0,1	4,2	1	,042
Controls	0[a]					0[a]				
(Scale)	,066[b]	0,0				,076[b]	0,0			

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

Results - The effect of distraction

- Mobile phone use had a detrimental impact on the accident risk of all patient groups
- Conversation with passenger had significant impact on the accident risk in urban area for PD group
- MCI drivers' accident risk was more than 20% while conversing through mobile phone
- The accident risk of AD drivers was 43%(!) and of PD drivers was 38% in rural area while conversing through mobile phone

Parameter Estimates of the GLM
Dependent variable: Accident Probability
Model: (Intercept), Distractor

MCI group

Area	Parameter	B	Std. Error	Hypothesis Test: Wald Chi-Square	df	Sig.
Rural Area	(Intercept)	0,12	0,0	14,4	1	0,000
	Conversation	-0,01	0,0	0,0	1	,888
	Mobile phone	0,19	0,1	10,3	1	,001
	No distraction	0[a]				
	(Scale)	,065[b]	0,0			
Urban Area	(Intercept)	0,26	0,0	77,5	1	0,000
	Conversation	0,21	0,0	25,6	1	,000
	Mobile phone	0,23	0,1	13,1	1	,000
	No distraction	0[a]				
	(Scale)	,051[b]	0,0			

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

Parameter Estimates of the GLM
Dependent variable: Accident Probability
Model: (Intercept), Distractor

AD group

Area	Parameter	B	Std. Error	Hypothesis Test: Wald Chi-Square	df	Sig.
Rural Area	(Intercept)	0,27	0,0	31,4	1	0,000
	Conversation	-0,09	0,1	1,5	1	,219
	Mobile phone	0,43	0,2	7,6	1	,006
	No distraction	0[a]				
	(Scale)	,109[b]	0,0			
Urban Area	(Intercept)	0,30	0,1	29,7	1	0,000
	Conversation	-0,12	0,1	1,7	1	,196
	Mobile phone	-0,14	0,1	0,9	1	,336
	No distraction	0[a]				
	(Scale)	,102[b]	0,0			

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

Parameter Estimates of the GLM
Dependent variable: Accident Probability
Model: (Intercept), Distractor

PD group

Area	Parameter	B	Std. Error	Hypothesis Test: Wald Chi-Square	df	Sig.
Rural Area	(Intercept)	0,08	0,0	3,6	1	0,057
	Conversation	0,06	0,1	0,8	1	,361
	Mobile phone	0,38	0,1	18,9	1	,000
	No distraction	0[a]				
	(Scale)	,087[b]	0,0			
Urban Area	(Intercept)	0,22	0,0	27,6	1	0,000
	Conversation	0,14	0,1	4,7	1	,030
	Mobile phone	-0,14	0,1	2,0	1	,161
	No distraction	0[a]				
	(Scale)	,053[b]	0,0			

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

Parameter Estimates of the GLM
Dependent variable: Accident Probability
Model: (Intercept), Distractor

Control group

Area	Parameter	B	Std. Error	Hypothesis Test: Wald Chi-Square	df	Sig.
Rural Area	(Intercept)	0,08	0,0	20,7	1	0,000
	Conversation	0,02	0,1	0,3	1	,593
	Mobile phone	-0,05	0,1	1,8	1	,176
	No distraction	0[a]				
	(Scale)	,041[b]	0,0			
Urban Area	(Intercept)	0,09	0,0	24,6	1	0,000
	Conversation	-0,06	0,1	5,4	1	,020
	Mobile phone	-0,04	0,1	1,3	1	,262
	No distraction	0[a]				
	(Scale)	,025[b]	0,0			

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

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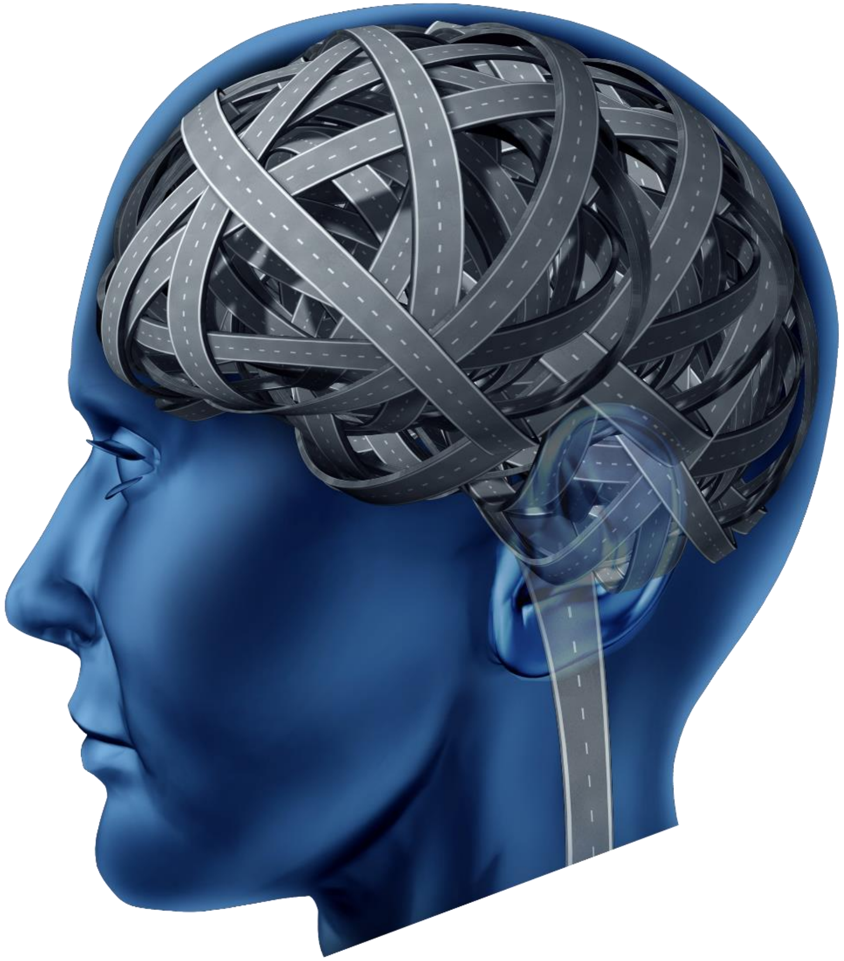
Conclusions - Discussion 1/2

- The presence of a brain disease had a detrimental impact on accident risk and especially for the AD group who crashed approximately 1 out of 5 incidents
- The traffic volume didn't have any significant effect on the accident risk
- Urban area leads to increased accident risk for the group of patients with brain pathologies (especially for the PD patients)
- The control group seemed unaffected regarding their accident risk when being distracted
- The use of the mobile phone had a deleterious effect on the accident risk of all three groups of patients in almost every examined condition

Conclusions - Discussion 2/2

- AD drivers had the worst "accident risk profile" followed by the PD group but only in urban area which constitutes a more complex driving environment. MCI group had an overall lower accident risk compared to AD and PD groups, but not compared to the healthy drivers.
- Observations of considerable practical importance;
  - provide quite useful information for the development of policies that aim at reducing the risk for car accidents and at improving aspects of driving performance (restrictive measures, training and licensing, information campaigns, medical and neuropsychological monitoring), especially in a sensitive group of car drivers, such that of drivers with MCI, AD or PD



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