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EXPLORATION OF ACCIDENT PROBABILITY OF DRIVERS WITH BRAIN PATHOLOGIES

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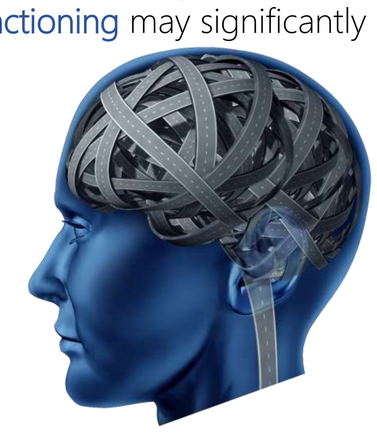
Background

- 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
- 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



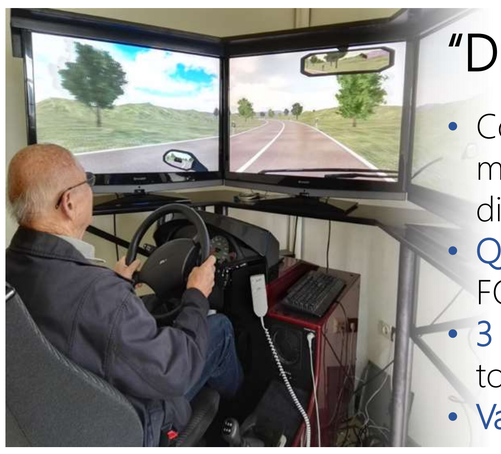
Objective and scope

- The analysis of the accident probability of drivers with cognitive impairments due to brain pathologies, through a large driving simulator experiment
- The investigation of the impact of driver distraction on the accident probability
- 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

Experimental 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

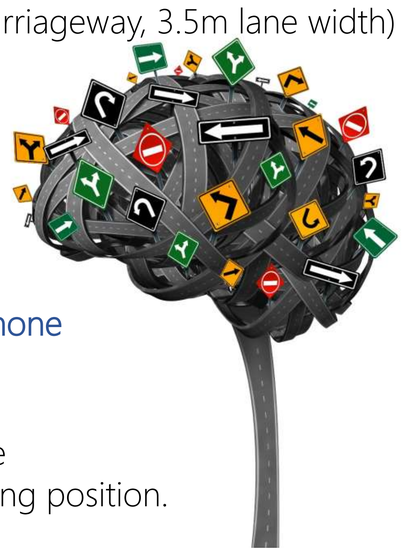
distrACT driverBRAIN
http://www.nrso.ntua.gr/distract/
http://www.nrso.ntua.gr/driverbrain/



"Driving at the simulator assessment"

- 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

- 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: Low 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.

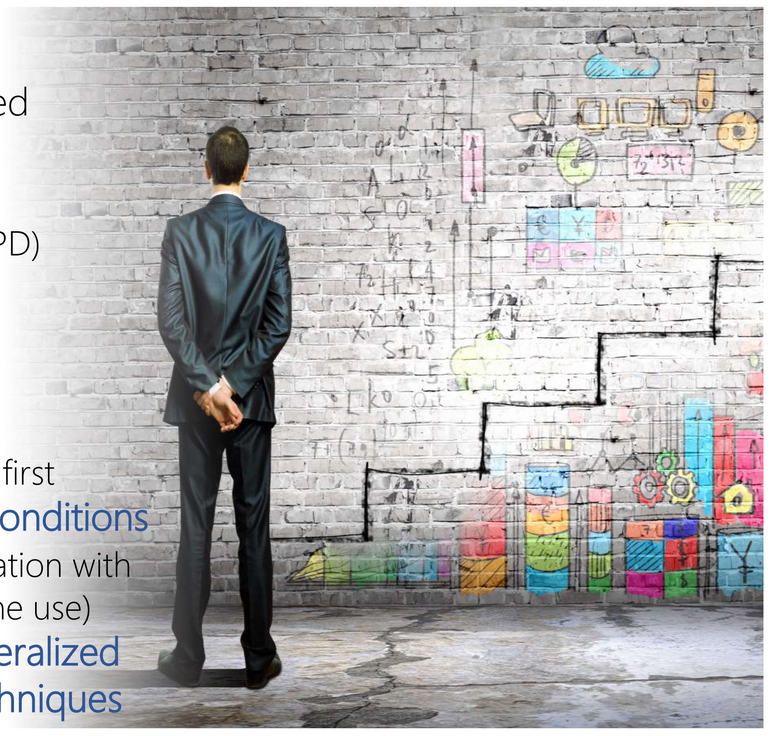


Sample Scheme

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.)

Results - Overview

- We examined and compared the accident probability 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



Parameter Estimates of the GLM
Dependent variable: Accident Probability
Model: (Intercept), Disease, No distraction Condition

	Low Traffic					High Traffic					
Parameter	B	Std. Error	Hypothesis Test: Wald Chi-Square	df	Sig.	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	Rural Area
MCI	-0,01	0,1	0,0	1	,916	0,09	0,0	3,2	1	,072	Rural Area
AD	0,15	0,1	5,4	1	,020	0,19	0,1	11,6	1	,001	Rural Area
PD	-0,03	0,1	0,2	1	,691	0,04	0,1	0,4	1	,521	Rural Area
Controls	0[a]					0[a]					Rural Area
(Scale)	,068[b]	0,0				,055[b]	0,0				Rural Area
Parameter	B	Std. Error	Hypothesis Test: Wald Chi-Square	df	Sig.	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	Urban Area
MCI	0,16	0,1	6,2	1	,013	0,15	0,1	4,4	1	,037	Urban Area
AD	0,23	0,1	9,6	1	,002	0,20	0,1	5,3	1	,021	Urban Area
PD	0,12	0,1	2,0	1	,156	0,19	0,1	4,2	1	,042	Urban Area
Controls	0[a]					0[a]					Urban Area
(Scale)	,066[b]	0,0				,076[b]	0,0				Urban Area

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

Accident probability GLMs

- AD participants in all 4 driving conditions had significantly higher accident probability by more than 15% compared to healthy controls of similar demographics
- PD participants had significantly higher accident probability than 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 probability in urban driving environment

The effect of distraction

- Mobile phone use had a detrimental impact on the accident probability of all patient groups whereas conversation with passenger had significant impact on the accident probability in urban area for PD group
- MCI drivers' accident probability was more than 20% while conversing through mobile phone
- The accident probability 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

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

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

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

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

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

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

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

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

Conclusions

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

- AD drivers had the worst "accident probability 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 probability compared to AD and PD groups, but not compared to the healthy drivers.