TRA2022

TRANSPORT RESEARCH ARENA
LISBON 2022

POSTER SESSION

The impact of cognitive disorders and other risk factors on reaction time of drivers: a Structural Equation Model approach

Dimosthenis Pavlou[a], Maria Oikonomou[a], George Yannis[a]

[a]National Technical University of Athens, Department of Transportation Planning and Engineering, Athens, Greece

INTRODUCTION

Decline in cognitive abilities and functions can be an important contributor to the driving problems encountered by older adults. A neuropsychological assessment may provide a practical approach in order to evaluate this aspect of driving safety risk. In particular, the neurological disorders affecting cognitive functions concern diseases with high prevalence in the general population: Mild Cognitive Impairment, Alzheimer's disease and Parkinson's disease.

OBJECTIVES

The objective of this work is the analysis of traffic and safety behaviour of drivers with cognitive disorders through a driving simulator experiment. More specifically, the study aims to capture the interaction of certain brain pathologies, other related parameters (i.e. demographic, medical, and neuropsychological) and driver distraction with respect to reaction time.

DATA COLLECTION

For the purpose of this research, a large-scale driving simulator experiment was carried out, comprising a medical/neurological and neuropsychological assessment of 225 active drivers (76% males - 24% females): 133 "patients" with a cerebral disease (28 AD patients, 45 MCI patients, 25 PD patients and 35 patients with other neurological disorders affecting cognition) and 92 "controls" without any cognitive disorder, and a set of driving tasks for different scenarios.

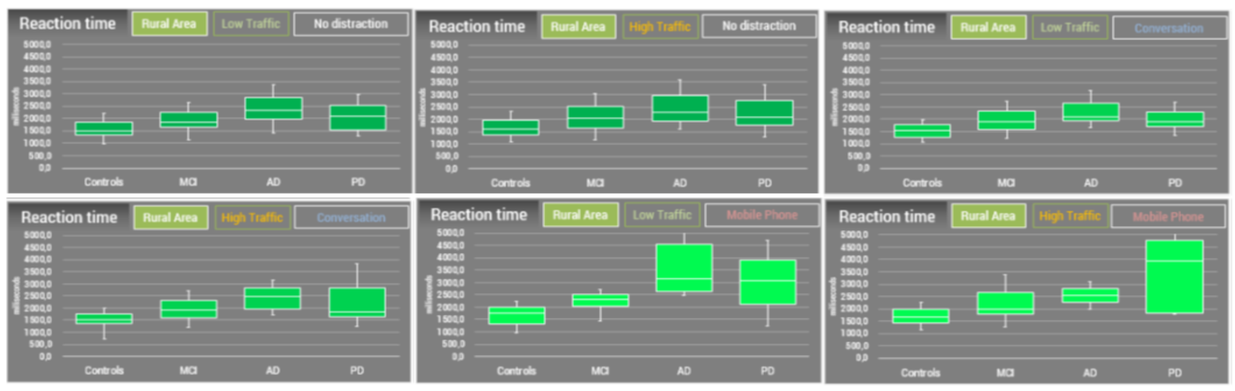

Figure 1: Boxplots of reaction time in rural area with different traffic volumes and distraction conditions

It was observed that controls have the best reaction times overall in rural area, whereas AD and PD groups have the worst reaction times (more than 40% worse reaction times than the control group), as shown in Figure 1. The mobile phone use has an important effect on reaction time for AD and PD groups.

METHODOLOGY

The statistical analysis methodology developed and implemented was based on Structural Equation Models (SEMs). The structural equation model is specified as: $\eta = B\eta + \Gamma\xi + \zeta$, where: η is a vector expressing the latent dependent (unobserved) variables; ξ is a vector expressing the latent independent (exogenous) variables and ζ is a vector expressing the regression error term in η.

RESULTS

With respect to the effect of cerebral disorders on reaction time, it was revealed that the presence of MCI, AD or PD had a significant negative impact on reaction time. Concerning the effect of age, young and middle-aged drivers were found to outperformed older drivers in term of reaction time. Neuropsychological and neurological state that are commonly impaired in patients with cerebral disorders had a significant unique contribution on predicting better reaction times. Regarding the effect of in-vehicle distraction, both distractors had a statistically significant negative effect on reaction time. Results demonstrated that area type was a critical factor affecting drivers' reaction time as in urban areas reaction time was significantly affected in a positive way. The estimation results are presented in Table 1, while an overview of the path diagram of the SEM is provided in Figure 2.

Table 1: Estimation results of the reaction time SEM

Latent variables	Est.	Std.err	Z-value	P(>|z|)
Neuropsychological State (latent 1)				
Witkin's Embedded Figure Test	1.000			
Brief Visuospatial Memory Test	1.962	0.048	40.927	<.001
Comprehensive Trail Making Test (1)	-6.752	0.405	-16.685	<.001
Hopkins Verbal Learning Test (RI)	0.415	0.020	20.818	<.001
Neurological State (latent 2)				
Tandem Walking: Errors	1.000			
Tandem Walking: Completion Time	5.557	0.873	6.364	<.001
Patient Health Questionnaire (PHQ-9)	9.956	2.416	4.120	<.001
Foot taping errors	0.829	0.170	4.885	<.001
Reaction time				
Disease – MCI	103.575	52.205	1.984	.047
Disease - AD	327.075	87.927	3.492	<.001
Disease - PD	381.056	88.544	4.304	<.001
Urban Area	-345.309	33.260	-10.382	<.001
Advanced Age	190.137	43.877	4.333	<.001
Distraction - Conversation	80.614	37.769	2.134	0.033
Distraction - Mobile Phone	225.921	54.088	4.177	<.001
Neuropsychological State (latent)	-20.899	6.464	-3.233	<.001
Neurological State (latent)	-789.943	226.67	-3.485	<.001

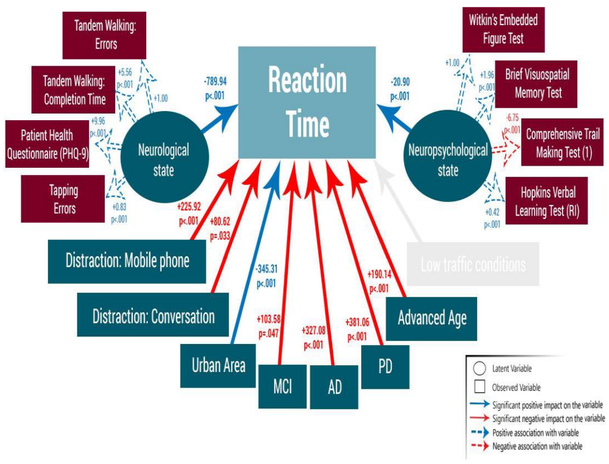

Figure 2: Path diagram of the SEM model for reaction time

CONCLUSIONS

The analysis of the neurological diseases affecting cognitive functions and other age-related and neuropsychological characteristics in combination with the driving performance of the general population is a very crucial domain and a scientific challenge. Enhanced understanding of the medical, behavioural and social issues related to impaired driving due to neurological diseases affecting cognitive functions will lead to more appropriate driver training, criteria for driver license renewal for persons belonging to vulnerable groups, more appropriate legislation and awareness campaigns.

Acknowledgements

This research was funded by the European Union's Horizon 2020 HADRIAN project (Project Number: 875597) funded by European Commission under the MG-2-1-2018 Research and Innovation Action (RIA).

HOSTED AND ORGANISED BY: ANI AGÊNCIA NACIONAL DE INOVAÇÃO

CO-ORGANISED BY: European Commission

IN COOPERATION WITH: IMT INSTITUTO DA MOBILIDADE E DOS TRANSPORTES, I.P. · CONSÓRCIO DE ESCOLAS DE engenharia FEUP • FCTUC • IST • EEUM • UA • FCTNOVA · LNEC LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL · magellan European Affairs Consultancy

TOGETHER WITH: ACARE · alice Alliance for Logistics Innovation through Collaboration in Europe · CEDR · ECTP INNOVATIVE BUILT ENVIRONMENT · ERTRAC · ERRAC The European Rail Research Advisory Council · ETRA European Transport Research Alliance · WATERBORNE