21st MEETING OF THE INTERNATIONAL TRAFFIC SAFETY DATA AND ANALYSIS GROUP (IRTAD)

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Distraction, Cognition, Behaviour and Driving Analysis of a large data set

George Yannis
Professor

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

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Structure of the presentation

- Background
- Research projects
- Objectives
- Experiment design
- Data
- Results
- Discussion
- Conclusions

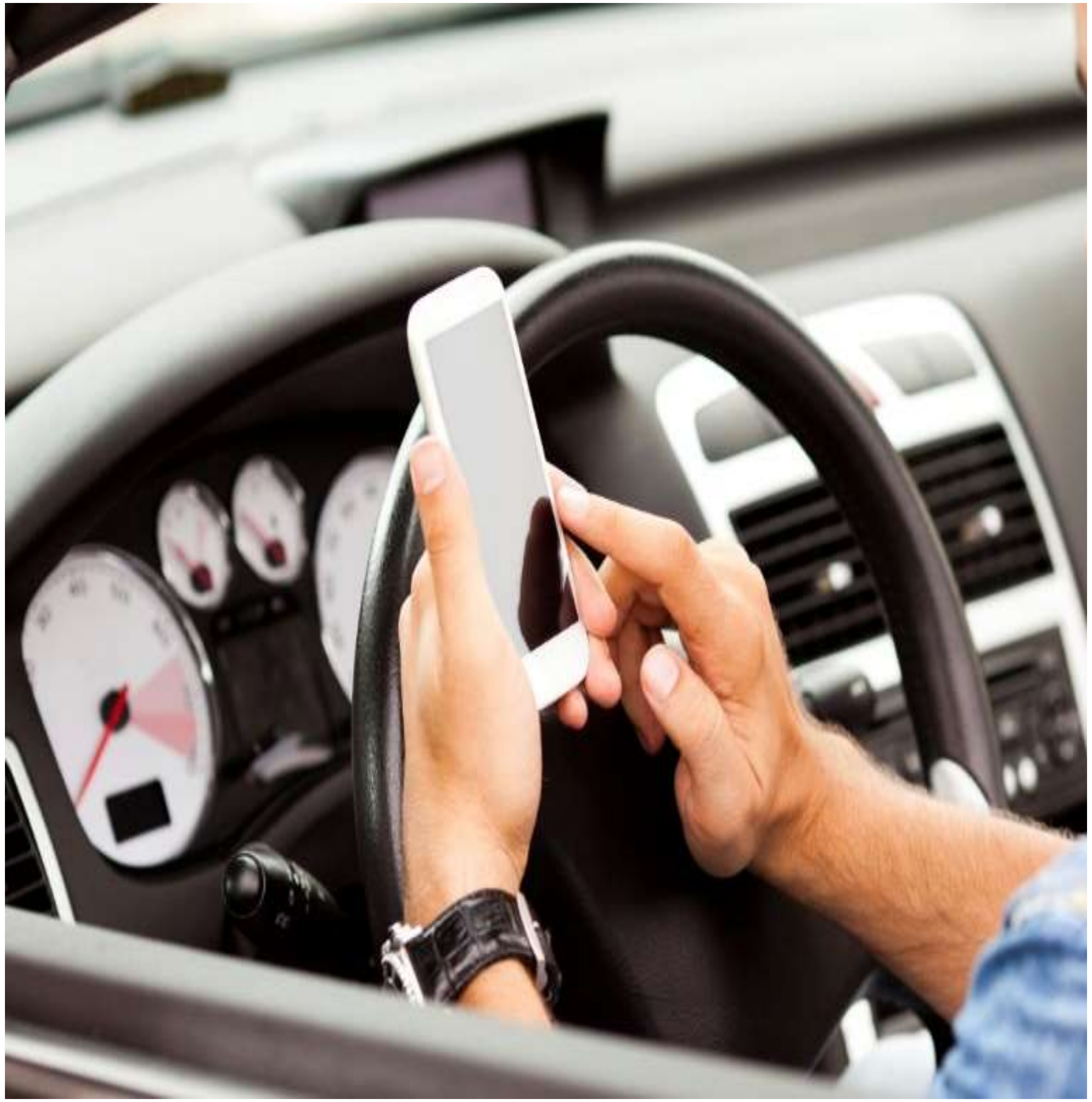
Background 1/2

- 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



Research projects - Distract & Driverbrain

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

distrACT

Causes and impacts of driver distraction: a driving simulator study

- inter-disciplinary
- granted through an open competitive procedure by the Ministry of Education, Lifelong Learning and Religious Affairs
- THALES research programme (2012-2015)

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

driverBRAIN

Performance of drivers with cerebral diseases at unexpected incidents

- inter-disciplinary
- granted through an open competitive procedure by the Ministry of Education, Lifelong Learning and Religious Affairs
- ARISTEIA research programme (2012-2015)

Objectives- Distract & Driverbrain

DISTRACT OBJECTIVES

- Identification and ranking of exogenous and endogenous causes of driver distraction
- Determination of the role of exogenous distractions on driving performance in different road and traffic conditions and the role of medical, neurological and neuropsychological conditions on driving skills, especially with respect to distraction
- Analysis of the impact of the driver's medical, neurological and neuropsychological condition on distraction in different road and traffic conditions
- Analysis of the combined impact of endogenous and exogenous distractions on driver behaviour
- Analysis of the impact of driver distraction on traffic flow and road safety
- Determination of recommendations for dealing with risky driver behaviour due to distraction.

DRIVERBRAIN OBJECTIVES

Investigation of the performance of drivers with cerebral diseases at unexpected incidents through a driving simulator experiment.

The basic research questions are:

- How cerebral diseases (AD, PD, and MCI) affect driving performance, especially at unexpected incidents and how they interact with the other medical, neuropsychological, demographic characteristics of the drivers and with road and traffic parameters.
- Which are the traffic and safety implications of impaired driving due to driver cerebral diseases.
- Which are the remedial measures to be taken for safe driving of people with cerebral diseases.

Interdisciplinary Group of Experts

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

University of Athens, Department of Psychology, Athens, Greece

University of Athens, 2nd Department of Neurology, "Attikon" University General Hospital, Athens, Greece

In total:

11 Faculty Members

- 3 Professors
- 3 Associate Professors
- 4 Assistant Professors
- 1 Invited expert

16 Research Associates and Assistants

Experiment Design

- 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 - behavioral questionnaires to the participants which cover a large spectrum of Cognitive Functions

- Transportation Engineers:
  - Driving at the simulator

Publications - Distract & Driverbrain

http://www.nrso.ntua.gr/distract/en/publication.html

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11 Project deliverables

1 Full Paper published in Scientific Journals

+4 Full Papers **under review** in Scientific Journals

+7 Full Papers **under preparation**

13 Full Papers in Scientific Conferences

24 Presentations in Scientific Conferences

http://www.nrso.ntua.gr/driverbrain/en/publication.html

driverBRAIN

11 Project deliverables

3 Full Papers published in Scientific Journals

+12 Full Papers **under review** in Scientific Journals

+10 Full Papers **under preparation**

19 Full Papers in Scientific Conferences

60 Presentations in Scientific Conferences

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

“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.

Participants - Distract & Driverbrain

	TOTAL PROGRESS	PARTICIPANTS	COMMENTS
DAY 1	Phase A (pre-simulator) 65% of neurological and neuropsychological tests	316 completed (192 patients)	
DAY 2	Driving at the Simulator	225 completed (136 patients) (27AD, 52MCI, 25PD, 32other)	49 simulator sickness drop outs 42 didn't move on to DAY 2 (their choice)
DAY 3	Phase B (post-simulator) 35% of neurological and neuropsychological tests	210 completed (127 patients)	16 didn't move on to DAY 3 (their choice) Overall, 106 didn't went through the whole experimental procedure

210 participants have completed all phases and assessments (127 patients)

"Driving at the simulator" Participants

225 participants

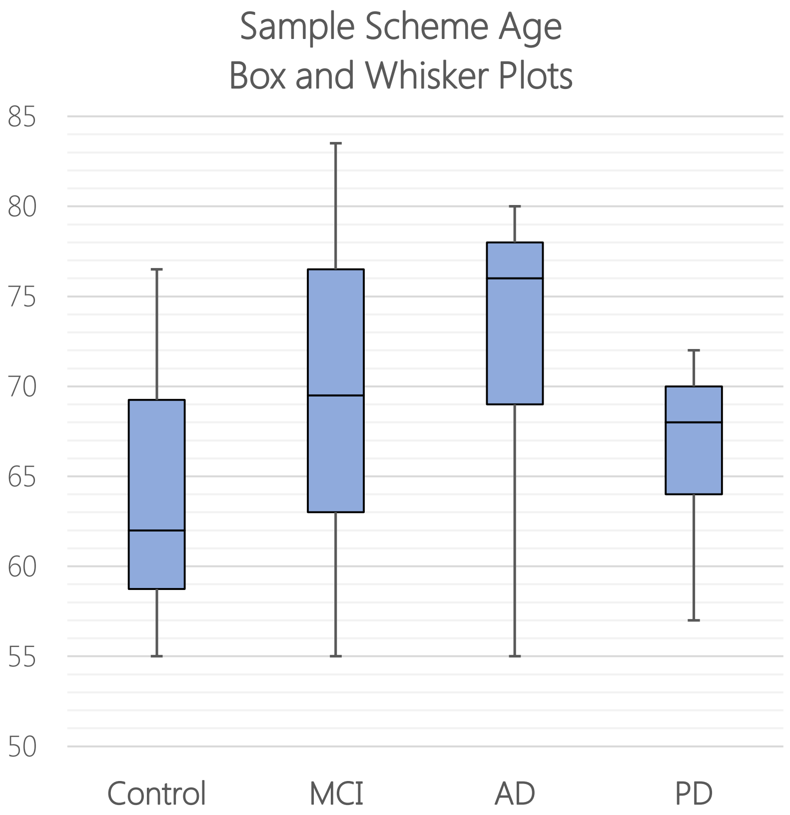
89 Controls, 52 MCI, 27 AD, 25 PD, 32 Other
153 Males, 72 Females

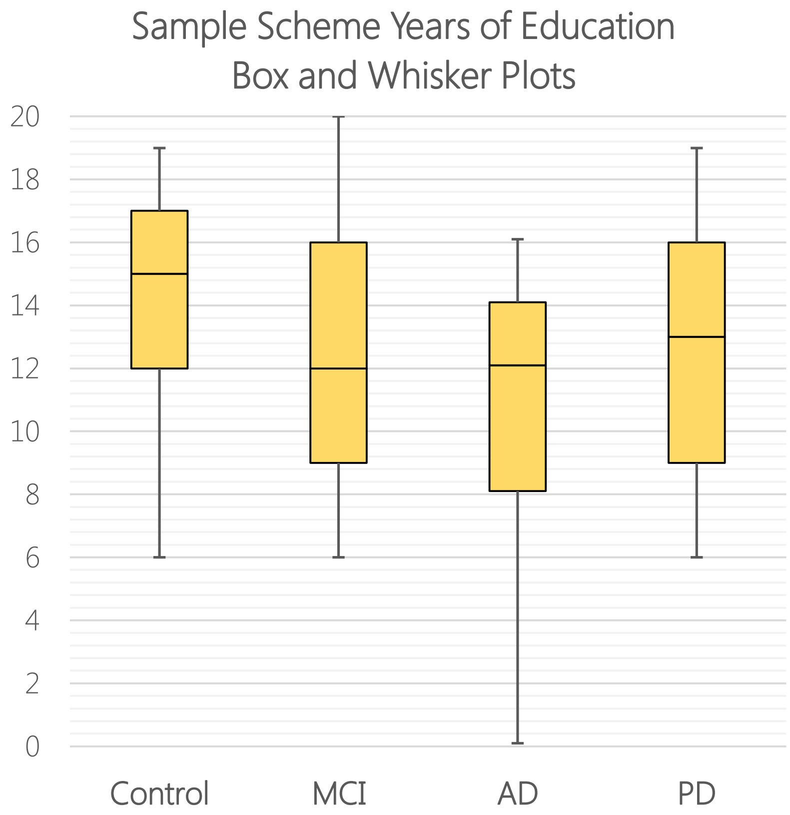
30 young (<35)	**42** middle aged (35-55)	**153** old (>55)
28 Controls 2 Other	29 Controls 3 MCI 5 PD 5 Other	32 Controls 49 MCI 27 AD 20 PD 25 Other
16,3 years of education 7,3 years of driving experience	15,0 years of education 25,2 years of driving experience	13,4 years of education 41,41 years of driving experience

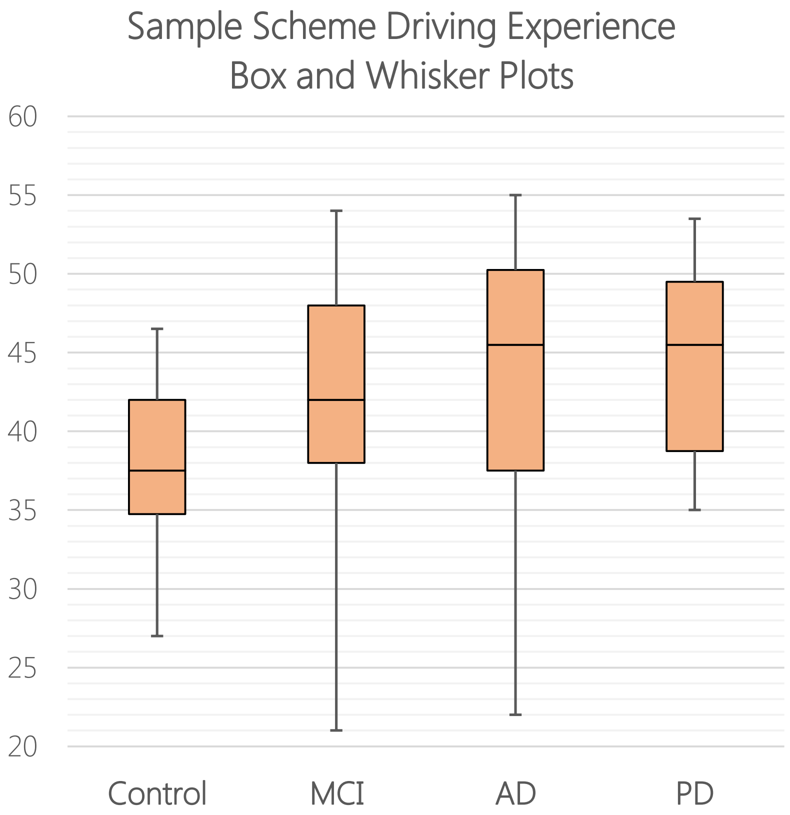
"Driving at the simulator" Older Participants

153 old (>55)

32 Controls, 49 MCI, 27 AD, 20 PD, 25 Other
115 Males, 38 Females



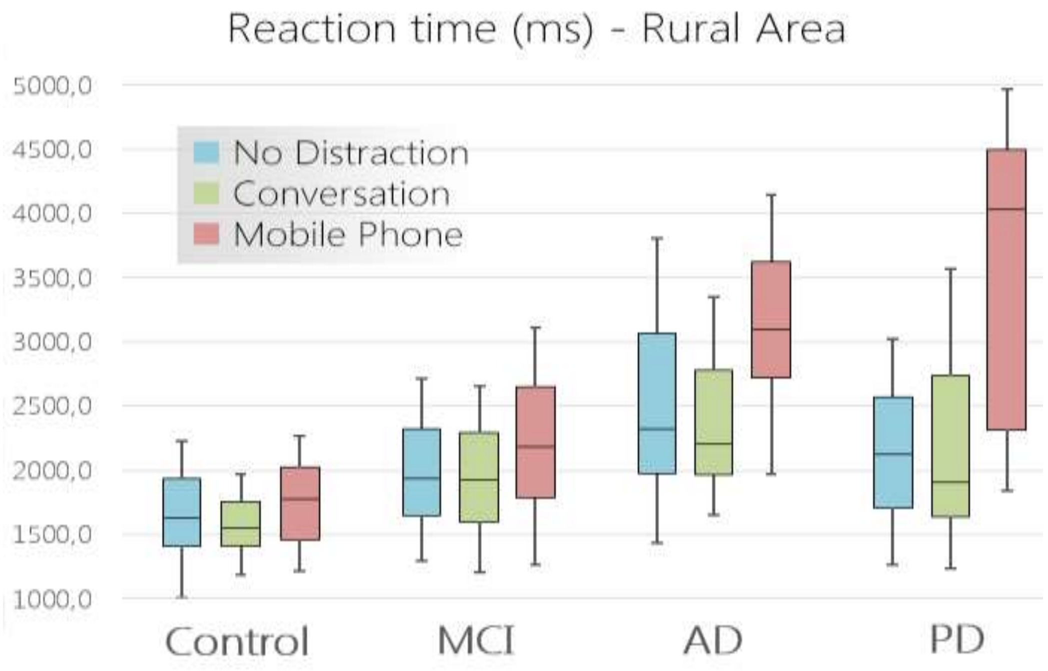


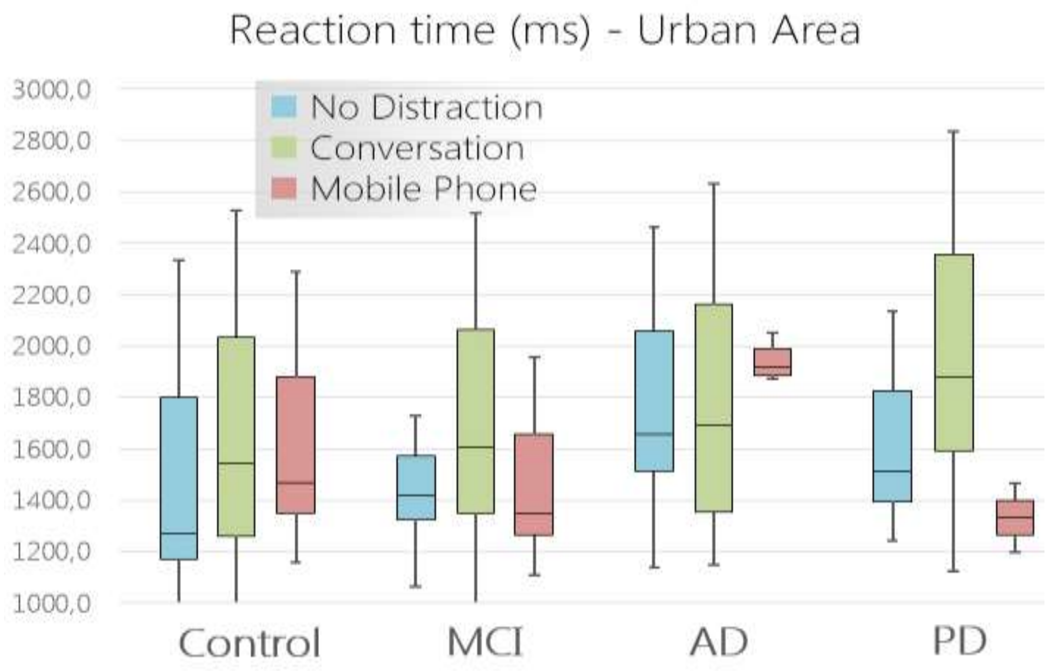


Dataset in numbers

316	participants in total
800	hours of neurological/neuropsychological tests
200	hours of driving at the simulator
2.500	trials driven in the simulator
6.000.000	bytes of “row” data
13.000.000	rows in the database
635	variables (driving simulator + questionnaire + neurological/neuropsychological)

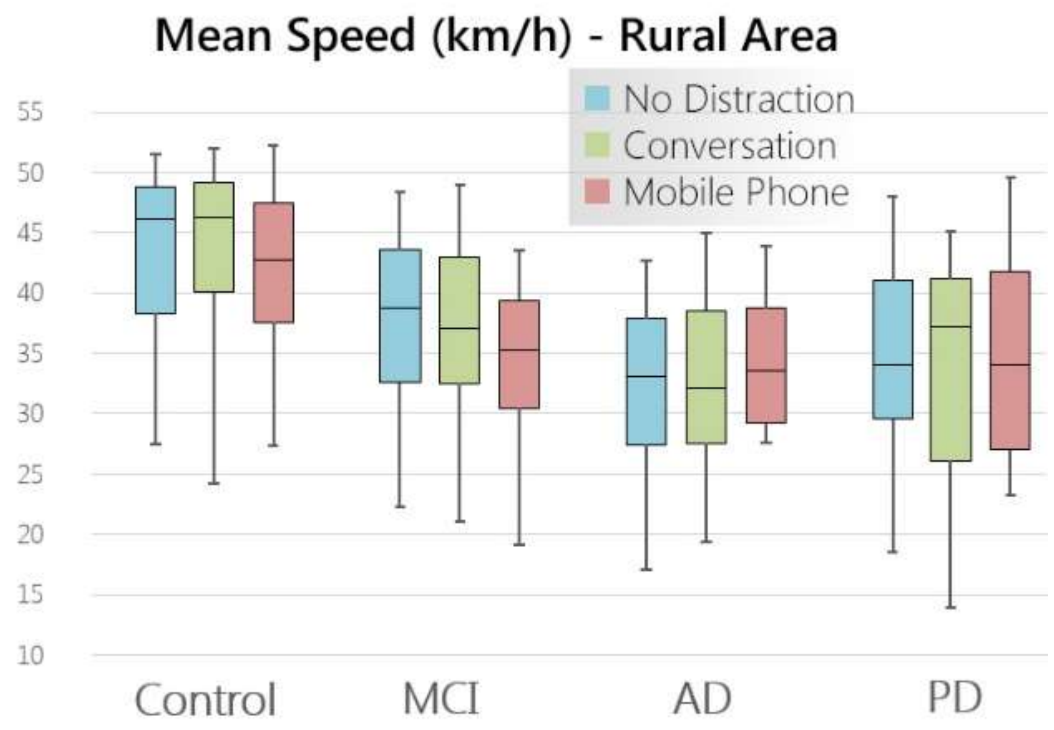
Basic Results - Reaction time

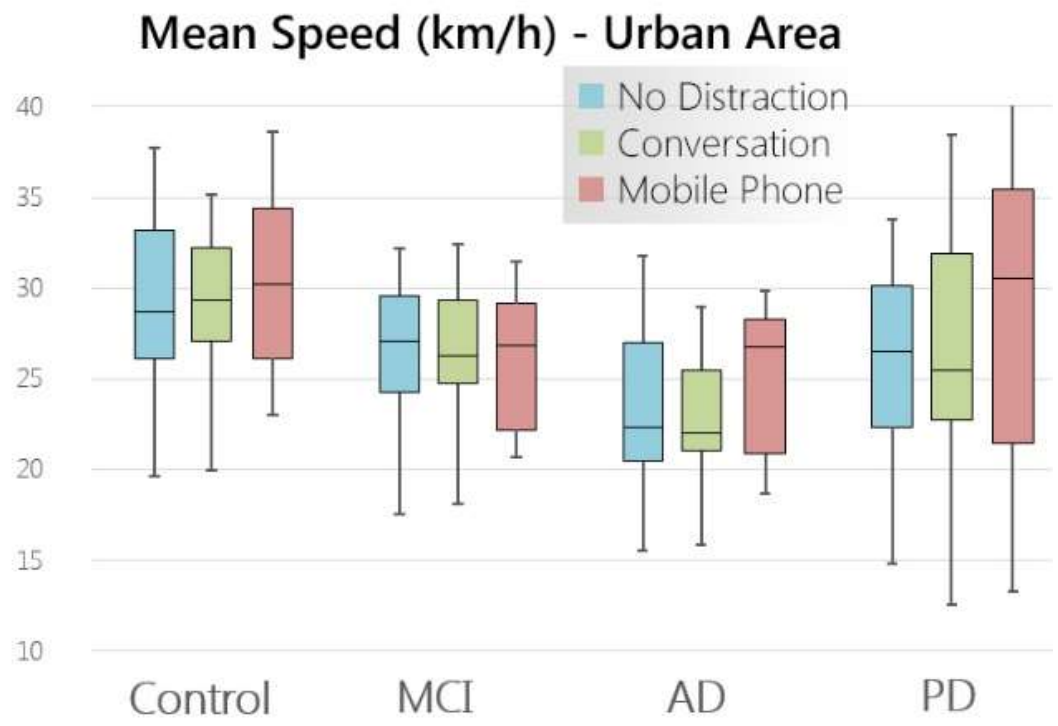




- In rural area AD and PD groups had the worst reaction times (more than 40% worse reaction times than the control group)
- Mobile phone use seemed to have a significant effect on reaction time for AD and especially PD groups
- AD and PD sample in mobile phone use in urban areas was very small, thus 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

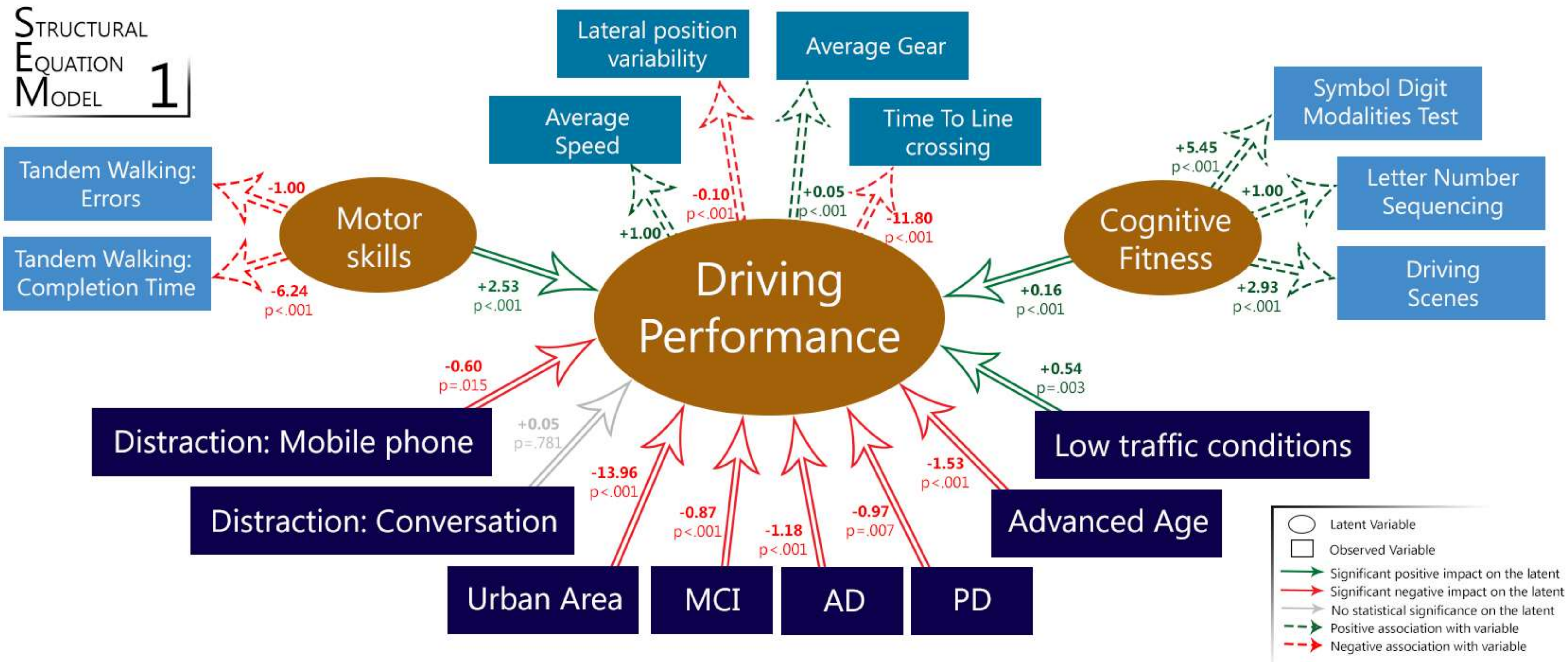
Basic Results - Mean speed



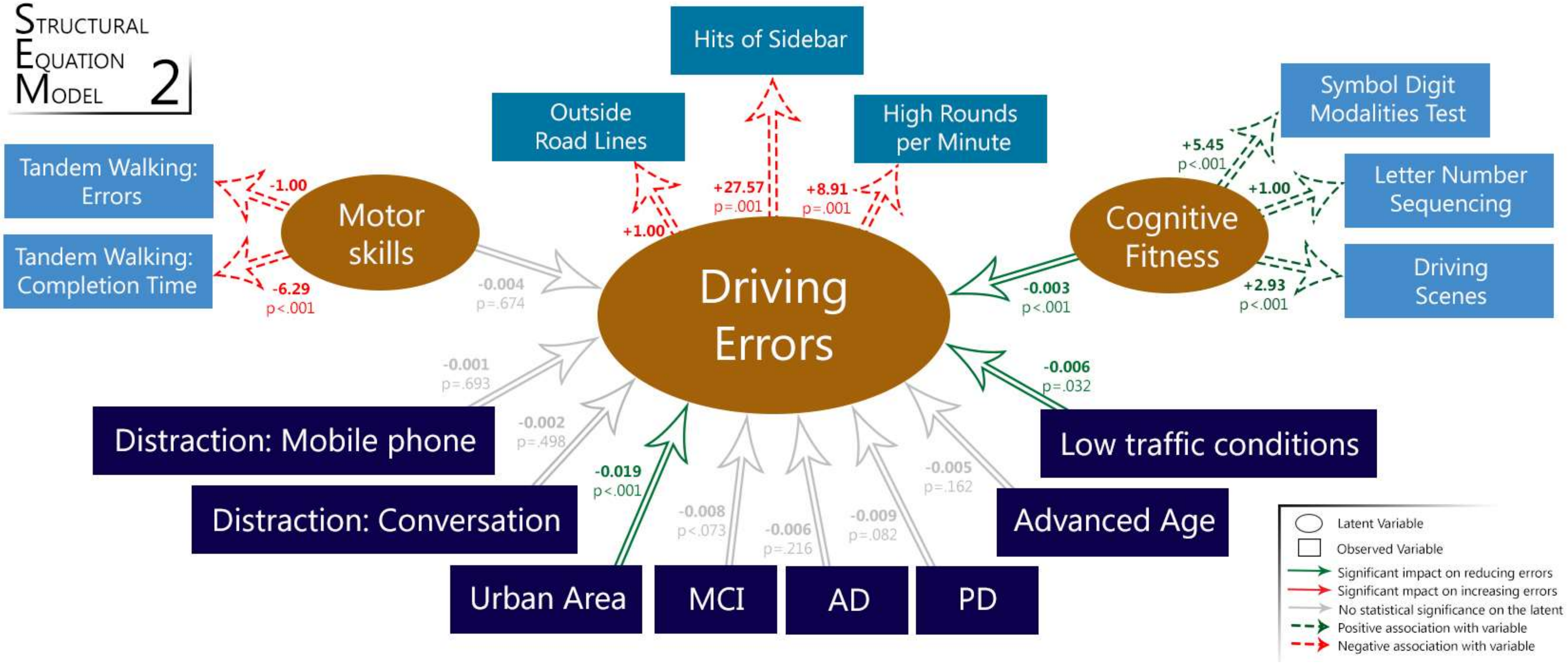


- Conversing with passenger appears to have no significant effect on speed in all examined groups
- Mobile phone use leads to increased speed for the AD group in urban area

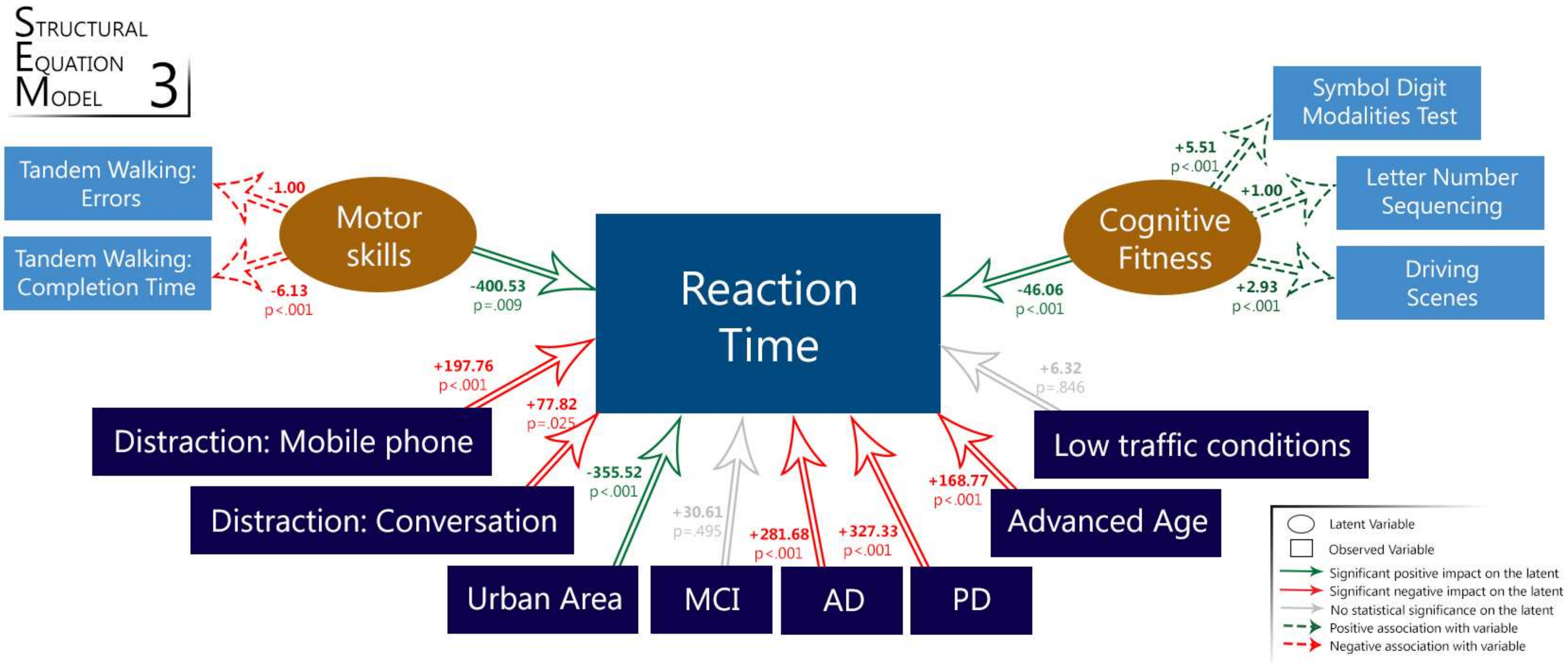
Structural Equation Models - Driving performance



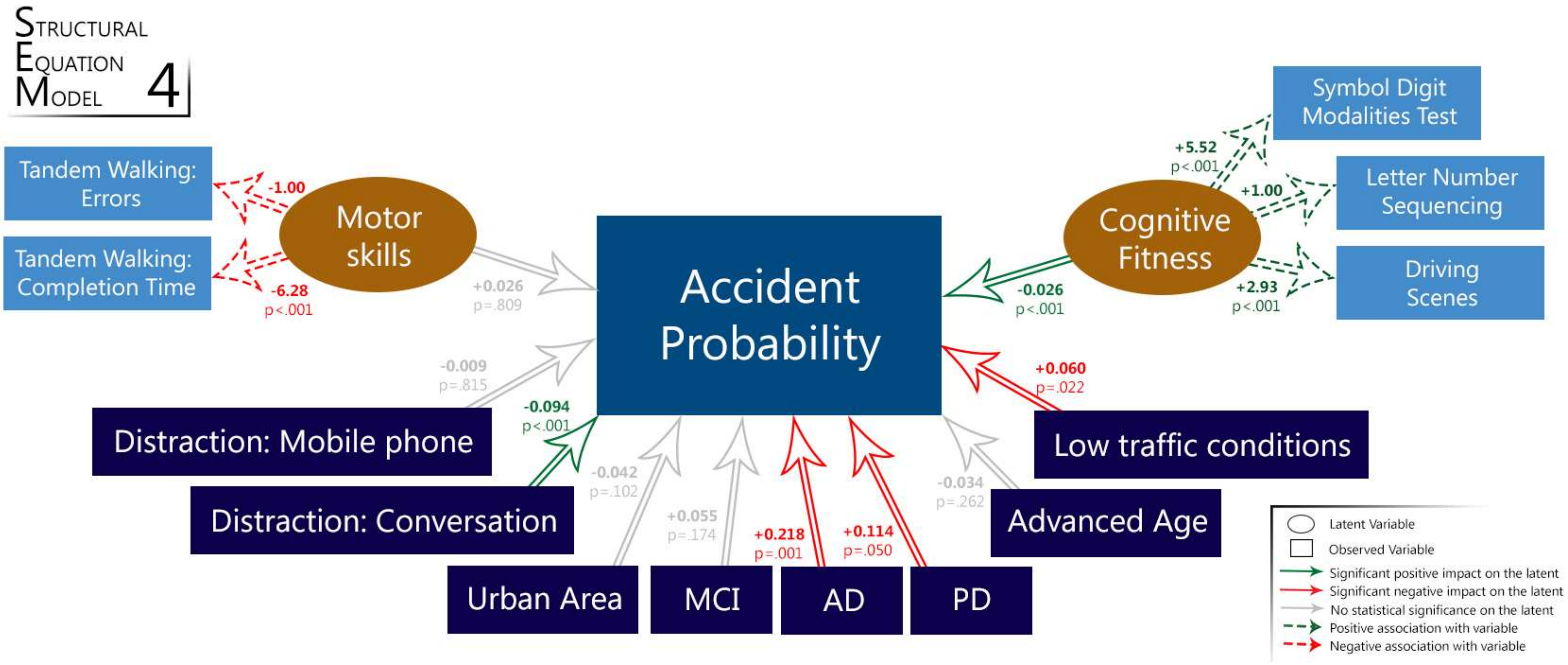
Structural Equation Models - Driving errors



Structural Equation Models - Reaction time



Structural Equation Models - Accident probability



Discussion - Cerebral diseases 1/2

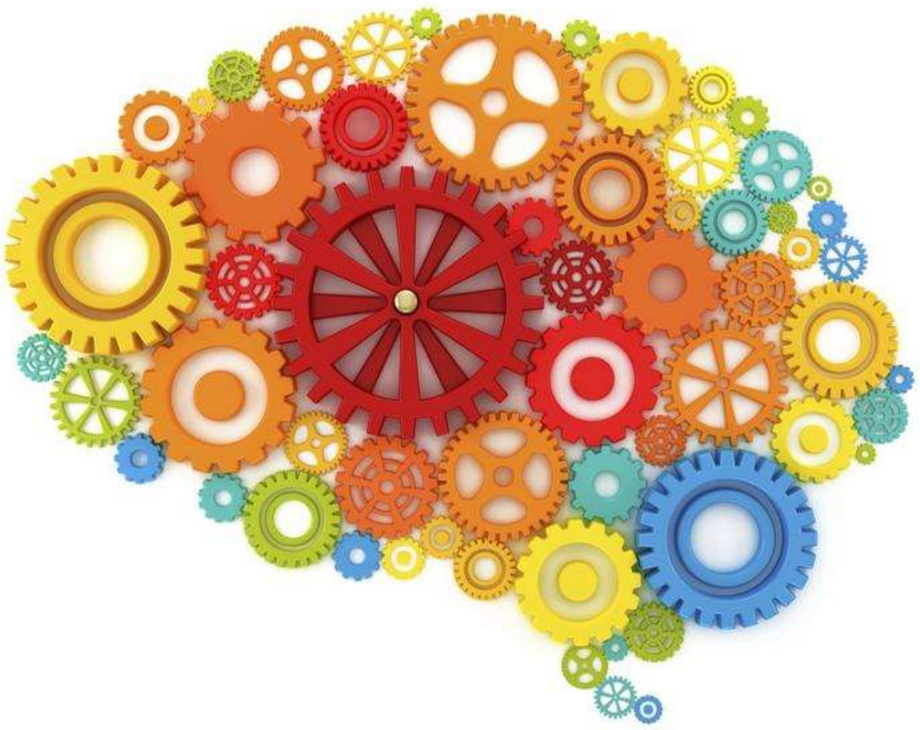
- Drivers with MCI, AD or PD were associated with significantly lower levels of the latent variable "driving performance" that reflected a broad range of driving indexes
- AD and PD were associated with a negative impact on reaction time and accident risk (not MCI)
- None of the clinical groups showed a significantly increased amount of driving errors
- The findings about the AD and the PD patients were in the expected direction and are in line with previous research, that indicates impairments in driving performance of the two clinical groups both in the case of driving simulator experiments and on-road evaluations

Discussion - Cerebral diseases 2/2

- The present analysis by utilizing latent variables that assess a broad range of driving indexes, indicates that patients with MCI had a significantly altered driving performance as compared to healthy controls
- Nonetheless, the parameter that renders originality to the present study is the development of latent variables for the evaluation of driving behavior that encompasses a variety of driving indexes
- Another novel element is the application of multivariate SEM models that make feasible the exploration of the unique impact of cerebral diseases on driving behavior.

Discussion - Cognitive fitness / motor skills

- "Cognitive fitness" had a significant positive effect on all outcome variables, namely, "driving performance", "driving errors", reaction time and accident risk
- The current analysis by applying the SEM methodology indicates the importance of cognitive fitness as a predictor of driving competence
- "Motor skills" had a significant positive effect on "driving performance" and reaction time, but not on "driving errors" and accident risk
- "Motor skills" appear to influence driving behaviour, but not at the same extent as "cognitive fitness" that reflects the level of functioning on cognitive domains, such as working memory, information processing speed, and visual attention

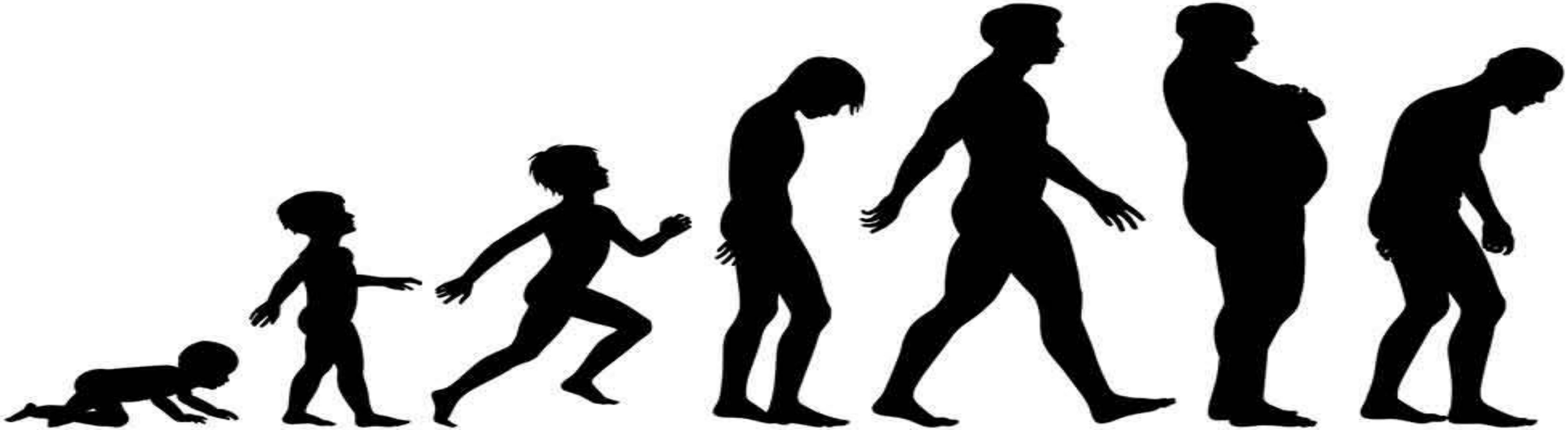


Discussion - Driver distraction

- Conversation with the passenger was not found to have a critical impact on driving indexes, indicating that drivers don't alter their driving behaviour in an important way under this type of distraction.
- Mobile phone use had a significant negative effect on all outcome variables, namely, "driving performance", "driving errors", reaction time and accident risk.
- The negative effect of cell phone on driving behavior can be probably explained by the accumulating role of two synergistic mechanisms.
    - Firstly, due to the amount of physical and cognitive resources that drivers allocate for performing the distraction task.
    - Secondly, by adopting a compensatory behaviour that however only partially counterbalances the impact of distraction on overall driving behavior.

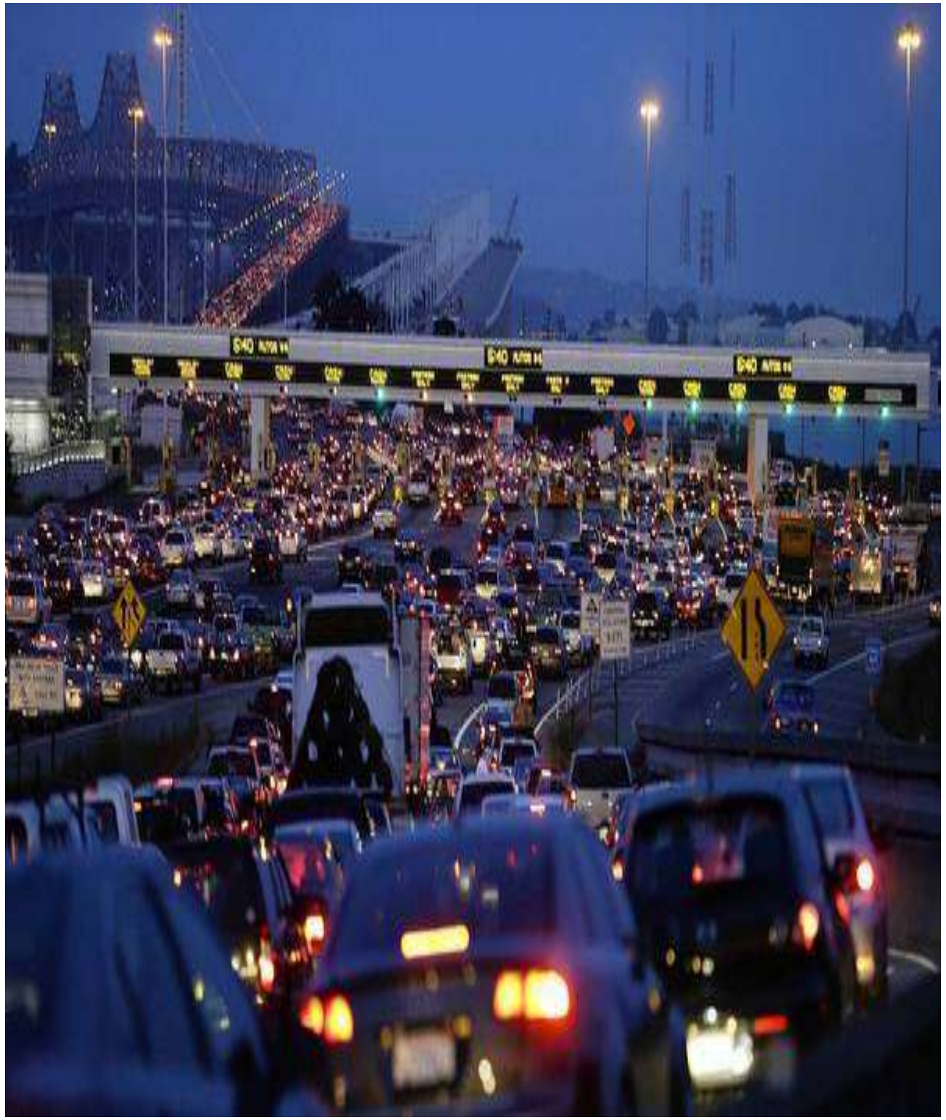
Discussion - Age

- Advanced age had a significant negative impact on "driving performance" and reaction time, whereas, its impact on "driving errors" and accident risk was not statistically significant
- As indicated by the significant main effect that was observed in the two SEM models, the role of advanced age on driving behavior appears to generalize as well on the control group of our study that included cognitively intact individuals



Discussion - Area and traffic characteristics

- Urban area had a significant negative impact on “driving performance”, whereas its impact on “driving errors” and reaction time was positive
- Low traffic conditions affected positively the “driving performance” and the “driving errors”, whereas it hadn’t any significant impact on reaction time. On the other hand, accident risk was significantly higher in low traffic condition
- A possible explanation of the counter intuitive finding about the increased accident risk under the low traffic condition could be that under the specific condition the drivers were less alert to react and avoid the crash on the occurrence of an unexpected incident



Future steps

- Exploration of the predictive capacity of the aforementioned predictors under on-road driving conditions

- Development of multimodal models aiming at predicting driving behavior separately for various age groups

- Development of multimodal models aiming at predicting driving behavior separately for the various clinical conditions

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