Risk factors, driver behaviour and accident probability. The case of distracted driving.

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Objective

The analysis of the effect of road, traffic and driver risk factors on driver behaviour and accident probability at unexpected incidents, with particular focus on distracted driving

The development of risky driver profiles and road characteristics leading to increased possibility of driver error
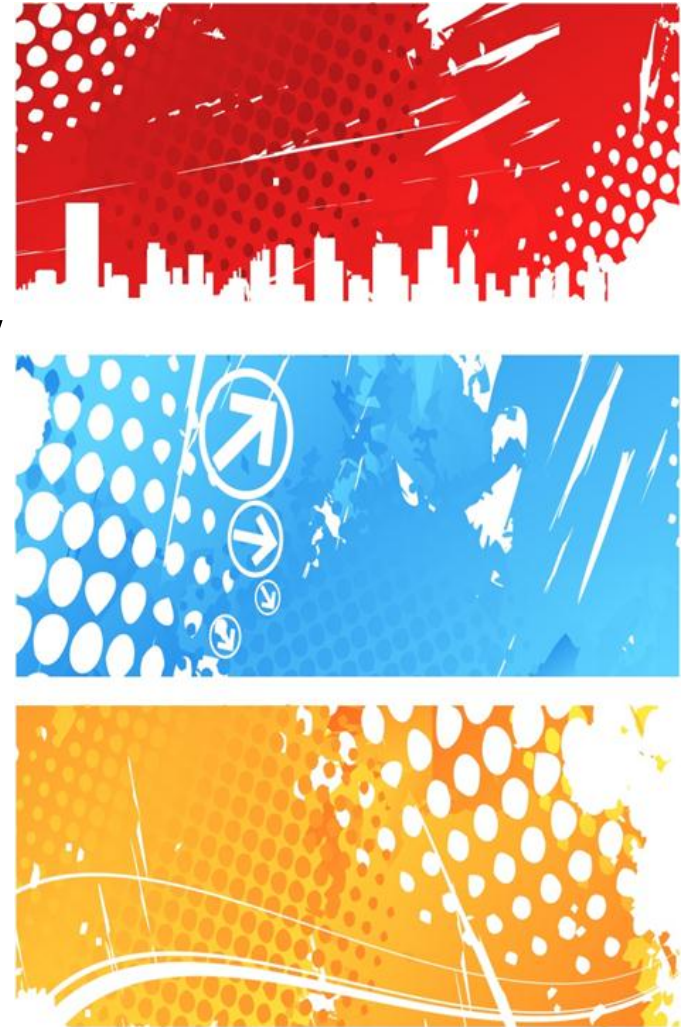
Methodological steps

- Literature review

- Methodological review

- Research questions

- Driving simulator experiment

- Statistical analysis

- Methodological contributions

- Key research findings

- Further research

Literature review

Several literature reviews were implemented in the following research topics:

Driver behaviour and road safety

↓

Driver distraction

↓

Types of assessing driver distraction

↓

Driving simulator characteristics

↓

Driving simulator studies on driver distraction

Methodological review

Two targeted literature reviews took place in order to investigate:

- key **driving performance parameters**
  - A lot of different methods and **measures** exist for evaluating driving performance

- **statistical analyses** implemented
  - In more than half of the examined studies the main statistical analysis is **repeated measures Anova**

- Latent model analysis and especially **structural equation models** have never been implemented in the field of driver distraction.

Research questions

1. **Design and implementation** of a simulator experiment aiming to deal with the basic limitations found in the literature:
   - Large and representative sample
   - Randomisation of trials
   - Adequate practice drive
   - Investigation of an optimum number of driving factors

2. Need to demonstrate a composite driving performance measure in order to examine driver distraction as a **multidimensional phenomenon**

3. Development and application of an **innovative statistical analysis methodology**

4. Estimation of the **combined effect** of distraction sources, driver as well as road and traffic environment characteristics directly on driving performance.

Driving simulator experiment (1/2)

A common simulator experiment in the framework of two research projects:

- **Distract** - Analysis of causes and impacts of driver distraction

- **DriverBrain** - Analysis of the performance of drivers with cerebral diseases

An **interdisciplinary** research team:

- Dpt. of Transportation Planning and Engineering NTUA
- Dpt. of Neurology of the University of Athens Medical School, UoA
- Dpt. of Psychology, School of Philosophy, Pedagogy and Psychology, UoA

distrACT
driverBRAIN

Department of Transportation Planning and Engineering, NTUA

Department of Neurology, Psychiatry and Social Medicine, UoA
Department of Psychology, UoA

#SaveKidsLives
with road safety

Driving simulator characteristics

- Foerst Driving Simulator FPF
- 3 LCD wide screens 40"
- total angle view 170°
- driving position and support base

Driving criteria

- Have a valid driving license
- Had driven for more than 3 years
- Had driven more than 2500km during the last year
- Had driven at least once a week during the last year
- Had driven at least 10km/week during the last year

The design of the driving scenarios is a central component of the present PhD thesis and includes:

Area type

- Rural area
  2,1 km long, single carriageway and the lane width was 3m, with zero gradient and mild horizontal curves
- Urban area
  1,7km long, lane width 3,5m, separated by guardrails

Distraction conditions

- No distraction
- Cell phone use
- Conversation with the passenger

Rural Road
2,1 km
Start
Finish

Urban Road
1.7 km
Finish
Start
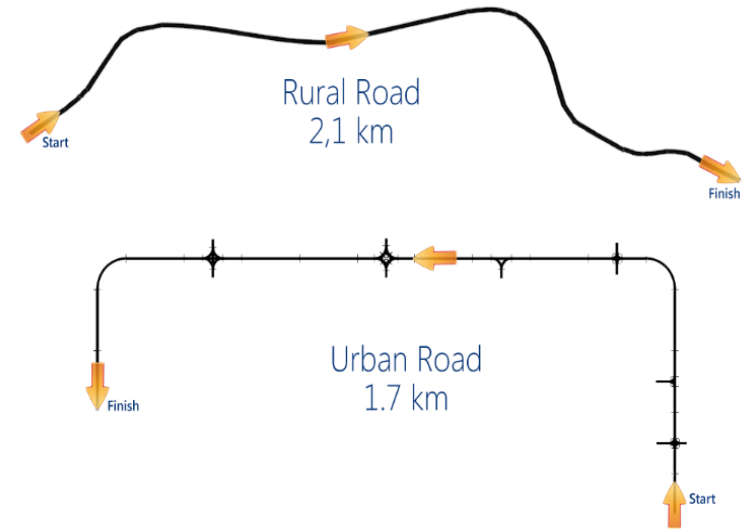
	Urban area		Rural area	
	Q_L	Q_H	Q_L	Q_H
No distraction	√	√	√	√
Cell phone use	√	√	√	√
Conversation with the passenger	√	√	√	√

Traffic scenarios

- Low traffic
  Q_L=300 vehicles/hour
- High traffic
  Q_H=600 vehicles/hour

Unexpected incidents

- Child crossing the road
- Sudden appearance of an animal

Randomisation

- The purpose of randomisation is to remove bias and other sources of extraneous variation, which are not controllable

Familiarisation

During the **familiarization** with the simulator, the participant practiced in:
- handling the simulator (starting, gears, wheel handling etc.)
- keeping the lateral position of the vehicle
- keeping stable speed, appropriate for the road environment
- Braking and immobilization of the vehicle

During this practice drive, two **unexpected incidents** took place.

The following criteria must be verified (there is **no time restriction**) before the participant moves on to the next phase of the experiment:

Questionnaires

Driving behaviour questionnaire
- Driving experience - car use
- Self -assessment of the older driver
- Distraction-related driving habits
- Emotions and behaviour of the driver
- Anger expression inventory during driving
- History of accidents, near misses, and traffic violations

Self-Assessment and memory questionnaire
- Memory
- Self assessment
- Driving skills

distrACT
driverBRAIN

Τομέας Μεταφορών
και Συγκοινωνιακής
Υποδομής, ΕΜΠ

Τομέας Νευρολογίας Ψυχιατρικής
και Κοινωνικής Ιατρικής, ΕΚΠΑ
Τομέας Ψυχολογίας, ΕΚΠΑ

Ερωτηματολόγιο Συμπεριφοράς Οδηγού

Το ερωτηματολόγιο το συμπληρώνει ο_____
(οι ερωτήσεις αφορούν τον εαυτό του)

Κωδικός Συμμετέχοντα:

Ονοματεπώνυμο Συμμετέχοντα:

Ημερομηνία πειράματος:

Ηλικία:

Φύλο (κυκλώστε):   Άντρας (1)   Γυναίκα (2)

Α. ΟΔΗΓΙΚΗ ΕΜΠΕΙΡΙΑ - ΜΕΤΑΚΙΝΗΣΕΙΣ

1. Πόσα χρόνια οδηγείτε;

2. Σας αρέσει η οδήγηση (κυκλώστε);   Ναι (1)   Όχι (2)

3. Πότε αποκτήσατε την άδεια οδήγησής σας;

4. Πότε λήγει η άδεια οδήγησής σας;

5. Είσαστε ή ήσασταν επαγγελματίας οδηγός (κυκλώστε);   Ναι (1)   Όχι (2)

6. Πόσες ημέρες την εβδομάδα χρησιμοποιείτε το αυτοκίνητό σας (κυκλώστε);   1 2 3 4 5 6 7

7. Πόσα χιλιόμετρα περίπου οδηγείτε την εβδομάδα (κυκλώστε);   <20 20-50 50-100 100-150 150+ Δεν ξέρω

8. Πόσες διαδρομές πραγματοποιείτε την ημέρα ως οδηγός (κυκλώστε);   1 2 3 4 5+

9. Υποδείξτε το μέσο μήκος των διαδρομών σας σε χιλιόμετρα (κυκλώστε);   1-2 3-5 6-9 10-15 16-29 30+ Δεν ξέρω

10. Σε σχέση με πέντε χρόνια πριν η οδήγησή σας (κυκλώστε);   Έχει περιορισθεί (1)   Είναι η ίδια (2)   Έχει αυξηθεί (3)   Δεν ξέρω (4)

Sample characteristics

The sample of the analysis consists of **95 participants**

- 28 young drivers aged 18-34 years old

- 31 middle aged drivers aged 35-54 years old

- 36 older driver aged 55-75 years old
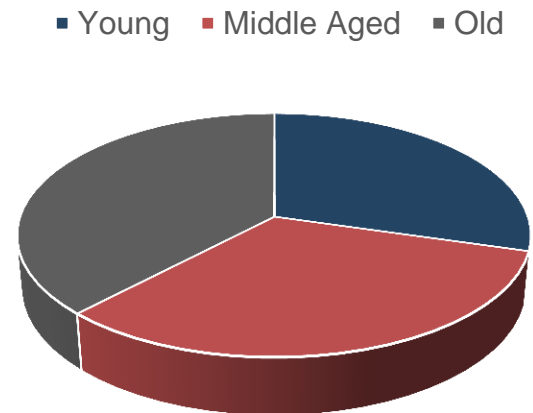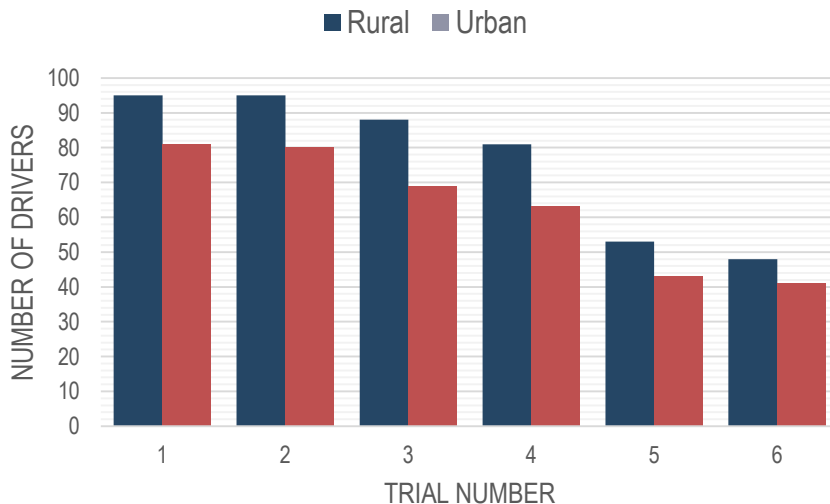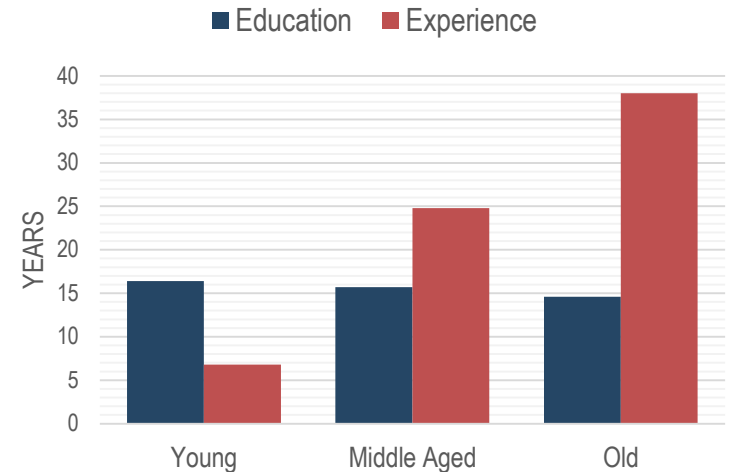
Statistical analysis methodology

Data collected from the driving simulator experiment and the respective questionnaires are analysed by means of a **dedicated statistical analysis method**:

1. **Descriptive analysis**
   (correlation table, boxplots)

2. **Regression analysis**
   (6 general linear mixed models)

3. **Factor Analysis**
   (2 factor analysis)

4. **Latent analysis**
   (4 structural equation models)

|	Variable	Explanation
1	Time	current real-time in milliseconds since start of the drive.
2	x-pos	x-position of the vehicle in m.
3	y-pos	y-position of the vehicle in m.
4	z-pos	z-position of the vehicle in m.
5	road	road number of the vehicle in [int].
6	richt	direction of the vehicle on the road in [BOOL] (0/1).
7	rdist	distance of the vehicle from the beginning of the drive in m.
8	rspur	track of the vehicle from the middle of the road in m.
9	ralpha	direction of the vehicle compared to the road direction in degrees.
10	Dist	driven course in meters since begin of the drive.
11	Speed	actual speed in km/h.
12	Brk	brake pedal position in percent.
13	Acc	gas pedal position in percent.
14	Clutch	clutch pedal position in percent.
15	Gear	chosen gear (0 = idle, 6 = reverse).
16	RPM	motor revolution in 1/min.
17	HWay	headway, distance to the ahead driving vehicle in m.
18	DLeft	distance to the left road board in meter.
19	DRight	distance to the right road board in meter.
20	Wheel	steering wheel position in degrees.
21	THead	time to headway, i. e. to collision with the ahead driving vehicle, in seconds.
22	TTL	time to line crossing, time until the road border line is exceeded, in seconds.
23	TTC	time to collision (all obstacles), in seconds.
24	AccLat	acceleration lateral, in m/s^2
25	AccLon	acceleration longitudinal, in m/s^2
26	EvVis	event-visible-flag/event-indication, 0 = no event, 1 = event.
27	EvDist	event-distance in m.
28	ErrINo	number of the most important driving failure since the last data set
29	ErrlVal	state date belonging to the failure, content varies according to type of failure.
30	Err2No	number of the next driving failure (maybe empty).
31	Err2Val	additional date to failure 2.
32	Err3No	number of a further driving failure (maybe empty).
33	Err3Val	additional date to failure 3.

Descriptive analysis

- **Database** development
  - Type of variable
  - Min, max, average value

- Several **boxplots** were developed in order to explain the effect of specific driver, road and traffic parameters as well as the examined distraction sources on selected driving performance measures

- A **correlation table** is investigating any of a broad class of statistical relationships between driving simulator variables
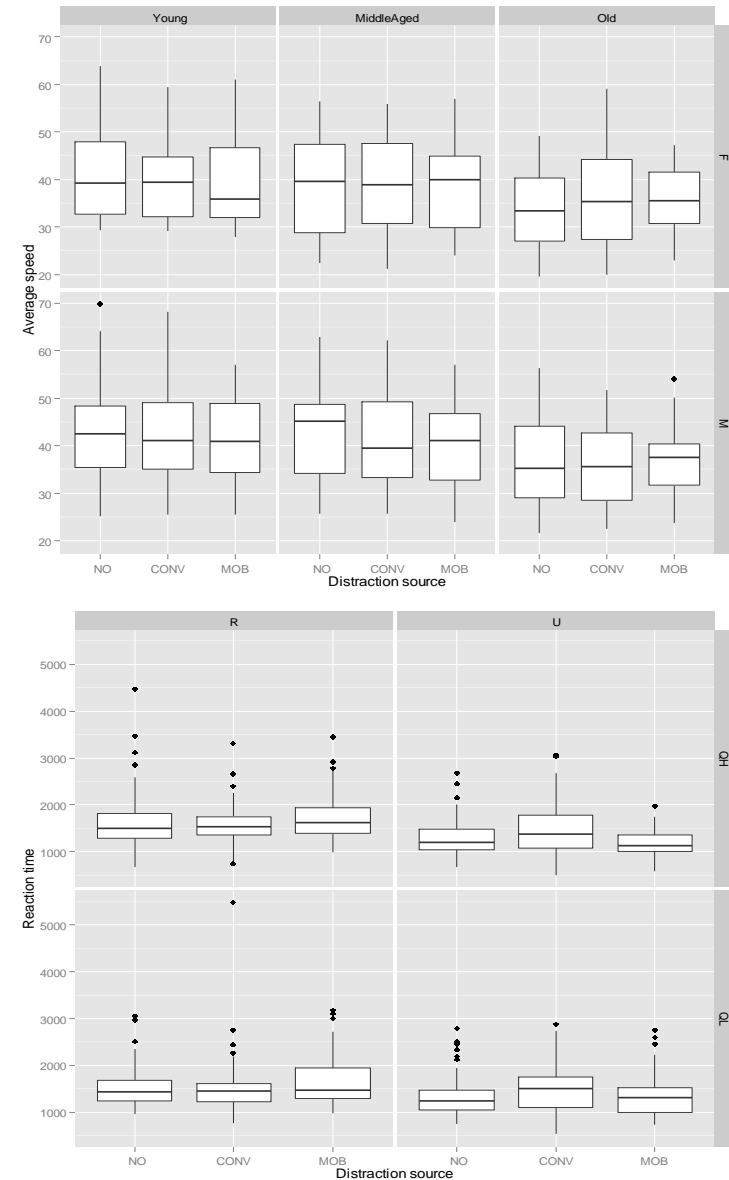
Regression analysis

- Within the framework of regression analysis, **6 general linear mixed models** are developed in order to identify several sets of explanatory variables that covary with specific driving performance measures of the driving simulator dataset.

- Average speed

- Reaction time

- Lateral position

- Average headway

- Speed variability

- Lateral position variability
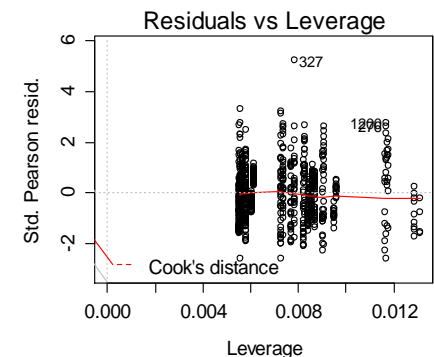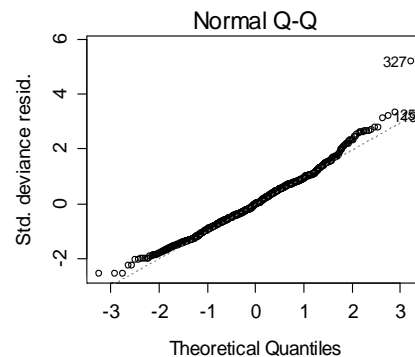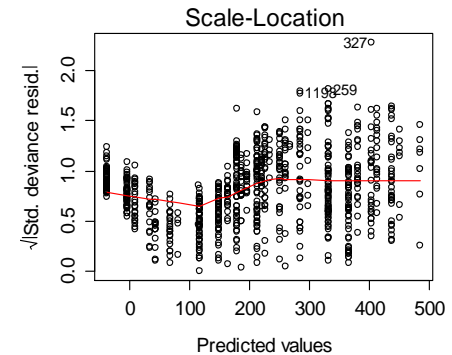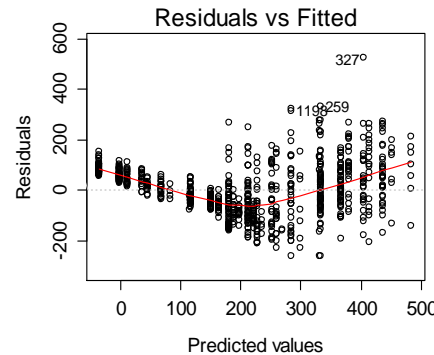
Factor analysis

- Two factor analysis are developed in order to investigate which observed variables are most highly correlated with the common factors of **driving performance** and **driver error** and how many common factors are needed to give an adequate description of the data

- Regarding **driving performance**, 5 factors are best fitted in the specific database. The interpretation of the results revealed that the five factors are: lateral measures, speed measures, vehicle direction measures, headway as well as vehicle revolation

- The variables that tend to explain better the "**Driver Error**" factor are: numbers of Outside Road Lines, Sudden Brakes and High Rounds per Minute
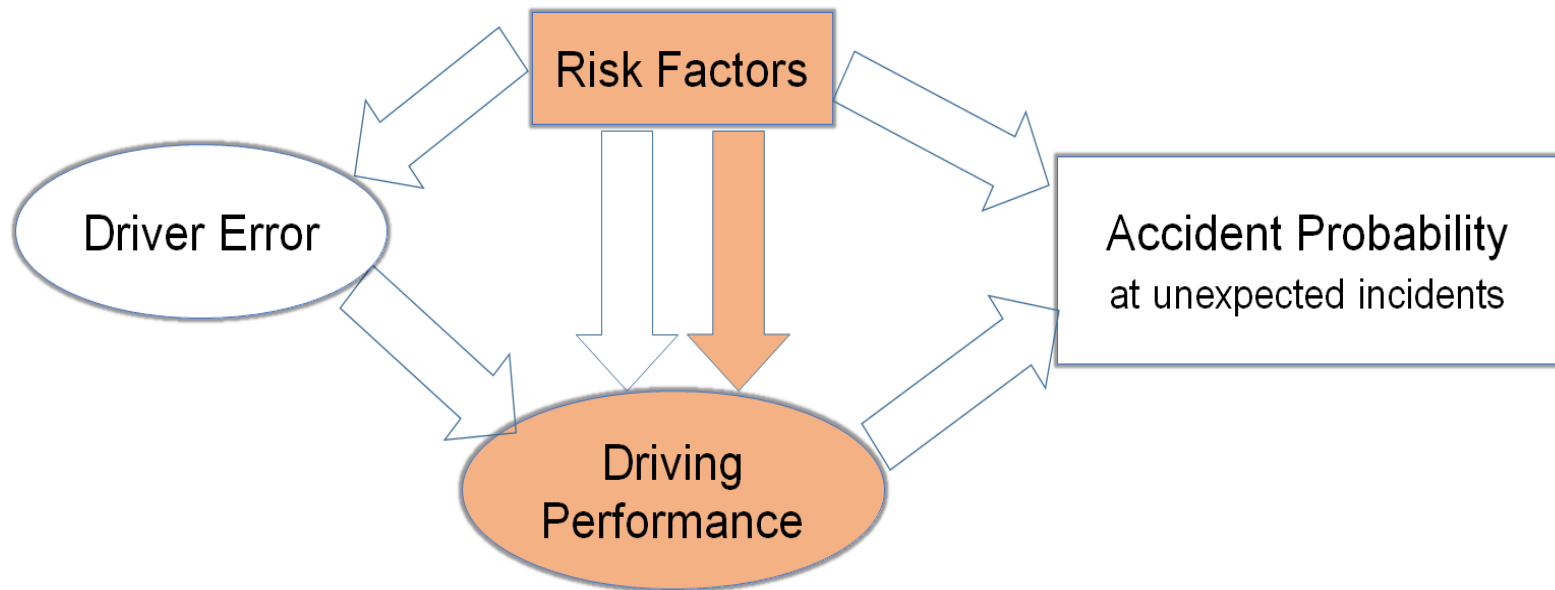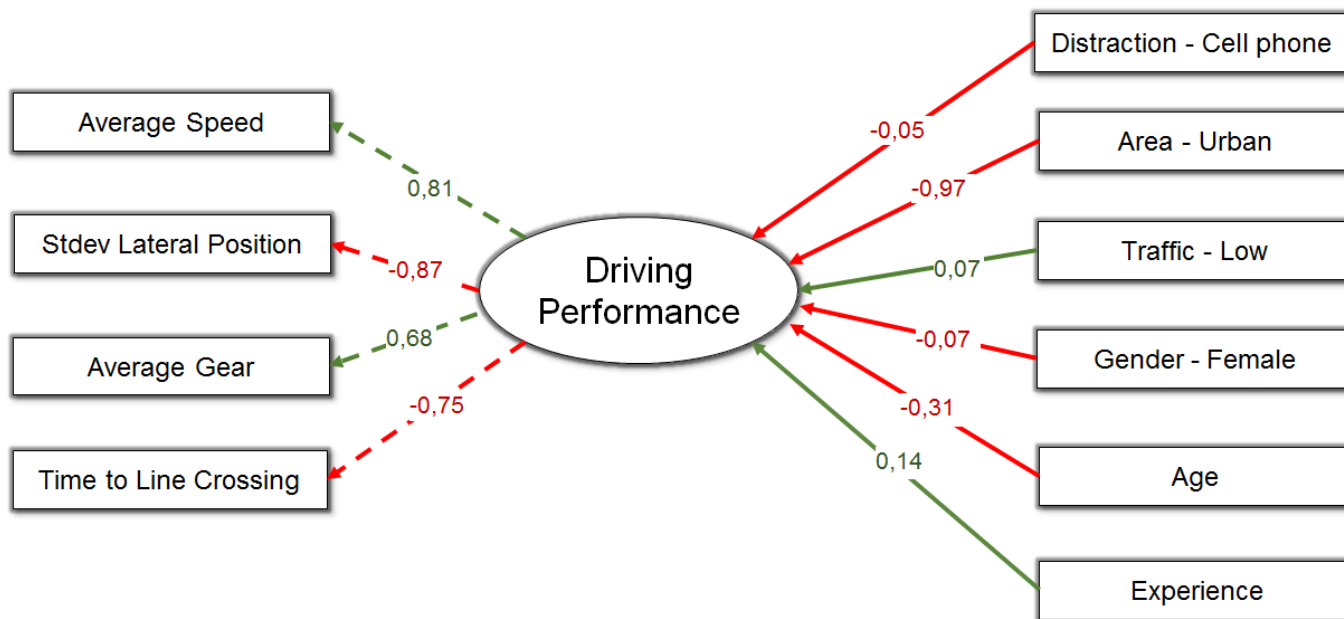
Latent analysis overview
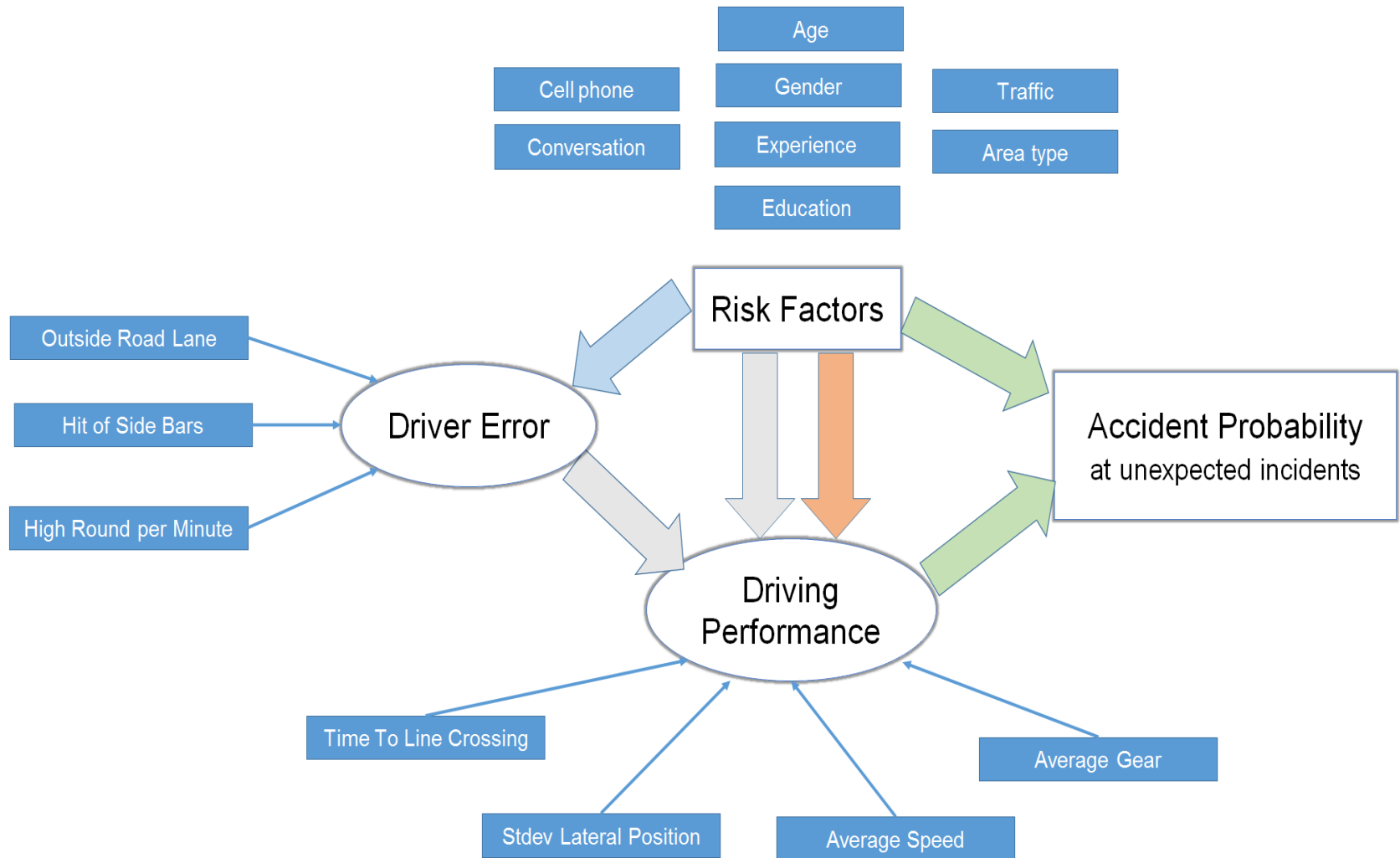
The latent variable reflects the underlying **driving performance** and the objective is the quantification of the impact of distraction, driver characteristics as well as road and traffic environment on driving performance

SEM regarding driving performance (2/2)

- The effect of **cell phone** on driving performance is definitely negative
- **Conversation with the passenger** does not has a statistically significant effect
- Risk factors that affect driving performance include driver characteristics (**age**, **gender**, driving **experience**), **area** type and **traffic conditions**
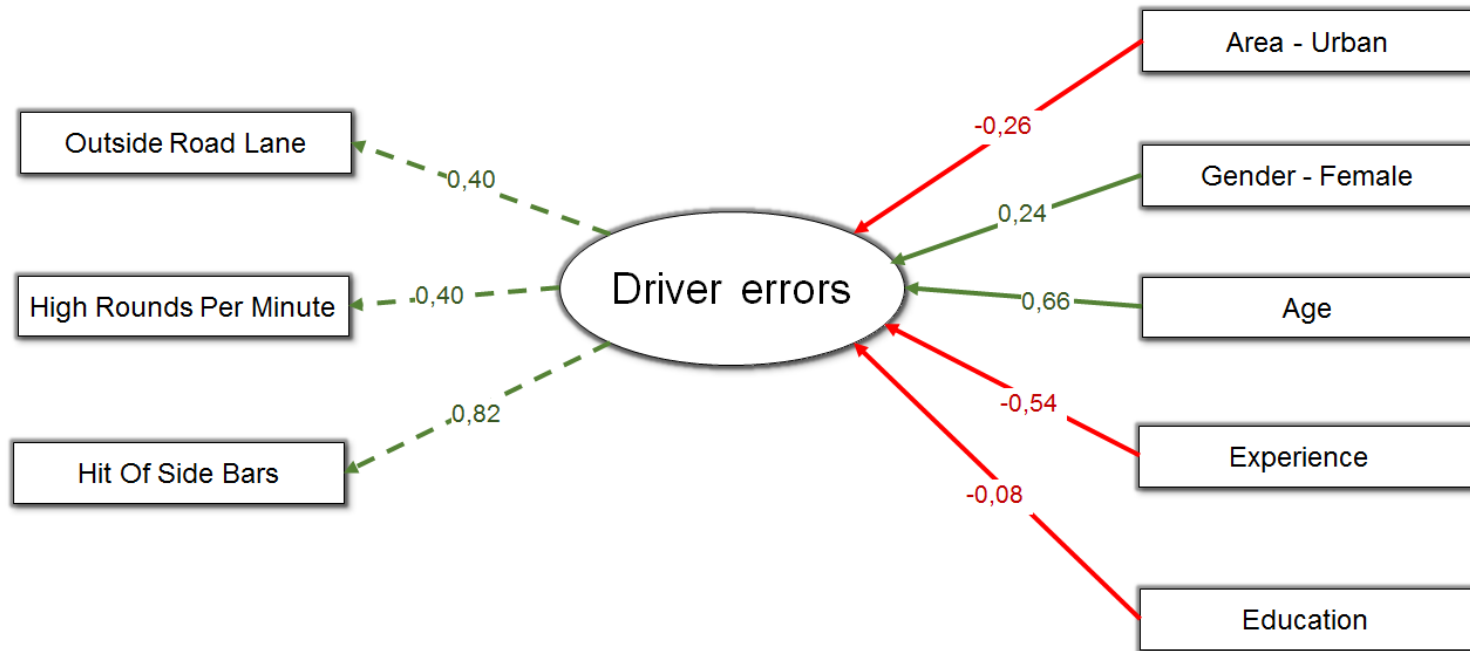
The latent variable reflects the underlying **driver error** and the objective is the quantification of the impact of distraction, driver characteristics as well as road and traffic environment on driving error
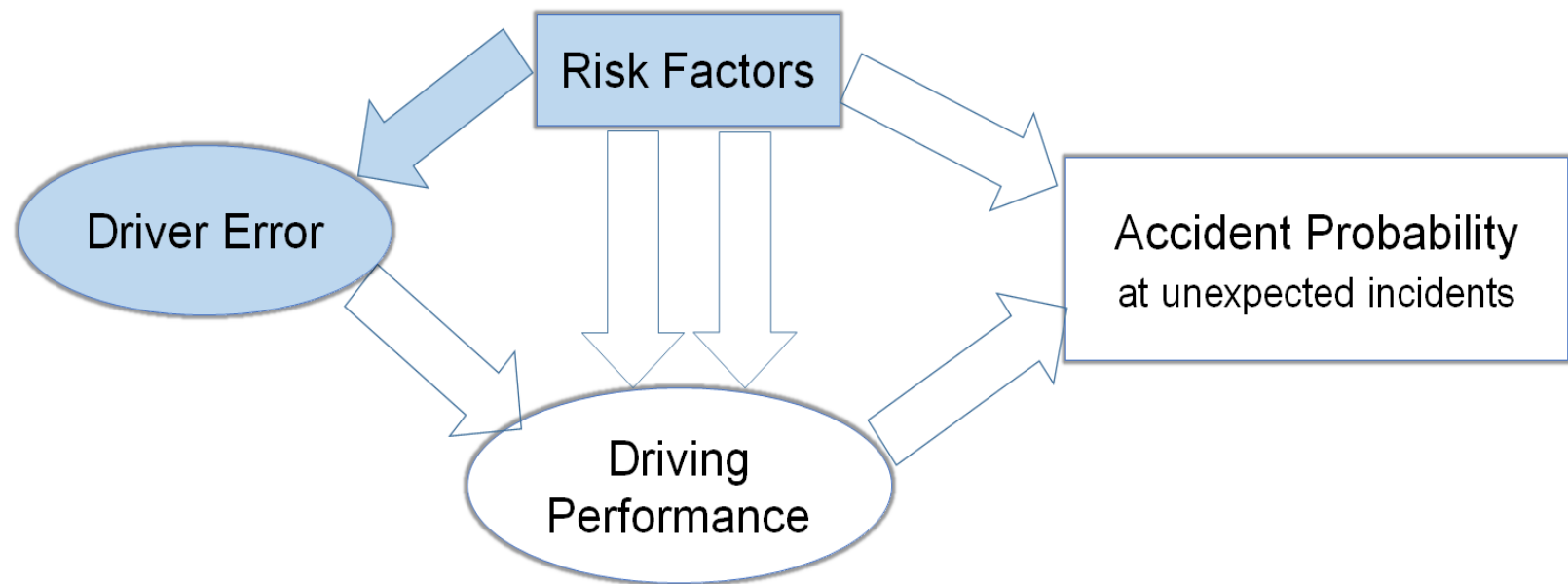
- Neither conversing with a passenger nor talking on the cell phone has a statistical significant impact on driver error
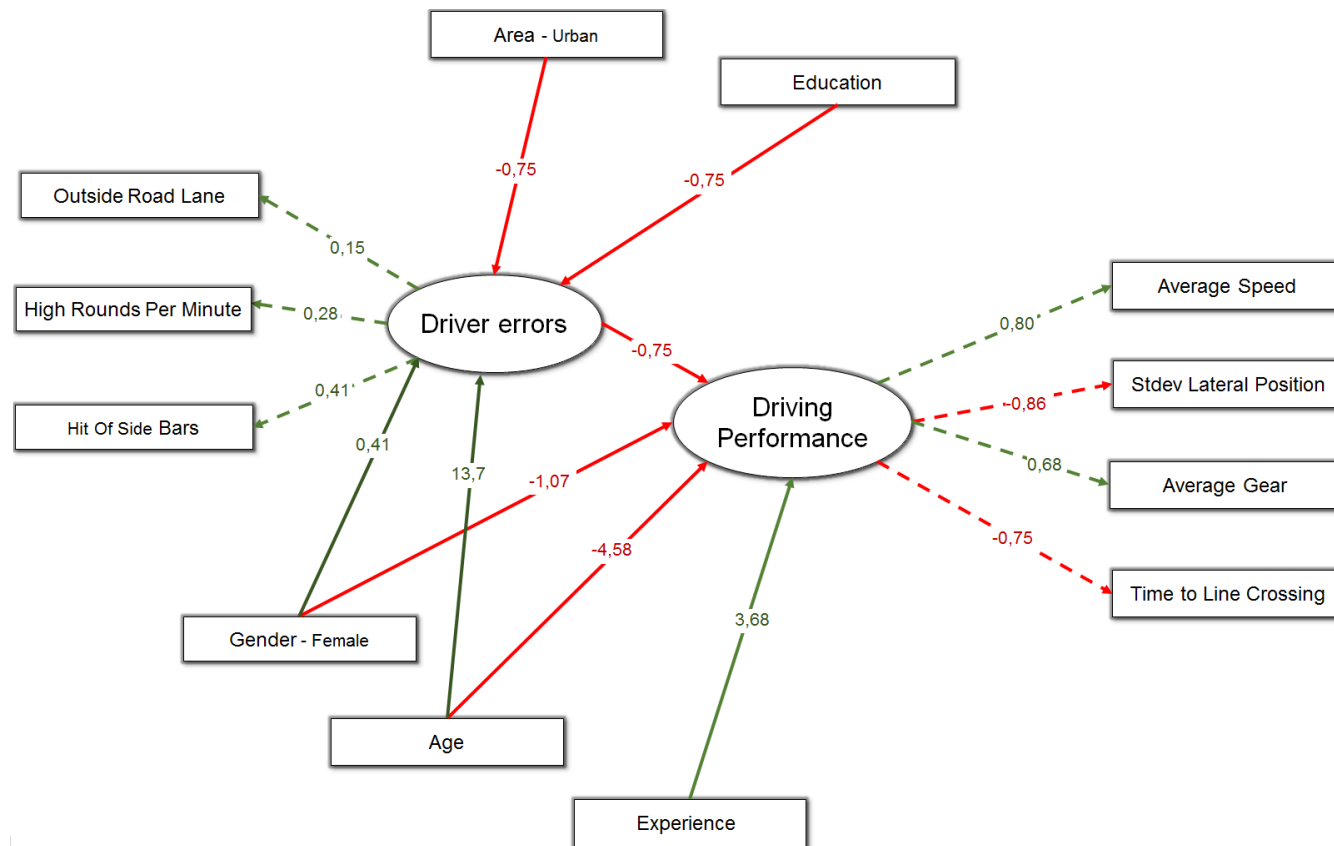- Risk factors that affect driver error include **gender**, **age**, **experience**, **education** and **area type**

Two latent variables are created regarding driving performance and driver error while the objective of this analysis is the quantification of the impact of driving errors, distraction, driver characteristics as well as road and traffic environment on driving performance
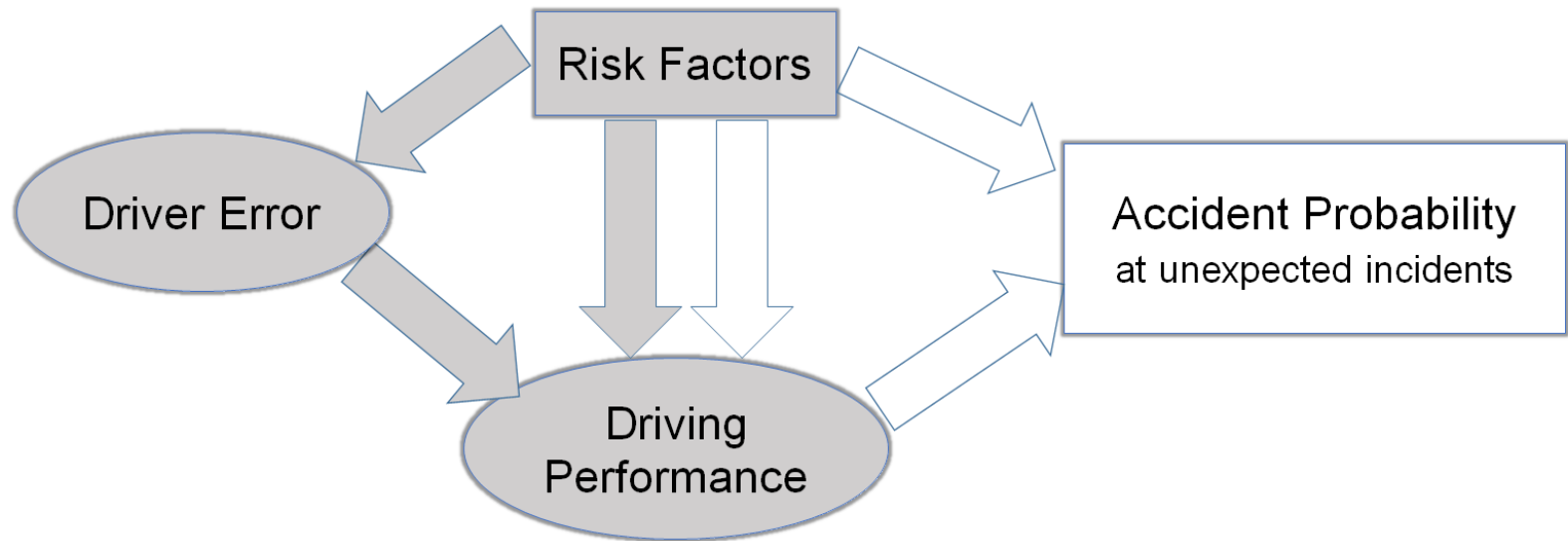
- Driver error is a crucial factor that negatively affects driving performance
- Neither **road characteristics** (area type, traffic conditions) nor the **distraction sources** examined (cell phone use, conversation with a passenger) have a significant impact on this model
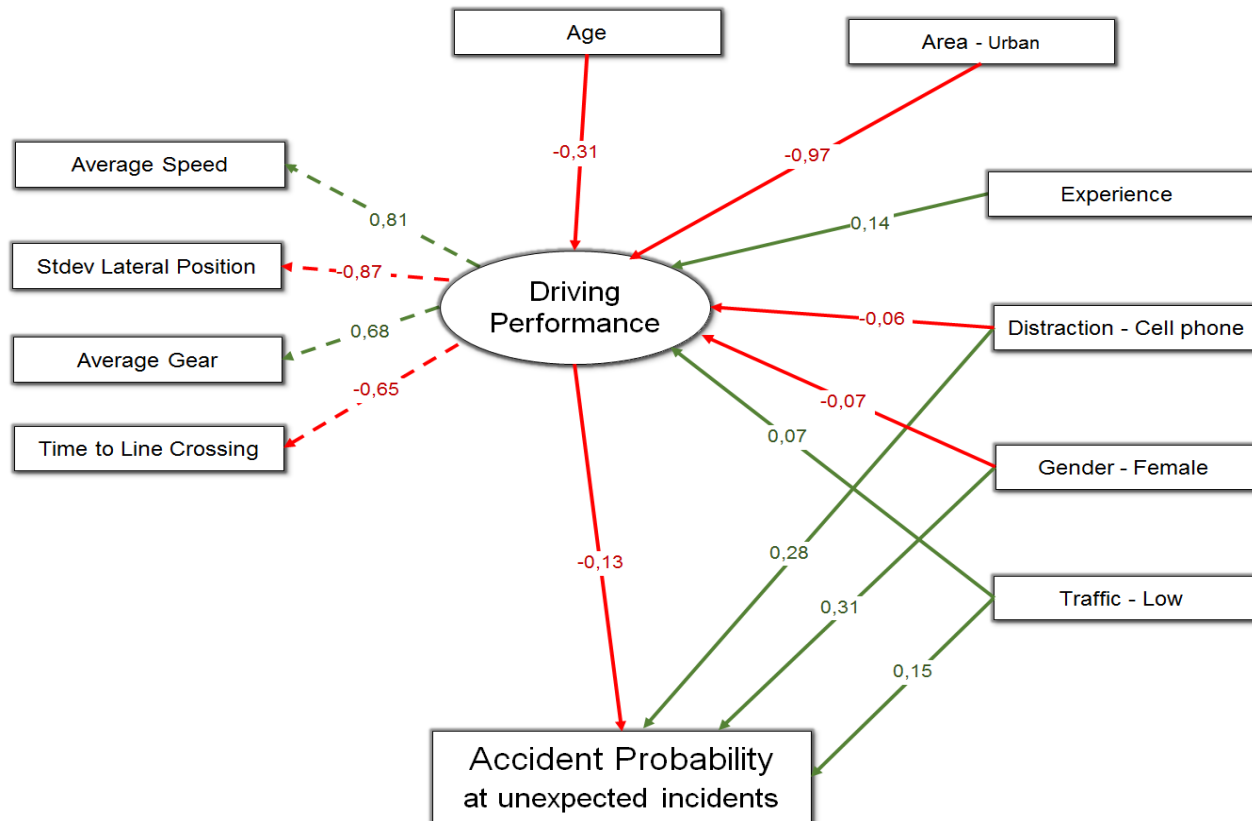
The latent variable reflects again the underlying driving performance of the participants and the objective is the quantification of the impact of driving performance, distraction, driver characteristics as well as road and traffic environment directly on **accident probability at unexpected incidents**
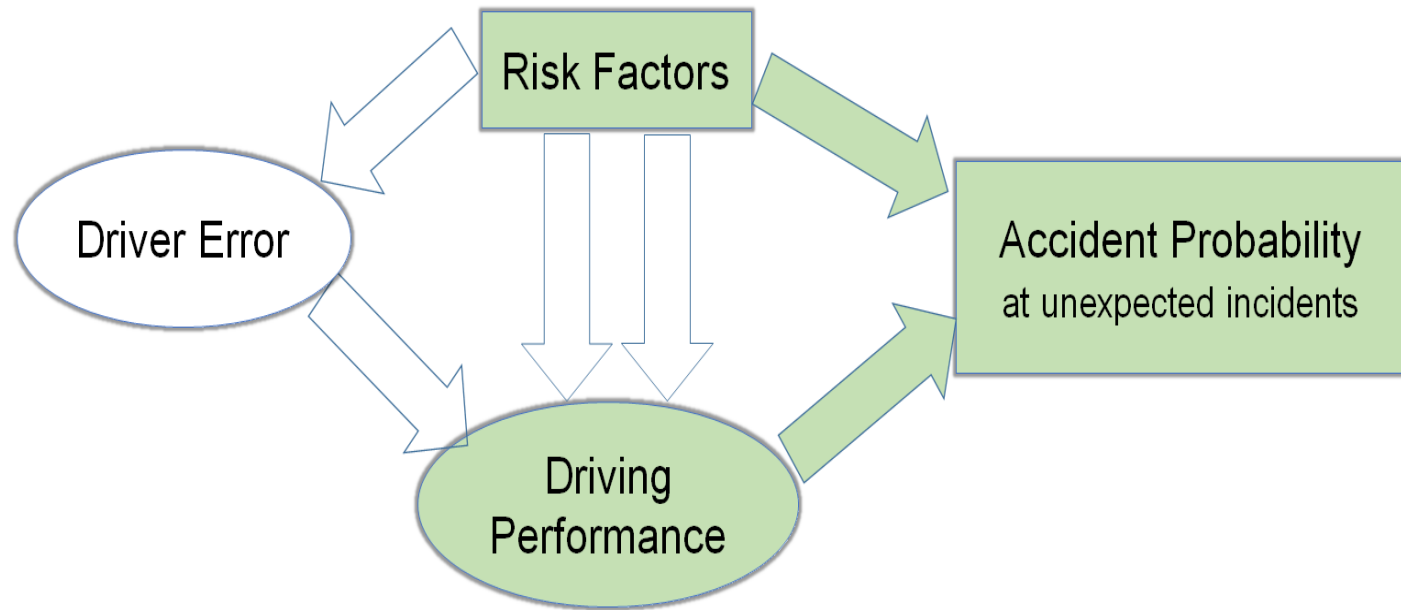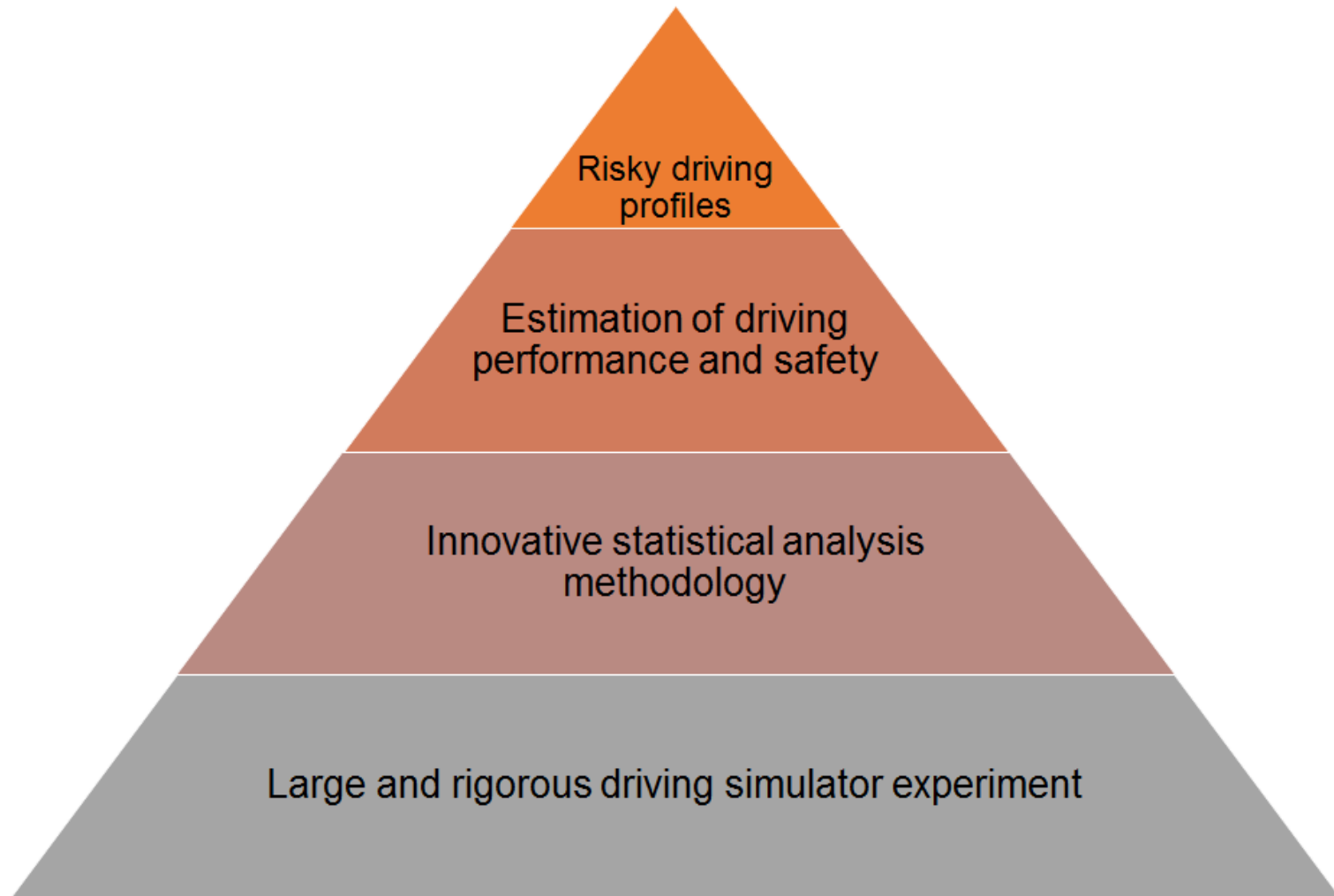
- **Cell phone** use has a negative effect on accident probability
- Drivers self-regulate their driving performance better while conversing with a passenger
- **Female** drivers at **low traffic** are more prone to accidents at unexpected incidents

Scientific contributions

Risky driving profiles

Estimation of driving performance and safety

Innovative statistical analysis methodology

Large and rigorous driving simulator experiment

Design and implementation of a large and rigorous driving simulator experiment

The basic limitations found in the literature that the present experiment tackled are the following:
- Large and representative sample
- Randomisation of trials
- Adequate practice drive
- Investigation of an optimum number of driving factors
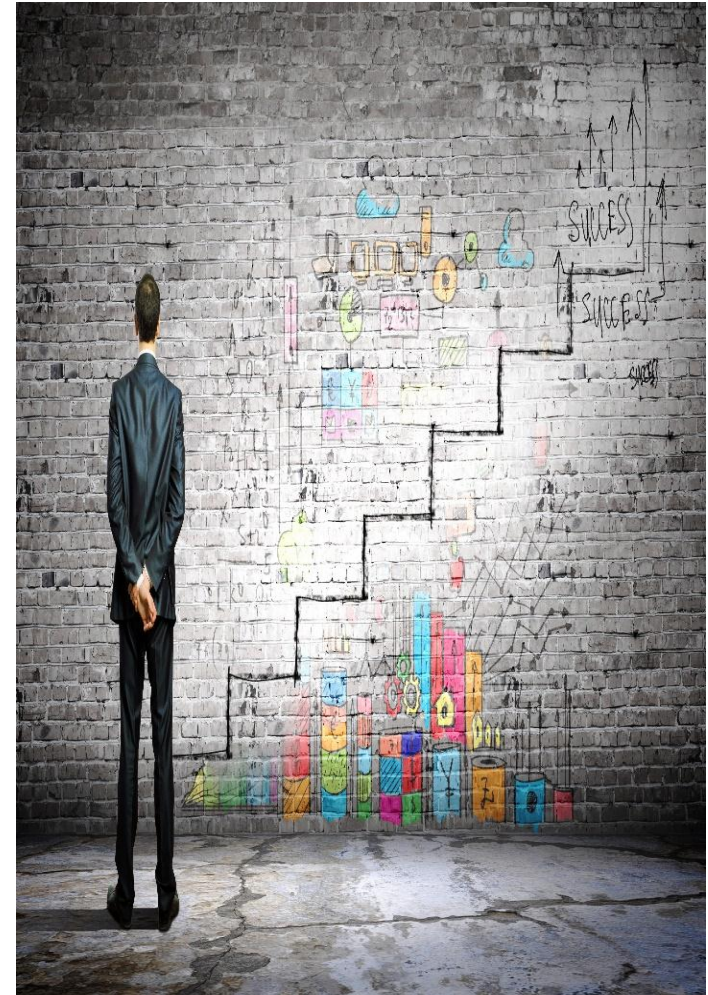
Methodological contributions (2/2)

- Development and application of an **innovative** statistical analysis methodology

- **Latent analysis** through Structural Equation models is implemented for the first time in the field of driving performance and traffic safety

- Estimation of the **combined effect** of distraction sources, driver as well as road and traffic environment characteristics directly on driving performance

Key research findings (1/2)

- Results regarding the effect of **driver distraction** indicate the different effect on driving performance between cell phone use and conversation with the passenger

- **Driver characteristics** play the most crucial role in driving performance (gender, age, experience)

- Driving performance is worst in urban areas and high traffic conditions probably due to the complex **driving environment**

Key research findings (2/2)

Development of risky driver profiles regarding driver error and accident probability at unexpected incident. Results indicate that:
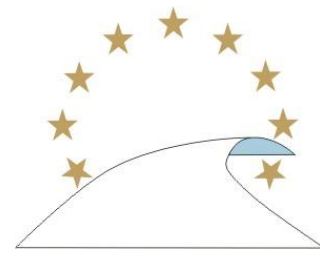
- more likely to commit driving errors are **young or old female drivers at urban areas**

- more likely to be involved in an accident at an unexpected incident are **female drivers in low traffic conditions while talking on the cell phone**

Further research

- Investigation of the effect of other parameters such as **alcohol**, **fatigue** etc. on driving performance through latent analysis

- Development of Structural Equation Model on different experimental methods (**Naturalistic experiments, field test etc.**)

- Further investigation of the parameters that affect the **compensatory** behaviour of the driver

- Investigation of different **types of cell phone** use such as a hands-free, Bluetooth, typing an sms etc.)

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