Modelling the inter-relationship between task complexity, coping capacity and crash risk

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Together with:
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The i-DREAMS project

- 13 Project partners:
  - National Technical University of Athens

    Universiteit Hasselt, Loughborough University, Technische Universität München, Kuratorium für Verkehrssicherheit, Delft University of Technology, University of Maribor, OSeven Telematics, DriveSimSolutions, CardioID Technologies, European Transport Safety Council, POLIS Network, Barraqueiro Transportes S.A.

- Duration of the project:
  - 48 months (May 2019 - April 2023)

- Framework Program:
  - Horizon 2020 - The EU Union Framework Programme for Research and Innovation - Mobility for Growth

Background

The **cornerstone of the i-DREAMS platform** is the assessment of task complexity and coping capacity

- **Task complexity** relates to the current status of the real world context in which a vehicle is being operated:
  - road layout (i.e. highway, rural, urban)
  - time and location
  - traffic volumes (i.e. high, medium, low)
  - weather conditions

- **Coping capacity** is dependent upon two underlying factors and it consists of several aspects:
  - **vehicle state** (e.g. technical specifications, actuators & admitted actions, current status)
  - **operator state** (e.g. mental state, behavior, competencies, personality, sociodemographic profile, health status)

Task complexity	Risk
Car wipers	Headway map levels
Car high beam	Speeding map levels
Time indicator	Overtaking map levels
Distance	Fatigue map levels
Duration	Harsh acceleration
Month	Harsh braking
Day of the week	Vehicle control events

Coping capacity - vehicle state	Coping capacity – operator state	
Vehicle age	Distance	Inter Beat Interval
First vehicle registration	Duration	Headway
Fuel type	Average speed	Overtaking
Engine Cubic	Harsh acceleration/braking	Fatigue
Engine Horsepower	Forward collision warning	Gender
Gearbox	Pedestrian collision warning	Age
Vehicle brand	Lane departure warning	Educational level

Objectives

Development of an integrated model of **driver-vehicle-environment interaction and risk** by:

- identify the most **critical precursors of risk** from both the task complexity and the coping capacity side
- implement an **integrated Structural Equation Model (SEM)** for understanding the effect of the aforementioned inter-relationship with risk
- compare the performance of such models on **different countries**

Data Collection

- A naturalistic driving experiment was carried out involving a hundred of drivers from Belgium, Germany and UK and a large database of thousands trips was created
- Data from the Mobileye system, a dash camera and the Cardio gateway which records driving behavior (e.g. speed, acceleration, deceleration, headway) along with GNSS signals were used
- In addition to the vehicle data, questionnaire data were also collected both before and after the trial

Methodological Overview

- Structural Equation Modelling (SEM) is widely used for modelling complex and multi-layered relationships between observed (e.g. number of speeding and headway events) and unobserved variables (e.g. crash risk)

- Observed variables are measurable, whereas unobserved variables are latent constructs

- The SEM is used to explore how the model variables are inter-related, allowing for both direct and indirect relationships to be modelled

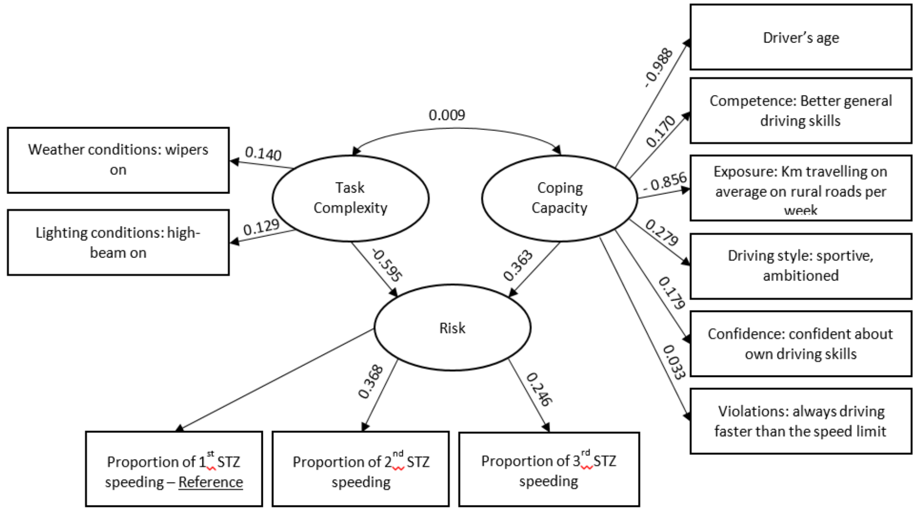
- These models are often represented by a path analysis, showing how a set of 'explanatory' variables can influence a 'dependent' variable

Results - Belgium

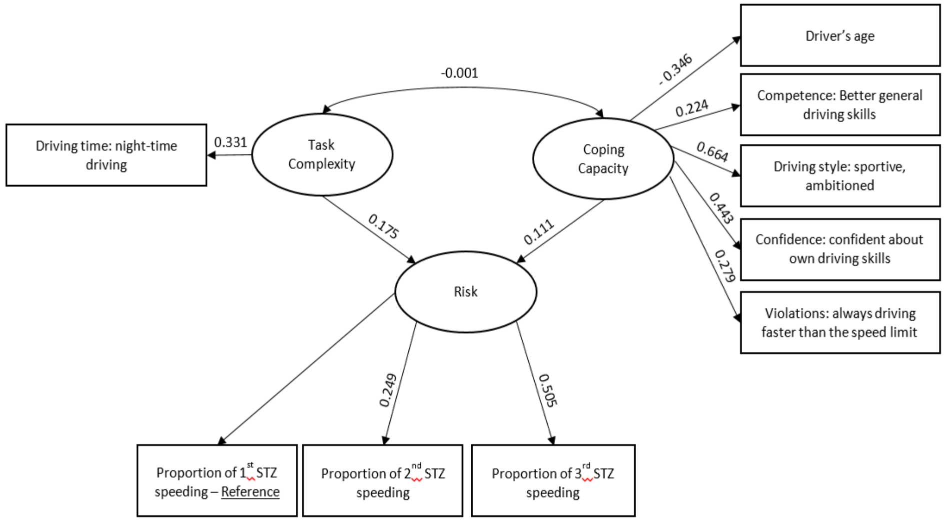
- In Belgium, task complexity and coping capacity **were positively correlated** in the majority of the models, which means that with higher task complexity comes higher coping capacity

- Task complexity was found to have **greater loadings on risk**, but that effect dropped when observing trips from phase 1 to phase 4 of the experiment

- In many of the developed models, the loadings revealed a spike in their values during phase 3 of the experiment and a small drop in phase 4, which points to the fact that the combination of real-time and post-trip feedback **significantly influenced** the relationship between task complexity, coping capacity and risk



Experiment Phase 1

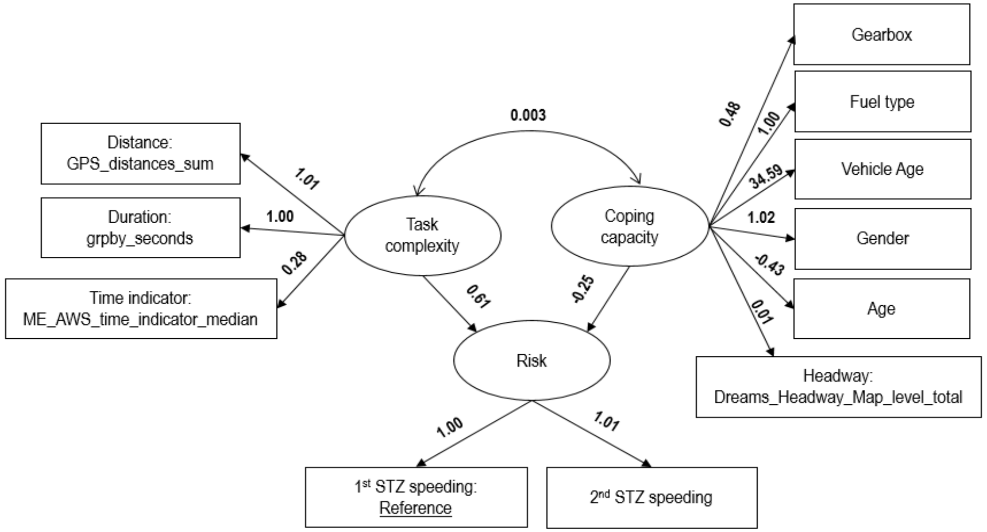


Experiment Phase 4

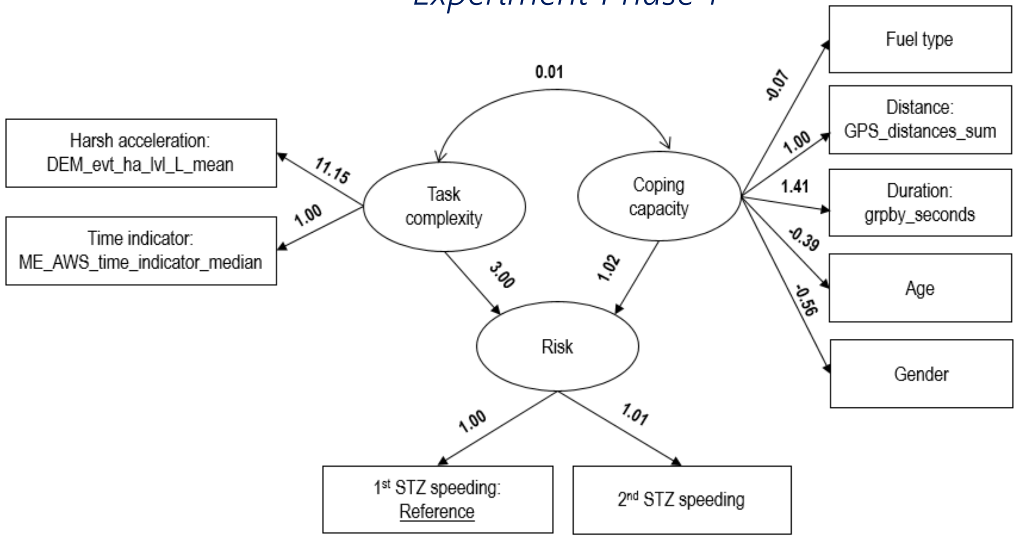
Results - Germany

- In Germany, the model for speeding revealed a positive correlation of task complexity and coping capacity with risk, but with the largest correlation in phase 2 of the experiment, where real-time warnings were introduced

- At the end of the experiment (phase 4), coping capacity was found to have its largest correlation with risk, while task complexity had its greatest loading during phase 3 of the experiment



Experiment Phase 1



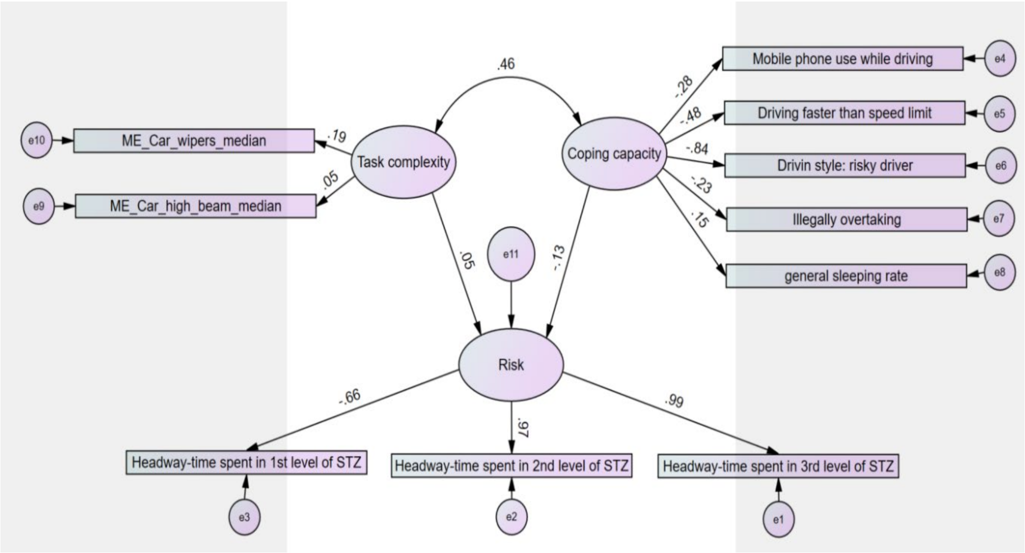
Experiment Phase 4

Results - UK

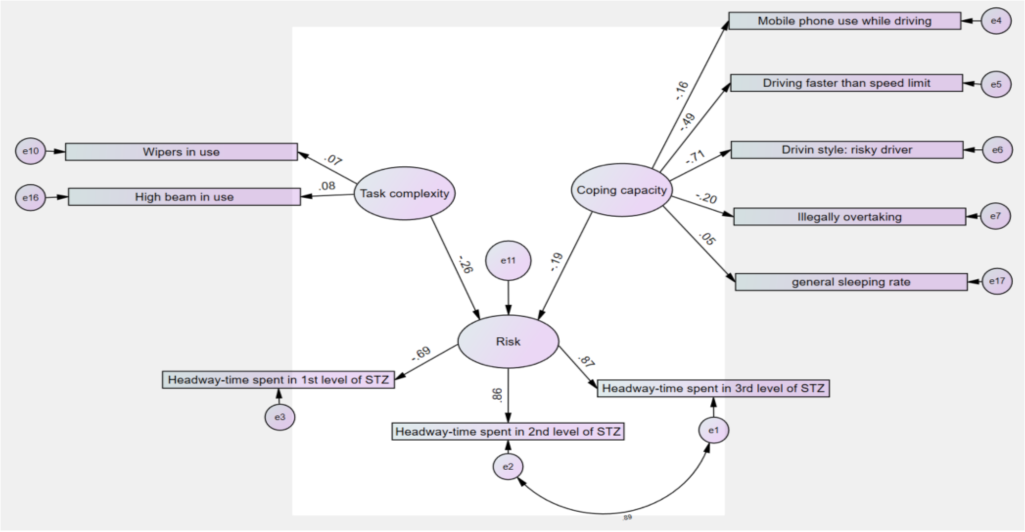
iDREAMS

➢ In UK, loadings from the SEM models demonstrate that coping capacity and task complexity **were positively correlated** in phase 1 and 3, but had no significant relationship in phase 2 and phase 4

➢ Like in Belgium, task complexity had a **stronger impact** on risk, with phase 3 showing the greatest effect



Experiment Phase 1



Experiment Phase 4

Discussion

- For the majority of the risk factors investigated, it was found that higher task complexity levels lead to higher coping capacity with the drivers. This means that drivers, when faced with difficult conditions, tend to regulate well their capacity to apprehend potential difficulties, while driving

- When looking into the relationship among the interaction of task complexity and coping capacity and its effect on risk, in Belgium and Germany, the influence of task complexity on risk was greater than the effect of coping capacity. Mixed results were observed in the UK

- The comparison of models fitted on data from the different phases of the experiments, validated that in the majority of the countries the interventions had a positive influence on risk compensation, increasing the coping capacity of the drivers and reducing the risk of dangerous driving behaviour

Conclusions

- A set of policy recommendations at different levels (EU, national and local authorities, industry, etc.) can be provided

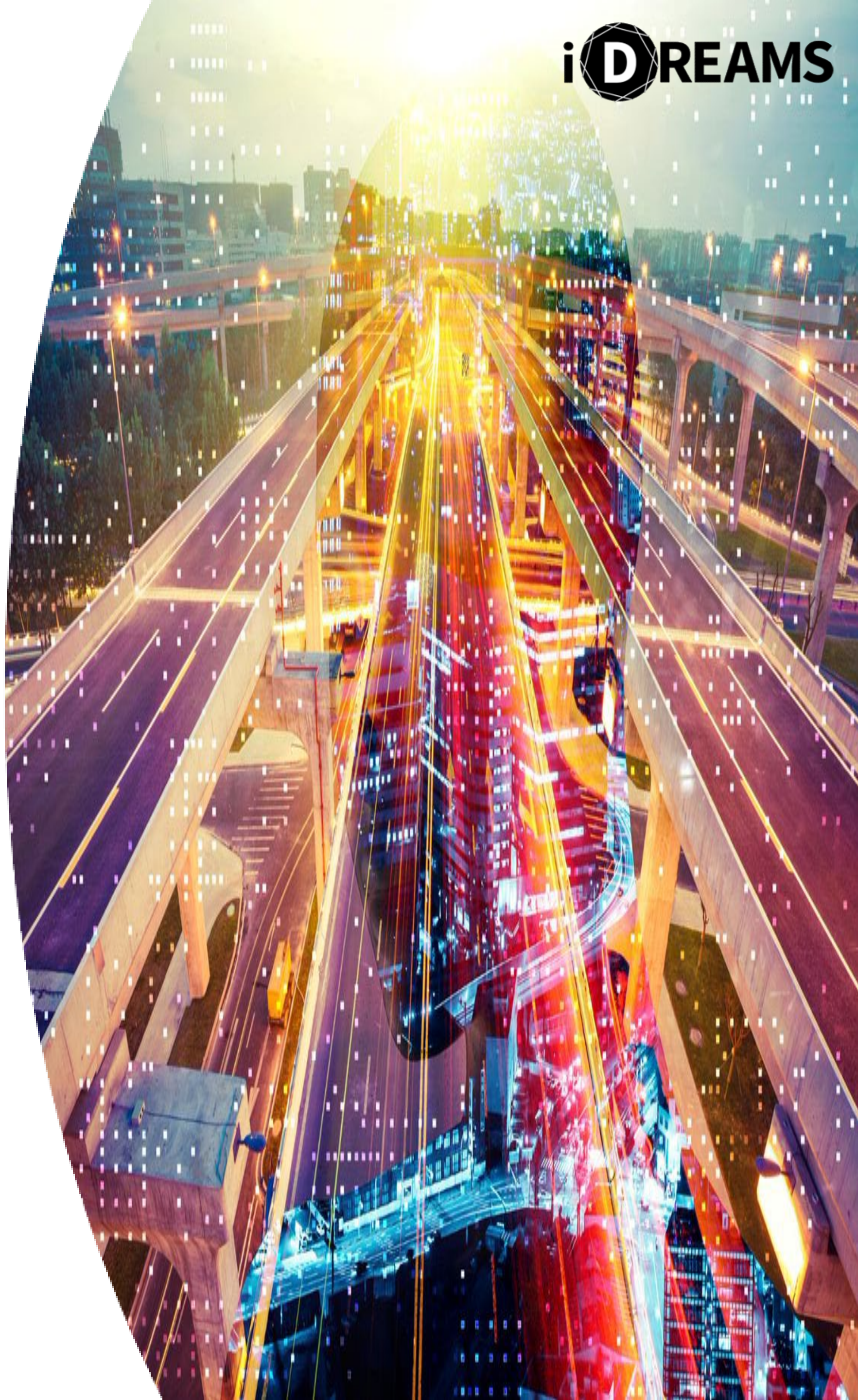
- The i-DREAMS system itself can directly improve safety once launched, but also additional safety benefits can be envisaged in the medium and long term as it is built on and further adapted to different contexts and industry needs, thanks to its modular nature

- The integrated treatment of task complexity, coping capacity and risk can improve behavior and safety of all travelers and all transport modes, through the unobtrusive and seamless monitoring of behaviour

- Authorities may use data systems at population level to plan mobility and safety interventions, set up road user incentives, optimize enforcement and enhance community building on safe travelling

Future Challenges

- **Additional task complexity and coping capacity factors**, such as road type, real-time weather information, more personality traits and driving profiles could be utilized
- The presence of a passenger, the drug abuse, the alcohol consumption or the seat belt use constitute some of the **high risk factors** that cause road crashes could be also included
- **Additional methodologies** could be explored for the understanding of the relationship between task complexity, coping capacity and crash risk
- **Factor analysis and microscopic data** analysis of the database collected could be implemented through econometric techniques and deep learning



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