Assessing the impact of personalized feedback on driving and riding behavior through a smartphone application

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Introduction

- Accurate monitoring of driver behavior has scientific and technical requirements.
- The Internet of Things (IoT) constantly offers new opportunities and features to monitor and analyze driver behavior through:
  - Wide use of smartphones and social media
  - Effective data collection and handling
  - Big Data Analysis
The BeSmart project

➢ Project partners:
  • National Technical University of Athens, Department of Transportation Planning and Engineering [www.nrso.ntua.gr](http://www.nrso.ntua.gr)
  • OSeven Telematics [www.oseven.io](http://www.oseven.io)

➢ Duration of the project:
  • 36 months (July 2018 – July 2021)

➢ Operational Program:
  • "Competitiveness, Entrepreneurship and Innovation" (EPAnEK) of the National Strategic Reference Framework (NSRF)
The BeSmart Objectives

The objectives of the project:

• Development of an innovative and seamless Internet of Things application

• Assessment and improvement of behavior and safety of all drivers (car drivers, powered two-wheelers, cyclists, professional drivers) along multi-modal trips

• Organization and exploitation of a naturalistic driving experiment of 200 drivers for 12 months
Research Scope

- Identification of the critical driving parameters that affect speeding behavior using data from:
  - Smartphone devices
  - Naturalistic driving experiment

- Investigation of the impact of driver feedback on driving behavior as expressed by the exceedance of speed limits
The BeSmart driving experiment

- The experiment consists of **6 different phases** differing in the type of feedback provided to drivers.

- The present study refers to the first two phases (car drivers – PTW riders):
  - **Phase 1** - no feedback to drivers - 12 weeks duration
  - **Phase 2** - personalized feedback in means of a trip list and a scorecard regarding drivers’ behavior - 10 weeks duration

- A total of **26,619 trips** from a sample of 147 car drivers and **3,853 trips** from 20 motorcyclists.
The BeSmart Application

- Driving behavior characteristics
  - Speeding
  - Harsh braking/ acceleration/ cornering
  - Mobile phone use (car drivers’ application)

- Travel behavior characteristics
  - Total distance
  - Road network type
  - Risky hours driving
  - Vehicle type
Smartphone data collection (1/2)

- A mobile application to **record user’s driving behavior** (automatic start / stop)
- A variety of APIs is used to read mobile phone **sensor data**
- Data is transmitted from the mobile App to the **central database**
- Data are **stored** in a sophisticated database where they are **managed and processed**
Indicators are designed using:
• machine learning algorithms
• big data mining techniques

The database analyzed was in .csv format
• Drivers’ trips are stored per row, the characteristics of which are stored in each column’s variables

State-of-the-art technologies and procedures in compliance with standing Greek and European personal data protection laws (GDPR)
Descriptive statistics – car drivers

- Both types of harsh events (accelerations and brakings) are reduced in the 2nd phase of the experiment.

- The percentage of driving above the speed limits and driving while distracted by the mobile phone is reduced in the 2nd phase of the experiment.

![Graph showing the average Ha and Hb counts with and without feedback.](image)

![Bar chart showing the percentage of mobile use and speeding duration with and without feedback.](image)
Descriptive statistics – PTW riders

- Both types of harsh events (accelerations and brakings) are **reduced in the 2nd phase** of the experiment.

**Average Ha and Hb Counts**

- The percentage of driving above the speed limits is **reduced in the 2nd phase** of the experiment.
Theoretical Background

Selection of statistical method:

- Need for fraction prediction – percentage of speeding time
- Generalized Linear Models (GLM) - Poisson Regression
- Introduce random effects to capture different driving behaviors and extend GLMs as Generalized Linear Mixed-Effects Models (GLMMs), given by the following formula:

\[ \log(\lambda_i) = \beta_0 + \beta_{ji} x_{ji} + \beta_{n-1} x_{n-1} + \epsilon \]
### Results (1/2) – car drivers

**GLMMs for the percentage of driving time above the speed limit**

<table>
<thead>
<tr>
<th>Trip Parameter</th>
<th>Estimate</th>
<th>s.e.</th>
<th>p-value</th>
<th>Sig.</th>
<th>Rel. Risk Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.702</td>
<td>0.0614</td>
<td>&lt;0.001</td>
<td>***</td>
<td>5.485</td>
</tr>
<tr>
<td>Exp. phase (0=no feedback, 1=feedback)</td>
<td>-0.392</td>
<td>0.006</td>
<td>&lt;0.001</td>
<td>***</td>
<td>0.675</td>
</tr>
<tr>
<td>Total trip duration (s)</td>
<td>0.204</td>
<td>0.036</td>
<td>&lt;0.001</td>
<td>***</td>
<td>1.226</td>
</tr>
<tr>
<td>Number of harsh accel. per trip (count)</td>
<td>0.161</td>
<td>0.002</td>
<td>&lt;0.001</td>
<td>***</td>
<td>1.175</td>
</tr>
<tr>
<td>Trip distance during risky hours [22:00-05:00]</td>
<td>0.029</td>
<td>0.001</td>
<td>&lt;0.001</td>
<td>***</td>
<td>1.029</td>
</tr>
<tr>
<td>Morning peak hour [06:00-10:00] (0=yes, 1=no)</td>
<td>0.027</td>
<td>0.008</td>
<td>&lt;0.001</td>
<td>***</td>
<td>1.027</td>
</tr>
<tr>
<td>Afternoon peak hour [16:00-20:00] (0=yes, 1=no)</td>
<td>-0.236</td>
<td>0.007</td>
<td>&lt;0.001</td>
<td>***</td>
<td>0.790</td>
</tr>
</tbody>
</table>
## Results (2/2) – PTW riders

GLMMs for the percentage of driving time above the speed limit

<table>
<thead>
<tr>
<th>Trip Parameter</th>
<th>Estimate</th>
<th>s.e.</th>
<th>p-value</th>
<th>Sig.</th>
<th>Rel. Risk Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.898</td>
<td>0.276</td>
<td>&lt;0.001</td>
<td>***</td>
<td>6.672</td>
</tr>
<tr>
<td>Exp. phase (0=no feedback, 1=feedback)</td>
<td>-0.145</td>
<td>0.013</td>
<td>&lt;0.001</td>
<td>***</td>
<td>0.865</td>
</tr>
<tr>
<td>Total trip duration (s)</td>
<td>0.194</td>
<td>0.095</td>
<td>0.042</td>
<td>*</td>
<td>1.214</td>
</tr>
<tr>
<td>Number of harsh accel. per trip (count)</td>
<td>0.248</td>
<td>0.005</td>
<td>&lt;0.001</td>
<td>***</td>
<td>1.281</td>
</tr>
<tr>
<td>Trip distance during risky hours [22:00-05:00]</td>
<td>0.018</td>
<td>0.003</td>
<td>&lt;0.001</td>
<td>***</td>
<td>1.018</td>
</tr>
<tr>
<td>Morning peak hour [06:00-10:00] (0=yes, 1=no)</td>
<td>0.067</td>
<td>0.015</td>
<td>&lt;0.001</td>
<td>***</td>
<td>1.069</td>
</tr>
<tr>
<td>Afternoon peak hour [16:00-20:00] (0=yes, 1=no)</td>
<td>-0.286</td>
<td>0.015</td>
<td>&lt;0.001</td>
<td>***</td>
<td>0.751</td>
</tr>
</tbody>
</table>
Conclusions (1/2)

- Both car drivers and PTW riders indicate similar behavior while exceeding the speed limits.
- Trip length and driving during the morning rush and night-time risky hours are exposure metrics positively correlated with the odds of speeding.
- Harsh accelerations are also associated with the odds of someone exceeding the speed limits, outlining a pattern of an overall unsafe driving behavior.
Conclusions (2/2)

- The present results capture and quantify the positive effects of driver feedback on one of the most important human risk factors; speeding.

- The ultimate objective when providing feedback to drivers is to:
  - Trigger their learning and self-assessment process, thus enabling them to gradually improve their performance.
  - Monitor the shift of driving behaviour as the application provides feedback.
Future research

- Investigating the impact of different types of personalized feedback communicated through the project application:
  - Incentives within a social gamification scheme, with personalized target setting,
  - Benchmarking and comparison with peers

- Examinations of the impact of feedback over time, the influence of its evolution on drivers and its consistency

- Microscopic data analysis of the collected database through machine learning techniques
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