How accurate are drivers' predictions of their own mobility? Accounting for psychological factors in the development of modern technology for electric vehicles

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The overall environmental impact of electric vehicles strongly depends on the source of energy used for charging. Research shows that no substantial change in CO_2-emission will be achieved when the energy used for charging is based on the current energy mix. (Heider, Büttner, Link, & Wittwer, 2009). Research efforts should focus on the connection of electromobility with renewable energy sources in order to optimize the environmental impact of this new technology. This is fairly difficult since renewable energy sources are highly fluctuating and hardly match to the energy demand that stems from mobility.

Technological solutions are based on intelligent load management systems (ILMS). Thereby, the vehicle is connected to the grid and the system optimizes charging as well as discharging processes. The ILMS guarantees that the battery has been charged appropriately at a previously defined time marker. Following this approach, electric vehicles will be charged when renewable energy is available. Even more, the batteries of the electric vehicles may be used as an energy storage providing energy for the grid in times of high demand.

However, ILMS are accompanied by substantial changes in user behavior. In order to choose the most efficient time intervals for charging (or discharging), departure times as well as upcoming route lengths have to be planned by the driver. In the present study, the main focus was on the skill perspective, analyzing the reliability of users' predictions of their mobility behavior relevant to ILMS.

Method

In the present study, we compared subjects' predictions of their future mobility behavior with their real mobility data. Conditions were adapted to future ILMS scenarios: After arriving at home, participants were asked to predict the departure time and length of their next trip. We provided a logbook for each participant to record her or his predictions as well as real departure times and route lengths. Further, we installed GPS tracking systems in every vehicle to verify the logbook data. In sum, participants were observed for a two week period. The task only had to be performed at home since the ILMS will be mainly implemented at home in the future. All vehicles had a combustion engine. We decided to use common vehicles since we collected skill data that are not affected by the type of vehicle used.

In accordance to Gärling, Gillhom, & Gärling (1998), participants were asked to classify their trips into work, shopping and leisure activities.

Before and after the two week period, we also collected questionnaire data about perceived impairment and insecurity.

Results

The data shows that both – departure time as well as route length estimations – were fairly accurate. Figure 1 displays the distribution of the departure time estimation errors in the present sample. The median of the estimation errors was -7, indicating a tendency to predict the departure time as being earlier than it actually is. An analysis of route length predictions showed that subjects tended to slightly underestimate the route lengths (median = -1). That is, subjects predicted to drive longer trips than they did in reality.

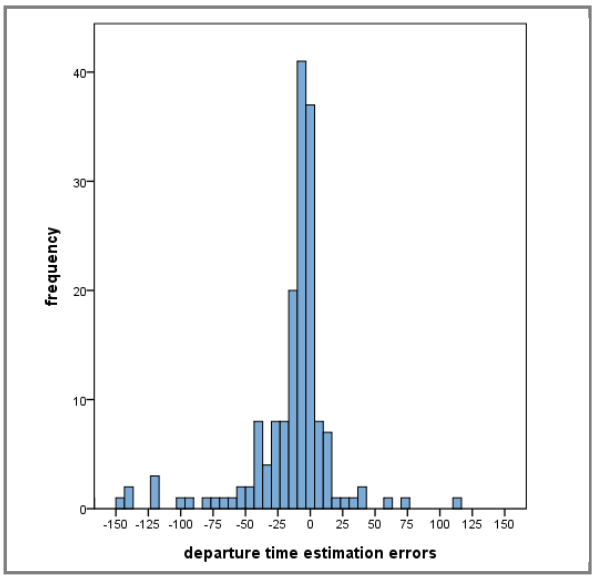

Figure 1. Frequency of departure time estimation errors.

Nevertheless, data also included extreme values that might potentially lead to insufficient battery levels in future ILMS scenarios.

Finally, we analyzed the influence of trip type on predictions of mobility behavior. The majority of trips were working trips, followed by leisure and shopping trips. The type of trip had a significant influence on the quality of subjects' estimations of departure time. The best predictions were made for working trips. Subjects showed the highest error rates for predictions of shopping trip departure times. An analysis of route length estimations revealed that the type of trip had no significant effect on the accuracy of predictions of route lengths.

Discussion

The present study was conducted to gain more information about the accuracy of users' predictions of their mobility behavior as demanded in future ILMS scenarios. Data revealed that predictions were fairly accurate. This holds for route length estimations in particular. Errors in departure time predictions were moderate and depended on the purpose of the upcoming trip.

Special attention should be drawn to extreme values. While the majority of estimations were accurate, data also included a reasonable amount of outliners showing extreme high error values. In real ILMS scenarios, such misestimations would lead to inefficient charging processes or – even worse – to insufficient battery levels. Since a single misjudgment may have worrying consequences, future research should focus on such outliners. A limitation of the current study was that participants were forced to predict their mobility behavior. This stands in contradiction to upcoming ILMS scenarios where people have the option to choose between direct and intelligent charging. Therefore, further research might concentrate on the subjects' perceived certainty in their own mobility predictions. Up to now it is unknown if people are aware of such inaccuracy. If so, people would probably avoid intelligent charging processes in moments of high uncertainty.

Analysis displayed that the type of trip had an influence on the accuracy of departure time predictions. In the present study, working trips had the best prediction rates. We assume that working trips, as daily events, are probably easier to predict than leisure or shopping trips that often do not follow a daily routine.

Route length estimations were not affected by the type of trip. This suggests that there is a general bias that affects route length estimations independent of trip type.

The present study shed light on the accuracy of users' mobility predictions relevant to ILMS. New technologies like electromobility may have a substantial influence on the environment but are accompanied by reasonable impact on the user. It is necessary to take challenges for the user into account. This is even more obvious for systems requiring user's participation.

References

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