Symposium: The Psychology of Sustainable Mobility

User Acceptance of Guided Charging: Results of a Field Study

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Introduction

Climate change programs also include the target of CO_2 reduction in the transport sector. The electrification of transport offers possibilities to use renewable energies in transport. Light-duty electric vehicles (e-vehicles) operate in urban commercial transport, electric bikes allow more people to bike and further electrification of public transport can pave the way for more sustainability in transport. Currently, public discussions and research funding provided by the government and industry target electric cars for personal transport. E-vehicles are not however the one-size-fits-all recipe. The question remains which role these could play in future and how this can be achieved. If a new purchased e-vehicle substitutes a conventionally fuelled car it would be a success, but what about an additional e-vehicle as second car in the household? Such a development may be counter-productive for sustainable mobility if it increases motorized travel. Following the premise of obtaining a higher degree of mobility with fewer resources, e-vehicles are thus only useful in an integrated transport planning strategy.

In addition to technological factors the user determines the success of new technology and services in transport. This session will illustrate the potential contributions of psychological research to the understanding and development of e-vehicle use.

The *first presentation* analyzes the question of how mainstream drivers will respond to e-vehicles. In the UK 40 car drivers were given the opportunity to test an electric car for one week. Based on this hands-on experience barriers and benefits of driving an e-vehicles were analyzed.

The intention to purchase an e-vehicle was investigated in a study reported in the *second presentation.* An online questionnaire was answered by car owners. The role of instrumental, affective and symbolic dimensions of car ownership as well as people's mind set of being a "car authority" vs. "pro-environmental" were analyzed.

The cost and capacity of batteries continue to be main barriers for the wide spread usage of e-vehicles. They battery capacity is a strong determinant of the feasible travel range. The *third presentation* focuses on the discrepancy between subjective and objective available range and determinants of the former including personality variables.

Intelligent load management systems that ensure the usage of an energy mix with higher percentage of renewable energies for charging e-vehicles need the support and participation of the users. It is important that the time the e-vehicle is connected to the grid for being loaded is predictable. Can people predict their mobility behavior? The *fourth presentation* sheds light on this question in a user study applying forecast logbooks and GPS tracking.

The *fifth presentation* reports a test of the implementation of guided charging that allows batteries to be charged as a function of the availability of renewable energies. In the test with 39 persons, it is found that effort and performance expectancies affected the users. They did not personalize the default charging routines according to their driving behaviour.

Presentation 1: How will mainstream drivers respond to electric vehicles?

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Electric vehicles have the potential to reduce transport emissions without curtailing personal car use. Encouraging widespread adoption of electric vehicles requires an understanding of likely responses of informed mainstream consumers. This paper reports a grounded theory analysis of responses to electric cars, based on semi-structured interviews conducted with 40 UK non-commercial drivers at the end of a seven-day trial of a battery electric car (20 participants) or a plug-in hybrid car (20 participants). Six core categories of response were identified: (1) cost minimization; (2) vehicle confidence; (3) vehicle adaptation demands; (4) environmental beliefs; (5) impression management; and, underpinning all other categories, (6) the perception of electric cars generally as 'work in progress' products. Results highlight potential barriers to the purchase of currently available electric cars by mainstream consumers. These include the prioritization of personal mobility needs over environmental benefits, concerns over the social desirability of electric vehicle use, and the expectation that rapid technological and infrastructural developments will make current models obsolete. Implications for effective marketing and promotion of future electric vehicles are discussed.

Presentation 2: Who adopts electric vehicles and what is the role of instrumental, affective and symbolic factors?

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Currently there is a strong focus on Electric Vehicles (EVs) to achieve carbon reduction targets. But consumers tend to be sceptical to adopt new technologies such as EVs. Hence, this paper aims to understanding who is likely to adopt EVs and why.

It is generally assumed that a small group of consumers are amongst the first to adopt new technologies. They are usually associated with a strong tendency to own the latest or newest technologies, referring to 'consumer innovativeness'. EVs have another distinctive feature: they are seen as low emission cars or as a way of being less dependent on oil companies. Hence, consumers might be focus on the newest technologies of EVs ('authorities on cars') as well as on their environmental aspects ('pro-environmental').

Those who are 'pro-environmental' or 'authorities on cars' might focus on different EV attributes, such as instrumental attributes (referring to functional performance and usefulness), affective attributes (referring to emotions evoked by owning new technologies), and symbolic attributes (referring to the identity or social status that is derived from owning new technologies).

This paper examines to what extent intention to adopt EVs is explained people who are 'authorities on cars' and 'pro-environmental'. In addition, interaction effects are examined. Moreover, he importance of instrumental, affective and symbolic attributes for people who are

'authorities on cars' and 'pro-environmental' is examined.

Results are presented from an online survey amongst 2729 car owners who bought a new or nearly new car in the past five years or intend to do so in the next two years. Respondents indicated their intention to adopt two different types of EVs: a plug-in hybrid vehicle and a plug-in fully battery electric vehicle.

Firstly, a significant main effect was found for 'pro-environmental', but not for 'authority on cars' on intention to adopt EVs. This implies that those who focus particularly on the environmental aspects of EVs are likely to adopt these vehicles. Moreover, a significant interaction effect was found, suggesting that the intention to adopt an EV is higher if people are pro-environmental and an authority on cars.

Next, we found that instrumental, affective and symbolic attributes of EVs were hardly relevant for those who are 'authority on cars', but strongly relevant for those who are 'pro-environmental'. The more pro-environmental people were, the less important instrumental attributes were considered to be and the more important affective and symbolic EV attributes were considered to be.

Overall, the results suggest that those who consider themselves to be pro-environmental are most likely to be the early adopters of EVs; they focus mainly on affective and symbolic attributes rather than on instrumental attributes.

Presentation 3: Interacting with scarce mobility resources: Psychological range levels in electric vehicles

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Range is a scarce and precious resource in electric mobility systems (EMSs) in comparison to combustion-powered mobility systems (CMSs). Moreover, there can be a gap between the technically available and the subjectively accessible range leading to suboptimal range utilization (Franke, Neumann, Bühler, Cocron, & Krems, 2010). To increase the potential of an EMS such gaps have to be bridged.

We suggest that accessible range should be structured according to three psychological range levels that act as comparator values in self-regulation (Miller, Galanter, & Pribram, 1960). Competent range is the maximum range that an individual user can obtain based on his system competence. Performant range is the range that is usually obtained by an individual user based on his driving habits. Comfortable range refers to the range that users actually utilize (the highest accepted trip distance, lowest accepted charge level). The gaps between these levels may be explained by psychological variables (e.g. control beliefs, practice with the system).

In the present study we aim to assess these range levels and understand their relation to psychological variables with data from an electric vehicle (EV) field study incorporating 40 private users who successfully applied for a six-month lease of an EV (see Cocron et al., in press).

For each psychological range level, both objective (e.g., average minimum of charge levels) and subjective indicators (e.g., range comfort zone in a standardized situation) were developed. Such indicator values were then related to relevant psychological background variables. These addressed, for instance, subjective range competence, daily practice with the EV, and control beliefs in dealing with technology (Beier, 1999).

Several of the variables yielded moderate effects indicating substantial explanatory power of psychological variables for the efficiency of range utilization and hence, for dynamics of mobility resources accessible to individual users. For example, comfortable range, as measured by the range comfort zone variable, was moderately related to general control beliefs in dealing with technology ($p<.05$, $n = 39$, two-tailed)

The pattern of results obtained in this study provides a detailed picture of the psychology of range interaction and thus the psychology of interacting with scarce and precious mobility resources. The sizeable variation in range level values and the substantial gaps between them point to the importance of user-related factors as parameters in the equation of available mobility resources. The relation of system competence to these variables points to the importance of training activities. Moreover, disposition-related effects could be used to derive adaptive training elements and predict range-related problems of individual users. Finally, theoretical and methodological components of this study may be transferable to other mobility- or energy-related domains. Future studies should examine these possibilities.

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Presentation 4: Can people predict their mobility behaviour? A user study analyzing the viability of intelligent load management systems 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).

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.

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.

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. We installed GPS tracking systems in every vehicle to verify the logbook data. In sum, participants were observed for a two week period. In accordance to Gärling, Gillhom, & Gärling (1998), participants were asked to classify their trips into work, shopping and leisure activities.

The data shows that both – departure time as well as route length estimations – were fairly accurate. Nevertheless, data also included extreme values that might potentially lead to insufficient battery levels in future ILMS scenarios.

The type of trip had a significant influence on the quality of subjects' estimations of departure time. An analysis of route length estimations revealed that the type of trip had no significant effect on the accuracy of predictions of route lengths.

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 since data 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.

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.

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Presentation 5: User Acceptance of Guided Charging in the E-Mobility Project "Mini E Berlin"

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Introduction

The introduction of electric vehicles delivers a huge potential for improved integration of renewable energies into the electric grid. Through a newly developed information technology - guided charging - the batteries can be charged as a function of the availability of renewable energies. Regarding the electric vehicle drivers, this means the following: (1) they should support guided charging by not bypassing it. (2) they define the time frame for when the guided charging is applied. The research question is: what determines the acceptance of guided charging?

Method/ Setting

During a field study, 39 electric vehicle drivers participated in guided charging. They could influence this outside controlled charging process through a web interface. The data was gathered during a six-month longitudinal evaluation study (Bühler et al., 2010). The qualitative interviews were transliterated and then evaluated through a combined inductive and deductive procedure (Kuckartz, 2005).

Results

There seems to be a positive appraisal of guided charging. Nevertheless, the disadvantages of guided charging are mostly seen as personal drawbacks. The expected advantages are mostly general without an immediate individual benefit. A closer look revealed, that the participants used the web-interface to enhance the time frame for guided charging quite infrequently. The main reasons for it were:

a) Adjusting the settings was seen as unnecessary for fulfilling the charging needs in day-to-day use.

b) Adjusting the settings was seen as cumbersome and without enjoyment.

Discussion

The results can be integrated into information technology acceptance theories (see Venkatesh et al. 2003): These theories show that there are performance expectancies and effort expectancies, which influence the acceptance of a technology. But both - effort and performance expectancies - seem to be insufficiently realized in the current state of guided charging.

These results suggest that a greater effort has to be made so that people actively support this technology (see importance of active action for acceptance, Schweizer-Ries, 2008).

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