How Does the Actual Usage of Electric Vehicles Influence Consumer Acceptance?

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Abstract Electric vehicles are being intensively discussed as a possible sustainable and energy-efficient means of transport. Throughout Europe, broad programmes have been launched to support electric vehicle research, field trials and market diffusion. However, for a successful diffusion of electric vehicles, their acceptance by consumers is crucial. So far this issue has not been analysed sufficiently involving actual users of recent electric vehicle models. What do electric vehicle users and those intending to use an electric vehicle in the near future really think about electric vehicles? How do these perceptions change if they actually use an electric vehicle in everyday life? In order to provide answers to these questions, a longitudinal set of survey data has been analysed of participants in field trials in the eight pilot regions for electric mobility in Germany. These findings are compared to the survey data of nearly 1,000 German car drivers classified into four groups (current electric vehicle users, non-users with a concrete purchase intention, electric vehicle-interested people and consumers with no interest in electric vehicles). The analyses and the comparison between the two studies indicate that gaining real experience with electric vehicles has a positive influence on some predictors of the acceptance of electric vehicles according to the diffusion of innovation model by Rogers (2003). This indicates the relevance of the visibility and observability of electric vehicles. For example, providing test drive opportunities allows consumers to experience electric vehicles themselves and might help to increase consumer acceptance.

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M. Hülsmann and D. Fornahl (eds.), *Evolutionary Paths Towards the Mobility Patterns of the Future*, Lecture Notes in Mobility,
DOI: 10.1007/978-3-642-37558-3_4,

1 Introduction

Electric vehicles[1] are a much discussed topic today, especially in the context of climate change, air quality and energy security. In several countries, governments are promoting the use of electric vehicles. The German federal government wants Germany to become a lead market for electric mobility by 2020. By then, 1 million battery-electric and plug-in hybrid vehicles are expected to be driving on German roads.

At present, the share of electric passenger cars in Germany is still very low: Only 0.01 % of the total fleet of passenger cars are electric. Thus, there is very little up-to-date research on actual consumer experiences and their acceptance of electric vehicles.

"Second generation" electric vehicles (i.e. with lithium batteries) have just started to enter the market and several models are now available or will be available soon from renowned international car manufacturers as well as from new enterprises all over the world, for example Mitsubishi, Tesla, Luis, Peugeot, Nissan, e-Wolf GmbH, Ford and Think. German automotive companies are also developing their own battery-electric or plug-in hybrid vehicles. In order to prepare for an electric future, the German Federal government is supporting several series of field trials of electric vehicles (e.g. "Electric Mobility in Pilot Regions", funded by Germany's Transport Ministry).

Driving an electric vehicle still implies having to deal with some challenges which could be critical from a consumer's point of view, for example, a limited driving range, a high purchase price and a long charging duration. However, there are also electric vehicle characteristics which offer advantages compared to conventional vehicles, for example low engine noise, fast acceleration, no local emissions or low running costs. Nevertheless, driving electric vehicles requires significant changes in consumer behaviour (Anable et al. 2011).

As consumer acceptance is a crucial precondition for the successful market penetration of electric vehicles, it is necessary that electric mobility concepts meet consumers' real needs. Up to now, most consumers have hardly any real experience with electric vehicles; many consumers have never even seen an electric vehicle. Skippon and Garwood (2011) state that new technologies with which consumers have not yet had any experience are "psychologically distant" (Liberman et al. 2007) and abstract. Asking consumers to evaluate such new products can hardly lead to valid predictions of actual future behaviour; consequently, surveys which focus mainly on non-users who are not yet familiar with the idea of electric mobility may not be useful for studying consumers' expectations of electric vehicles. Consumers themselves have even indicated in market research studies that they feel they do not know enough about electric vehicles (Fraunhofer IAO and PwC 2010). As other recent market research studies have

[1] In this paper electric vehicles include battery-electric and plug-in hybrid vehicles as well as four- and two-wheeled vehicles.

shown (e.g. ADAC 2009; Roland Berger 2010; TÜV SÜD and Technomar 2009), expectations of the attributes of electric vehicles by non-users are therefore strongly influenced by the attributes of conventional vehicles which serve as the main frame of reference. The question is how these expectations and perceptions might change if consumers are given more information. A study of Anable et al. (2011) provides evidence that receiving more information about a specific new technology such as electric vehicles could influence consumer acceptance, i.e. purchase intentions. This indicates the relevance of conducting studies involving consumers who have already gained more knowledge and experience with the particular technology, in particular actual users, in order to draw conclusions about the future acceptance of this technology. Since electric vehicle owners are still rare, it is important to analyse user acceptance in field trials in which consumers can test electric vehicles for a longer period of time.

In this chapter, we explore how actually using an electric vehicle influences individuals' acceptance, in particular their perception of the specific characteristics of electric drive vehicles. To this end, we analyse questionnaire data from two studies. The first data set (*study 1*) presents longitudinal data from user surveys conducted within the German electric vehicle pilot regions: participants in these field trials were asked about their perception of electric vehicles before and after using the vehicle for a certain period of time (one week to three months). A second data set (*study 2*) provides cross-sectional data on the perceptions of electric vehicles by several consumer groups, for example, individuals who expressed a high interest in buying an electric vehicle and respondents who have actually acquired and used an electric vehicle. The results of both studies are comparatively discussed on a qualitative basis against the background of Rogers' diffusion of innovation model and of prior empirical studies on battery-electric and plug-in-hybrid vehicles.

2 Theoretical Framework and Prior Empirical Findings

In this chapter, acceptance is defined as the willingness to adopt, i.e. to regularly use an electric vehicle in everyday life. The adoption of innovations (i.e. ideas, applications or objects that are perceived as new) by individual consumers is analysed using Rogers' diffusion of innovation model (Rogers 2003). According to this model, besides socio-economic characteristics, the decision to adopt or reject an innovation is influenced by its attributes as perceived by the individual: (1) the *relative advantages* (and disadvantages) of an innovation compared to conventional alternatives on the market; (2) the *compatibility* with the adopter's values, experiences and needs; (3) the *complexity*, i.e. how easy it is to understand and use the innovation; (4) the *trialability*, i.e. the possibility to test the innovation before the decision to adopt; and (5) the *observability* or visibility of an innovation and its consequences (Fig. 1).

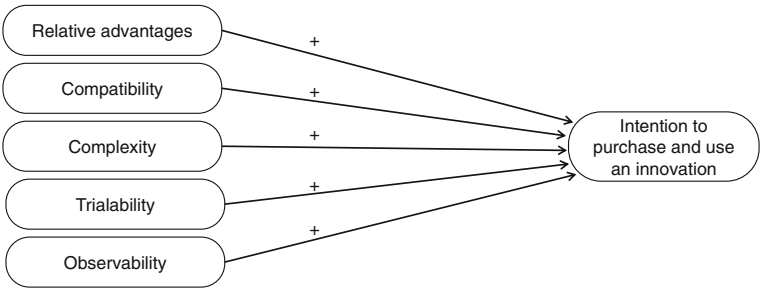

Fig. 1 Theoretical model to explain the intention to purchase and use an innovation, adapted from Rogers (2003)

Applied to electric vehicles, this implies that (1) electric vehicles will be evaluated based on their *relative advantages* when compared with conventional vehicles as well as other modes of transport. As outlined above, when comparing electric vehicles to conventional vehicles, consumers might perceive their high purchase price as well as their low driving range in combination with long charging durations as major disadvantages. On the positive side, electric vehicles could score highly from a consumer viewpoint with regard to driving pleasure and noise, positive image and zero exhaust emissions. Regarding the *compatibility* of electric vehicles (2), evaluating mobility panel data for Germany (Kley 2011) shows that the majority of weekly travel profiles (roughly 60 %) can be covered by the current range of electric vehicles (24 kwH battery) and overnight charging. However, the consumers' perception might differ with regard to electric vehicles matching their travel profiles as they might not keep track of their exact driving profile, or might still prefer to be flexible concerning spontaneous longer trips. Besides individual needs, values play an important role when evaluating whether electric vehicles are perceived as compatible. For example, consumers who believe strongly in the protection of the environment and resources may perceive electric drive vehicles as an attractive and sustainable means of transport which allows them to reduce the environmental impact of their car use (Skippon and Garwood 2011). With regard to the *complexity* of use (3), electric vehicles are sometimes said to be easier to use than conventional cars (e.g. Knie et al. 1999) as they do not have e.g. a gearshift. However, consumers who have not had the opportunity to actually drive an electric vehicle might expect them to be more complex. With regard to the remaining factors of the diffusion of innovation model (Rogers 2003) (4 and 5), as stated before, there are only a few electric vehicles already on the roads, so that *trialability* and *observability* might be perceived as relatively low.

In order to promote the acceptance of electric vehicles, it is important to analyse the perception of these attributes and their role in the acceptance of electric vehicles; particularly, how the evaluation of attributes changes when consumers gain more information and experience, with electric vehicles and expectations become more realistic. That changes do indeed take place is shown by a study by

Carroll and Walsh (2010), who surveyed 42 participants of a public drive event with electric vehicles (with the SmartFortwo electric drive) both before and after a test drive. Participants indicated a higher intention to use an electric vehicle as a regular car after the trial and their ratings based on their actual experience exceeded their previous expectations of several vehicle attributes (acceleration, top speed, braking performance, comfort, range, operation of controls). In other short field tests of electric vehicles, the participants were similarly enthusiastic about the vehicle's performance and in some cases acceptance, i.e. usage and purchase intentions, increased (Skippon and Garwood 2011; CABLED 2010). Other recent studies have pointed out that some participants of field trials (Graham-Rowe et al. 2012) or early users (Kurani et al. 2007) adapted themselves to the special characteristics of plug-in-hybrid vehicles and electric vehicles, for example, they changed their driving behaviour or rethought their lifestyles.

In addition to these recent studies, several authors have analysed data from field trials conducted in the late 1990s or the early 2000s, when electric vehicles experienced their first boom (e.g. Knie et al. 1999). Their results are basically in line with the findings described in more recent studies. Both Gould and Golob (1997) and Gärling (2001) surveyed participants of electric vehicle trials before and after using the vehicles.

The respondents ($n = 53$) in the study by Gould and Golob (1997) participated in a 2-week long trial of electric vehicles (prototypes). After the trial, the participants were more positive about electric vehicles as a key technology to solving air pollution than beforehand. Regarding the reasons for buying an electric vehicle, the environmental benefit was cited the most frequently before the trial. After the trial, the most frequently selected reason for acquiring an electric vehicle were the lower running costs.

Gärling (2001) analysed the perceptions of 42 families as well as of 32 owners of a conventional Renault Clio who participated in field trials with the Renault Clio Electrique (range 60–70 km) and came to different conclusions. In the family-sample, significant differences were found between the ratings for buying intentions, safety and usefulness before and after the trial. After the trial, purchase intentions were lower than before; the electric vehicle was perceived as less useful for shorter and longer leisure trips and was perceived as less safe than before. The author assumes one reason might be that this make of electric vehicle is not very popular in Sweden, so some respondents might not have distinguished between the make and the technology. Another reason could be the fact that the respondents—mostly families with children—compared the electric vehicle to their conventional car, which was usually larger than the electric vehicle. In the second group of consumers, the owners of a conventional Renault Clio, no significant effects were found of the trial on their ratings. However, more than half of the participants reported problems with the range.

Thus, these early studies present different effects for acceptance before and after use. However, these results relate to the first generation of electric vehicles and are not fully transferable to the current situation, as they refer to vehicles and charging

infrastructures which were less developed than those currently on the market or soon to be available.

3 Research Questions

The presented outline points out the need for studies which analyse acceptance of electric vehicles of the current generation by actual users who integrated the electric vehicle into daily routines. Thus, we focus on analysing how the preconditions of acceptance identified by Rogers are perceived and how they differ or develop, respectively, when consumers have gained experience on using electric vehicles. These questions are explored by means of two studies providing both longitudinal data (*study 1*) to analyse possible changes due to the experience of driving electric vehicles and cross-sectional data (*study 2*) to analyse differences in acceptance between consumers using electric vehicles with consumers still intending to adopt electric vehicles for regular usage.

4 Study 1

The first two authors of this chapter are members of the team which coordinated the social scientific accompanying research of the pilot regions for electric mobility, in which the users of electric vehicles are surveyed on their expectations as well as their actual experiences with the vehicles. This project created the dataset for the first study.

4.1 Methodology

Sample and procedure. The first study presented is conducted within the programme "Electric Mobility in Pilot Regions" which was implemented by the German Federal Ministry of Transport, Building and Urban Development. In eight pilot regions several kinds of electric vehicles (two-wheelers, transporters, and passenger cars) are tested by several types of users (private as well as commercial). Additionally, the vehicles are used in various business models: car-sharing or hired car, as company or fleet vehicles or in exclusive private use. Every region conducts several projects on electric mobility, including several field trials. For all of these projects, identical surveys were developed and—if possible—distributed to the participants of the field trials. A longitudinal design was applied in order to identify possible changes in consumer acceptance over time:

- Survey T0 assessed consumer expectations of electric mobility prior to vehicle delivery.

- Survey T1 assessed impressions of the vehicles and electric mobility after a few weeks of usage.
- Survey T2 assessed impressions after several months of usage.

The survey includes questions on the vehicle types, planned usage, demographics, expected advantages and disadvantages of the vehicles, and item batteries with general aspects of acceptance as well as more detailed questions about specific attributes of the electric vehicle and the infrastructure. The survey was available online as well as in a paper version.

In this chapter, we analyse changes in perceptions between the T0 and T1 survey by comparing selected items based on a sub-sample of 145 participants who took part both in the T0 and T1 survey.

Table 1 shows that the majority of this sub-sample uses a battery-electric car. Most of the cars are used very frequently and mainly for private purposes. As far as data was available, the respondents are mostly male, highly educated, middle-aged and married or in a relationship. This corresponds to sample characteristics of similar studies (e.g. Gould and Golob 1997).

Measures and analyses. In order to measure the acceptance of electric vehicles, i.e. the willingness to adopt, participants were asked to indicate to what extent they

Table 1 Characteristics of the sample, the vehicles, frequency and mode of use

Attribute	Share
Vehicle	
Battery-electric car	56 %
Pool of different electric vehicles	16 %
Two-wheelers	20 %
Battery-electric transporter	6 %
Plug-in-hybrid car	2 %
Mode of use	
Predominantly private use	40 %
Predominantly commercial use	22 %
Duration of use	
1 week	35 %
2–4 weeks	15 %
5 weeks to 2 months	11 %
More than 2 months	9 %
Frequency of use	
(almost) every day	50 %
1–3 days per week	26 %
1–3 days per month	15 %
Less often	7 %
Gender	
Male	70 %
Female	29 %
Age	
Range	21–72 years
Mean	39 years

are willing to "substitute a conventional vehicle by an electric vehicle". As for most other items, evaluations were provided on a six-point Likert scale (1 = "do not agree at all"; 6 = "fully agree").

With regard to Rogers' (2003) diffusion of innovation model, several items refer to the first three factors as described in the following, while (4). trialability and (5). observability were assumed to be given by embedding the survey within the fleet trials.

1. With regard to *relative advantages* (and disadvantages) of electric vehicles, participants were asked for a general evaluation of the possibility to save money by using the electric vehicle (instead of a conventional vehicle) and, in more detail, about the perception of the purchase price, the operating as well as the service and maintenance costs. Furthermore, the participants were asked to evaluate charging time, availability of public charging stations, driving pleasure and driving comfort, acceleration, maximum speed, and driving noise. Moreover, the participants were to evaluate the range and their confidence in the indicated range and if there are any positive reactions of others towards the electric vehicle.
2. With regard to the *compatibility* of the electric vehicle with the individual values, experience and needs, the participants were asked about the perceived usefulness in everyday life, the environmental friendliness and if the participants are enthusiastic about the electric vehicle.
3. In relation to the perceived *complexity*, participants rated the ease of using as well as of charging the vehicle.

For these indicators of Rogers' (2003) diffusion of innovation model, we analyse how evaluations change before and after using an electric vehicle in a field trial. To test for statistically significant changes in attitudes, paired t-tests are conducted.

4.2 Results of Study 1: How Do the Predictors of Acceptance Change When Consumers Have Gained Experience in Using Electric Vehicles?

In the following, the results of the survey are presented for each diffusion factor of the innovation model.

4.2.1 Relative Advantages of Electric Vehicles

Table 2 summarises the results of the items referring to the relative advantages of electric vehicles. The general potential to save money by using the electric vehicle is rated positively on average. When looking at answers to more detailed

Table 2 Evaluations of the relative advantages of electric vehicles concerning the aspects costs, range and infrastructure and performance

	T0 mean	T1 mean	n	Interpretation
Costs				
Saves money	4.51	4.69	118	No difference
Low purchase price	2.00	1.81	31	No difference
Low operating costs	4.79	4.76	58	No difference
Range and infrastructure				
Sufficient range	3.92	3.65	103	No difference
Confidence in indicated range*	3.53	3.93	85	Perception more positive in T1
Short charging time**	3.64	3.17	101	Perception more negative in T1
Availability of public charging stations***	2.85	2.14	95	Perception more negative in T1
Performance				
Driving pleasure***	4.47	5.11	92	Perception more positive in T1
Good acceleration**	4.60	5.02	94	Perception more positive in T1
Adequate maximum speed	4.01	4.09	103	No difference
Good driving comfort	4.13	4.27	106	No difference
Agreeable driving noise	4.93	4.96	106	No difference
Image				
Positive reactions of others**	4.70	5.19	69	Perception more positive in T1

The items were rated on a 1–6 scale, where "1" means "does not apply at all" or "not at all" and "6" means "applies perfectly" respectively "fully". Mean values from 1 to 2.5 are interpreted as negative, mean values of 2.51–4.5 as undecided and mean values from 4.51 to 6 as positive. Significance level: $*p < .05$, $**p < .01$, $***p < .001$

questions, it can be seen that the participants know about the specific cost structure of electric vehicles: purchase prices are rated negatively, operating costs, in contrast, positively. None of the evaluations regarding costs changes significantly between T0 and T1.

The range of the electric vehicles is rated neither positively nor negatively and is the same for T0 as for T1. Similarly, there is no strong confidence in the indicated range, but the evaluations become more positive in T1. The charging time is a critical issue for the respondents: the evaluations are in the middle spectrum and become more negative in T1. The evaluations regarding the public charging infrastructure are neutral in T0 and become (significantly more) negative in T1.

Before using the electric vehicles (T0), the participants expect a high level of driving pleasure which is rated even more positively after using the vehicle for some time (T1). Equally, in T1, the participants are positively surprised by the acceleration of their vehicles. Maximum speed and driving comfort are rated neither positively nor negatively in the T0 and the T1 surveys and ratings do not change over time. Driving noise is rated positively in both surveys and, again, perceptions do not change between T0 and T1.

Participants expect positive reactions of others to the vehicle (T0) and actually perceive them as even more positive after having used the vehicle for some time (T1).

4.2.2 Compatibility with the Adopter's Values, Experiences and Needs

As shown in Table 3, the usefulness of the vehicles as well as their environmental friendliness are positively rated. Perceptions do not change between T0 and T1. The statement that the respondent is enthusiastic about the electric vehicle is rated positively by the average participant and becomes more positive at T1.

4.2.3 Complexity

The participants in the field trials expect that using their vehicle will be easy in the T0 questionnaire. Their ratings are even more positive while using it. Similarly, expectations concerning the handling of the vehicle are positive and become better in the course of usage.

Charging was not expected to cause any problems according to the statements of the participants in the T0 survey and the evaluations become even more positive when using the vehicle (Table 4).

4.3 Summary and Discussion of Study 1

Even though the majority of the participants do not have concrete purchase intentions (57 % in T0 and 46 % in T1 "do not agree at all" resp. "tend not to agree" with the statement "substitute a conventional vehicle by an electric vehicle"), for most of the items, the respondents evaluate electric vehicles and their attributes positively: twelve item ratings are in the positive range of the Likert

Table 3 Evaluations regarding the compatibility of the electric vehicle

	T0 mean	T1 mean	n	Interpretation
Useful in everyday life	4.98	5.17	117	No difference
Environmentally friendly	5.16	5.10	126	No difference
I am enthusiastic about the electric vehicle**	4.64	5.03	132	Perception more positive in T1

The items were rated on a 1 to 6 scale, where "1" means "does not apply at all" or "not at all" and "6" means "applies perfectly" respectively "fully". Mean values from 1 to 2.5 are interpreted as negative, mean values of 2.51 to 4.5 as undecided and mean values from 4.51 to 6 as positive. Significance level: *p< .05, **p< .01, ***p< .001

Table 4 Evaluations regarding the complexity of using the electric vehicle

	T0 mean	T1 mean	n	Interpretation
Ease of use***	4.84	5.34	134	Perception more positive in T1
Handling easy to learn***	5.12	5.69	93	Perception more positive in T1
Easy handling of charging**	5.07	5.45	108	Perception more positive in T1

The items were rated on a 1 to 6 scale, where "1" means "does not apply at all" or "not at all" and "6" means "applies perfectly" respectively "fully". Mean values from 1 to 2.5 are interpreted as negative, mean values of 2.51 to 4.5 as undecided and mean values from 4.51 to 6 as positive. Significance level: *p< .05, **p< .01, ***p< .001

scale, six in the neutral range, while two are rated negatively. All items measuring the compatibility as well as the complexity of the electric vehicle received mean ratings in the positive range. By contrast, the respondents are still sceptical towards some aspects regarding the relative advantages of the vehicles.

Looking at the changes, it transpires that of all the items integrated into the analyses, most ratings do not significantly change between T0 and T1; eight ratings become more positive (spread over all factors of Rogers' (2003) diffusion of innovation model), and two items are rated more negatively (both assessing relative advantages). In the following, the results are discussed in detail.

4.3.1 Relative Advantages

The costs of electric vehicles are assessed sceptically by the participants: the purchase price is evaluated as unsatisfactory—for future as well as actual users. Graham-Rowe et al. (2012) found similar results. On the other hand, the participants appreciate the low operating costs of electric vehicles. No change in evaluations could be observed between T0 and T1 with regard to costs.

Aspects of range and infrastructure receive mixed reviews: participants seem undecided regarding the aspects range, confidence in the indicated range and charging time, i.e. the ratings are in the middle of the spectrum. While perceptions of range do not change between T0 and T1, confidence in range increases. In contrast, the evaluations of the charging duration and the availability of charging stations become more negative.

It can be assumed that the short range of electric vehicles compared to conventional vehicles is perceived by users as a limitation of their personal mobility and autonomy. This interpretation corresponds with the results of other studies: Gould and Golob (1997) found that participants in field trials with electric vehicles have high requirements regarding the range (more than 100 miles). Although they kept a travel diary and thus knew that most of their trips were less than fifty miles per day, the tolerance towards the limited range is low. The experience with the electric vehicles did not influence the perceptions of desired range. Similarly, Gärling (2001) found that 70 % of the participants in a 9-week field trial perceived the range of their electric vehicle (65 km) as too short. They required a range of at

least 130 km. Graham-Rowe et al. (2012) who interviewed battery-electric vehicle users reported that users became more aware of their driving profiles because they had to plan their journeys because of limited range and long recharging times. Knie et al. (1999) found similar results.

However, confidence in the indicated range obtained better ratings in the group of actual users in our study. Consequently, the participants perceive they are better able to handle the limited range. The evaluation of the CABLED (2010)-trial came to similar results: it turned out that the longer people used them, the vehicles were driven more miles, i.e. they were driven more frequently and for longer journeys. Thus confidence in the vehicles may have increased and 'range anxiety', i.e. worries that the vehicle has insufficient battery performance or charge to reach the destination may have decreased. The fact that range is a complex issue from the user perspective has also been pointed out by a recent study by Franke et al. (2011) which showed that the perception of what is a comfortable range varied substantially among the participants in a field trial.

Medium and negative ratings of charging time and public charging infrastructure respectively in T0, which become even more negative in T1, indicate that the already low expectations of the participants were not met by actual usage experience and that these aspects might be critical issues.

The variables concerning performance aspects received medium (maximum speed, driving comfort) to positive (driving pleasure, acceleration, and driving noise) ratings. The evaluation for acceleration and driving pleasure in T1 became more positive than in T0. In the 1990s, Knie et al. (1999) found that such perceived advantages can induce that technical constraints of electric vehicles were not necessarily considered as a barrier to adopting an electric vehicle. Our first analyses point to the direction that this conclusion may still be valid.

Positive reactions of others are rated positively and evaluations become better between T0 and T1. Axsen and Kurani (2009) showed that social interactions in households and social networks shape the evaluations of plug-in-hybrid vehicles and probably also of electric vehicles generally. The majority of the networks named at least one social interaction that they had perceived as being highly influential on the evaluation of plug-in-hybrid vehicles. For example, these interactions included asking others about their potential motives for buying a plug-in-hybrid vehicle or seeking for help to understand technical aspects. Thus, a perceived increase of positive reactions of third parties towards the electric vehicle might lead to a better acceptance of the electric vehicle.

Taking an overall look at the items which assess perceived *relative advantages* before and during actual use, it turns out that most of the ratings remain basically unchanged, while they become more positive for some aspects and more negative for others. Thus it is difficult to draw a general conclusion as to how users appraise the relative advantages of electric vehicles after usage experience.

4.3.2 Compatibility

The *compatibility* of the electric vehicle with the users' values, experiences and needs, i.e. enthusiasm, is rated positively and assessments became better in the course of usage.

Usefulness in everyday life is rated positively as well and there is no difference between T0 and T1. In contrast, in the study of Graham-Rowe et al. (2012), the utility of the electric vehicles was perceived as limited since the interviewees hesitated to make longer journeys with their vehicles because of their scepticism regarding range.

Evaluations regarding environmental friendliness were very positive and did not change between T0 and T1. This is in line with findings of Skippon and Garwood (2011). In addition, Graham-Rowe et al. (2012) found that some users appreciate the "feel-good factor" related to environmental benefits when driving an electric vehicle. The perception that the car is environmentally friendly might, however, lead to rebound effects (Fuji 2010), i.e. higher consumption related to energy-efficient technologies.

In sum, based on these aspects, the evaluations of compatibility with values, experiences and needs seem to be in a positive range, at least for the issues under study.

4.3.3 Complexity

Handling the vehicle did not cause any problems: learning how to use it, the ease of use as well as handling of charging are all rated positively and the ratings further increase in T1. The results of the survey show that, although some of the vehicles driven are not yet ready for the market, this does not seem to be a challenge for the participants. They do not expect difficulties nor do they indicate that they experienced any. Using an electric vehicle is not perceived as complex.

4.4 Limitations of Study 1

The generalisability of these findings is certainly limited due to the special characteristics of the participants: the sample is quite homogeneous regarding gender, age and education. Thus it is not possible to draw conclusions for other potential users of electric vehicles. In addition to this, field trials can be regarded as a special case of adoption, because the participants are part of special programmes and often do not have to pay the full costs of vehicle use. Additionally, as the usage phase is declared an official test and is limited in time, it can be assumed that the participants display relatively positive attitudes and a higher degree of tolerance towards possible disadvantages of the electric vehicles. When the electric vehicle is used as an additional vehicle instead of replacing an existing one in the household or the

company fleet, this may lead to similar effects. Further, the vehicles might be highly promoted; possibly more than in the case of purchasing a conventional car. Thus the final or actual adoption has to take place after the field trials.

However, 20 % of the respondents in the first study used their vehicle for more than one month. The participants were also able to integrate the vehicles in their everyday life, since the majority used it at least once per week. A wide variety of battery-electric or plug-in hybrid vehicles were field-tested in the pilot regions. Based on these arguments, we assume that valid conclusions can be drawn from our results for the actual adoption of electric vehicles in the current market phase.

5 Study 2

In order to compare consumer groups who differ in their affinity towards electric vehicles and to identify promising target groups for electric mobility, as well as relevant factors for adoption, one of the authors of this chapter together with her colleagues conducted a large online survey in Germany in 2010 with potential car buyers (cf. Peters et al. 2011).

5.1 Methodology

Similar to *study 1,* the questionnaire of this online survey includes items assessing perceived attributes of electric vehicles according to Rogers' (2001) diffusion of innovation model, and the participants' likelihood to purchase and use an electric vehicle, as well as socio-demographic items. Moreover, the affinity towards electric vehicles, i.e. the knowledge and general interest in electric vehicles, was measured.

The survey sample ($N = 969$) contains 81.4 % men. The mean age was 40.9 years, the modus of monthly household income was € 2,001–3,000, the average household size was 2.48 persons, and the average number of cars owned by a household was 1.43.

The participants were divided into different consumer groups according to their use of an electric vehicle as well as their interest in electric vehicles: (1) actual users of electric vehicles (n = 92), (2) consumers intending to adopt electric vehicles in the future (n = 244), (3) consumers interested in electric vehicles, but without concrete purchase intention (n = 352), and (4) consumers who are not interested in electric vehicles ($N = 281$).

Analyses of variance were conducted in order to analyse differences in the perceived characteristics of electric vehicles between these consumer groups. In the following, we summarise the results of these analyses based on Peters et al. (2011).

5.2 Results of Study 2: How Do Consumers with Different Levels of Affinity Towards Electric Vehicles Differ in Their Acceptance of Electric Vehicles?

The analyses generally show that the more interested respondents are in purchasing or using an electric vehicle, and the more experience they have, the more they tend to evaluate relevant characteristics and aspects of electric vehicles in favour of these vehicles.

Comparing consumers with purchase intentions with those who are interested but have not (yet) decided to adopt an electric vehicle, compatibility with own habits and needs, driving characteristics, operational costs and environmental consequences as well as social norms are evaluated significantly more positively by the consumers with intentions to purchase. The respondents who are not interested in electric vehicles rate these aspects even more negatively than the respondents who are interested but without intention to purchase.

While these groups thus show many differences in their perceptions of electric vehicles, consumers with concrete purchase intentions and users hardly differ significantly from each other in the assessed perceptions. Only the trialability of electric vehicles is rated clearly lower by the first group, as well as by all other non-users when compared to the group of actual users. With regard to the other aspects which were assessed, users and consumers with intention to purchase perceive electric vehicles as nearly equal (or slightly superior) to conventional vehicles in terms of driving characteristics, and slightly lower in terms of basic characteristics, like security or storage capacity. Operational costs and environmental consequences are perceived to be clearly in favour of electric vehicles. Also, the perception of compatibility of electric vehicles with own habits and needs, ease of use and social norms is clearly in the upper, i.e. positive range of the scale. Infrastructure, not surprisingly, is perceived as highly superior for conventional vehicles. For more details on the survey and its results, we refer to Peters et al. (2011).

5.3 Discussion of Study 2

The prevailing correspondence between actual users and consumers with concrete intention to purchase indicates that consumers who already intend to adopt an electric vehicle in the near future have come to almost the same conclusions regarding the properties of electric vehicles as actual users, and thus may have rather realistic expectations. However, they have not yet implemented their intention into real action. The results suggest that, in fact, a perceived or objective lack of possibilities to try out and evaluate electric vehicles in use and to compare different models in real life could be one significant barrier to actual adoption.

Such a pronounced decision-making and evaluation behaviour is typical of the group of early adopters, according to Rogers (2003). Moreover, the currently still limited availability of electric vehicles and the expectation of future price reductions could inhibit the final purchase decision. Consumers with intention to purchase could still be waiting for a larger variety of models to enter the market at a lower price, which is a reasonable forecast of market development.

6 Final Discussion and Conclusion

In this chapter, we surveyed participants of heterogeneous field trials and analysed how increasing experience with electric vehicles influenced the predictors of individual acceptance in applying a longitudinal design. Further, perceptions of electric vehicles by both individuals highly interested in buying an electric vehicle and respondents who have acquired and used an electric vehicle are compared in order to identify potential differences between these different consumer groups.

The results of the survey in the pilot regions (*study 1*) suggest that the participants are already very aware of the advantages and disadvantages of electric vehicles since the majority of the ratings of the items do not change between the T0 and T1 survey. Some relative advantages, for example, regarding performance or image, are more positively evaluated in T1. All of the items in the complexity factor received better assessments in the T1 survey, thus the users were positively surprised by the easy handling of the vehicles, although ratings before using them were already very positive. However, purchase intentions are still very limited—in the T0 as well as in the T1 survey. Thus there may be other reasons for these low intentions to adopt an electric vehicle than those analysed in this chapter.

The results of the cross-sectional online survey (*study 2)* concerning differences between the various consumer groups generally indicate a clear relation between a more positive perception of the relevant characteristics of electric vehicles with more experience and interest in electric vehicles and are therefore in line with the findings from the pilot regions.

When comparing the results of these two studies, it has to be considered that they differ in some aspects. The survey with participants in the field trials applied a longitudinal design: the same respondents were questioned at two different times whereas the cross-sectional survey compares different consumer groups. Moreover, the samples are different: in the first study participants of field trials and in the second one German car drivers were questioned, including electric vehicle owners who have regularly used an electric vehicle. However, both studies point out that increased information about and experience with electric vehicles positively influence the evaluation concerning some aspects of the vehicles. These results correspond to previous studies which indicate that it is crucial to expose customers to electric vehicles or to give them detailed information, on the one hand, to study acceptance of electric vehicles, and on the other hand to promote

actual adoption of electric vehicles (cf. for example Anable et al. 2011; Carroll 2010; Martin et al. 2009). This finally points to the great importance of enhancing the trialability and observability of electric vehicles.

Acknowledgments We gratefully acknowledge funding from the German Federal Ministry of Transport, Building and Urban Development (BMVBS) and the German Federal Ministry of Education and Research (BMBF). Special thanks go to the participants of our surveys and the projects which provided the data.

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