Is EV experience related to EV acceptance? Results from a German field study

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Abstract

Electric Vehicles (EVs) provide a promising solution to rising CO_2 emissions and, in the long term, the dependence on oil. In the present study, we examined how the current state of EV technology is perceived and accepted by a sample of early adopters and how experience influences the evaluation and acceptance of EVs. In a 6-month field trial, data from 79 participants who drove an EV in the Berlin metropolitan area were assessed at three data collection points (before receiving the EV, after 3 and 6 months of usage). Participants reported a wide range of advantages, but also barriers to acceptance. They perceive EVs positively and show positive attitudes towards EVs and possess moderate purchase intentions. Experience can significantly change the perception of EVs. Many advantages became even more salient (e.g., driving pleasure, low refueling costs) and several barriers (e.g., low noise) were less frequently mentioned. Experience had a significant positive effect on the general perception of EVs and the intention to recommend EVs to others, but not on attitudes and purchase intentions. Our findings reveal that EVs are already evaluated positively, but in order to achieve widespread market success in Germany, solutions are needed for important barriers like acquisition costs. Providing real-life experience could be a promising marketing strategy.

Key Words: Electric vehicle, acceptance, experience, advantages and barriers, purchase intentions, field study

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1. Introduction

1.1. Background

In an era when climate change and limited fossil fuel resources are highly relevant concerns, the widespread adoption of renewable energy-based transportation has become critically important. In the EU, one fifth of CO_2 emissions are produced by automobiles (European Commission, 2012). In order to comply with the Kyoto protocol, the EU must reduce emissions by approximately 20% by 2020 (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety), and therefore, automobile emissions must be significantly reduced. These facts underline the need for the development of alternative propulsion systems. Electric vehicles[1] (EVs), vehicles with an electric power train that only work on a battery, represent one promising technological development that has the potential to significantly reduce CO_2-emissions emitted by automobiles (King, 2010). Still, there is a debate about the real environmental benefit of EVs. According to Hawkins, Singh, Maieau-Bettez and Strømman (2012), the real amount of potential CO_2-emissions savings depends on many factors (e.g., production, electricity mix used for charging). In addition to questions concerning the real environmental benefit of EVs, the question concerning the future market success of EVs is of interest. Driving an EV involves many aspects to which a driver of conventional cars has to adapt, including limited range, the charging procedure, regenerative braking, and extremely low noise (Urban, Weinberg, & Hauser, 1996). Potential EV consumers must be willing to manage these additional challenges and currently pay a relatively high purchase price; though, the lower energy prices for recharging would (partly) offset the higher acquisition costs over time (Wietschel et al., 2012). In order to support the widespread adoption of EVs, it is important to develop a better understanding of potential consumers' perceptions of EVs. Specifically, it is important to learn which advantages they are aware of, whether some barriers are insurmountable for them, and if they are willing to manage the challenges of an EV. This study aims to investigate the perception of EVs, including advantages and barriers, as well as acceptance of EVs. Furthermore, the present research aims to help determine whether consumers' perception and acceptance changes after intensive EV usage. These issues were addressed in a field study with drivers who lived in the Berlin metropolitan area and drove an EV for 6 months.

1.2. Perception and acceptance of EVs

To assess the willingness of potential consumers to adopt EVs, researchers in several countries have investigated the potential market share of EVs, including Australia (Higgins, Paevere, Gardner, &

[1] With the term electric vehicle (EV) we refer to a pure battery electric vehicle (BEV) in the present paper. However, several results and conclusions may also generalize to plug-in hybrid electric vehicles (PHEVs) and BEVs with range extender (EREVs).

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Quezada, 2012), Japan (Kuwano, Tsukai, & Matsubara, 2012), Canada (Ewing & Sarigöllü, 1998), the USA (Hidrue, Parsons, Kempton, & Gardner, 2011), and Germany (Lieven, Mühlmeier, Henkel, & Waller, 2011). The typical conclusion from this research is that EVs are not fully competitive (Dagsvik, Wennemo, Wetterwald, & Aaberge, 2002) and the demand is weak (e.g., Achtnicht, Bühler, & Hermeling, 2012). Reasons for this might be several concerns of potential consumers including identified limited range, high costs, limited charging infrastructure (e.g., Ziegler, 2012; Egbue & Long, 2012) and charging time (e.g., Hidrue et al., 2011). These findings provide a clearer picture of the potential for EV adoption; however, the aforementioned research is based on people who typically had no prior experience with EVs. Potential consumers tend to inaccurately predict their interest in products with which they have no experience (Hoeffler, 2003). Given this tendency, it seems promising to focus more on studies that examine acceptance of EVs within the context of real-life experience.

1.2.1. Perception and acceptance of EVs after testing EVs

Some previous studies have assessed perception and acceptance of EVs after providing participants with direct EV experience. In the UK, Skippon and Garwood (2011) as well as Graham-Rowe et al. (2012) gave drivers the opportunity to test an EV on a 10 mile route for 7 days. Skippon and Garwood (2011) reported that participants endorsed the environmental benefits of EVs, assumed that refueling costs are lower compared to a conventional car and were partly willing to consider an EV with 150 km range as a second car. In contrast, Graham-Rowe et al. (2012) reported that participants were rather skeptical about EVs' suitability for daily driving needs and many improvements were needed before participants would be willing to purchase an EV. Additionally, Graham-Rowe et al. (2012) reported that on the one hand many participants were skeptical about the overall CO_2 production of EVs, but on the other hand some individuals reported a "feel-good factor" due to the environmental benefits of the EV. Carroll (2010) studied fleet users and managers who reported that they were more positive about EVs after they had tested them between 1 to 4 weeks. Turrentine, Garas, Lentz, and Woodjack (2011) found similar results: Drivers reported that they have more favorable opinions of EVs and higher purchase intentions after a one year lease of an EV. Taken together, in studies with drivers that have directly experienced EVs, perceptions of EVs vary and purchase intentions were relatively high (e.g., Skippon & Garwood, 2011; Jabeen, Olaru, Smith, Braunl, & Speidel, 2012) compared to those of EV-inexperienced drivers.

When comparing findings of studies with EV-experienced (e.g.,Gärling & Johansson, 1999; Graham-Rowe et al., 2012) and EV-inexperienced drivers (e.g., Egbue & Long, 2012), concerns about EVs were found to be mostly similar, including range, costs, infrastructure, charging time, battery issues, lack of noise, reliability, uncertainty with service availability and safety concerns.

Furthermore, people with or without EV experience perceive environmental friendliness, high energy efficiency, being the future of automobile travel and financial benefits such as lower running costs as advantages (e.g., Egbue & Long, 2012; Jabeen et al., 2012). Still, there seem to be important differences between EV-inexperienced and experienced drivers: Barriers such as 'trip planning' (Jabeen et al., 2012) and advantages including fun driving (e.g., Turrentine et al., 2011), smooth driving, high torque and low noise (e.g., Jabeen et al., 2012) seem to be more salient after gaining EV experience, as they were only reported in studies with EV-experienced drivers. Better insight into the effect of experience on EV acceptance is attainable by utilizing pre-post comparisons.

1.2.2. Perception and acceptance of EVs in pre-post studies

Only a few studies with pre-post comparisons exist in which the change in attitudes towards EVs and willingness to pay for, purchase or use was investigated within the context of ongoing EV experience. In an 11-week trial, EV users' attitudes did not change with increasing experience, but willingness to purchase and perceived safety decreased over time (Gärling & Johansson, 1999). Gould and Golob (1998) found an increase in perceived environmental friendliness after a 2-week field trial. In a more recent study, Carroll (2010) showed that experience produced an observable influence: More drivers were willing to use an EV after a test drive than before. With a stated preference approach, Jensen, Cherchi and Mabit (2013) found that participants' willingness to pay for range, battery life and top speed after EV usage increased within a 3-month field trial.

To our knowledge, there are no studies that explicitly investigated changes in consumers' reports of EV advantages and barriers during the process of gaining EV experience. Jensen et al. (2013) investigated selected EV attributes that are potential disadvantages when using EVs (e.g., purchase price, range). Many potential advantages and barriers were not included in these analyses. When reviewing the literature, it became apparent that there are advantages and barriers that were only reported in studies with EV-experienced drivers. Furthermore, most of those advantages and barriers are features that can be directly experienced when testing an EV (e.g., low noise, smoothness). It might be the case that these EV-specific attributes become more salient when experiencing an EV. As the available literature on EVs indicates that the market potential of EVs is relatively low (e.g., Ziegler, 2012) and that several concerns exist (e.g., Egbue & Long, 2012), it is important to identify the advantages and barriers that are perceived and can be reinforced or positively changed through experience with EVs. This leads to our first research questions: *Which advantages and barriers do users/potential consumers perceive?* Given the reviewed literature, we can further specify this question: *Do users/potential consumers perceive environmental friendliness, lower running costs, energy efficiency, low noise, smooth driving, fun, and home-charging as advantages and limited range, charging infrastructure and duration, battery issues, reliability,* *uncertainty with service availability, low noise as a safety problem, and other safety concerns as barriers? (Q1a).* Furthermore, we aim to answer the following questions: *Do reported advantages and barriers change when using an EV for a longer period of time? Are changes in reports more likely to be positive when advantages and barriers can be directly experienced? (Q1b)*

Apart from potential advantages and disadvantages, the reviewed literature (e.g., Carroll, 2010; Gärling & Johansson ,1999) indicates that experience has a positive influence on acceptance. Burgess, King, Harris and Lewis (2013) also reported that experience is a crucial factor, because drivers reported that it has the potential to change peoples' perception of specific EV attributes (e.g., low noise).Yet, recent studies that directly perform pre-post comparisons regarding changes in EV acceptance over the process of gaining long-term experience are lacking. Older published research on long-term experience (Gärling & Johansson,1999; Gould & Golob, 1998) utilized an earlier generation of EVs with substantially lower performance capabilities. This study aims to bridge this gap and investigates the following questions: *How is the current state of EV technology perceived and is it acceptable to users/potential consumers? (Q2a) Does perception of EVs and acceptance change while testing an EV for a longer period of time? (Q2b)*

1.2.3. Defining perception and acceptance

In order to investigate the previously mentioned research questions, acceptance must be defined. In the scientific literature, different variables were assessed to make conclusions about acceptance or adoption of EVs. In several stated preference studies (e.g., Ziegler, 2012), individuals' preferences for different vehicle attributes (e.g., energy source, range, and price) were investigated. Based upon such data, conclusions can be drawn regarding the circumstances under which people would choose an EV and the potential market share of certain EVs. Other than this approach, attitudes (e.g., Gärling & Johansson, 1999) and direct questions regarding willingness to purchase (e.g., Gärling & Johansson, 1999) or use an EV (e.g., Carroll, 2010) were primarily used as indicators of acceptance. However, some authors investigated perceived advantages and barriers (e.g., Egbue & Long, 2012), perception of EVs (e.g., Burgess et al., 2013) and the willingness to recommend an EV (Jabeen et al., 2012).

According to Schade and Schlag (2003), acceptance is one's attitudinal and behavioral reaction after exposure to a product. Prior to exposure, only 'acceptability' can be assessed, which is a pure attitudinal construct. Schade and Schlag's (2003) definition of acceptance is the basis for our conceptual framework (Figure 1). Consistent with this definition, acceptance of EVs can only be assessed by measuring attitudes and behavior, which is assessed via behavioral intentions (e.g., purchase intentions, intention to recommend). In Schade and Schlag's (2003) study, attitudes are simply reflected in the degree to which a product or system is acceptable, but this does not reflect the various attitude assessments that were used in earlier research (e.g., Gärling & Johanssen, 1999). To expand the concept of attitudes in the present study, attitudes are defined as "predispositions to respond, or tendencies in terms of 'approach/avoidance' or 'favourable/unfavourable' " (p. 2, Van der Laan, Heino, & De Waard, 1997) with respect to EVs. Van der Laan et al. (1997) describes two dimensions (Satisfaction and Usefulness) that cover 'attitudinal' acceptance of technological innovations. This concept is often used in transportation research (e.g., Vlassenfort, Brookhuis, Marchau, & Witlox, 2010). More general opinions regarding, for instance, suitability for daily life or environmental benefit of EVs, are neither covered by the definition of Schade and Schlag (2003), nor by the definition of Van der Laan et al. (1997) and are therefore summarized in this study as 'general perception' of EVs. Given that general perception and different indicators are of interest in this study, a further research question is formulated: *How do general perception of EVs, attitudes towards EVs, as well as the intentions to recommend and purchase interact? (Q3)*

2. Summary of hypotheses

First, regarding Q1 (see section 1.2.2), several advantages and barriers when using an EV that were highlighted in section 1.2.1 and 1.2.2. were reported in studies with EV-experienced users and can be directly experienced when integrating an EV into the daily routine. They might be less salient for EV-inexperienced consumers. Consistent with results of pre-post-comparisons (e.g., Carroll, 2010) that suggest that experience with an EV influences the perception of EV attributes, we expect that:

> *H1: After experiencing an EV, the relevance of low noise as a benefit, high torque, smooth driving, fun, and home-charging as advantages and range and the need for planning as barriers will be higher than before.*

Based on previous research, it is unclear if, and in which direction, the perception of the other hypothesized advantages and barriers will change. Therefore, we chose an exploratory approach.

Second, referring to Q2, findings from different studies (Carroll, 2010; Turrentine et al., 2011) indicate that opinions about EVs and purchase intentions are positively influenced by experience. This could be due to the fact that EVs are relatively new products and most people had little, if any, direct experience with such a vehicle by 2010. Many features like acceleration, sound or range are not comparable to a conventional vehicle, misconceptions regarding EVs exist in many consumers' minds (Burgess et al., 2013) and people in general are skeptical about emerging technology (Hacker, Harthan, Matthes, & Zimmer, 2009). When an EV is successfully integrated into a person's daily routine and is judged to be suitable for daily needs, the general perception of, and attitudes towards, EVs are expected to become more positive. In line with the findings reported above, attitude studies have found that direct experiences with a new product lead to more extreme attitudes (e.g., Smith & Swinyard, 1983). Regarding EVs, perceptions and attitudes seem to become more positive. Based on this argumentation, our hypotheses are:

H2: General perception will become more positive after experiencing an EV.

H3: Attitudes towards EVs will become more positive after experiencing an EV.

As reviewed in section 1.1.2 and 1.2.2, some previous studies showed that behavioral intentions seem to be positively influenced by experience (e.g., Turrentine et al., 2011). Thus, we propose the following hypotheses:

H4: Intention to recommend will increase after using an EV for some time.

H5: Purchase intentions will increase after using an EV for some time.

Third, referring to Q3 (section 1.2.3), longitudinal studies examining the associations between general EV perceptions, attitudes, intention to recommend, and purchase intentions do not exist. If an individual perceives general features of an EV (e.g., suitability for daily life) more positively, he will probably evaluate this kind of vehicle in a more positive (more satisfying and useful) way and vice versa. Therefore, we expect that:

H6: Before and after driving an EV, general perception of, and attitudes towards, EVs are positively correlated.

According to Kraus (1995), attitudes are one important predictor of behavior; however, the strength of the relationship depends on the kind of behavior and different moderating variables. Additionally, Jabeen et al. (2012) showed that the perception of EVs positively influences the intention to recommend and purchase EVs. Thus, people who have a more positive evaluation (perception, attitudes) of EVs should be more willing to recommend and purchase this kind of vehicle. Therefore, we hypothesize that:

H7: General perception and attitudes towards EVs predict the intention to recommend.

H8: General perception and attitudes towards EVs predict purchase intentions.

Furthermore, intention to recommend and purchase intentions are highly correlated in different studies (e.g., Jabeen et al., 2012). Reichheld (2006) argued that the intention to recommend is closely related to the consumer’s own behavior in many areas. In accordance with this, we expect that:

H9: Intention to recommend and purchase intentions are positively correlated.

To provide a clearer picture of our conceptual framework, we summarized the different constructs and their relationships in Figure 1.

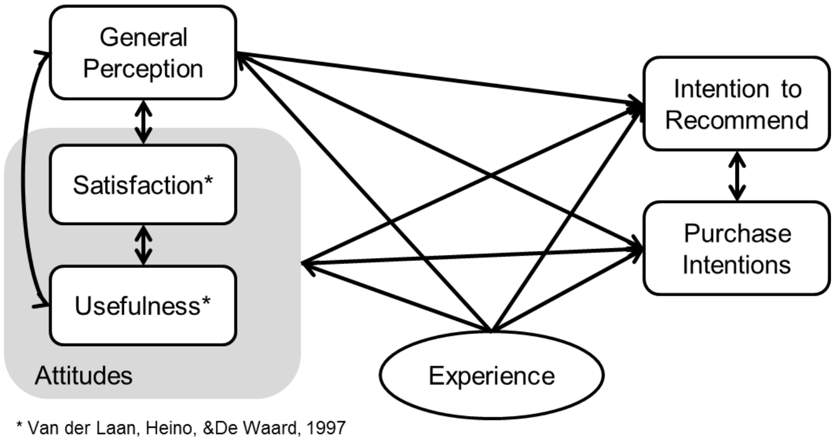

Figure 1. Conceptual framework of the relationships among the study's constructs.

Note. All arrows represent assumed positive relationships.

3. Methods

3.1. Study Design

The present paper presents the results of a large scale field study conducted in the Berlin metropolitan area, which was part of a series of international EV field trials (Krems, Weinmann, Weber, Westermann, & Albayrak, 2013; Vilimek, Keinath, & Schwalm, 2012). In two study periods, 80 participants (40 participants per study period) used an EV, the MINI E, either from the end of June 2009 to January 2010 or from February to August 2010 in their daily routine. Participants were assessed three times: before receiving their car (T_0), after 3 months of driving (T_1) and when returning the car after 6 months (T_2). Through the application of repeated measurements, changes in attitudes and behavior were observable.

3.2. Participants

More than 1200 people from the Berlin metropolitan area applied for the study via an online application form. Eighty households that fulfilled certain criteria (e.g., agreed to an installation of a home charging station, willingness to take part in scientific surveys and to pay the monthly leasing rate of 400€[2]) were selected. The recruitment and selection process is described in more detail in Cocron et al. (2011) and Neumann, Cocron, Franke and Krems (2010). Data was only collected from the one person per household who was expected to be the primary EV user (main user approach). In

[2] The leasing rate is about the same as for a comparable gasoline model with similar leasing conditions. The leasing rate without participating in the scientific study was 650€.

the first period, one participant dropped out before T_1 and another withdrew from the study at a later time. In the second period, one participant did not complete all 6 months.

Seventy-nine participants (67 men, 12 women) completed T_0 and T_1. They were on average 49 (*SD* = 9.6) years old. Except for one, all participants lived in the city of Berlin; one lived in a suburb 25 km away of the city center. Most participants (70.1%) had no experience with any form of electric drive train in a vehicle. Three-quarters of participants were highly educated (75.6% held a university degree), 12.8% completed an apprenticeship, 9.0% finished vocational school and 2.6% reported graduation from high school as their highest degree. Most households (53.4%) consisted of three or more persons, two adults lived in 39.2% of the households and the sample included 7.6% single-households. Few participants (6.3%) did not own a car before the study and 26.6% reported that the EV would substitute for one of their vehicles. The majority of participants had a second car available during the study (one additional car: 48.1%; two: 31.6%; three or more: 10.1%). The household size and available vehicle fleet correlated significantly ($r = .31$, $p = .006$). The majority of participants (91.1%) endorsed using the EV for work trips that varied considerably in length ($M = 17.5$ km, $SD = 10.7$). German early adopters in other studies (e.g., Wietschel et al., 2012) showed similar distribution on sociodemographic variables. Compared to the population of early adopters, German car drivers in the representative large-scale survey “Mobility in Germany 2008” (Mobilität in Deutschland, MiD; infas and DLR, 2010) were younger ($M = 42$), included fewer men (51%), were not as highly educated (40% had at least a university of applied science entrance qualification) and had smaller household sizes (36% of households had three or more persons) (see Franke & Krems, 2013b).

3.3. Data collection

To investigate study hypotheses, portions of the conducted interviews and questionnaires were used.

3.3.1. Perceived advantages and barriers of EVs

In the first two interviews (T_0 & T_1), participants were asked the following open-ended questions: 1) “*In your opinion, what are the greatest advantages of electric vehicles like the MINI E?*” and 2) “*In your opinion, what are the greatest barriers to acceptance of electric vehicles?*” At T_1, users were asked to answer based on their experiences beforehand.

Recordings of the interviews were transcribed verbatim and coded using the qualitative data analysis software package MAXQDA 10. The qualitative content analysis by Mayring (2000), particularly the inductive category development, served as a guideline for coding. After coding all of the obtained interview data, reliability was checked, categories were interpreted and frequencies of assigned categories were analyzed. Because qualitative analysis might be biased or highly subjective due to the dependence on researchers' coding and interpretation of transcribed data, two different strategies to verify analyses were pursued, as suggested by Elliott, Fischer and Rennie (1999). First, two researchers on the research team coded both the first 25% of the transcripts and continually discussed category development and text interpretation. For the overlapping 25% of the data, the interrater reliability using Cohen's κ proved to be very good (κ = 0.81, *p* = .000; Landis & Koch, 1977). This procedure was used to ensure that categories were shared between coders and that the interpretation was valid. Notably, only minimal interpretation was needed, because participants made mostly clear statements, at least in terms of the advantages and barriers they reported. While coding the rest of the material, researchers discussed more complex text passages. Second, some illustrative quotes were included in this paper to give the reader the opportunity to follow our interpretation. At the conclusion of content analysis, researchers subdivided the categorized advantages and barriers into "non-experiential"/not directly experienced or "experiential"/ directly experienced and frequencies were analyzed.

3.3.2. Perception, attitudes towards EVs and behavioral intentions

Regarding *General Perception* of EVs, five items (see Table 1) were consistently used at all points of data collection. These items were summarized to create the scale *General Perception* of EVs (.67 ≤ Cronbach's α ≤ .70). A 6-point Likert Scale from 1 (*completely disagree*) to 6 (*completely agree*) was applied for all items, as well as for all intention items.

Furthermore, the *Van der Laan Acceptance Scale* (Van der Laan et al., 1997), an instrument for measuring acceptance that contains two dimensions (*Satisfaction* and *Usefulness*) was implemented. Only users who participated in the second study period were asked at all points of data collection to respond to the nine semantic differentials (ranging from -2 to 2) while evaluating the EV. Users participating in the first period were asked at T_1 and T_2, but not at T_0. Four of nine semantic differentials belong to the *Satisfaction* scale (e.g., *pleasant – unpleasant*, *nice – annoying*). The other five items represent the *Usefulness* scale (e.g., *useful – useless, bad – good*). The internal consistency of *Usefulness* (.64 ≤ Cronbach's α ≤ .82) and *Satisfaction* (.70 ≤ Cronbach's α ≤ .86) was satisfactory at all data collection points.

One item was administered to assess the *Willingness to Recommend* an EV (Table 1). It included the wording, "would recommend to my best friend", which has been shown to reliably predict customers' behavior in most contexts (Reichheld, 2003). Three items assessed purchase intentions (see Table 1). In particular, two items assessed the *Willingness to Pay*. These items were anchored on realistic leasing rates and purchase prices for EVs which would be comparable to the test vehicle in performance. The third item assessed the *Willingness to Purchase* an EV after the project, but it was only administered in the second study period at all three points of data collection (first period: T_1 & T_2).

Table 1. Overview of items assessing general perception of EVs, intentions to recommend and purchase an EV.

Scales (Cronbach's alpha) and associated items
General Perception (.67 ≤ Cronbach's α ≤ .70)
Electric vehicles are a key solution to solving air pollution. (Gould & Golob, 1998)
Electric vehicles are the means of transport for the future.
Electric vehicles should play an important role in our transportation systems.
Electric vehicles provide driving pleasure.
Electric vehicles are suitable for everyday use.
Willingness to Recommend
I would recommend electric vehicles like the MINI E to my best friend.
Willingness to Pay (.57 ≤ Cronbach's α ≤ .62)
At the moment, I could imagine leasing an EV like the MINI E for a monthly rate of 650€.
I would pay one third more for an EV than for a comparable conventional vehicle.
Willingness to Purchase
I am seriously planning to purchase an EV after this study.

Note. For all three data collection points, internal reliability was calculated. 6-point Likert scale.

3.4. Test vehicle

The test vehicle was a converted standard MINI Cooper, commonly referred to as the MINI E (two-seater, 150 kW power, 220 Nm torque, top speed of 94 miles/h (≈150 km/h), without a sound generator), range of 104 miles (≈168 km) on a single charge under 'normal driving conditions'. A lithium ion battery pack that took up the rear seats and part of the trunk stored the power and was rechargeable using 32 and 12 Ampere. The regenerative braking system of the EV transferred kinetic energy from the momentum of braking back into the battery. Besides using the public charging stations that were available in Berlin, all users could recharge at home using a "wallbox". An empty battery took approximately four hours (32 Ampere) to charge.

4. Results

4.1. Perceived advantages of EVs and barriers to acceptance – Qualitative data (H1 & exploratory approach)

To investigate perceived advantages and barriers, frequencies of reported categories and the changes in participants' reports were analyzed. The McNemar test, with Yates correction for continuity, was performed to test if participants significantly changed their reports of perceived advantages and barriers. If preconditions of the McNemar test were violated, we used the binomial test. Because the experience effect was of interest, the effect size was calculated according to Green and Salkind (2003) (i.e., the proportions of participants that endorsed the particular advantage or barrier at T_0 was subtracted from the proportion of participants that endorsed the advantage or barrier at T_1). Although participants were asked to report general advantages and barriers, it became clear in the interviews that they often spoke in personal terms. It was not possible to distinguish between advantages/barriers that were perceived to be general or personal in most cases; therefore, this differentiation was not included in the analyses. However, some of the reported advantages and barriers could have been directly experienced while integrating the EV in daily life and others could not. This is addressed in the presentation of the results.

4.1.1. How perception of advantages changes with EV experience

Statistical results regarding perceived advantages are shown in Table 2. The most frequently reported experiential advantage was the *low noise emission* of the vehicle. After 3 months, participants were even more enthusiastic about the *low noise emission* and changes in reported frequencies were significant.

> "It might sound trivial, but I almost think that the greatest advantage is that [the EV] is silent. That's the best part about the whole thing." (T_1, *Participant 27*)

Table 2. Advantages that were reported at different data collection points.

Advantage	Percentage of participants (%)		χ^2 (McNemar)	p	effect size[b]
	T_0	T_1			
Experiential advantage					
Low noise emission	38.5	56.4	4.97	.026	0.18
Driving experience	17.9	47.4	16.69	.000	0.29
Acceleration	14.1	23.1	-	.143[a]	0.09
Fun	6.4	20.5	-	.013[a]	0.14
Pleasant driving	3.8	20.5	-	.002[a]	0.17
Regenerative braking	3.8	11.5	-	.146[a]	0.08
Low refueling costs	11.5	28.2	5.33	.021	0.17
High energy efficiency / low consumption	10.3	11.5	-	1.000[a]	0.01
Home charging/ no need to go to gas stations	1.3	16.7	-	.002[a]	0.15
Less driving with a bad conscience (subcode of **environmental friendliness**)	0	12.8	-	.002[a]	0.13
Non-experiential advantage					
Environmental friendliness	85.9	57.7	13.78	.000	-0.28
Less/ no emissions (CO_2)	75.6	37.2	22.13	.000	-0.37
• Less local pollutant emissions (exhaust gases while driving)	29.5	10.3	-	.001[a]	-0.19
• Less local pollutant emissions if energy source is renewable/clean	29.5	6.4	-	.000[a]	-0.24
Usage of alternative energy sources for mobility	26.9	16.7	-	.134[a]	-0.10
Potential external storage	7.7	0	-	.031[a]	-0.08
Technology of the future	3.8	5.1	-	1.000[a]	0.01

Note. N = 78; Categories were included if greater than or equal to 5% of the participants reported it, main categories are written in bold; [a] binomial distribution was used because precondition was violated; [b] effect size calculation according to Green and Salkind (2003).

Features related to the EV *driving experience* were reported as advantages by almost half of the participants, but only after experiencing the EV. Before the EV was delivered, some participants expected the very fast *acceleration* to be an advantage, but only a few participants reported *fun*, *pleasant driving* and/or *regenerative braking* as expected advantages. After 3 months, *fun* and *pleasant driving* was seen as an advantage by more participants and individual reported attitudes had changed significantly over time.

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After 3 months, compared to prior to EV delivery, the number of participants who reported the *low 'refueling' costs* of an EV as an advantage more than doubled. After experiencing the EV, the perception of this feature changed significantly.

At both data collection points, around 10% of the participants perceived the *high energy efficiency,* and therefore *low consumption,* as one important advantage. There was no experience effect found for this feature.

Another category of advantages included that EVs could be *charged at home* if possible and participants do not need to make extra trips to gas stations. At T_0, just 1.3% reported this feature as an advantage, but after experience with the EV, 16.7% noted it as benefit. Participants' reports changed significantly.

The environmental friendliness per se is an advantage that could not have been directly experienced. However, driving with *less of a bad conscience* is a direct experience that the participants had. After 3 months, some drivers endorsed this quality because of perceived environmental friendliness. This change was significant.

Overall, *environmental friendliness* of the EV is the most frequently reported advantage. This category includes *less CO_2-emission* through EV usage, particularly lower inner-city air pollution. Some participants mentioned that this advantage would only appear if the energy used for charging was generated using low CO_2 technology (e.g., solar or wind power).

> "CO_2-neutral, on the condition that renewable energy is used, because if we use nuclear power or energy from coal-fired power plants, it wouldn't make much sense really" (T_0, *Participant 22*)

After using the EV for 3 months, *environmental friendliness* was mentioned less frequently when participants were asked to report advantages of EVs. There was a significant change in individuals' reports over time.

At T_0, another major non-experiential advantage was the *usage of alternative energy sources for mobility.* Although this category implies that electric vehicles are independent of fossil fuels, they depend on energy which could come from various sources. At T_1, it was mentioned less often, but the change in participants' reports between T_0 and T_1 was not significant.

> "I think the greatest advantage for the future is that energy can be generated or produced in many ways, using solar, wind, nuclear, coal or water energy. This energy can be used to operate vehicles. One is not tied to one specific kind of energy, oil, but has the opportunity to generate electricity from different sources." (T_1, *Participant 23*)

An EV as *potential external storage* was only reported as a relevant advantage at T_0; at T_1 none of the participants mentioned it. Participants' endorsement of this feature changed significantly after EV usage. Few participants reported *EVs are a technology of the future* as an advantage at either data collection point. No significant change was observed after experience with the EV.

In sum, as expected in Q1a, environmental friendliness, lower running costs, efficiency, low noise, fun, and home-charging were reported as advantages by participants. Furthermore, different driving characteristic such as acceleration and regenerative braking, usage of alternative energy sources for mobility and EVs as potential external storage were additionally reported. The hypothesized 'smooth driving' is most likely comparable to the reported 'pleasant driving'. Furthermore, different experiential features of the EV (e.g., low noise, pleasant driving) were more frequently reported after experience. However, perception of some features such as 'acceleration', which is likely comparable to 'high torque', were unaffected by experience. Other than that, we can conclude that perception of low noise, smooth driving, fun, and home-charging as advantages increased for the participants after gaining experience, and therefore, our data support hypothesis H1.

With two exceptions, the endorsement of most non-experiential advantages (e.g., environmental benefits) was negatively influenced by experience (i.e., these advantages were not mentioned as frequently anymore). In sum, the valence of the experience effect varied.

4.1.2. Barriers to acceptance and how perceptions change with EV experience

Reported barriers for acceptance and their statistical values are presented in Table 3. At T_0, the most frequently reported experiential barrier to widespread adoption of EVs was *limited range.* Although the percentage of participants who mentioned this barrier increased from 56.4 to 70.5%, the change in participant endorsement was not significant.

Compared to T_0, 20% more participants mentioned *limited space* due to the battery as a disadvantage at T_1. Experience had a significant effect. Participants partly distinguished between limited passenger and cargo space.

Regarding *charging*, different features were mentioned as barriers: *unsatisfying infrastructure, long charging duration*, or simply, the handling of the cable. In sum, every feature was reported less frequently as a barrier after 3 months of EV usage; however, only *charging duration* changed significantly. The *battery* (apart from size) as barrier was also mentioned more frequently at T_1. Participants evaluated the *battery* as heavy, and its battery life as unsatisfactory. Experience had a significant impact.

Table 3. Barriers to acceptance of EVs that were reported at different data collection points.

Barrier	Percentage of participants (%) T_0	Percentage of participants (%) T_1	χ^2 (McNemar)	*p*	effect size[b]
Experiential barrier					
Limited range	56.4	70.5	2.89	.091	0.14
Limited space / battery size	41.0	57.7	6.25	.037	0.17
Limited passenger space	11.5	21.8	1.89	.170	0.10
Limited cargo space	3.8	19.2	-	.008[a]	0.15
Charging	34.6	29.5	0.27	.607	-0.05
unsatisfying infrastructure	29.5	20.5	1.24	.265	-0.09
long charging duration	16.7	5.1	-	.035[a]	-0.12
Battery (except size)	32.1	14.1	-	.004[a]	-0.05
state of development of battery	14.1	3.8	-	.039[a]	-0.10
weight	11.5	2.6	-	.016[a]	-0.08
Low noise level as safety issue	14.1	2.6	-	.004[a]	-0.12
Limited usability	9.0	16.7	-	.210[a]	0.08
Limited flexibility / need for planning	9.0	7.7	-	1.000[a]	-0.01
Non-experiential barrier					
Acquisition costs	43.6	20.5	7.61	.006	-0.24
battery costs	9.0	6.4	-	.774[a]	-0.03
Societal resistance to change	19.2	5.1	-	.007[a]	-0.14
Availability of EVs on the market	5.1	3.8	-	1.000[a]	-0.01

Note. N = 78; Categories were included if greater than or equal to 5% of the participants reported it; main categories are written in bold, [a] binomial distribution was used because precondition was violated; [b] effect size was calculated according to Green and Salkind (2003).

Especially in the beginning, participants mentioned *low noise* as a barrier. Many participants' reports changed significantly over time. Less than 3% mentioned the acoustics as a barrier after experience with the EV. Some participants were conflicted about this feature and simultaneously reported it as an advantage and a disadvantage. They were concerned about the safety consequences of low noise and missing important noise-related feedback, but were pleased with the silent driving. As a consequence, we analyzed the data differently, coding 3 groups: drivers who only endorse it as an advantage, only as barrier or as both. At T_0, 28.2% of the participants perceived the low sound level as an advantage, 10.3% felt ambivalent about it and 3.8% perceived the low noise exclusively as a barrier. One significant change was observed over time. At T_1, many more participants (53.8%) reported the low noise exclusively as an advantage (p = .002). After 3 months, 2.6% of the participants were conflicted (p = .070) and none of the participants reported this feature exclusively as a barrier (p = .250), but these latter changes were not significant.

Limited usability of an EV, which is closely related to other barriers (e.g., range, acquisition costs and unsatisfying infrastructure), was also reported as a barrier to acceptance. The percentage of participants who identified this feature as a barrier was higher at T_1; however, changes in reports between T_0 and T_1 were not significant.

> "… and that [the EV] is not as functionally versatile, because you can't go on vacations with it or drive longer trips."(T_1, *Participant 74*)

At both data collection points, some participants reported that driving an EV requires more planning and organization than driving a conventional automobile, because EVs are less flexible (*limited flexibility / need for planning*). Experience did not significantly change perception of this barrier.

Although participants leased the EV, *acquisition costs* was a non-experiential barrier, because they paid a reduced leasing rate. At T_0, *acquisition costs,* including high *battery costs,* was the second most frequently endorsed barrier, but at T_1, only 19.2% reported this feature as a barrier. The McNemar test showed that the impact of experience was significant.

Another barrier that participants mentioned is best described as *societal resistance to change.* Some participants mentioned that the majority of the German population has a very specific conception of what a car should be and which characteristics and functions it must have. In addition, they reported that the population is skeptical about new products. Thus, this would be a barrier to widespread EV adoption. Participants' perceptions regarding this category changed significantly after experience with the EV. *Societal resistance to change* was perceived as much less of a barrier.

> "Well, I think that most people are somehow afraid of first losing mobility through the limited range and then they're scared of 'the unknown' " (T_0, *Participant 16*)

One barrier that was identified that is probably not as valid today is that the availability of EVs on the market is unknown or very limited.

As expected in Q1a, limited range, charging infrastructure and duration, battery issues, and low noise as a safety problem are perceived as barriers. Contrary to our expectation, reliability, uncertainty with service availability and other safety concerns were not reported by at least 5% of the participants. Additionally, barriers such as limited usability and societal resistance to change were identified. Participant endorsement of some barriers changed with experience. Some barriers became more relevant (e.g., limited space) and others were mentioned less frequently (e.g., low noise); thus, experience did not always positively influence perceptions. Our hypothesis (H1) that the salience of 'need for planning' and 'limited range' as barriers will increase after using an EV was not supported by our data.

4.2. Perception, attitudes, intention to recommend, and purchases intentions – Quantitative data

Regarding the questionnaire, all variables were tested for univariate outliers in accordance with the Grubbs (1969) procedure; 14 scores (*Usefulness*: 1, *Satisfaction*: 5, *Willingness to Recommend*: 4) were excluded. Experience effects for continuous variables were analyzed using paired samples t-tests and ANOVAs with repeated measures, depending on the number of data collection points. Relationships between the different variables as hypothesized in Figure 1 were analyzed using correlations and regression analyses. Assumptions for regression analyses were tested according to Field (2013). Tests assessing multicollinearity, for instance, revealed that variance inflation factors (VIF) were below the critical value of 10 and tolerance values were above .25 (Urban & Mayerl, 2008) for all regression analyses. In Table 4, descriptive statistics of all analyzed variables are presented.

Table 4. Descriptive statistics for variables used in the analyses.

Variables	Point of data collection								
	T_0			T_1			T_2		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
General Perception [LS]	74	4.68	0.64	74	4.99	0.60	74	4.95	0.57
Satisfaction [SD]	38	1.65	0.36	75	1.66	0.39	75	1.45	0.54
Usefulness [SD]	39	1.40	0.43	77	1.35	0.45	76	1.23	0.55
Willingness to Recommend [LS]	75	4.93	0.79	76	5.38	0.80	74	5.34	0.73
Willingness to Pay [LS]	76	3.40	1.13	77	3.09	1.22	77	3.17	1.17
Willingness to Purchase [LS]	37	3.89	1.15	77	4.14	1.25	77	4.01	1.41

Note. The maximum available sample (*N*) is analyzed for each variable after outlier exclusion. *N* may be smaller when testing relationships between two variables in an analysis. Therefore key descriptive statistics are repeated for the final *N* used in the analyses (e.g., section 4.2.1). [LS] 6-point Likert Scale, [SD] Semantic Differential from -2 to 2 according to Van der Laan et al. (1997).

4.2.1. Perception and experience with an EV (H2)

Results of analyses of *General Perception* of EVs indicated that the evaluation of EVs was positive at all data collection points (Table 4). A repeated measures ANOVA revealed a significant experience effect for *General Perception*, $F(2, 134) = 10.85$, $p = .000$, $\eta^2_p = .14$. Post hoc tests (Bonferroni) showed that participants perceived EVs less positively before receiving the car than after 3 months of experience, $M = -.324$, $p < .001$, or 6 months, $M = -.279$, $p = .002$. The difference between *General Perception* of EVs at T_1 and T_2 was not significant. The results support hypothesis H2 which proposes that EV-experienced drivers perceived EVs in a more positive way.

4.2.2. Attitudes and experience with an EV (H3)

Data obtained from the Van der Laan Acceptance Scale (Van der Laan et al., 1997) showed that users judge the EV as satisfying and useful at all data collection points (Table 4). For the repeated measures ANOVA, only data from the second study period were analyzed, because the first study period data were not collected at all measurement points. Participants in the second study evaluated the test vehicle as satisfying, T_0: $M = 1.65$, $SD = 0.36$; T_1: $M = 1.62$, $SD = 0.37$; T_2: $M = 1.55$, $SD = 0.42$, and useful, T_0: $M = 1.40$, $SD = 0.43$; T_1: $M = 1.30$, $SD = 0.44$; T_2: $M = 1.30$, $SD = 0.50$, at all points of data collection, but *Usefulness* and *Satisfaction* slightly decreased. Results of a repeated measures ANOVA did not reveal a significant experience effect for *Satisfaction*, $F(2,74) = 1.31$, $p = .277$, $\eta^2_p = .03$, or *Usefulness*, $F(2,76) = 1.22$, $p = .300$, $\eta^2_p = .03$, and did not support hypothesis H3.

When analyzing the whole sample, *Satisfaction* and *Usefulness* correlated strongly with each other, T_0: $r = .55$, $p < .001$; T_1: $r = .62$, $p < .001$; T_2: $r = .82$, $p < .001$.

4.2.3. Intention to recommend and experience with an EV (H4)

Participants' willingness to recommend EVs like the MINI E to friends (WTrecommend) increased over time (Figure 2). A repeated measures ANOVA revealed a significant experience effect, $F(2, 142) = 15.38$, $p < .001$, $\eta^2_p = .18$. A post hoc test (Bonferroni) showed that the difference between T_0 and T_1 was significant, $M = -.486$, $p < .001$. Additionally, the increase in *Willingness to Recommend* an EV between T_0 and T_2 was significant, $M = -.403$, $p < .001$. No significant difference was observed between T_1 and T_2. These results support hypothesis H4.

4.2.4. Purchase intentions and experience with an EV (H5)

In addition to intention to recommend, purchase intentions were assessed. *Willingness to Pay* (WTpay) was relatively low and decreased somewhat over time (Figure 2). Participants more frequently endorsed the statement that they were willing to purchase (WTpurchase) an EV after the study (Figure 2). Forty percent (T_1) and 39% (T_2) of participants reported that they "agreed" or "completely agreed" with the statement, "I am seriously planning to purchase an EV after this study", after 3 and 6 months, respectively. A repeated measures ANOVAs revealed that *Willingness to Pay* changed significantly over time, $F(1.883,141.238) = 3.49$, $p = .033$, $\eta^2_p = .04$ (Huynh-Feldt correction).

A post hoc test (Bonferroni) showed no significant differences between T_0, T_1 and T_2. However, the direction of the obtained effect was the opposite of the direction that we hypothesized (H5).

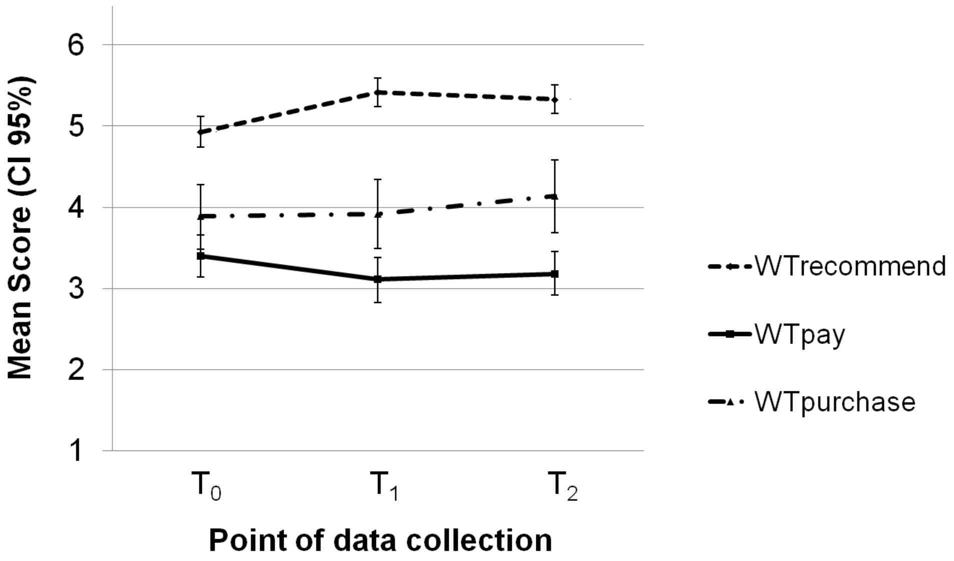

Figure 2. Results for intentions to recommend and purchase

Note. WTrecommend: $N = 72$, WTpay: $N = 76$. WTpurchase: $N = 37$. For WTpurchase, only data from the second study period were analyzed, because the first study period data were not collected at all measurement points. Results after outlier exclusion, 6-point Likert Scale.

4.2.5. Relationship between general perceptions of EVs and attitudes towards EVs (H6)

Participants who evaluated the EV as more useful, viewed EVs more positively, T_0: $r = .47$, $p = .004$; T_1: $r = .55$, $p < .001$; T_2: $r = .61$, $p < .001$. Also, *Satisfaction* and *General Perception* of EVs showed medium to strong correlations, T_0: $r = .34$, $p = .047$; T_1: $r = .47$, $p < .001$; T_2: $r = .61$, $p < .001$. These results support hypothesis H6 (i.e., attitudes towards EVs are positively correlated with general perception).

4.2.6. Perception and attitudes predicting intention to recommend EVs (H7)

In multiple linear regression analyses, the predictive value of *General Perception, Satisfaction* and *Usefulness* on *Willingness to Recommend* was computed. The three predictors accounted for 16% (T_1) and 36% (T_2) of the variance in participants' intention to recommend an EV (Table 5). Only the predictor, *General Perception,* significantly predicted the criterion at T_2. In sum, our hypothesis (H7) that perception and attitudes predict the intention to recommend an EV is not supported by the reported findings.

Table 5. Perception and attitudes predicting *Willingness to Recommend* at all points of data collection.

Point of data collection	Predictor	n	ß	*SE b*	*p*	Part correlation	Zero-order correlation
T_0	General Perception	34	.36	.20	.059	.33	.33
	Satisfaction	34	.02	.35	.916	.02	.16
	Usefulness	34	.03	.30	.904	.02	.19
	R^2_{adj} = .064, $F(3,31) = 1.78$, $p = .172$						
T_1	General Perception	70	.21	.15	.119	.17	.38
	Satisfaction	70	.07	.28	.646	.05	.33
	Usefulness	70	.24	.23	.109	.18	.40
	R^2_{adj} = .163, $F(3,67)$ =5.54, $p = .002$						
T_2	General Perception	68	.25	.16	.042	.21	.48
	Satisfaction	68	.10	.25	.577	.06	.50
	Usefulness	68	.34	.26	.067	.19	.56
	R^2_{adj} = .360, $F(3,65) = 12.21$, $p = .000$						

Note. Results after outlier exclusion.

4.2.7. Perception and attitudes predicting purchase intentions (H8)

For the criterion *Willingness to Pay* 19% of the variance was explained by the model at T_0 and *General Perception* proved to be a significant predictor (Table 6). At T_1 and T_2, the regression models did not reach significance.

Multiple linear regression analyses for the criterion *Willingness to Purchase* only revealed significant results for data collected after experiencing the EV (T_1 & T_2), but not for data collected at T_0 (Table 7). These models explained 16% of the variance in the data. At T_1, *General Perception* significantly predicted *Willingness to Purchase*. In contrast, *Satisfaction* was the only significant predictor at T_2. In sum, our results do not support the hypothesis that perception and attitudes predict purchase intentions (H8).

Table 6. Perception and attitudes predicting *Willingness to Pay* at all points of data collection.

Point of data collection	Predictor	n	ß	*SE b*	*p*	Part correlation	Zero-order correlation
T_0	General Perception	34	.41	.31	.023	.37	.46
	Satisfaction	34	-.18	.54	.350	-.15	.10
	Usefulness	34	.25	.47	.195	.21	.34
	R^2_{adj} = .186, $F(3,31)$ =3.28, p = .025						
T_1	General Perception	71	.16	.31	.289	.13	.10
	Satisfaction	71	-.01	.53	.933	-.01	.01
	Usefulness	71	-.09	.48	.568	-.07	-.02
	R^2_{adj} = -.026, $F(3,68)$ =.393, p = .758						
T_2	General Perception	71	.19	.30	.184	.16	.19
	Satisfaction	71	.27	.44	.208	.15	.17
	Usefulness	71	-.23	.48	.311	-.12	.10
	R^2_{adj} = .017, $F(3,68)$ = 1.41, p = .248						

Note. Results after outlier exclusion.

Citation: Bühler, F., Cocron, P., Neumann, I., Franke, T., & Krems, J. F. (in press). Is EV experience related to EV acceptance? Results from a German field study. *Transportation Research Part F: Traffic Psychology.*
Date: 05.05.2014

Table 7. Perception and attitudes predicting *Willingness to Purchase* at all points of data collection.

Point of data collection	Predictor	n	ß	*SE b*	*p*	Part correlation	Zero-order correlation
T_0	General Perception	33	.34	.33	.086	.31	.31
	Satisfaction	33	-.12	.58	.570	-.10	.02
	Usefulness	33	.02	.50	.916	.02	.11
	R^2_{adj} = .019, $F(3,30) = 1.21$, $p = .322$						
T_1	General Perception	71	.47	.29	.001	.39	.36
	Satisfaction	71	.02	.49	.904	.01	.11
	Usefulness	71	-.21	.44	.159	-.16	.05
	R^2_{adj} = .160, $F(3,68) = 4.30$, $p = .008$						
T_2	General Perception	71	.25	.34	.067	.20	.33
	Satisfaction	71	.49	.50	.015	.27	.39
	Usefulness	71	-.26	.55	.224	-.13	.29
	R^2_{adj} = .164, $F(3,68) = 5.64$, $p = .002$						

Note. Results after outlier exclusion.

4.2.8. Relationship between intention to recommend and purchase intentions (H9)

At T_0 and T_2, participants who would recommend the EV are also more willing to pay for an EV, T_0: $r = .25$, $p = .032$, $N = 75$; T_2: $r = .28$, $p = .014$, $N = 74$. Only after experience with the EV did *Willingness to Purchase* an EV correlate with *Willingness to Recommend*, T_1: $r = .82$, $p < .001$, $N = 76$; T_2: $r = .43$, $p < .001$, $N = 74$, and *Willingness to Pay*, T_1: $r = .31$, $p = .007$, $N = 77$; T_2: $r = .37$, $p = .001$, $N = 77$. Thus, results largely support hypothesis H9 (i.e., intention to recommend is positively associated with purchase intentions).

5. Discussion

The present research aimed to investigate perception (including advantages and barriers) and acceptance of EVs. Additionally, it was of interest whether perception and acceptance change after intensive EV usage. These issues were addressed in a field study with drivers who lived in the Berlin metropolitan area and drove an EV for 6 months. Seventy-nine users who had the opportunity to experience an EV in their daily life for 6 months were studied.

5.1. Perceived Advantages of and Barriers to EV acceptance

A major aim of the present study was to examine which advantages and barriers EV users perceive (Q1a). Furthermore, it was of interest whether these perceptions change over time and if changes in reports of experiential advantages and barriers are more likely to be positive (Q1b). EV drivers perceive a variety of advantages. In sum, nine main categories (e.g., environmental friendliness, low noise) emerged through our analyses that partially reflect the expected advantages, as well as the perceived positive features (i.e., advantages) reported by Graham-Rowe et al. (2012). They could be categorized into experiential advantages (i.e., advantages that could be directly experienced) (e.g., low noise emission) and more abstract or non-experiential advantages (e.g., environmental friendliness). Most experiential advantages, including low noise emission, pleasant driving, fun, refueling costs, as well as the opportunity to 'refuel' at home were mentioned much more frequently after users gained experience using their EV.

Results revealed that after experiencing an EV, some non-experiential advantages became even less relevant. Thus, environmental benefits of EVs became less important over time, which is contrary to findings from Gould and Golob (1998). The decrease in the number of EV users reporting the usage of renewable energy sources as an advantage also became apparent. Still, compared to other countries, MINI E drivers in Germany were more likely to report that charging with renewable energy played an important role in their evaluation of the vehicle (Vilimek et al., 2012).

Regarding barriers, the ten identified main categories included most of the concerns reported in previous studies (e.g., Carroll, 2010; Graham-Rowe et al., 2012). Many EV users changed their opinion on experiential barriers after using the EV; charging duration and infrastructure, battery issues and low noise level were less frequently reported as barriers after experiencing the EV. Another experiential barrier that was quite specific to the test vehicle was limited space. It was perceived as a barrier by many more participants after experiencing the EV. However, in newer vehicles, batteries are integrated in ways that require less space; thus, this disadvantage is likely to become much less salient in the near future. However, several experiential barriers were not significantly influenced by experience. Limited range, for instance, remained a highly relevant barrier over the course of the study. Therefore, our data does not support the findings of Jensen et al. (2013), which showed that the importance of range increases after testing an EV, as our data suggest that it remains stable. Research indicates that daily range practice has a positive impact on the efficiency of users' interaction with range (Franke & Krems, 2013a), but this does not seem to influence the perception of range, as it remains a major barrier for acceptance even after gaining substantial experience with an EV. Still, it is unclear, for instance, how many EV users experienced range as a personal or general barrier. The results regarding space and range match with EV manufacturers' goals of reducing battery size, while simultaneously enlarging space and increasing range. Today, many EVs on the market have higher space capacity, and therefore, should already be more suitable for daily use. Alike Pearre, Kempton, Guensler, & Elango (2011) we expect that battery range is likely to improve in the future; thus, this barrier will become less significant than has been observed here. Additionally, one could argue, according to Franke, Neumann, Cocron, Bühler and Krems (2012), that training drivers to achieve better utilization of limited mobility resources in EVs might help to bridge the gap until more advanced batteries become available. To overcome the 'range barrier' at the present time, EV manufacturers also offer free rental cars for a few days per year for long trips that exceed the EV range.

Charging is closely related to range. One finding from our study is that under the present study's conditions (i.e., home charging station with 32 ampere fuse, 4-hour charging duration), charging duration became less of a barrier with increasing experience and home charging was even described as an advantage after the EV was integrated into daily life. These results are consistent with the findings of Turrentine et al. (2011). A sample of US drivers enjoyed charging at home and evaluated the charging time as adequate. In sum, we have observed that EV charging is suitable for daily life if drivers have access to personal (i.e., home-based) charging infrastructure. Still, under other circumstances, experience might have the opposite effect. For instance, experience might negatively influence EV users who do not have access to personal charging infrastructure, because of the inconvenience of relying on public recharging stations.

Perceptions of several reported barriers that could not have been directly experienced while driving an EV (referred to in this paper as 'non-experiential' barriers) were also investigated. For example, 'availability of EVs on the market' remained unchanged over the course of the study. In contrast, acquisition costs and perceived societal resistance to change were less frequently reported as barriers after experiencing an EV. Still, acquisition costs were an often reported barrier. In Norway, other benefits (e.g., no purchase tax, free parking, free ferry usage), in addition to cheaper running costs, are provided by the government to compensate for the high purchase price of EVs. At the same time, EVs are also more successful on the Norwegian market than in many other European markets.

Notably, low noise level is seen more as an advantage than as a barrier. Specifically, after driving an EV for a longer time, this particular EV characteristic was perceived very favorably. Additionally, none of the EV-experienced drivers described it exclusively as barrier; however, some participants were ambivalent and endorsed this special feature of EVs as both an advantage and a safety problem. This might be considered in the debate regarding sound generators for EVs. A detailed account of the advantages and disadvantages of driving a silent EV in urban traffic as well as the influence of experience on drivers' evaluation of low noise can be found in Cocron and Krems (2013). Although safety issues still need to be addressed, it should be taken into account that this feature could impact the market success of EVs.

Overall, in our study experience affects potential consumers' perception of the advantages and barriers of EVs; however, advantages do not become barriers or vice versa. Moreover, it seems to be the case that experiential advantages (e.g., low noise, fun) and barriers (e.g., charging duration) were of higher relevance and more positively evaluated respectively (i.e., advantages are strengthened, barriers are weakened) after gaining direct experience with an EV. These findings have several different implications. Providing EV experience could serve as a promising strategy for marketing EVs. This is consistent with Burgess et al. (2013), who argued that first-hand experience could change consumers' perception of EV performance. Notably, the test EV that we provided was quite agile relative to other available EV models. Thus, this result might not generalize to different EV models. However, even if positive perceptions of the EV driving experience do not generalize to other currently available EVs, this finding could have potential implications for the design and marketing of future EVs.

5.2. Perceptions, attitudes, intention to recommend, and purchase intentions

We evaluated how the current state of EV technology is perceived and accepted (Q2a) and whether perceptions and acceptance change after experiencing an EV (Q2b). At all data collection times, the general perception of EVs including, for instance, suitability for daily life, was quite positive. Consistent with Carroll (2010), experience had a favorable impact on user opinions; participants' general perception of EVs was *even more* positive after gaining experience.

Data obtained from the Van der Laan acceptance scale (Van der Laan et al., 1997) revealed that participants highly valued *Usefulness* and *Satisfaction* of the EV at all data collection points. Scores remained high throughout the study and no experience effects were detected. Given these results, it appears that current EV technology already meets the expectations of users, is judged to be satisfactory in everyday life, and experience does not influence these attitudes. Notably, it is very likely that our sample is more comparable to a population of early adopters, and therefore, might not be representative of the general population of potential consumers. Nevertheless, early adopters may be crucial for widespread acceptance of new technology, a topic that will be discussed in more detail later, and the positive evaluation observed here indicates that the development of EVs is trending in the right direction.

This research also examined several behavioral indicators of EV acceptance. As a whole, the sample was willing to recommend EVs and this intention even increased after experiencing the EV. Regarding purchase intentions, participants in this sample exhibited considerable variability, and EV experience had little impact on intentions. However, at all data collection points, between 13% and 27% of the sample were willing to spend more money for an EV than a conventional car. Even more participants (around 40%) endorsed that they were ready to purchase an EV. These results are comparable to those found in previous studies conducted with samples of EV-experienced drivers (e.g., Jabeen et al., 2012). Although the intention to recommend and purchase might be overestimated here because our sample most likely consisted of early adopters, these results are notable as they indicate that current EV technology is already acceptable for some potential consumers.

Another behavioral indicator of acceptance of EVs is the usage intensity after receiving an EV. In this study, considerable effort was made to collect usage data. However, for the present research, data quality was insufficient due to technical problems and multiple potential confounding factors that could not be controlled. Because we had to exclude many participants from analyses, it was not possible to make valid conclusions about usage intensity and changes over time. Thus, usage data are not reported here.

Regarding Q3, our results reveal that there is no association between general perception and the various indicators of acceptance investigated here, a finding that does not support our conceptual model (Figure 1). More positive perceptions of, and attitudes towards, EVs does not predict higher intention to recommend or purchase an EV. Several researchers (e.g., Ajzen, 1991) have shown that attitudes and behavioral intentions tend to be rather unreliable predictors of enacted behavior and that other factors (e.g., subjective norms and perceived behavioral control) might also influence the relationship. Furthermore, the possibility of a significant relationship is higher if attitudes and behavioral assessments correspond in their 'levels of specificity' (Kraus, 1995). Given that the major objective of the present research was to show how EVs are perceived and accepted, we required scales that assess more general EV evaluations and behavioral indicators. Investigation of the factors that influence EV purchase behavior was beyond the scope of the present research, but is of high interest for future investigations.

In sum, participants were given 6 months to experience many of the positive and negative aspects of living with and driving an EV. We were able to demonstrate that experience with EVs influences users' evaluation of EVs. Previous research has demonstrated the effect of experience on a variety of specific domains, including interaction with range (Franke & Krems, 2013), usage of regenerative braking (Cocron et al., 2013), perception of acoustics (Cocron & Krems, 2013) and driver interface (Neumann, Franke, Cocron, Bühler, & Krems, 2013). The present study builds on this work by showing the effect of experience on a more global level—EV acceptance.

Although our sample is not representative of the population of German car owners and likely consists of a higher percentage of early adopters (Rogers, 2010), our findings have important implications for the potential widespread adoption of EVs. Satisfaction of early adopters seems to be an important pre-requisite for general acceptance of EVs. For instance, early adopters could influence others via word-of-mouth or incidentally promote emulation while using their EV (Rogers, 2010). If early adopters perceive barriers after experiencing the EV and are skeptical of the product, it is important to improve the characteristics of the product. According to Rogers (2010), a product will have a high probability of success when innovators and early adopters, approximately 16% of the potential market, accept the product.

5.3. Comparing qualitative and quantitative results

The combination of qualitative and quantitative results provides interesting information. When taking all perception results (i.e., advantages, barriers, general perception of EVs) into account, we can conclude that shortly after gaining experience with an EV, the perception of many EV features is positively influenced. Findings from Burgess et al. (2013) emphasize the importance of real-life experience. This supports our assertion in section 5.1 that giving potential EV consumers the opportunity to test an EV might be a promising means for supporting EV acceptance, and thereby, the expansion of the EV market. Direct experience can help to overcome consumers' misconceptions which may be based on older EV models (e.g., slow, strange design, embarrassing). Burgess et al. (2013) referred to these perceptions as the "traditional view".

When combining quantitative and qualitative data, another interesting point comes to light. The EV was perceived positively (e.g., suitable for daily life) and evaluated as useful and satisfying, even though several barriers like limited range were still reported. The negative evaluation of range and other barriers could be one potential explanation for the discrepancy between attitudes and intention to recommend or purchase.

5.4. Implications for future research

As stated earlier, our sample consists of urban residents with the opportunity to charge at home and who are early adopters of EVs. It would be interesting to determine if our results would generalize to a sample that is more representative of the population of German car owners. Early adopters' experiences, perceived barriers and suggestions for improvements serve as an important first step. The next step is to determine how users living under other circumstances (e.g., users who do not have access to private charging infrastructure) perceive and accept EVs, whether experience also affects them in similar ways, and what level of experience is necessary to change their EV-related perceptions.

Additionally, countries that have moved beyond the "early adopter stage" should be investigated. In Germany, encountering an EV on the road is still a noteworthy event. In comparison, in countries like Norway where the EV market is more mature, EVs are already highly integrated into the driving culture. According to Burgess et al. (2013), mere exposure to EVs can positively influence consumers' perceptions and attitudes. Thus, it is of interest whether direct EV experience for an extended period of time still has a positive effect on non-EV drivers' perceptions of EVs in such countries.

Furthermore, the 6-month test period offered in this study is relatively long and is likely not an economically viable business strategy. Realistically, potential consumers might be allowed to test an EV for approximately one day. It has not yet been investigated whether this relatively short test duration leads to changes in consumers' evaluation of EVs.

6. Conclusion

The present research explores EV drivers' acceptance of current EV technology and the impact that real-life experience has on perception and acceptance of EVs. Experience can significantly change perception of the EV's advantages and barriers in both positive and negative directions depending on the specific type of advantage or barrier. Our findings reveal that currently available EVs are already acceptable and suitable for daily life in urban areas, provided that a home charging station and a second car are available. However, for widespread market success, solutions are still needed to overcome important barriers such as limited range and acquisition costs. On the other hand, widespread adoption of EVs might be supported if features such as the 'fun factor' and low noise are retained in future EV designs. In addition to technological solutions, some new marketing strategies are required to demonstrate that EVs have favorable characteristics beyond the environmental benefits. These strategies could also target misconceptions related to EVs and societal resistance to change. Given these goals, first-hand experience seems to be a promising strategy.

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