# Public Perception and Acceptance of Electric Vehicles: Exploring Users' Perceived Benefits and Drawbacks

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**Abstract.** In this research, we describe an empirical study, which aimed at identifying influencing factors on acceptance of electric vehicles. Understanding individual arguments and to reach a high usage rate of these vehicles in the public and a broad acceptance, the identification of possible pro-using motives as well as perceived drawbacks is essential, which would allow a sensitive and individually-tailored communication and information policy. Using an exploratory approach, a questionnaire study was carried out in which participants were requested to indicate the level of acceptance and the intention to use electric cars. The questionnaire items were taken from several focus groups, which had been carried out prior to the questionnaire study. Outcomes show that the traditional car is perceived still as much more comfortable, and receives a high trustfulness in comparison to electric cars. In addition, user diversity in terms of age and gender was found to considerably the perceived benefits and barriers. Female users but also aged persons show a higher level of acceptance, which might be due to their higher environmental consciousness in contrast to male persons and younger participants. Interestingly, the self-reported level of domain knowledge (significantly higher in men) did not show a large influence on the level of acceptance.

**Keywords:** Electro-Mobility, electric vehicles, technology acceptance, user diversity, adoption behavior of novel technologies.

## 1 Motivation and Related Work

Facing the increasing threat through climate change, $CO_2$-emissions and the thereby caused air pollution, the area-wide roll-out of electric vehicles might be an adequate escape from shortcomings of fossil oil resources [1]. From a technical point of view, alternative vehicles, such as plug-in hybrid electric vehicles, are –technologically– quite mature and thus might serve as valuable alternatives to traditional car technology [2] [3]. The potential of electric mobility has been studied in recent research from a technical [4] [5] [6], economic [7], logistic [8], environmental [9] and inner-urban [10][11] [12] point of view. However, research showed also that there is considerable struggle for electric vehicles to create appropriate markets [13], at least

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in Germany. A high consumer acceptance for alternative fuel vehicles is an important prerequisite to determine the practicality of a successful implementation [14]. Still, however, there is a far-reaching reluctance to accept a novel mobility concept in urban environments [15]. Speculating, the reluctance of citizens towards electric mobility and novel developments in the automotive sector might have very different reasons.

First, traditional experiences with cars could be an influential factor. For a long time, citizens value the huge potential of having a car, connected to the feeling of independence (in time and space) and universal access, which has a profound tradition in history [16]. Car consumption has always been much more than mere rational choice [17]. Car consumption represents a behavior that is naturally linked to emotional attitudes, social esteem and branding [18] [19] [20]. A second factor to adopt novel instead of an old, traditional and highly conversant technology is related to the willingness of citizens to tolerate risks as well as uncertainties in how far the novel technology bring more than the traditional technology does [21] [22] [23]. In this context, technology acceptance and social reasons of technology adopting behavior comes into fore [24] [25] [26]. A third factor for the reluctance to adopt novel technology is the user diversity and the increasing diffusion of modern technology with a diversely skilled user group [27] [28] [29] [30]. Especially age and gender are crucial factors, which might influence substantially the adoption behavior of novel technology [31] [32] [33]. A forth point regards the usability, the ease of using the technical system and its perceived usefulness [34] [35] [36]. Also the way information presentation is delivered [37] [38] [39] is a key factor that determines the technology acceptance and the readiness of users to adopt a novel technology [40] [41].

While those human factors are sufficiently examined in information and communication technology [42], still, for electric mobility there is yet not sufficient knowledge about perceived benefits and barriers.

## 2 Questions Addressed and Logic of the Exploratory Approach

In this study we focus on user opinions regarding the use of traditional car technology in comparison to electric cars. Understanding the individual motives and barriers in the context of novel car technology is a highly relevant topic for modern societies. In order to learn which using motives militate in favor of using these technologies and which kind of using barriers are prevalent, we take user diversity in terms of age and gender as a specific focus.

There is a considerable need to explore and to understand the components contributing to users' acceptance of electronic car technologies. Regarding the specific information needs and the requirements for a sensitive communication strategy it is important to learn which of the reported pro-using motives and barriers are more decisive than others and which of both, using arguments or barriers is prominently influencing the intention to use electric car technology. Outcomes are expected to allow insights into the major public opinion drivers for and against

electric mobility. This is not only be useful for taking acceptance issues into account, but may also elucidate the public awareness of a diligent information politics and communication rationale in this field.

# 3 Method

## 3.1 Variables and Procedure

As independent variable the type of vehicle (car vs. E-car), gender and age (young: 20-40 years, middle-aged: 41-60 years, older: 61-75 years) were examined. Dependent variable was the level of acceptance (benefits) and non-acceptance (barriers). As both, benefits and barriers might be based on different arguments, we examined environmental-related, cost-related, comfort-related, trust-related and technology-related argumentations for both, benefits and barriers, when using cars and electric cars. All participants evaluated the benefits and barriers for both vehicle types in succession. Avoiding sequence effects, the order of items related to cars (benefits/barriers) and E-cars (benefits/barriers) was altered across participants.

## 3.2 Questionnaire

In order to collect comprehensive opinions and to reflect them across a broader sample of women and men of different ages, we chose the questionnaire-method. The items and sections used in the questionnaire were based on previous empirical work in our workgroup, in which we collected argumentation patterns and user experience (focus groups) of female and male persons of a wide age range [36] [37] [38]. The questionnaire was delivered online (filling in took about 40 minutes). The questionnaire was arranged in five main sections (Figure 2).

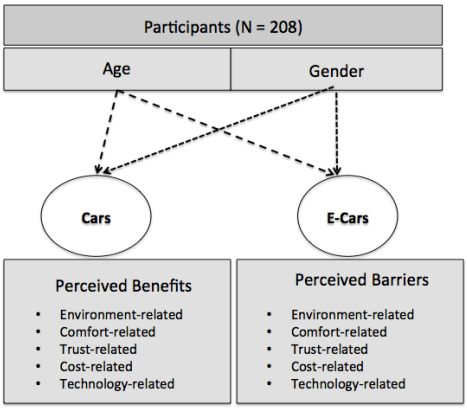


**Fig. 1.** Structure of the questionnaire

**Demographic Data:** The first part included demographic data.

**Benefits /Barriers of cars:** The second part focused on pro-using and con-using arguments regarding the use of cars. The motives and barriers were conceptualized along five dimensions (identified on the base of user argumentations in the focus groups which had been carried out prior to the questionnaire study: environment-related arguments, cost-related arguments, comfort-related arguments, trust-related arguments as well as technology-related arguments. Items had to be answered on a Likert Scale (1 = I do not agree at all, 4 = I completely agree). Per dimension, we used three items and summarized the answers to an overall score (due to analysing purposes).

**Benefits /Barriers of E-cars:** The third focused on pro-using and con-using arguments regarding the use of E-cars**.** Again, the motives and barriers were conceptualized along the five dimensions (environment, comfort, costs, trust and technology). Note that these dimensions were used for benefits and barriers likewise. In Table 1, exemplary items are given.

**Table 1.** Item examples for the evaluations of benefits and barriers of cars and E-cars. Items had to be answered on a Likert Scale (1 = I do not agree at all, 4 = I completely agree).

| **Car: Benefits** | **I use/would use a car, because** |
|---|---|
| Environment | ... filters reduce the pollution of the environment |
| Costs | ... taxes and insurances have reasonable costs |
| Comfort | ... driving experience is fine |
| Trust | ... my car has never run out on me |
| Technology | … care technology has a long tradition |
| **Car: Barriers** | **I do not use/would not use a car, because** |
| Environment | ... fossil resources are scarce |
| Costs | ... purchase of a car is too expensive |
| Comfort | ... long trips with the car are bothersome |
| Trust | ... there are too many accidents |
| Technology | … I do not understand current car electronics any more |
| **E-car: Benefits** | **I use/would use an e- car, because** |
| Environment | ... electric mobility safes the environment |
| Costs | ... it is affordable on the long run |
| Comfort | ... driving noise is reduced |
| Trust | ... novel technology is up-to-date |
| Technology | …electric mobility is the future |
| **E-car: Barriers** | **I do not use/would not use an e-car, because** |
| Environment | ... it still consumes electricity produced by nuclear power |
| Costs | ... accessory charges are high |
| Comfort | ... I do not want to plan the refueling exactly |
| Trust | ... electricity is not trustworthy for me |
| Technology | … technology is not yet mature enough |

### 3.3 Participants

Overall, 208 persons in an age range of 18-75 years of age took part (51% were mal, 49% female). All of them were experienced drivers and had a high education. Participants were reached through the social networks of younger and older adults and reacted to advertisements in the local newspaper. Participants were not gratified for their efforts. In order to learn about the level of domain knowledge about electric mobility participants had to indicate their self-reported knowledge (Likert scale, 1= very low, 4 = very high). Figure 1 shows the descriptive outcomes. While age groups had a comparable knowledge, women reported a significantly lower domain knowledge than men ($F1,207) = 61.2$, $p<0.00$).


**Fig. 2.** Descriptive outcomes regarding the self-reported knowledge in electric mobility

## 4 Results

The data was analyzed by using multivariate analyses of variance (MANOVA) and variance analyses for repeated measurements, if applicable. The significance level was set at 5%. Significance outcomes within the less restrictive 10% level were referred to as marginally significant.

### 4.1 Evaluation of Benefits, Contrasting Cars and E-cars

A first analysis regards the evaluation of benefits for cars and E-cars, respectively. In order to get insights into the main argumentation line, items were summed up for each of the five categories.

The MANOVA yielded a significant effect of the vehicle type regarding environmental-related benefits ($F(1,202)=105.9$; $p<0.000$), for cost-related benefits ($F(1,202)=27.7$ $p<0.00$, also for comfort-related benefits ($F(1,202)=37.9$ $p<0.00$ and for trust-related arguments ($F(1,202)=31.6$ $p<0.00$. Interestingly, technology related benefit perceptions did not differ between car and e-car (n.s.). In Figure 2, descriptive results are given evaluations (Cars: gray bars; E-cars: black bars).

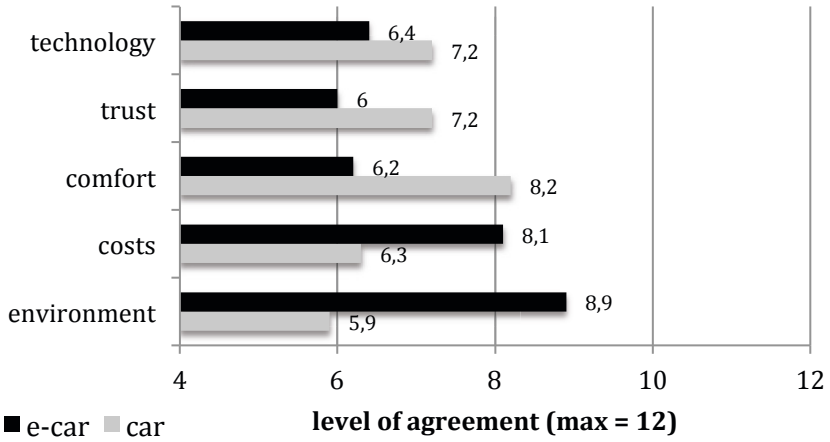


**Fig. 3.** Level of agreement (means) for the total group regarding perceived benefits on different argumentation dimensions for cars and e-cars (4 = not at all, 12 = completely agree)

Both vehicle types differ distinctly in all categories. Apparently, the perceived benefits of using a car are diametrically opposite to the benefits, which militate in favor of the E-car. User diversity is a critical factor that significantly influenced the perception of the benefits. In Table 2, the outcomes regarding the impact of user diversity on perceived benefits is presented (age and gender as well as interacting effects).

**Table 2.** Perceived benefits: User diversity (age, gender) as well as 2 and 3-way interactions

| Dimension | Age | Gender | 2-way interaction | 3-way interaction |
|---|---|---|---|---|
| Environment | -- | F (1,202)=16.9; p<0.03 | vehicle x gender (F(1,202)=4.5; p<0.04 | vehicle x gender x age F(1,202)=2.4; p<0.09 |
| Costs | -- | -- | vehicle x gender F(1,202)=4.9; p<0.04<br>vehicle x age F(1,202)=7.7; p<0.01 | -- |
| Comfort | -- | -- | vehicle x age F(1,202)=3.5; p<0.03 | -- |
| Trust | -- | -- | -- | -- |
| Technology | -- | -- | vehicle x age F(1,202)=7.7; p<0.01 | -- |

Regarding environmental benefits, women report stronger environmental benefits in the E-car, especially with increasing age (three fold interaction, Figure 3). When focusing on costs, 2-way interactions of vehicle type x gender ($F(1,202)=4.9$; $p<0.04$) and vehicle type x age ($F(1,202)=7.7$; $p<0.01$) were found. The benefit was perceived more strongly in women and with increasing age (Figure 4).

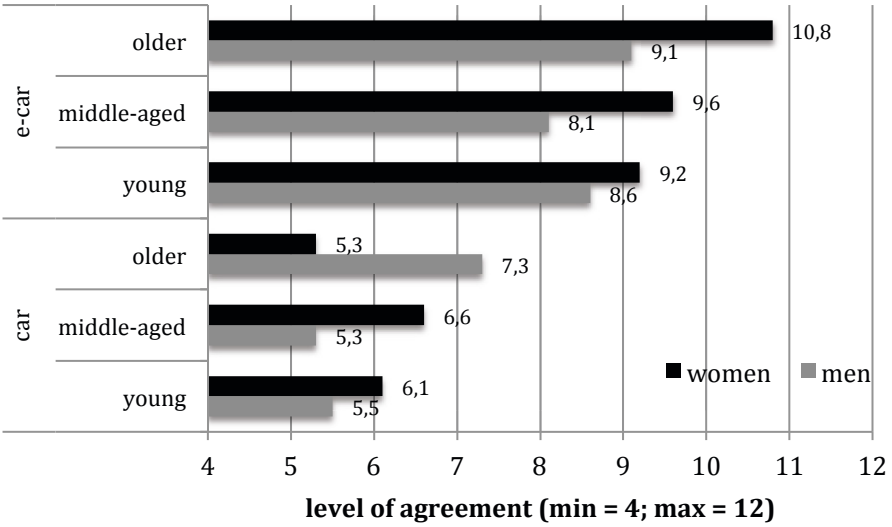


**Fig. 4.** 3-way interacting effect of age x gender x vehicle type regarding the perceived benefits in terms of environment protection (4 = not at all, 12 = completely agree)

It is highly insightful that one and the same argument – cost saving – is used for both vehicle types as a benefit, though with different connotations ("E-cars are more cost saving on the long run" vs." tax and assurance is less costly in cars"). Another interesting finding regards the interaction between vehicle type x age for the perceived comfort (Figure 5).

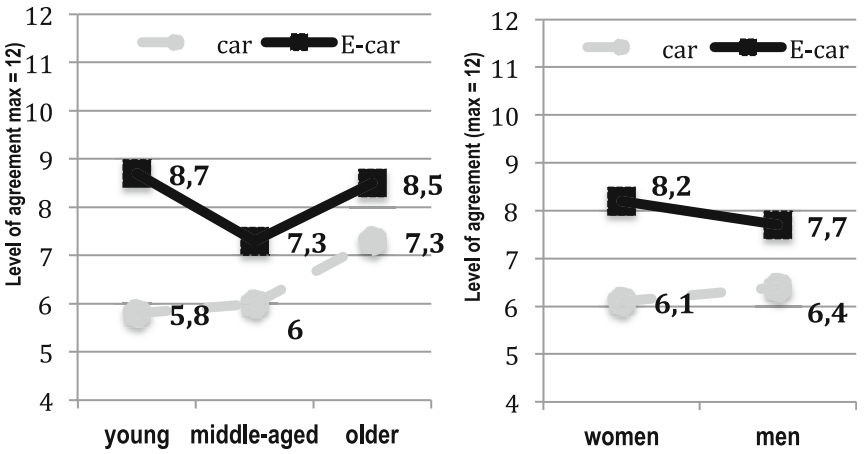


**Fig. 5.** 2-way interacting effect of vehicle type x gender (left) and vehicle type x age regarding the perceived benefits in terms of costs (4 = not at all, 12 = completely agree)

The comfort perception is related to age: With increasing age, the perceived comfort is rated as more advantageous, especially in the traditional car.

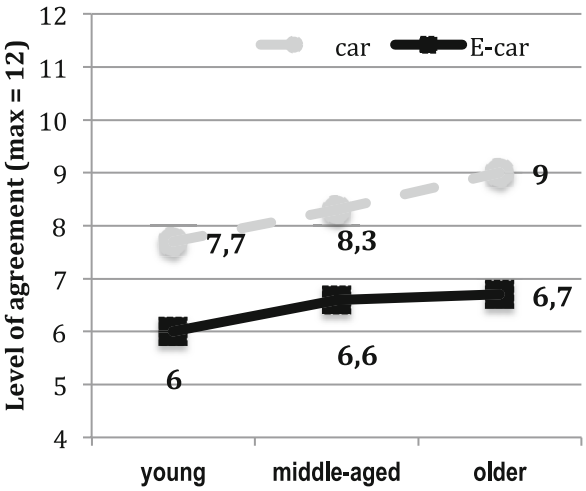


**Fig. 6.** 2-way interaction of vehicle type x age regarding the perceived comfort (4 = not at all, 12 = completely agree)

### 4.2 Evaluation of Barriers, Contrasting Cars and E-cars

A next analysis regarded the perceived barriers of using cars and E-cars, respectively. Again, first the descriptive outcomes with respect to the nature of the seen disadvantages are depicted (along the five dimensions, Figure 4).

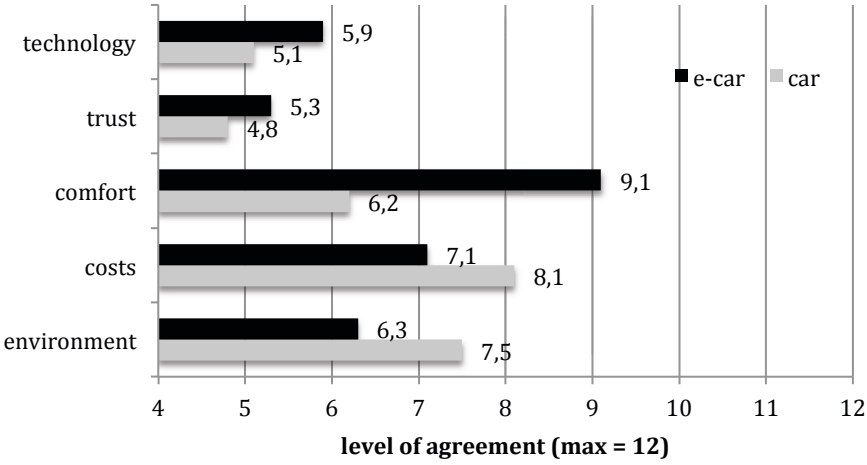


**Fig. 7.** Level of agreement (means) for the total group regarding perceived barriers for cars (gray bars) and e-cars (black bars) (4 = not at all, 12 = completely agree)

As can bee taken from Figure 4, perceptions of barriers using a traditional car in comparison to the E-car differ distinctly from each other, in nearly all argumentation lines.

Significant differences between both vehicle types regard environmental-related barriers ($F(1,202)=156.2$; $p<0.000$), cost-related barriers ($F(1,202)=5.5$ $p<0.02$, also comfort-related barriers ($F(1,202)=168.1$ $p<0.00$ and technology-related disadvantages ($F(1,202)=9.3$ $p<0.03$. Trust did not impact the perceived disadvantages for neither vehicle technology. For the perceptions of barriers, user diversity did not play a major role neither when using a car noir an E-car. (Table 3).

Only age impacted the perceptions of negative costs (the younger participants, the higher were the perceived costs in both vehicle types).

**Table 3.** Perceived barriers: User diversity (age, gender) as well as 2 and 3-way interactions

| Dimension | Age | Gender | 2-way interaction | 3-way interaction |
|---|---|---|---|---|
| Environment | -- | -- | -- | -- |
| Costs | F (1,202)=23.9; p<0.01 | -- | -- | -- |
| Comfort | -- | -- | -- | -- |
| Trust | -- | -- | -- | -- |
| Technology | -- | -- | -- | -- |

### 4.3 Effects of Domain Knowledge on Perceived Benefits and Barriers

A final analysis regarded the question if the self-reported knowledge about electric mobility does impact the acceptance. One could have expected that persons with a high information level in the context of electric mobility ground their attitudes for or against a novel technology on a deeper understanding in comparison to persons, which rely predominately on a quite superficial public knowledge. Correlation analyses (Spearman Rho) revealed only marginal relations between domain knowledge and acceptance. Interestingly though, domain knowledge did not impact any of the perceived benefit arguments (in neither dimension), but impacted mainly the perceived barriers (in both vehicle types).

Car: With increasing knowledge, the more negative are the perceived environmental consequences($r = -1.6$; $p<0.05$), the less negative are the perceived costs ($r =-1.7$ $p<0.05$) and the less negative are the perceptions of the car technology ($r =-1.4$ $p<0.05$). E-car: The more participants reported to have high domain knowledge of electric mobility, the lower are perceived costs ($r =-1.6$ $p<0.05$), perceived risks ($r=-3.2$ $p<y.0.05$) and potential technology barriers ($r =-1.6$ $p<y.0.05$).

## 5 Discussion and Future Research

Overall, this study yielded insights into users' attitudes towards electric cars (in comparison to traditional car technology). Main arguments against electric cars are the low comfort and technological barriers (in terms of availability of charging stations). In contrast, the comfort perception (including design, feel and looks as well as optics) in traditional care technology is still perceived as much higher compared to the electric car, especially with increasing age.

Gender and age were significant drivers of acceptance, especially in women, which have a higher environmental consciousness in comparison to men. User diversity though did not play a major role in the explanation of barriers. Apparently, the arguments militating against the use of both vehicles types are not modulated by age and gender but represent a quite generic view, what has implications for public information and communication strategies.

However even if the findings here represent a valuable insight into users' attitudes, there is also a cautionary note. Respecting the validity of empirical findings it is of crucial importance, whether the acceptance towards a novel technology is examined in persons, already using electric cars and having practical experience with the technology. Critically, one could argue that novices cannot "feel" the potential of electric mobility as long as they do not rely on real operating experience. Even if this argument cannot be dismissed, there is still a knowledge gap about the public discourse and potential ambivalent attitudes to electric mobility, in combination with individual beliefs, uncertainty as well as perceptions of potential benefits and risks. The understanding of individual beliefs and general attitudes are of crucial impact as the public opinion also considerably impacts on the cognitive mind setting of future users. Therefore, we selected a quite uninformed sample of a wide age range, to get a broad insight into attitudes. In future studies though we will examine expert users and explore also attitudes towards electric mobility in the context of public transport.

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