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Identifying personas in prospective electric vehicle users in regard to the user-interface to lessen range anxiety

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Abstract

Electric vehicles (EV) are supposed to be more ecologically friendly and sustainable compared to combustion powered vehicles (CPV) because they do not rely on fossil fuels. To further promote the mass implementation of such vehicles range anxiety needs to be diminished, that is the fear of stranding with the vehicle because of the limited resources. Research has shown that the user-interface in such vehicles has the potential to lessen feelings of range anxiety. Also research suggested that there are possibly distinct user groups with different requirements. So far most research regarding this topic involved early adopters. This study tries to close the gap in research by using a user-centered approach to investigate these user groups within the non-early adopters. To achieve this goal the persona method was used which aims at synthesizing archetypical user profiles which can be used for the further design process. Eight semi-structured interviews were conducted with prospective electric vehicle users, which were transcribed and coded. Subsequent analysis yielded three different personas with distinct user requirements. Based on these future research could, under consideration of general design guidelines for user-centered design, build prototypes to assess their usability.

Samenvatting

Het wordt ervan uitgegaan dat elektrische voertuigen (EV) duurzamer en beter voor het milieu zijn dan conventionele voertuigen (CV) omdat ze niet afhankelijk zijn van fossiele brandstoffen. Om de brede implementatie te bevorderen is het nodig om reikwijdten angst te verminderen, dat is de angst daarvoor met het voertuig te stranden omdat er maar beperkte resources beschikbaar zijn. Uit onderzoek blijkt dat dit door het middel van een user interface bereikt kan worden. Verder blijkt dat er de mogelijkheid bestaat dat er verschillende gebruikersgroepen zijn met verschillende benodigdheden. Tot nu toe is het meeste onderzoek gedaan naar early adopters wat dit onderwerp betreft. Deze studie probeert dit te onderzoeken en neemt daarbij een user-centered perspectief om de user groepen binnen de niet-early adopters te exploreren. Om dit te bereiken is de personas methode gebruikt die het doel heeft om archetypische gebruikersprofielen te formuleren die in het verdere designproces kunnen worden gebruikt. Er zijn acht semigestructureerde interviews gedaan met eventuele latere gebruikers van elektrische voertuigen, de interviews werden getranscribeerd en gecodeerd. Uit de navolgende analyse bleek dat er drie personas zijn met verschillende benodigdheden. Gebaseerd op deze personas kan toekomstige research, met behulp van algemene design richtlijnen voor user-centered design, prototypen ontwerpen en testen.

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1 Introduction

Rising concerns about the ecological footprint, the consumption of natural resources humans account for, the anthropogenic amplification of the natural greenhouse effect and the limitedness of fossil fuel have led to a recent upswing in advancement and sales of electric vehicles (EV). In 2015 the threshold of one million EVs was exceeded, while in 2011 just around 60 thousand were registered worldwide (International Energy Agency, 2016). In comparison to traditional combustion-powered vehicles (CPV) electric vehicles solely rely on electric energy drained from an internal battery. Therefore no fossil fuels are directly used for powering the car which's burning does contribute to the amount of greenhouse gases in the earth's atmosphere. So EVs do have the potential to be more sustainable than CPVs. Although there are some concerns regarding the battery and the source of the energy with which it is being charged, scientific consensus is that EVs have a smaller environmental impact than CPVs do. Therefore the implementation of such vehicles should be promoted (Romm, 2006; Thomas, 2009; Notter et al., 2010; Hawkins, Singh, Majeau-Bettez & Strømman, 2013). The goal of this study is to investigate how the user-interface of an EV can be improved to enhance usability for different users.

To really have a significant impact on the environment, the use of EVs must become more common in the population. Although it is predicted that the sales of EVs will continue to rise extensively (Becker, Sidhu & Tenderich, 2009), the market share of EVs in 2016 was still as small as 0.86% (EV Volumes, 2016). In order to make the vehicles more appealing for potential customers, reasons why people do not buy EVs have to be examined. And those are diverse: the higher average price in comparison to CPVs with similar configurations, uncertainty about the future subsidy granted by the government, less sufficiently qualified car dealerships for inspections and reparations, or, as the Wall Street Journal states, simply having not enough knowledge and information about EVs (Chernova, 2014). So far most accounts focus on how to change human behavior or attitude towards EVs. Rauh, Franke and Krems (2014) for example evaluated how the level of experience influences how people make use of their EV. Thus comparatively little has been done to make the system fit the user, although a user-centered perspective might be more promising in terms of product implementation (Abras, Maloney-Krichmar & Preece, 2004).

One concern has been influencing the public evaluation of EVs from the very beginning, range anxiety. Range anxiety is believed to be one of the main barriers why people decide not to buy an EV but a CPV (Luettringhaus & Nilsson, 2012). It is defined as the negative feelings related

with the limited range and stronger dependency on charging stations when comparing to CPVs (Rauh, Franke & Krems, 2015). Contrary to conventional vehicles EVs need to be recharged with electric energy, which does take significantly longer. Energy consumption in EVs also is a lot more prone to environmental influences than conventional combustion engines are, for example cold weather does have a profound impact of up to 20% on how much resources are needed to power the car (Yuksel & Michalek, 2015). Combined these factors add up to range anxiety in prospective customers. To boost the sales and to overcome range anxiety companies are especially focused on extending the maximum range of the EV. This might be achieved by constructing larger batteries, developing faster charging stations or by implementing systems in the EV that make it possible to quickly change the empty battery for a new, fully charged one. Although it definitely is important to improve the range of EVs, research suggests that this problem should not be that critical with today's EVs. According to Needell, McNerney, Chang & Trancik (2015) 87% of the needs the participants had could be met with an average EV. So the system needs to be more appealing for the prospective users and make them feel more comfortable regarding the use of the limited resources. One way to achieve this goal is by providing the user with a supporting interface in the form of a display. Neumann & Franke (2016) found that the reliable presentation of range and consumption related issues have the potential to enhance the experience for the human when using an EV. This way the user's competence increases and he or she will feel more certain when thinking about handling an EV. Enhanced competence and trust in the EV through the implementation of a well-designed user interface therefore has the potential to minimize feelings of range anxiety.

Franke and Krems (2013) found that people do differ in the extent to which they experience range anxiety when approaching different personal thresholds. They did a 6 month field-study, involving 40 participants, to examine how early adopters handled the use of the available resources when driving an EV. The participants did show three different range levels which were labeled by the researchers as competent, performant and comfortable range. Competent range is the maximal distance a person is willing to drive in an EV, so here range anxiety is perceived as a direct threat. The average distance a person drives with the vehicle was named his or her performant range. When operating within the performant range, this can already evoke feelings of range anxiety, because unexpected incidents could potentially make the individual worrying about whether they can reach their destination with the available resources. Comfortable range is the range in which users feel confident and do have sufficient resources. More important, they found that these range

levels vary strongly between different people. Franke and Krems identified different personality traits that were responsible for the variation in range levels. This is an indication for the existence of distinct user groups which probably also have divergent requirements when it comes to the design of the user interface.

Research investigating the user requirements of EVs and especially their user interface has mostly been conducted with early adopters. (Morton, Schuitema & Anable, 2011; Egbue & Long, 2012; Franke & Krems, 2013; Plötz, Schneider, Globisch & Dütschke, 2014; Namdeo, Tiwary & Dziurla, 2014; Rauh, Franke & Krems, 2015; Neumann & Franke, 2016). So the design implications provided presently are possibly in need for more research, as different groups in the theory of technology adoption lifecycle do have different characteristics. Rogers (2010) describes early adopters as being on average younger, having leader positions and being higher educated. After the small percentage of innovators, early adopters are one of the firsts to acquire and use newly available technology, in this case an EV. This is because they are more open and interested in what the technology might has to offer and they strive to be part of a change (Beal, Rogers & Bohlen, 1957). Theoretically you would expect them to have relatively small range anxiety, because of their curious and open nature. However, the early adopters and innovators just make up for approximately one fifth of the total amount of prospective customers therefore it is important to examine how to reach the rest of the population. Those are these people who have not bought an EV yet, the prospective users. Rauh, Franke and Krems stated as a limitation of their research that it was only done with early adopters and that subsequent research should also consider other groups, because of the differences in personality. That is, different groups in the innovation adoption cycle probably hold fundamentally different believes, have different needs and different expectations. Therefore what they need to be provided with by the user interface might not be what early adopters need and has not been investigated yet.

To investigate the possible different user groups the user-centered personas technique is used. It is a tool to analyze qualitative data to give designers and developers an idea about what the target audience looks like and which differences there are within it. Although it is most commonly used in a concrete design process (see LeRouge, Ma, Sneha & Tolle, 2013), the method has come to use in scientific context too (Randolph, 2004). The end products of a personas study are fictionally enriched descriptions of stereotypical user groups, it illustrates their behavior, goals, attitudes and wishes. Therefore it provides the researcher or designer with a clear and concise picture of the goal population and therefore facilitates user-centered design. Miaskiewicz and

Kozar (2011) have evaluated the main advantages for this kind of study: the method focuses on the properties of the user and not on those of the design, it prioritizes the users and identifies differences among them. Also it creates a distance between the designer and the prospective user, therefore helping to prevent biased design. When thinking about designing for a concrete person the developer is much more bounded to what this hypothetical person may want or need.

However, the method is not without criticism, Chapman and Milham (2006) question the scientific value of the method, as they say it is not verifiable or falsifiable and does not explain how big the part of the population is that is covered by one persona. Also the relatively subjective nature of the methodology has been criticized. Long (2009) has examined these claims by empirically testing the effect of the use of personas in a design context and has come to the conclusion that there is evidence for significant improvements when using the method. Thus the personas technique appears to be suitable for exploring the hypothetical different user groups in the target audience.

Range anxiety being one of the main problems that remains when talking about the mass implementation of EVs, a properly designed user-interface has the potential to help people overcome or lessen these feelings. As research suggest there might be different user profiles with varying requirements which can be examined using the user-centered personas technique. There is a niche in research, because so far most studies investigated early-adopters' needs and expectations. So the research question this study tries to answer is: Which are the different personas in prospective electric vehicle users in regard to the user interface to lessen feelings of range anxiety?

2 Methods

2.1 Participants

Participants recruited were mostly acquaintances and friends of the researcher and were informally approached. The total amount of participants which were interviewed is 16, 7 of them were males and 9 females. Age ranged from 20 to 52, with a mean age of 31.31 years (SD=13.19). However, half of the interviews could not be used because one of the researchers failed to take off the interviews correctly. So for this study just 8 participants could be used, their mean age was 27.0 (SD=9.20) and ranged from 22 to 48. Six were females and two males. All of them were German, they all were volunteers and did not receive any reward for participating. Exclusion criteria for selecting participants were the possession of an EV, not to have a valid driver's license or not being able to drive a vehicle because of various reasons like bad vision, dementia, drug addiction or other

bodily or mental impairments. Whether or not the participants had driven an EV before or how much prior knowledge they had about the topic did not affect their suitability for the study. These criteria made sure that the participants were non-early adopters and did have sufficient experience and knowledge about driving and handling a vehicle. Before the interviews were conducted ethical approval was obtained by the Ethics Committee of the University of Twente.

2.2 Materials

Semi-structured face to face interviews were carried out with the participants. The designed interview consisted of 60 questions (see Appendix) of which one was demographic, eight questions were generally related to EVs, personal vehicle use and the proposed psychological range levels by Franke and Krems (2013), 46 were about the user interface in an EV and how it could help the participants to deal with limited resources and five asked the participants to prioritize the discussed features. Questions about range anxiety aimed at pointing out how much the participants knew about EV's range and whether they were aware of range related problems and how they are influenced by different factors. The first part of the questions involving the display were open and aimed at investigating what the participants came up with on their own. The second part of it took a closer look at those features mentioned to clarify and evaluate them. In total 12 different features were examined. They were partly derived from a comparable interview study by Neuman & Krems (2016) and partly by comparing what functions companies like Tesla and BMW provide the user with to make them more comfortable about the range of their vehicles (Stewart, 2016). Also some were taken from what is commonly used in conventional vehicles like the display of the current speed, a clock or a warning when resources drop underneath a certain point. The interviews were held in German.

2.3 Procedure

The participants were approached directly by the researcher and asked if they were willing to participate in the study. They were selected because they were easy to address, as most of them were friends or relatives. Therefore convenience sampling was done and no randomization applies. Before the interview was started the recording device was checked on functionality and eventually started. In the beginning the interviewer instructed the participants about the goal, the content and the duration of the interview. Also the participants were asked whether they had fully understood the terms of the interview and they signed the informed consent.

When the participants were instructed and had signed everything the first part of the interview was conducted, covering demographic data, personal vehicle use and knowledge about EV's range. When finished, the participants were asked if they wanted to take a break before continuing with the second part. Subsequently they were asked which features they would like to be presented with to overcome or mitigate range anxiety. Instructions were to come up with as many features as possible without help and then to tell the researcher when they could not think of anything new anymore. After that the participants were presented with further functions by the researcher. To obtain more concise descriptions and to rule out misunderstandings the participants were asked how they would like the information to be presented, how that would help them and how important they thought these functions were. Here it has to be noted that interest was solely in features which relate to range in any way, for example multimedia features were not taken into consideration. When the participants did start to mention non-relevant things they were told by the researchers to refocus on features that would support them with dealing with the resources of the EV. For the last part of the interview, the prioritization, the participants were given a list with all features to make it easier for them to overview all of them (see Appendix A). After that, the participants were debriefed thanked for their help.

The interviews usually took between 25 and 35 minutes, mostly depending on how many follow-up questions had to be asked and how much the specific participant elaborated on his or her answers. Follow-up questions were used when the participants did not seem to understand a question or did not understand it in the way it was intended. Also when the participants did not answer the question sufficiently the researcher intervened and asked them to expand the answer.

2.4 Analysis

To analyze the interviews they were transcribed by the researchers, which both were native speakers of German. After that, the bottom-up approach inductive coding was used to structure the data. The research is explorative, there were no prior codes making inductive coding more suitable as opposed to a deductive method. For this Atlas.ti 8 was used, a software assisting with the analysis of qualitative data. Codes were derived from plain text and applied to the rest of the interviews. As more of the interviews were coded, codes underwent constant adjustment to fit the data as good as possible. This yielded a total amount of seven different codes.

The coding of the interviews was the basis for identifying and examining the different user personas. To accomplish this Castro Acuña and Juristo Juzgado (2008) formulated seven steps

based on those of Cooper and Reimann (2003). They based them on previous research regarding the use of personas technique in a human-computer interaction context. The first step is to identify the different behavioral variables, after that the participants are mapped on these dimensions. Following that significant behavior patterns are identified which are shared by a group of participants. Based on that, characteristics and goals are synthesized, and checked for redundancy and completeness. After that the descriptions get expanded with attributes and behaviors of the personas.

To identify the behavioral variables the coded interviews were used, it was looked for variables different people had expressed different meaning, content or expectations about. To identify the different personas the participants were mapped in terms of the behavioral variables and clusters were identified. Then the specific characteristics of these personas were further examined by looking at the coded interviews and after that specific descriptions of the hypothetical personas were given.

3 Results

3.1 Mapping on dimensions

In the following section the different behavioral variables are presented and the emerging personas are discussed and mapped on these variables. In total nine different ones became clear when analyzing the data the interviews yielded. Based on that three different personas could be identified, those are the conventionalist (n=3), the realist (n=3) and the idealist (n=2). Some variables relate to the personality of the personas while others are purely about how they would like the display to be designed. First the former will be presented and after that the latter.

General opinion regarding EVs

The first variable used for the mapping was the general opinion towards EVs. It ought to reveal the attitude of the personas which probably is influenced by prior knowledge and what they consider important, so it is a general indicator for the corresponding persona's point of view. The conventionalist showed the most negative attitude towards EVs, although it still was moderate. Opposing stands the idealist who has a very positive meaning about EVs, the realist lies in between, holding a relatively positive attitude. The following quote demonstrates a conventionalist who does have a neutral opinion regarding EVs and is the lowest achieving persona on this dimension.

I have thought about buying [an EV], but I quickly have come to the conclusion that it is not suitable for me. Because it is not fully developed yet, the range is too short, the charging times are too long. (Participant 6)

On the other hand this participant, being an idealist, expresses a positive attitude.

I see a lot of advantages [in EVs]. First of all it is more ecological. Also it is forward-looking, I think in the future most of the cars will be powered by electricity. (Participant 3)

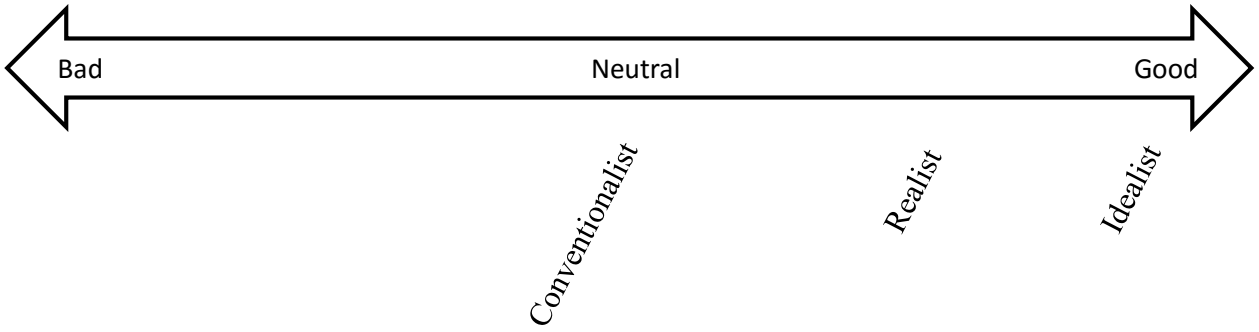


Figure 1. Average mapping of personas on general opinion regarding EVs

Range of EV perceived as

The second dimension was the perception of the participants whether the range of an EV would be suitable for them. In general, the evaluation of the range is negative, meaning that none of the personas finds the range to be enough for all their needs. Usually the non-suitability for longer trips like vacation or visiting family or friends was brought up. The conventionalist does perceive the range as not sufficient for everyday trips, while the idealist believes it is. Again, the realist lies in between, acknowledging that an EV probably would be enough for everyday situations, but not for more frequently occurring longer trips. These two quotes clarify how range was perceived by the different personas. The first one being one of a conventionalist.

No! That would definitely be not far enough for me! It is just not enough and you do not know where the next charging point is, no. (Participant 5)

And the second one being said by an idealist who shows mild concerns about the suitability in regards to range.

For everyday situations this would definitely be far enough for, but not if I would go on vacation. (Participant 3)

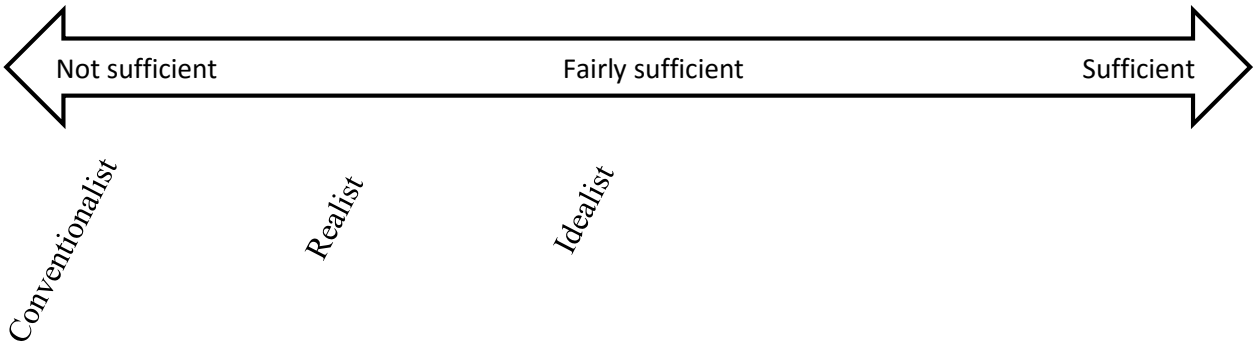


Figure 2. Average mapping of personas on perceived sufficiency of EV's range

Concern about environment

The next behavioral variable is the concern about the environment. It was brought up by all participants as a main motivator for considering to buy an EV or when weighing the pros and cons of such a vehicle. The concern a persona expresses gives insight in its mindset and goals and can therefore be of importance when designing a tailored display. The variable was frequently mentioned along with remarks about ecology and sustainability and differed between participant groups. Idealist being most concerned and conventionalist the least. Realists showed high concern, but slightly less than the idealists. Because the majority expressed concerns about the environment at some point the general trend is rather positive with even the conventionalist being mildly concerned. This is shown in the following quote made by a conventionalist.

> *I have to admit that for me personally the ecological benefits are not that important, although in general they are. (Participant 3)*

This realist made clear that the environmental advantages are highly important when evaluating EVs.

> *I have thought about it, especially since EVs are believed to be much more environmentally friendly and I really do care about the environment. (Participant 4)*

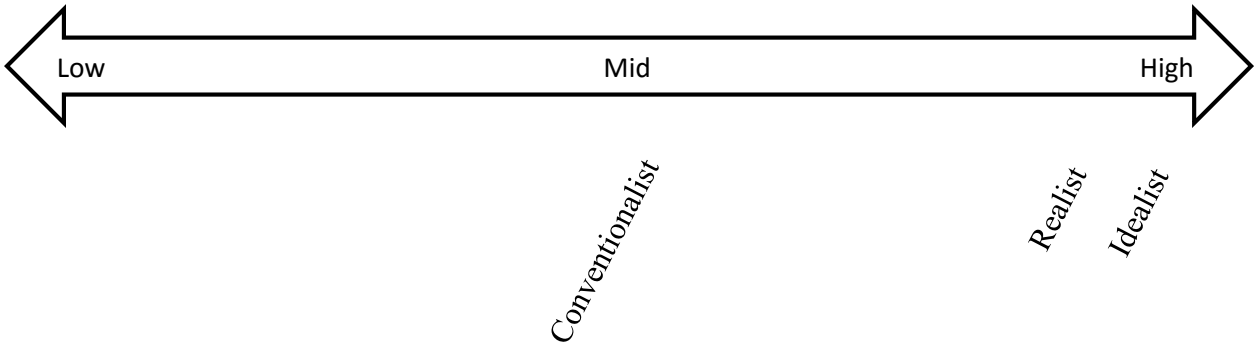


Figure 3. Average mapping of personas on concern about environment

Competent range

The following behavioral variable is the competent range the participant have. It is based on the psychological range levels discussed in the introduction and describes the maximal amount of resources a user is willing to use before recharging the battery. The idealist showed the most eagerness in using the whole available range of an EV while the conventionalist preferred having a bigger safety buffer. As before the realist is the mean between the two, being willing to spend more resources than the conventionalist and less than the idealist. This quote of an idealist clarifies what a small need for having a lot charge left looks like.

> *I think, because there are not so many charging points and you do not know where the next one is I would like to have at least 30km range left. (Participant 1)*

On the other hand, this participant stands example for a conventionalist having a larger need for a safety buffer.

> *I have to have 50 till 80km left. I would favor 80, because under bad circumstances it might just be 50 or so. So yes, 80km. (Participant 7)*

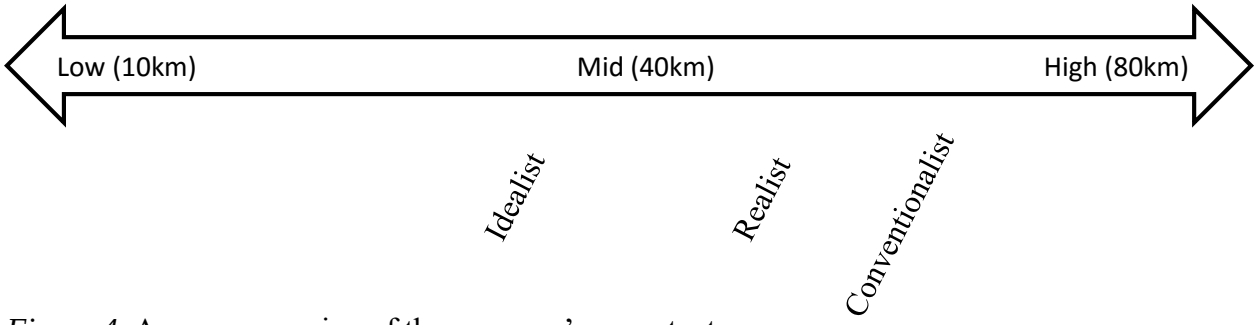


Figure 4. Average mapping of the personas' competent range

Frequency longer distances travelled

How often the participants do go on longer trips is reflected in the variable frequency longer distances travelled. Usually the non-suitability of EVs for travelling larger distances was mentioned as a limitation by the participants. The distribution of participants for this variable is less clear than for the other variables and therefore the personas are less distinct. That is because how often somebody travels larger distances is influenced by many other factors like for example his or her employment or family. However, a pattern still was identifiable and in general the realist did engage in this kind of behavior the most, while the conventionalist did the least and was therefore commonly travelling large distances. The idealist laid in between, but came closer to the realist than the conventionalist. In the following quote a conventionalist who usually does travel shorter distances is presented.

> *I usually just drive to my job or to do grocery shopping, that is approximately 2km. Otherwise I have to drive somewhat longer, but I do not really do that often. (Participant 5)*

Here a quote of a realist is presented, demonstrating the other side of the dimension. Thus he or she does larger trips more often.

> *I do frequently drive home from the place I study, that is approximately 130km. (Participant 4)*

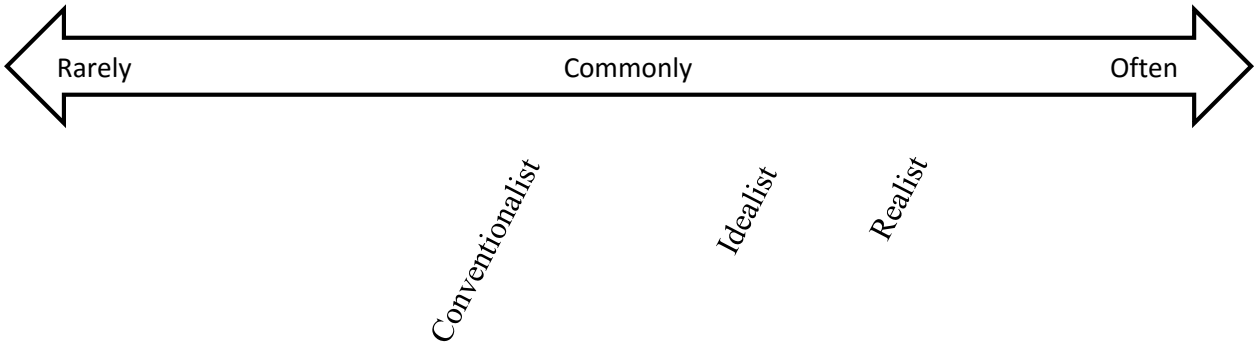


Figure 5. Average mapping of personas' frequency of larger travelled distances

Reliance on supporting display features

The last behavioral variable that is not purely about the user-interface is reliance on supporting display features. It gives information about the degree to which the personas put their

trust into the display features to reach their destination safely and with the least experienced range anxiety. Trust in the different functions did also influence this variable. The idealist relied the least on the display features shortly followed by the realist. The conventionalist did rely the most on the features of the display. The following quote shows an idealist's attitude regarding the use of the features.

> *I would like to check that on my own, the remaining charge. So that I say to myself: you have 30% left, now you need to go and recharge your car. When it gets really critical, I would like to be warned. But usually that would not happen, I would recharge before I would need the function. (Participant 1)*

Opposing to the idealist the conventionalist demonstrated bigger reliance on the features of the display. In the following quote a conventionalist shows that he or she would rely on the function that indicates how long the car still needs to charge.

> *That's quite important, otherwise you have no idea. Especially if the car is still new, then you still need some time to figure it out, to get a feeling for it. (Participant 7)*

Figure 6. Average mapping of personas on their reliance on supporting display features

Curiosity about innovation

Curiosity about innovation is the next variable and the first one of those which are only about the design of the user-interface. It indicates how strong the participants' desire is to be presented with innovative information. An example for this might be that they like to see the corresponding indicators in Kilowatts and not in other units which would be more like those in a CPV. The conventionalist showed low fascination for innovations and would rather see the display

to be as much as that of a CPV as possible. Idealists on the other hand wanted the display to involve novelties. In between are the realists who liked innovations they expected to be useful, but did not want an overwhelming mass of new features. The non-curiosity of the conventionalist is illustrated in the following.

> *So that you can see how many kilometers you have driven in total and how many since the last recharge. You should not change too much, otherwise it can get hard to adjust. (Participant 7)*

In contrast, this realist shows more eagerness about the implementation of innovative information.

> *Although, I think I would prefer Kilowatt, because then you will probably get a feeling for it. (Participant 8)*

Figure 7. Average mapping of personas on their curiosity about innovation

Desired customizability

The next dimension is desired customizability. It gives information about the extent to which the personas typically like to have the possibility to individualize the display and its functions. The conventionalist showed the least desire to be able to make custom changes, while the idealist regards this as a very important point to improve range related handling of the car as does the realist. It has to be noted that in the interview there was not explicitly asked how the participants would like to alter the display themselves. Nevertheless a lot of participants did mention that they would like to do so, but some participants' opinion regarding this might not have come the surface. Therefore the quote demonstrating low desire for customizability does not

perfectly represent the variable, but it does give an indication about the mindset of the conventionalist.

> *I would like to have the navigation system to show me the route to next charger when I have to recharge, and then always at the same level, otherwise it would confuse me. (Participant 5)*

The two following quotes are both from idealists and show which differences there are in between those who want the user-interface to be customizable.

> *It would be nice if you could activate that separately whenever you need it, or when you could decide whether or not you would like to see this information when you have arrived. (Participant 1)*

> *Maybe in respect to the last kilometers I have driven, but then in different steps which I can choose myself. Not totally weird numbers like 37.8 km, but maybe 100km, 50km and 20km or something like this. (Participant 3)*

Figure 8. Average mapping of personas on their desired customizability

Desired obtrusiveness of alarm signals

A very important feature for the participants was a warning system which alarms them when their remaining range drops under a certain level. One corresponding behavioral variable is the desired obtrusiveness of these alarm or alarms. Obtrusiveness in this case either meant multiple signals or stronger signals. The conventionalist and realist show the biggest desire for being reminded in a more pushy fashion than the idealist, who laid in the midsection of this dimension. However, in general the need for being alarmed sufficiently is relatively high for all personas. An

example for an idealist who wants to be warned not overly obtrusive, but still visually is seen in the following quote.

> *I really do not like sounds as signals, they just startle you while driving. I would like to have some kind of blinking or flashing. (Participant 1)*

The conventionalist on the other wanted to be warned more frequently and therefore more obtrusively as is seen in this example.

> *Then maybe with a flashing display and a sound for the last 50km or the last 20%, 15%, 10% and 5%. Thus in steps of five percent. And it would be nice if the signal would intensify as the charge gets less. (Participant 7)*

Figure 9. Average mapping of personas on their desired obtrusiveness of alarm signals

3.2 Personas

Persona 1: The conventionalist

Derek is 55 years old and has worked for an insurance company for over 25 years. He is well paid and lives with his wife in a reasonably sized house which they bought when they planned on having children. Derek has a daughter and a son which both moved out as they are going to university now. He once or twice thought about maybe buying an EV in the future, when he saw how good-looking and prestigious the new Tesla was. But he does not see why he should buy such a vehicle now when it is not fully developed and still puts obstacles in his way. Especially being in a position which does not allow him to be fully independent is disliked by him and he feels that the limited range of an EV is putting him in this position. Although he usually just drives to work, to visit

some close by friends or to do grocery shopping and does not go on longer trips frequently, he does not feel comfortable with the fact that going on vacation with this car is something that is not done easily. In general he is a little suspicious of battery powered transportation, since batteries can get damaged and lose power over time. Also replacing such a big battery probably is very expensive, an expense you do not have with a normal car. Although he sees all these downsides he likes the idea of an EV in general, if it was further developed and if he got sufficient support from the car to be able to handle all the new things he has to keep in mind.

This support might be given to him through the user-interface in the car. When thinking about an EV on the one hand he would like it to be as much as the good old car he knows without any unnecessary new and confusing gadgets. But on the other hand he wants the display in the car to strongly assist him in regards to range relate issues. So he likes features which are built-in a conventional car like remaining fuel, a kilometer counter or the outside temperature. But to handle the new situation as good as possible he also wants to be presented with information like the closest charger. Best would be an implementation in the standard navigation system, so he does not need to adapt too much. That way he can estimate on his own when he should start being concerned about recharging the car.

Because an EV is such a new technology he does not feel comfortable with changing the features in the display himself. He would like to just have it presented in the most convenient way, which the designers and developers probably know best, he thinks. As long as this information is manageable for him and he can make sense of it, he does not want a fancy display that is overwhelming him with all kind of functions. With one exception, when he drops below a certain threshold he wants to be warned by the car quite obtrusively.

Thus generally speaking Derek wants a display in the electric car which resembles that of a normal car as far as possible. He does rely on the car company to make a good job with choosing how things are presented. He feels a little intimidated by the fact that the car just has limited range and wants the display to always give him information on how he is doing and wants it to harshly warn him when he just comes to close to a critical point.

Figure 10. Reprinted from [surprised shocked businessman in suit] (n.d.). Copyright Scheriton. Retrieved from https://www.stockfreeimages.com/19517217/Surprised-Shocked-Business-Man-in-Suit.html

Persona 2: The realist

Sarah is 29 years old and planning to soon have a baby with her husband. Together they live in a smaller city where they already bought a house. Her hobbies are meeting with her friends, playing tennis and reading a lot about various topics she finds interesting, which changes almost monthly. She would say about herself that she is open-minded and she would like to contribute something to the good of society and the future of her child or children. She can do so best by changing her everyday life, she believes. Recently she saw a documentary about how electric vehicles have evolved in the past twenty years and what impact they can possibly have. After doing some extra research she realized that there is no alternative in the future and that there has to be a change away from fossil fuels. She would like to be part of the solution, but wonders whether an EV would be suitable for her and her family, especially when she is planning on having children in the near future.

Sarah still thinks range is a big issue, but she does know that she could easily do most of her trips with an EV. Like going to work or to pick up her future son or daughter from friends or school. Just going on vacation and visiting her mother who lives quite far away made her doubting. She thought about it rationally and came to the conclusion that it might be a little extra work on top, but all in all is a small price to pay for being part of a change and a good role model for her child or children. Nevertheless Sarah sees which disadvantages come with an EV and would like to be supported in managing the resources if she would drive one. She thinks that she can do it herself, but also is curious to explore what new things come with this type of car. Thus she likes to get to know new things, but simultaneously she has no need for ‘just for fun’ information. What she sees has to be helpful or her in some way.

To make the best use of the car and its features she wants the display to be individually customizable. That does not mean that Sarah does not appreciate a well-structured display designed by professionals, she just wants the freedom to choose between for example Kilowatts and remaining battery in percent. So she feels confident to do minor changes and believes that those would benefit her substantially. She thinks that she will keep an eye on the fuel state herself. But she also knows that from time to time she can get lost in thought and with the faster consumption of total resources in an EV she thinks that a warning system is a big must have. Therefore she wants to be warned early and frequently.

In general she considers the range related information in the user interface as a must have for feeling comfortable when using the car. She wants it to show her new things compared to a normal car, but does not want it to be cluttered with useless information she cannot remove.

Figure 11. Reprinted from [young woman leans against pole in afternoon sunlight] (n.d.). Copyright Bburges. Retrieved from https://www.stockfreeimages.com/1634879/Young-Woman-Leans-Against-Pole-in-Afternoon-Sunlight.html

Persona 3: The idealist

Patrick, 25, is single, just started in the job market as an IT expert. He is living in a relatively small apartment in a big city, close to his workplace. When he is not busy working there, he mostly is at home playing video games and watching documentaries about technology being currently in development. He already considered buying an EV in the close future. He believes that the technology now is developed enough, unlike it was in the past five to ten years. He is fascinated by how well the electricity powered engine replaces a combustion powered one and even beats it when it comes to speed and acceleration. For him another big advantage is that this way he can help protecting the planet and contribute to slowing down global warming. As a well-informed person he knows that the end of the fossil fuel era will come soon and new means of transportation are necessary.

Yet being limited in his freedom to go where he wants to go to without restraints is something that bothers him. He knows that almost always the car would fit his needs, since his family is living in the same city and as already said his workplace does also lie in proximity and he does not really like to go on vacation by car. But he thinks that you can never know what the future might bring. What if his job has him to go somewhere further away? Then the limited range would become a problem.

He is very curious about how the display can help him in new fascinating ways with dealing with it. For him it is not just the practical use, but interest in how things were managed by the car company. He enjoys trying every single function the display has to offer and ideally wants to be able to change as much as possible in it, he sees the car a little as a toy for grown-ups. As much as he thinks that the company did a good job, he thinks that if he does it himself he can do a better job. Tailoring the display for his needs contributes to making him less afraid of getting in critical situations. He believes that with the variety of functions and the individualization he is competent

enough to not get in real trouble. Therefore e has no need for an overly obtrusive warning system, he would be fully aware of everything that happens with the car at almost any time. This does not mean that he does not want one, it should just be considerate and not distract him while driving.

Thus he is competent with technology and wants to experience the innovations in the display firsthand. Also he likes to adjust things like he thinks it is best. He is not afraid that he would get in critical situations when driving an EV, as he considers himself fast learning.

Figure 12. Reprinted from [young nerd] (n.d.). Copyright Djma. Retrieved from https://www.stockfreeimages.com/13748731/Young-nerd.html

4 Discussion

4.1 Explanation of results

The research question was which the different personas are in prospective electric vehicle users when it comes to a range anxiety lessening user-interface. Based on the acquired data and the subsequent analysis three different personas could be distinguished. The conventionalist, the realist and the idealist, which all differed on the nine proposed dimensions. The first persona is the most skeptical one, the conventionalist does want the display to be as much as that in a CPV as possible since this puts him or her in a known environment and does not need him or her to adapt strongly. The second persona, the realist, does like to experiment with the newly introduced features of an EV, but only favors those which really help him or her with dealing with the limited range. The third persona, which is the idealist, likes the idea of EVs the most. He or she is technical affine and has comprehensive experience when it comes to new technology. The idealist enjoys using the new technology and likes to tailor the display himself.

As expected, if regarding the findings of Franke and Krems (2013), differences in psychological range levels were found for the personas. Personas especially differed in terms of competent range, the personal maximum amount of resources a person is willing to spend before recharging the vehicle. The conventionalist has the smallest competent range, meaning he or she will experience more range anxiety when being put in the same situation. Opposed to that stands the idealist with the need for the smallest safety buffer and the most confident handling of the limited resources. In between the two is the realist, whose competent range is larger than the idealist's, but smaller than the conventionalist's. These differences in psychological range levels do play an important role as they are a possible basis for the diverging needs the personas have and

which became clear in when constructing the personas based on the data. Because the conventionalist has the largest competent range, this persona experiences more range anxiety in potentially critical situations and therefore also showed different outcomes on the other dimensions which go along with other design implications, as stated in the results.

4.2 Comparison with literature

Dissimilarities in what groups of people want in a display of an EV have been found before. There has been done research in how early-adopters evaluated and understood the different functions present in the display of an EV (Neumann & Krems, 2016). Using 40 participants in a six month trial, they found an overall bigger need for transparency and integration of new information like the implementation of trustworthy and understandable presentation of remaining range. More importantly for the current research, they acknowledged an inconsistency in how the users wanted these information to be presented. Some preferred them to be as close as possible to the way they are presented in CPVs, thus favoring units like remaining kilometers. While others liked the presentation of novel information more, like kW. These apparent group differences in preferences in early adopters are comparable to what has been found in the current study, involving non-early adopters. A main difference between the proposed personas is how similar they want the display to be like that of a CPV. And although Neumann and Krems did not check for underlying user personas the findings allow for the existence separate user groups comparable to those found for the non-early adopters in this study. This is true at least for the desire to have the display designed more in terms of a traditional CPV or more focused on innovation and the implementation of new features.

Strömberg et al (2011) had similar findings. They put participants who did not have any prior experience regarding EVs, thus non-early adopters, in a driving simulator and either presented them with a more familiar or a more innovative user-interface. After the test interviews were done to investigate how the participants experience the different displays. In line with the current research and the findings of Neumann and Krems they found some people to prefer the more innovative display and others the more familiar one. So apparently group differences on that dimension were present in early adopters as well as in non-early adopters, thus further supporting the outcomes of this study.

Franke, Rauh and Krems (2015) investigated individual differences in range stress while encountering a critical range situation for the first time. The 74 participants were non-early

adopters, as none of them owned an EV. Among other things they found trust in the range estimation system and system knowledge to be related to lower experienced range anxiety. Franke, Rauh and Krems explain part of their results with the transactional model of stress which basically states that stress comes from a discrepancy between the demands put on a person by the external environment and the abilities this person has to fulfill those demands. Originally formulated by Lazarus and Folkman (1987) the transactional model of stress emphasizes the importance of control believes in the emergence of stress, as it is seen as the result of a person not feeling able to control the environment he or she is in. The theory and the findings of Franke, Rauh and Krems support and explain what was found in this study. Range anxiety is a form of stress and in this context develops because the limited resources of the car put demands on the user he or she might feel unable to deal with. The different personas feel able to cope with these limitations differently well. Best doing is the idealist who has technological expertise and general trust in technology, and therefore feels able to handle the situation. That is for example why the idealist does not have a need for an obtrusive warning system in the car, he or she feels like being in charge of the situation and just needs to be supported by the user-interface in case of finding himself or herself in a situation that puts comparatively high demands on him or her. The conventionalist on the other hand has a low level of expertise and therefore a bigger need of being supported by the display. Lazarus and Folkman underline the importance of making the person feeling able to control the situation to overcome and lessen feelings of stress. That can be accomplished by taking into account the findings of this study and adapting the display to the specific user persona.

So to make it possible for the user to handle the EV, respectively its user-interface, with the least amount of adaption efforts designers need to keep in mind the different personas. To provide a user-centered human factors solution they need to focus on the needs of the particular persona they want the display to be most suitable for. As they all have different levels of knowledge and expertise and accompanying different needs and desires the descriptions should be checked thoroughly before considering to make any decisions regarding the design of the interface.

4.3 Strengths and Limitations

The current research can help designers to create a user-interface which is more suitable for the corresponding group of prospective electric vehicle users in reducing range anxiety and therefore improving the overall user experience. However, the study also has some limitations. The first and most important one is the sample. From originally 16 just eight interview could be used

for the subsequent analysis of the data. This resulted in less concise classification of the personas, as some compromises had to be made. Some participants did, although the persona they were classified into stereotypically does not, show high levels on a particular dimension. Decisions had to be made on how to construct the persona and how to classify the participants on some occasions because of this ambiguity of the data (see Appendix B). This does not necessarily mean that the results are not valid, but it may allow for different interpretations with slightly different outcomes and possibly could have been prevented with the gathering of more valid data. Another thing that has been impacted by the loss of data is the generalizability of the findings. The sample is hardly representative for the whole or any subpopulation as it was collected by convenience sampling and consists of people of varying age, sex, social status and profession. Therefore the external validity of the findings is threatened. However, this does not inevitably mean that what has been found is not transferable to different settings, but aspects of the results may not be applicable.

A strong point of the research was the flexibility with which the interviews could be conducted. One of the nine behavioral variables only came up because this was the case. Desired customizability was brought up by many participants although no question in the interview was directly related to it neither was there otherwise asked. Still enough data could be gathered about that aspect of the interface so that it could be used as one of the behavioral variables for the analysis. This was possible because the semi-structured interviews allowed the interviewer to be relatively free and to check broadly what the participants were trying to tell. The follow-up questions which were thought of before also provided the researcher with an easily accessible tool to quickly check what the participants' mindset was about that topic. This was further promoted by the fact that the interviewer could freely decide to further go in on a topic that he thought could yield some useful information, which it finally did.

4.4 Future research

Before follow-up research can be done it has to be investigated whether or not the findings of this study are valid, generalizable and can be used in the design process for a whole population. This can be done by replicating the study on a larger scale and by using quantitative analysis methods to receive robust and empirically based findings. Kim and Wiggins (2016) for example proposed a way of quantitative analysis that led to the desired outcome. They used factor analysis to define the different personas. However, that research was done using questionnaire data. So the first step to construct a similar study based on the current research would be to construct a questionnaire on

basis of what was found here. After that the steps described by Kim and Wiggins are to be done and subsequent analysis should reveal whether or not the persona stand an empirical study.

When the findings are indeed generalizable, another possibility to expand the knowledge and especially focus on a user-centered design process is to develop prototypes based on the different personas while also taking general design guidelines into consideration. Future research thereby could form the basis for an improved user-interface that effectively helps people dealing better with the range situation while driving an EV without having extensive prior experiences with driving such a vehicle. Developing such prototypes would make it possible to do usability tests to assess whether the results of this study are valid and if they can actually make the system better fit to the human. So a logical next step would be to convert the findings of this personas study together with commonly accepted user-centered design guidelines into specific design implications for the user-interface.

4.5 Conclusion

Three different user personas were found: the conventionalist, the realist and the idealist. All three do possess different characteristics, needs and user requirements. When designing the user-interface in an EV these need to be taken into consideration. The findings are in line with and well supported by earlier research related to this topic. A starting point for future research is the formulation of specific design implications or the construction of prototypes, ideally whilst taking into account design guidelines for user-centered design.

5 References

Abras, C., Maloney-Krichmar, D., & Preece, J. (2004). User-centered design. Bainbridge, W. *Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications, 37*(4), 445-456.

Beal, G. M., Rogers, E. M., & Bohlen, J. M. (1957). Validity of the concept of stages in the adoption process. *Rural Sociology, 22*(2), 166-168.

Becker, T. A., Sidhu, I., & Tenderich, B. (2009). Electric vehicles in the United States: a new model with forecasts to 2030. *Center for Entrepreneurship and Technology, University of California, Berkeley, 24.*

Chernova, Y. (2014, September 28). *What's Holding Back Electric-Car Sales?* Retrieved from https://www.wsj.com/articles/what-s-holding-back-electric-car-sales-1411937798

Cooper, A., & Reimann, R. (2003). About Face 2.0: The Essentials of Interaction Design. Indianapolis, IN: Wiley.

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy policy, 48,* 717-729.

EV Volumes (2016). *Global Plug-in Sales for 2016.* Retrieved from http://www.ev-volumes.com/news/global-plug-in-sales-for-2016/.

Franke, T., & Krems, J. F. (2013). Interacting with limited mobility resources: Psychological range levels in electric vehicle use. *Transportation Research Part A: Policy and Practice*, 48, 109-122.

Franke, T., Neumann, I., Bühler, F., Cocron, P., & Krems, J. F. (2012). Experiencing range in an electric vehicle: Understanding psychological barriers. *Applied Psychology, 61*(3), 368-391.

Franke, T., Rauh, N., & Krems, J. F. (2016). Individual differences in BEV drivers' range stress during first encounter of a critical range situation. *Applied ergonomics, 57,* 28-35.

Kim, H.M. & Wiggins, J. (2016, June 18). *A Factor Analysis Approach to Persona Development using Survey Data*. Paper presented at: 8th Evidence Based Library and Information Practice Conference, Philadelphia.

Lazarus, R. S., & Folkman, S. (1987). Transactional theory and research on emotions and coping. *European Journal of personality, 1*(3), 141-169.

International Energy Agency (2016). *Global EV Outlook 2016 Beyond one million electric cars.* Paris, France: IEA Publications.

LeRouge, C., Ma, J., Sneha, S., & Tolle, K. (2013). User profiles and personas in the design and development of consumer health technologies. *International journal of medical informatics, 82*(11), e251-e268.

Long, F. (2009). Real or imaginary: The effectiveness of using personas in product design. *Proceedings of the Irish Ergonomics Society annual conference, 14,* Irish Ergonomics Society.

Luettringhaus, H., & Nilsson, M. (2012, October). ELVIRE approaches to mitigate EV drivers' range anxiety: Technical paper by ELVIRE–European research project on ICT for electric vehicles. In *19th ITS World Congress*, Vienna, Austria.

Miaskiewicz, T., & Kozar, K. A. (2011). Personas and user-centered design: How can personas benefit product design processes? *Design Studies, 32*(5), 417-430.

Morton, C., Schuitema, G., & Anable, J. (2011). Electric vehicles: Will consumers get charged up. In *Universities's Transport Study Group Conference January*.

Namdeo, A., Tiwary, A., & Dziurla, R. (2014). Spatial planning of public charging points using multi-dimensional analysis of early adopters of electric vehicles for a city region. *Technological Forecasting and Social Change, 89*, 188-200.

Needell, Z. A., McNerney, J., Chang, M. T., & Trancik, J. E. (2016). Potential for widespread electrification of personal vehicle travel in the United States. *Nature Energy, 1*, 16112.

Neumann, I. & Krems, J.F. (2016). Battery electric vehicles – implications for the driver interface. *Ergonomics, 59*(3), 331-343.

Plötz, P., Schneider, U., Globisch, J., & Dütschke, E. (2014). Who will buy electric vehicles? Identifying early adopters in Germany. *Transportation Research Part A: Policy and Practice, 67*, 96-109.

Randolph, G. (2004). Use-cases and personas: a case study in light-weight user interaction design for small development projects. *Informing Science: International Journal of an Emerging Transdiscipline, 7*, 105-116.

Rauh, N., Franke, T., & Krems, J. F. (2015). Understanding the impact of electric vehicle driving experience on range anxiety. *Human factors, 57*(1), 177-187.

Rogers, E. M. (2010). *Diffusion of innovations*. Simon and Schuster.

Stewart, J. (2016, September 22). Here's your first look at Tesla's new autopilot and UI. Retrieved from https://www.wired.com/2016/09/tesla-software-version-8-autopilot-user-interface/.

Strömberg, H., Andersson, P., Almgren, S., Ericsson, J., Karlsson, M., & Nåbo, A. (2011, November). Driver interfaces for electric vehicles. *Proceedings of the 3rd International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (pp. 177-184). ACM.

Yuksel, T., & Michalek, J. J. (2015). Effects of regional temperature on electric vehicle efficiency, range, and emissions in the United States. *Environmental science & technology, 49*(6), 3974-3980.

6 Appendices

Appendix A: Interview scheme-English

Introduction: In the interview we will ask you about your thoughts, opinions and expectations regarding a user interface/display in an electric vehicle. We are especially interested in the concept of *range anxiety* and how a display can influence it.

I would like to tell you some things before we start the interview. Your personal data and the data will be treated anonymously. You are free to end the interview at any given time or not to answer a particular question. The whole interview will be recorded and will take approximately 45 minutes.

Sign Informed Consent

At first we will ask 0.1 to 2.2.2. Secondly we give a short intermezzo to elaborate how the interview will proceed. With the answers to the questions 3 and 3.1 we get to know which display features the participants can think of. These questions will be followed up until the participant cannot come up with any more features. We keep track of which features the participant has mentioned on a list. If the participant has not mentioned a feature out of the list the corresponding question from 3.2.1 to 3.2.10 will be asked. Questions under the heading Explanation/Evaluation features from 4.1 to 4.10.1 are aimed to provide information about the participants' understanding of the feature and how important they perceive it to be. The goal of question 5 to 5.3 is to get a prioritization of the features by the participant.

Question number	**Question**	**Purpose/Explanation**
0.1	How old are you?	Personal data
	General	
1	Did you ever consider to buy an EV?	General opinion of participant regarding EV's; gives insight in the level of knowledge the participant has
	Range anxiety	
2	What do you know about the range of EV's?	General knowledge about EV's range; is the participant aware of range issues? does he/she know about range anxiety
2.1	What do you think how far an EV can go?	At the end 2.2 the participant is informed about the average range of an EV (SOURCE)

2.1.1	Do you think that this is far enough for you?	
2.1.1.1	How do you use the vehicle that this is (not) far enough for you?	
2.2	Can you think of anything that might influence the draining of the battery?	Come to know if the participants is aware of varying consumption and the factors that cause it.
2.2.1	What about environmental factors?	If only personal influences have been thought of
2.2.2	How do you think you have an influence on the energy consumption?	If only environmental influences have been thought of
2.2.2.1	What about the influence of your driving style?	
2.2.2.2	What about the influence of activation of extra functions of the car (for example air-conditioning)?	
2.2.2.3	What about the loading of the car?	
2.3.1	When you are using your EV with how much percentage of charge left would you like to arrive at your destination (and therefore the next charging possibility)?	Comfortable range
2.3.2	What do you think how much percentage of charge you would use per day?	Performant range; participants were instructed about the range of EV's, so they should be able to answer, otherwise it will be asked for kilometers and calculated afterwards how much percentage that would be
2.3.3	What do you think how far you personally can go when driving an EV?	Competent range
Intermezzo	So far we have mainly asked you questions concerning what is called 'range anxiety'. Which describes the stress experienced when considering the limited range of an EV. The next part of the interview will focus on the user interface/display. As it has proven effective/ is expected to help the	Clarifying what will be next and what was before. Clarifying what is expected from the participant in the second part. If the participant wishes he/she can take a break. The participant is asked whether he/she has understood what range anxiety is, otherwise

	user to manage the EV and limited resources more effectively.	further explanation is given/questions are answered
	Design display	
3	What do you think a display should show you?	Features the participant would like to have included
3.1	Can you explain what you mean by that?	Clarifying how the participant imagines the features
3.2.1	What about *average consumption*?	
3.2.1.1	In which unit would you like to be presented with the information?	Like kWh/km, km/kWh, percentage charge status/km etc.
3.2.1.2	In which way would this be helpful for you?	Is asked after every new item. How participant use the tool and with which intention
3.2.2	What about *instantaneous consumption*?	
3.2.2.1	In which unit would you like to be presented with the information?	
3.2.2.2	In which way would this be helpful for you?	
3.2.3	What about *charge status*?	
3.2.3.1	In which unit would you like to be presented with the information?	
3.2.3.2	What about *remaining range*?	
3.2.4.1	In which unit would you like to be presented with the information?	
3.2.5	What about *past consumption* for a given journey? (For example from home to work)	Motion patterns are highly repetitive, being able to know how much resources were need for past journeys might give a source of information which is perceived as more reliable

3.2.5.1	In which way would this be helpful for you?	
3.2.6	What about the amount of energy won by *regenerative braking*?	
3.2.6.1	How would you like this information to be presented?	
3.2.6.2	In which way would this be helpful for you?	
3.2.7	What about information about the *closest charging station*?	
3.2.7.1	How would you like this information to be presented?	
3.2.7.2	In which way would this be helpful for you?	
3.2.8	What about *occupational status of the charger*?	
3.2.8.1	How would you like this information to be presented?	
3.2.8.2	In which way would this be helpful for you?	
3.2.9	What about an *odometer*?	An instrument for measuring the distance travelled by a wheeled vehicle
3.2.10	What about the *outside temperature*?	
	Design Display importance of features	
4.1	What do you think which of these features are most important?	The participant is shown a list with the features (see below); features named now are to be easily accessible (presented big/permanently/etc. on the display)
4.1.1	Why do you think that?	

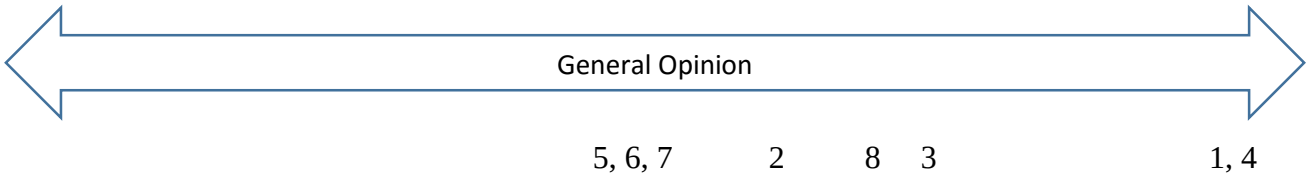
4.2.1	What do you think which features are the least important?	Features named now do not need to be always present/big (accessible through for example a switch on the wheel)
4.2.2	Why do you think that?	

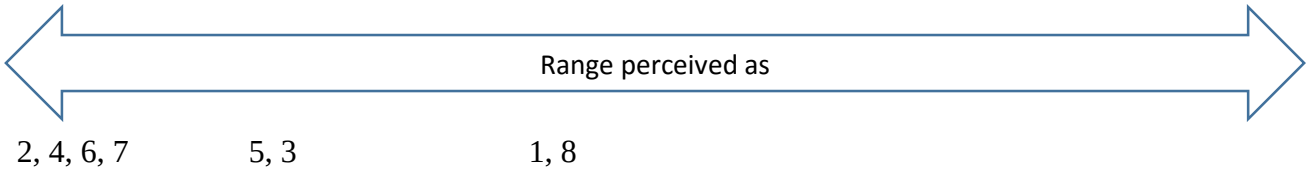
Debriefing: We have reached the end of the interview. We would like to thank you for taking the time to help us with our study. Is there anything you would like to say or do you have any questions left? If you are interested in the outcome of the study we can send it to you later.

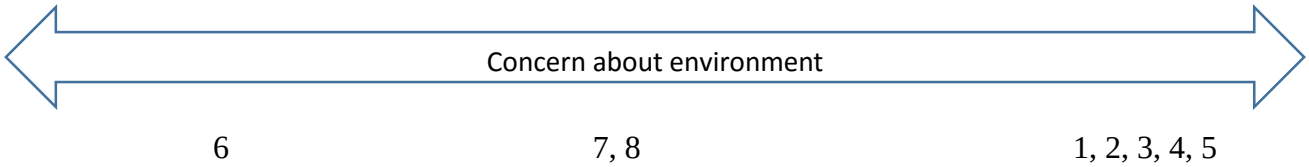
Display feature checklist

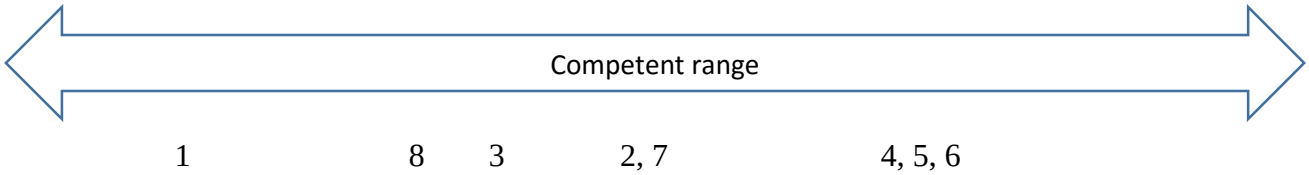
Remaining range	
Instantaneous consumption	
Average consumption	
Charge status	
Past consumption	
Regenerative braking	
Closest charger	
Occupational status of the charger	
Outside temperature	
Odometer	
Speed	
Additional features mentioned by participant:	

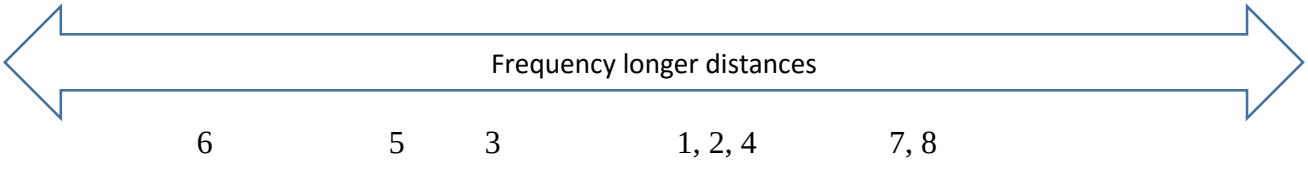
Appendix B: Mapping of participants on behavioral variables

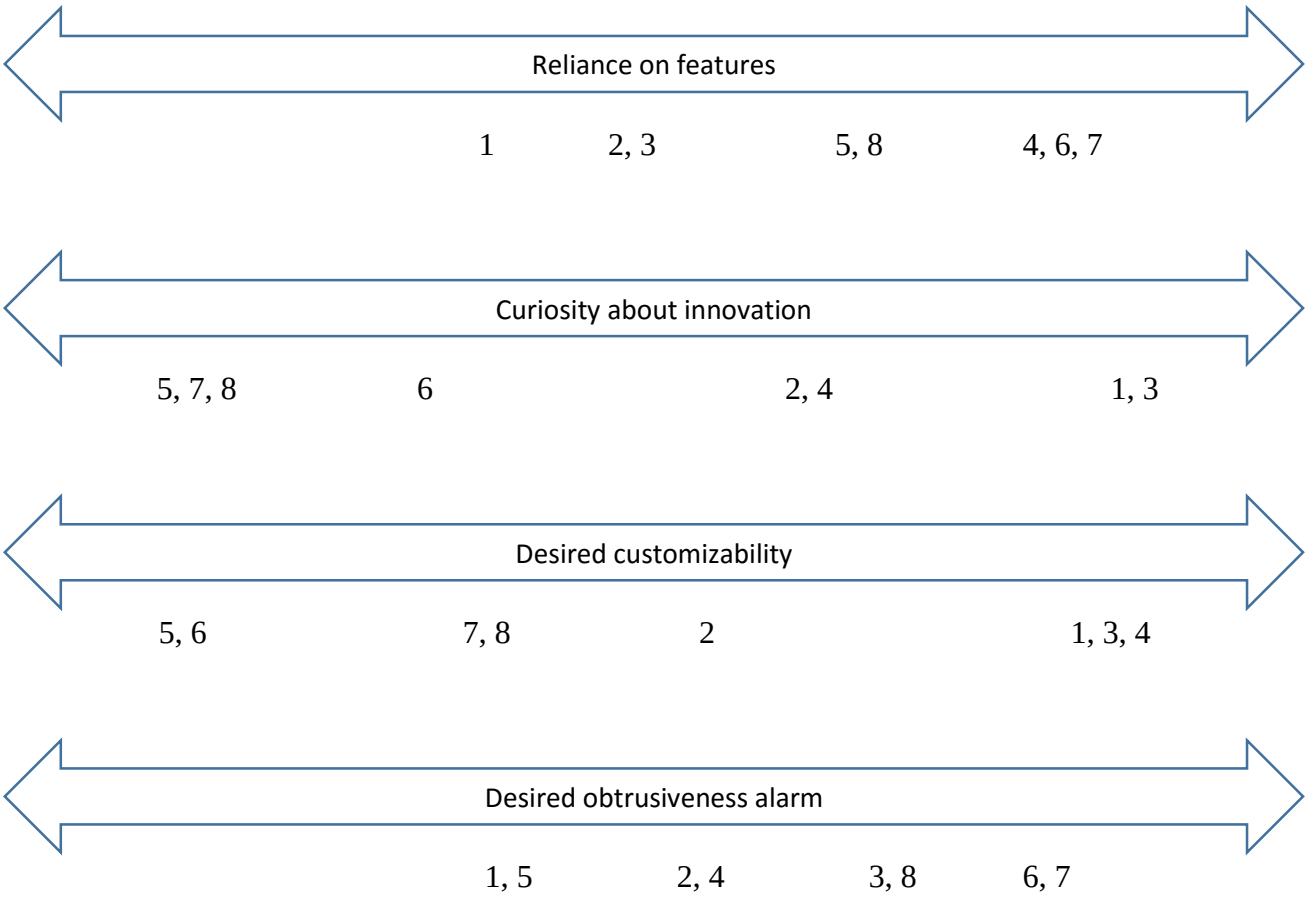











Reliance on features
1
2, 3
5, 8
4, 6, 7
Curiosity about innovation
5, 7, 8
6
2, 4
1, 3
Desired customizability
5, 6
7, 8
2
1, 3, 4
Desired obtrusiveness alarm
1, 5
2, 4
3, 8
6, 7