BACHELOR THESIS

User requirements for non-early adopters to ease range anxiety in an electronic vehicle

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Abstract

This study researched which requirements non-early adopters have for a dashboard in an electronic vehicle to ease and/or preclude range anxiety. For this a qualitative user requirement analysis was performed consisting of eight semi-structured interviews with non-early adopters about their needs to ease and/or preclude range anxiety. These interviews yielded nine topics non-early adopters want. Whilst early and non-early adopters have clear similarities on requirements, it did become clear that non-early adopters do have extra needs, mostly with regard to the possibilities of charging an electronic vehicle. Furthermore, this study found clear design implications based on the user requirements within these topics. Thereby giving insight in design possibilities for a dashboard of an electronic vehicle. However, these design implications also shed light on the fact that not all early-adopters are alike and do not have the same requirements. From all the requirements mentioned a first set-up for a dashboard in an electronic vehicle is proposed. Since this study was in an interview setting, requirements in a driving setting could differ. It is advised that the proposed dashboard is used for further research and testing to create a dashboard that eases and/or precludes range anxiety for the majority of the population.

Table of Contents

The Dutch government has made promises regarding the ambition of the sale of vehicles with electronic propulsion (Dutch Government, 2016). The government aspires that in the year 2035 all newly sold cars have the possibility of electronic propulsion and in 2050 all newly sold cars must have the possibility to drive without emission. This means that all newly sold cars cannot have a combustion engine for propulsion but instead, for instance, have a hydrogen or electronic propulsion based engine (Dutch Government, 2016). These aspirations have been worked out in the Green Deal Elektrisch Vervoer 2016-2020 (government with representation of the transportation, innovation and environment sector) that states that in the year 2020 10% of the newly sold cars must be vehicles with the possibility of electronic propulsion and in 2025 15% of newly sold cars must be cars with a non-combustion engine (Dutch Government, 2016). Despite government willingness consumers are not en masse buying vehicles with the possibility of electronic propulsion. On the first of January 2017 only 3% of the vehicles in the Netherlands have this possibility. This is a combination of electronic vehicles (non-combustion engine, 6%) and hybrids (plug in (39%) and non-plug in (55%)) (CBS, 2016). So, the goals set by the government are a long way from being reached.

Considerations of people for buying and not buying electronic vehicles (EVs) are well studied. For instance, Graham-Rowe et al (2012) found that barriers against the purchase of an EV include the durability, maintenance and servicing costs of an EV. Besides these barriers participants were concerned with the limited range, limits on pleasure and comfort. Additionally, they undervalued vehicle aesthetics, were wary to commit to purchasing EVs until sufficient advancements had been made and were sceptical about the net environmental benefits of an EV. Another major impediment was described by Sovocool and Hirsh (2009), they concluded that the lack of a greater market penetration of EVs lies with the rejection of consumers to pay the higher price for them and that people do not take future savings into account. Egbue and Long (2012) went further and besides describing the barriers for the purchase of an EV also ranked them. They concluded that the biggest barrier for people to purchase an EV is the limited range of the battery of an EV.

Bunch, Bradley, Golob Kitamura, & Occhiuzzo, 1993 and Thomas, 2010 have also identified the limited rage of an EV as a problem for users. The range of an EV is linked to the performance of the battery (Axsen, Kurani, Burke 2010). It is the battery that is the source of the energy, and it is therefore responsible for the power and distance a car can travel (Axsen et al, 2010). From this it could be concluded that the barrier of the limited range of an EV is a technological problem, because when the quality of the battery would be increased the barrier of the limited range would lessen (Axsen et al, 2010).

However, Axsen et al (2010) shows that batteries that are on the market nowadays fulfil the needs and would be sufficient to fulfil the distance early buyers would need from their vehicle. The same is proposed by Cocron, Bühler, Neumann, Franke & Krems (2011) and Krems, Franke, Neumann, & Cocron (2012). Cocron et al (2011) conclude that with the modern electric propulsion systems the problem of perceived limited range of EVs is more a psychological barrier than a technical problem. At the start of their study the majority of participants expected to be constrained by the range of the electronic vehicle. While data after a usage of three months showed that for more than 94% of the users the range would be sufficient. This perceived limitation of range manifests itself in concern and fear of the driver of not reaching the final destination (Tate, Harpster & Savagian, 2008). This concern is dubbed range anxiety (Tate et al 2008).

Anxiety is a basic human emotion that functions as a warning signal to develop a coping strategy against possible threats (Zeidner and Matthews, 2011 and Beckers et al 2007). Based on a study on articles on range anxiety Nilson (2011) states that range anxiety in an electronic vehicle is a worry that a situation of not being able to reach the final destination or charging point happens because of uncertainty of what will happen if this situation arises. And to not be able to find a solution when this situation happens and that one will be in an uncomfortable situation when this situation arises.

Most people do not cope with the experience of range anxiety itself, but deal with the limited range by avoidance of situations in which range anxiety could arise (Franke et al, 2012). They do this by keeping a comfortable zone of the available range as a comfortable range buffer (Franke et al, 2012). This is worked out in the conceptual framework for understanding range anxiety of Franke and Krems (2013). In this framework, the comfortable range buffer is appraised against the range left at the destination of the trip (range left minus distance). Based on the outcome of the appraisal either the driver will perceive this as a threat/challenge (range left is smaller than the comfortable range buffer), or not. The interpretation of the discrepancy between comfortable and range left is influenced by a second appraisal. In this second appraisal a check of possible coping resources is performed, when these resources are sufficient stress will be reduced (Rauh, Franke & Krems, 2015). In this model the comfortable range buffer is based on trait variables (general beliefs about dealing with technology) and coping resources (knowledge and skills on saving energy while driving) that are constantly changing (Rauh et al, 2015). While the energy necessity for the remainder of the current trip is a perception of relevant variables on the mobility resources and mobility needs (environmental factors) (Rauh et al, 2015). This means that according to the framework drivers would need a lot of information while driving to ease anxiety.

In 2015 Rauh et al published one of the first user experience studies with the purpose of finding what information drivers would like in critical range situations. It was concluded based upon suggestions of the participants that were put in a situation in which range anxiety occurs, that a feedback system with individual driving style, charging stations and detailed consumption information could help drivers better manage critical range situation. The necessity of a feedback system was mentioned earlier by Sovocool and Hirsh (2009) and Graham-Rowe et al (2012). They proposed that if drivers do not get feedback on their negative patterns and habits they will become frustrated because the car would not perform as anticipated. Graham-Rowe et al (2012) found that some drivers in their study indeed became frustrated with the lack of feedback. This shows that a good feedback display for users is essential to ease drivers range anxiety.

Rauh et al (2015) identified multiple aspects where a feedback display could help the driver according to the participants. Broadly drivers wanted feedback so that they can accurately evaluate the comfortable range buffer and have certainty about energy consumption and how they can influence this (Rauh et al, 2015). See Table 1.1 for an oversight of the user needs of the study of Rauh et al (2015). With this research Rauh et al (2015) have given insight in the needs of drivers in a critical range situation.

Table 1.1
User needs regarding range anxiety in the study of Rauh et al (2015).

Difference between remaining range and remaining trip length
Remaining range
Remaining trip length
Energy consumption
Recommendations on energy saving

Franke and Krems (2013) did however state a concern for their research on comfortable range of an EVs since their research was dependent on early adopters. Rogers (2003) defines five categories of adopters based upon the speed with which they adopt to new ideas. Early adopters (and the faster group of innovators) make up around 16% of the population. According to Rogers (2003) early adopters differ from later adopters of new technologies in socioeconomic status, personality variables, and communication behaviour. Rogers (2003) for instance found that early adopters, in comparison to groups that are less prone to adopt new ideas, were more active in seeking information and have greater knowledge of innovations. Franke and Krems (2013) noted that because of the differences in personality traits their results are not applicable on the entire population. The same might be true for the user requirements Rauh et al (2015) found for an interface design to lessen range anxiety. This could mean that the information in a display for later adopters should have more knowledge components about saving energy while driving which is a major component in the framework for understanding range anxiety (Franke and Krems, 2013). The same might be true based on the personality traits. For instance, early adopters have a greater ability to cope with uncertainty and risk (Rogers 2003). This could mean that non-early adopters needs for a feedback display could differ on other aspects as well.

That non-early adopters have different needs for a feedback display is further indicated by a study on non-early adopters and their responses and needs after using an EV. Graham-Rowe et al (2012) for instance found that non-early adopters were frustrated by not getting feedback on the effect of their driving style on energy saving. They also found that non-early adopters cared less about the environmental benefits of EVs but cared more about meeting their mobility needs (both utilitarian goals as well as positive affective experiences) than early adopters. The drivers in their research were particularly concerned about the range that they would be able to cover with the car and as a precaution did not use electronic devices in the car that also ran on the car's battery (for instance the stereo or electronic windows). Besides feedback on energy consumption and ways to manage the range of the vehicle Graham-Rowe et al (2012) also concluded that non-early adopters have a higher need of feedback on the environmental benefits of driving in an EV. Because of the differences between early and non-early adopters the needs that Rauh et al found in their 2015 study for a feedback dashboard might not be applicable for non-early adopters.

A feedback dashboard can be seen as a system for which users have needs. A common way to describe needs of users are user requirements (Spath, Hermann and Peissner and Sproll, 2012). These are statements that define the needs of the consumer and even if requirements are technical or design specifications the user is still in focus (Spath et al, 2012). Sommerville (2004) divided user requirements in functional requirements (system functionalities and services) and non-functional requirements (for instance performance and usability). Maidan (2008) makes the same distinction. A user requirement tells something about what the system will do for a certain user while a system requirement (non-functional requirement) describes a system property. It is import to take the needs of the user into account when designing a system. As van't Riet, Berg, Hiddema & Sol (2001) have demonstrated that designers alone can overlook important needs that are of great importance to users. Multiple studies have shown that in the development phase of an information system there is little attention for the requirements future users will have (Button 1993; Forsythe, 1995; Greenbaum & Kyng, 1991). If user needs are not taken into consideration in the development phase it can lead to less acceptance of the system (Kujala, 2003) and it will not satisfy all of their needs (Sauer, 1993).

Since a dashboard with feedback can help drivers to deal with situations in which range anxiety might occur, and that this anxiety is one of the largest contributors of a not wider acceptance of electronic vehicles, it is important that not only early adopters will see their needs fulfilled in a feedback dashboard but also non-early adopters. To gather their needs and requirements this study wants to give answer to the question: "*What user requirements do non-early adopters have for a feedback display in an EV to preclude and/or ease range anxiety*".

To answer this research question a user requirement analysis will be used. In the analysis the focus is on the content of the dashboard for an EV, such as what information do participants want via dashboard (and what not), should this consist of detailed information or not and what sources should be the basis for this information? It is expected that, although in this study the focus lies on non-early adopters of EVs, (some of) the needs from the study of Rauh et al (2015) (table 1.1) will be identified as a requirement. In this study when speaking about an EV, an electronic vehicle without a combustion engine is meant.

Method

Participants

For this study participants with driving experience, and that do not own an EV, were asked if they wanted to participate in the study. These two criteria were used as exclusion criteria (driving experience and not owning an EV was a necessity, otherwise participants did not qualify for this study) to make sure the participants were non-early adopters. Possible participants were recruited in the professional network of the researcher. As a result, these participants may not be a representation of society as a whole. After confirmation an electronic invitation was sent to set up the interview. All eight participants (aged between 25 and 39 M=31.3 SD=4.9) were interviewed in November 2017. Of the participants four are male and four are female. For this study ethical approval was obtained from the University of Twente.

Material

For this study an interview was developed. The interview consists of three parts. Part one is a scenario in which the respondents were introduced to range anxiety. This part is a translation to Dutch of the comfortable range scenario task (CRST) (Franke, Günther, Trantow, Rauh, and Krems, 2015). This part was added to the interview to give the participants a good understanding of range anxiety and what it means for them. This way range anxiety was made clear in an easy way it helped in the interview to make statements clearer. In the CRST participants have to answer how comfortable they are with different ranges left in the battery while the destination is a fixed distance away. This is done on a response cards (four in total) with different statements, a six-point Likert (completely disagree to completely agree) scale on the y-axis and ten displayed ranges left in the battery on the x-axis (45 to 90 km with 5 km interval), see appendix A for the scenario and the response cards.

The second part of the interview involved a semi structured interview, so there was a predefined guideline with topics that needed to be discussed that was used as a checklist; see appendix B for the interview scheme. The natural flow of the interview was leading in when and how the topics were asked and handled. In the interview the participant was asked to speak about functionalities, or about information in a dashboard of an electronic vehicle. By doing so giving insight in possibilities to ease and/or preclude the uncertainty to reach the destination of a trip while driving. Bruseberg and McDonagh-Philp (2002), stated that users give answers based on their current knowledge when asked what they want. Since the subjects of this study are non-early adopters of electronic vehicles this conservative thinking might be problematic when researching possible requirements. To overcome this, beforehand certain topics were specified and during the interview, when participants did not mention a certain topic, a question to evaluate the topic was asked. This is in line with the strategy of Lines and Howe (2004), that it is better for users to evaluate than to generate possible functionality.

Part three of the interview consisted of some general questions about the participants' demographics (age, gender, driver licenses) and their view on electronic vehicles (likelihood to buy an electronic vehicle (5-point Likert scale), reason for this (open answer), estimation of the range of an electronic vehicle (open answer) and how many times they feel they will travel further than this range (open answer)). A complete schedule of part three of the interview can be found in appendix C.

All the interviews were recorded on a Samsung S6 via the app Voice recorder.

Procedure

To see if the semi structured setup of the second part of the interview worked, to practise the interview technique, and to see if the questions and/or interview scheme needed adjustments, prior to the interviews for the study a pilot interview was held. Results of this interview were not used in the data analysis of this study. In the pilot interview the semi structured setup worked well and the other parts of the interview could be finished without any problems. Besides some small textual changes and more extensive explanation so that participants would understand the interview better no changes were made to the initial questionnaires and interview setup.

After agreeing to participate in the study, participants received an electronic invitation to schedule the date and time for the interview. Each interview started with a short introduction about the study and about range anxiety, this was followed by a short introduction about the structure and duration of the interview (around 45 minutes). It was stressed that the researcher was looking for the opinion of the participant and that there are no false or incorrect answers. The participant was then informed that the audio of the interview would be recorded and the responses would be processed anonymously. All the participants then signed an informed consent and were asked if they wanted to receive the results of the study after the study was completed. After the participant was told that he or she could stop the interview at any time and had the opportunity to ask questions, the interviewer handed over the scenario and told the participant to read this in his or her own speed. When the participant had finished reading the scenario the four response cards with different questions based on the scenario were handed over for filling in. When the response cards were filled in and handed back in, the recorder was activated and the second part of the interview started. Importance of topics that were not mentioned by participants themselves were asked and when answers were not clear, or multi-interpretable, follow-up questions were asked. When all the topics of the interview were discussed and participants stated that they did not have anything more to add the recorder was stopped and the last part of the interview was handed over.

After the interview the participants were thanked for their participation and asked about their experiences with the interview. All the participants stated that they felt the interview was pleasant and the subject of the study interesting.

Data analysis

From the recordings of the interviews a verbatim transcription was made using Microsoft Word. From these transcriptions all the statements of the participants were coded. Since the purpose of this study is to find what kind of requirements non-early users of electronic vehicles have, and no framework for their needs are presently known, the transcriptions were analysed following steps of inductive coding. For this procedure the program Atlas.ti was used. Firstly, the interviews were sorted into relevant text fragments. Relevant text fragments are parts of the interview that are related to a subject that is of importance in relation to the research question. The relevant text fragments were then coded for the first time, so every fragment was labelled based on the content of the fragment. After the first two interviews were coded this way, the labels were evaluated. Some labels were added, some were combined and some were removed/renamed. This led to an initial template that was used and constantly modified while coding the different interviews and comparing the content of the text fragments with the same label with each other. This was done to stay close to the actual content and answers of the participants. After a few iterations of coding all the interviews a clear high-level order of codes emerged. This was a coding scheme in which all the relevant text fragments were labelled with a clear topic that the text fragment was about. After this higher order code scheme was constructed, all the interviews were coded again to add lower lever labels to the relevant text fragments. This step was done multiple times until a clear low-level coding scheme emerged with which all the interviews were coded. These lower level labels consist of polarity (was the statement positive, negative or neutral about the labelled topic) and the basis on which the topic should be based. In the end this resulted in a coding scheme that included broad general information in the higher order codes and more detailed information in the lower order codes. The higher-level codes gave a distinct insight in topic level user requirement while the lower level codes gave a more detailed view on user requirements within these topics.

From the first part of the interview the comfortable range threshold was calculated. Franke et al (2012) define this as the point where users transition from a perfectly comfortable feeling (lowest range with the best score) to the range with a decreased range comfort (first range where there is not a best score). From the score on the four response cards a mean is calculated and this is divided by the trip distance (60km). The inverse of this score is dubbed the preferred safety buffer by Franke et al (2012).

Results

In this section the research question *What user requirements do non-early adopters have for a feedback display in an EV to preclude and/or ease range anxiety* will be answered. To do this, firstly the participants will be described, as a group, to give insight in this group and to draw conclusions about non-early adopters. In the second part the user requirements will be presented. This will be done topic wise, where all the requirements relating to a topic are bundled in one section.

Description of non-early adopters

Most of the participants in this study, were (very) unlikely to buy an EV as their next car (M=2.1 SD=1.2). As main reasons for not wanting an electronic vehicle participants stated price, driving range and the lack of charging possibilities.

From the data of the first part of the interview the comfortable range buffer of the participants is calculated. Firstly, the distance (in km) was calculated (M= 76,6 SD 8,5 Min= 67,5 Max 91,9) and from that the comfortable range buffer (M=79%, SD= 8% Min 65% Max = 89%).

User requirements

From the interviews with the participants nine topics emerged that they would like to see in a dashboard of an electronic vehicle to ease range anxiety. These topics will be discussed in detail in separate paragraphs.

Driving range.

All users want to know how much range they have left in their electronic vehicle at any given time. They see it as a fundamental part of the dashboard of an electronic vehicle as a replacement of the traditional fuel measurer.

"The basis is of course, but I think that is obvious, that you want to see an estimate of how many kilometers you can drive with that car.[1]" (Participant 2)

For this topic, participants named several requirements, for instance what should be taken into account in this calculation and how to deal with different users of the car. The most named user requirement with regard to the driving range is that this should be based upon driving style. There are however design implications because there is disagreement between participants on which basis should be calculated (current charge, trip or a longer period of time).

Less important for the participants (named by five out of eight participants) was that in the calculation of the driving range the route profile was taken into account. That is to say how do the specifics of the route of the current trip affect the available range of the EV? While some see it as an important requirement others are skeptical.

One participant named as a requirement the possibility to switch between user profiles for the different drivers of the car for the calculation of the available driving range. Other participants also struggled how to overcome the calculation of an accurate driving range when the car has multiple users however they opted to 'solve' this in the way the driving range was calculated via the driving style (shorter periods of time as a basis). Table 3.1 states all the requirements with regard to driving range.

[1] Quote is translated from Dutch. See appendix D for original quote and translation.

Table 3.1

User requirements for driving range. The requirements are ordered from the most towards the least important.

User requirement	***Implications for Design***
As a driver I would like to have information about how much range I have left *based on driving style*	A dashboard must offer information on the range that is left in the battery. Important is that is based upon the driving style. There was disagreement if this should be the driving style of this trip, the current charge of the battery or a certain distance. Since participants felt strongly about their preference giving them an option of one of these three is advised.
As a driver I would like to have information about how much range I have left *based on the weather*	Besides driving style participants want that in the calculation of the driving range the weather conditions are taken into account.
As a driver I would like to have information about how much range I have left *based on the route profile*	Besides driving style and the weather respondents would like that the road profile is part of the calculation of the driving range which is shown in the dashboard. Since respondents are skeptical that the driving range can be calculated correctly based upon the road profile it is important that they get information so that drivers can validate this information. All participant feel that it is necessary for the dashboard to be connected to the navigational system of the car for this to be calculated correctly.
As a driver I would like to have *different user profiles* for the calculation of the driving range.	A driver is able to pick a user profile for the calculation of the driving range left. For this it is necessary that the calculation of the usage is split per user and that it is possible to create users.
As a driver I would like that the information about my driving range was *based on* data of *previous instances* if I rode the route before	For this historical data and a link with the navigational system is a necessity. Besides that, it is an extra option next to a calculation of driving range based upon driving style, weather and road profile since there is not always historical data on the current trip. Further in the dashboard it must be made clear on which of the two options the driving range is calculated.
As a driver I would like information on what the driving range is in the *worst-case scenario*.	For this option there should be an extra indicator in the dashboard for the driving range in the worst-case scenario (next to the driving range based upon earlier mentioned options. Besides that, parameters of the worst-case scenario (for instance traffic jams, bad weather conditions and/or road blocks) should be defined.

Energy necessity.

Most participants (five participants) would like to see some information on how much energy is needed for their trip. It differentiates from driving range in that driving range focuses on how far the car can go with the current energy usage while energy necessity is about how much energy is needed to reach the destination.

"Yes, if you assume a clear destination then it would not only be nice to see how many kilometers there are left but also a link with a navigation system or something where you then clearly see how many kilometers I have to drive so that you do not have to bet to reach your destination.[2]" (Participant 3)

Participants mostly wanted this information because they want to make the comparison if they will reach their destination with the current driving range themselves, rather than having the car do that for them. To make this comparison they want to know what the distance is in an easy to understand number, namely kilometers. Participants (three out of the eight) that did not want this requirement see this as a requirement solely in the navigational system.

One participant wanted to have an option to see if with the current energy level, it is possible to return home again (as some sort of point of no return indicator). It was however stated that this would become less important when one would drive more often with an EV. Table 3.2 states all the requirements with regard to energy necessity.

[2] Quote is translated from Dutch. See appendix D for original quote and translation.

Table 3.2

User requirements for energy necessity. The requirements are ordered from the most towards the least important.

User requirement	***Implications for Design***
As a driver I would like that the remaining energy it takes to reach my destination is *easy to understand*	Participants would like to see that the calculation of how much energy it takes to reach their destination is shown in kilometers. They prefer this over percentages or other forms in which they have to make calculations.
As a driver I would like that the insight of how much of my battery it takes is *calculated based on the distance of the trip*	As a basis for the calculation for how much energy it takes to drive the current trip participants see the distance of the trip as it has been calculated by the navigational system.
As a driver I would like that the *components that influence the amount of battery it takes are taking into account* in the calculation of the insight of how much of my battery it takes to complete my trip	Participants would like to have an accurate estimation of the amount of battery it takes to complete their trip. For this they feel it is necessary that all the components that influence this are taken into consideration. Components participants named include driving style, route profile, weather and traffic. Besides trip specific components (for instance traffic) these are the same components as the components participants want in the calculation of the driving range.
As a driver I would like to have information if my driving range is *enough to get home*.	A comparison with the current driving range and the calculated distance to reach home must be made. And when 'the point of no return' is reached the driver should be notified.

Energy consumption.

A few participants (three participants) would like to see detailed information on the current energy consumption (what contributes to the energy consumption). For them it gives them comfort and security to have insight in how the driving range is calculated. Other participants (five) feel that this is too much information and do not see the added value to see a detailed energy consumption on top of the driving range. Table 3.3 states all the requirements with regard to energy consumption.

"For example, it would help me if you would see how much you have used in the last 30 km. And that you then see what was it that used that energy.[3]*"* (Participant 5)

Table 3.3
User requirements for energy consumption. The requirements are ordered from the most towards the least important.

User requirement	***Implications for Design***
As a driver I would like to be able to see ***which*** *tasks* are using energy *at any given time*	Task that are using energy should be shown to the driver. However, since not all participants feel the need for this information it should be able to be shown when needed.
As a driver I would like to be able to see ***how much*** energy certain tasks cost *at any given time*	Detailed information on how the calculation of energy use should be able to be shown to the driver. Since not all participants want this information it should be information that is not on the dashboard on first sight. It should however be easily accessible for users that have this need.

Difference of driving range and energy necessity.

There is disagreement between participants if an option which shows if the destination is reachable with the current driving range and calculation of the distance to the destination is needed. Some (five out of eight participants) would like to see this so that at any given time they have the security of knowing that they will reach their destination (or that they have to take action) while others (remaining three participants) want to do this comparison themselves. This topic differs from driving range and energy necessity in that this is the outcome of the driving range minus the energy necessity (will I reach my destination or not). Table 3.4 states all the requirements with regard to result.

"Yes and that the car mainly makes the estimate am I going to get there or not if that is possible.[3]*"* (Participant 6)

[3] Quote is translated from Dutch. See appendix D for original quote and translation.

"I do not want that thing to calculate that, so I would not want to see you can still drive 10 km or you still have 10km left or so. It might be more convenient but I would still like to see you have to drive so many kilometers and you still have so many kilometers of battery based on your driving style left.[4]" (Participant 2)

Table 3.4

User requirements for difference of driving range and energy necessity. The requirements are ordered from the most towards the least important.

User requirement	***Implications for Design***
As a driver I would like to get a *notification* when the driving range is *insufficient to reach my destination*.	A calculation between the driving range and destination must be made and the driver must get an auditory or visual clue when the difference between the two is negative (distance is further than driving range)
As a driver I would like to *see* if my driving range is *sufficient to reach my destination.*	The result of the calculation is constantly shown in for instance the navigational system. Participants opted some sort of color coding with green being able to reach the destination, orange for pay attention (combination with the buffer) and red when the destination is outside the range.

Buffer.

Most participants (seven participants) would feel safer and would experience les anxiety if there was a kind of buffer in the driving range or some sort of margin in information about reaching their destination. Table 3.5 states all the requirements with regard to charging possibilities.

"That you can set that up, maybe I will reach it on the limit, but I want to leave something so I would like that warning.[4]" (Participant 4)

[4] Quote is translated from Dutch. See appendix D for original quote and translation.

Table 3.5

User requirements for buffer. The requirements are ordered from the most towards the least important.

User requirement	***Implications for Design***
As a driver I would like to get a *warning* if the *difference* between the *remaining battery and the calculated distance* of the trip becomes *smaller than a predefined margin*	Participants would like it if they would get a warning (visual or auditory) if the calculated distance of the trip becomes larger than the range that is left including a safety margin. Some participants would like to set this number themselves so the margin should be able to be changed.
As a driver I would like that the *calculated amount* of *driving range* has a *margin*	The calculated amount of driving range should have some slack in the favor of the driver (some left when the range becomes 0). However, there are participants that do not see this as a desirable requirement so an option to turn this possibility on or off is necessary.

Energy saving tips.

All participants would like to get tips on how to save energy from the dashboard. The saving of energy would mean that the driving range of the EV will increase and that the car has an extended range when the tip is followed up.

"I think at the very moment that you are going to get stress or anxiety that you will not reach your destination that you do not start thinking about things like that and that you will miss certain things. So it can certainly be of added value to get such notifications.[5]"

(Participant 1)

Most important within this topic is the requirement that the tips that are given via dashboard are suggestions on changeable actions of the driver. This means that when the tip is given the driver can actually change something to lessen the energy use of the car. Besides that, participants stated that they feel it is important that these suggestions are given to them when it is necessary (range is not enough to reach their destination for instance).

[5] Quote is translated from Dutch. See appendix D for original quote and translation.

Less named is that participants feel that the tip they get via the dashboard should be a suggestion which they can ignore without any hinder.

One participant stated that feedback when driving with optimal conditions would be a nice requirement. Table 3.6 states all the requirements with regard to energy saving tips.

Table 3.6
User requirements for energy saving tips. The requirements are ordered from the most towards the least important.

User requirement	***Implications for Design***
As a driver I would like to get suggestions on *changeable actions* that I perform *that are not optimal* for my energy consumptions	The driver should be presented with options how to change certain behavior based upon the energy consumption of that behavior and if it can be changed positively (for instance lower your speed or change gear). There should be an option to only get the solution and an option to see the behavior as well since respondents differ on this point.
As a driver I want the information on how to save energy *when it is necessary*	The information with tips on how to save energy should only be presented when there is the possibility that there is not enough energy to reach the final destination with the current energy usage. When there is enough energy left to reach the destination the information still should be available (via an on/off switch or reference card) for learning purposes and to see if a change of course is possible.
As a driver I would like to get *suggestions about routes* I can take that would save me energy	The navigational system should give information about alternative routes that are less energy consuming.
As a driver I would like to be able to *ignore suggestions* of energy saving	The suggestion of energy saving should stop by itself or the driver should be able to hide/stop it.
As a driver I would like that the suggestions for energy saving *are simple and clear*	The suggestions for energy saving should be simple to understand (pictogram and/or voice commands) and in a logical position. Respondents do not want to have to think or search for the suggestion in the stressful instances that they might not reach their destination. The suggestion should be on the other hand proportional to the cause so that it does not cause concern when there is not (for instance when a soft tire causes insufficient usage of energy and one would reach the destination).
As a driver I would like to get information *on changeable actions* that I perform *that are optimal* for my energy consumptions	The system should give positive feedback on current behavior when that behavior is optimal in the energy consumption (for instance this is a good speed).

Saving effects.

Participants (five out of eight) would like to get information on how much more range they would get when they decide to follow a suggestion to save energy so that they can make an informed decision to follow the suggestion. It is extra information when a driver gets tips on saving energy. While under the topic energy savings, the requirements are specified on just the tips on energy saving, in this topic the requirements are specified on effect a certain tip will have/had. This is important to participants because they feel they have to give something up (speed, comfort) and want to know what this decrease in comfort gains them. Table 3.7 states all the requirements with regard to saving effects.

"Just like with your phone when you say I want to take an energy-saving measure that means that your speed is reduced, the screen reduced. That kind of information you want to see with regard to what that yields.[6]*"* (Participant 4)

Table 3.7
User requirements for saving effects. The requirements are ordered from the most towards the least important.

User requirement	***Implications for Design***
As a driver I would like to have information on the effect on driving range a decision *to follow through on an energy saving tip **has***	The effect on the driving range of a certain action must be tracked and shown to the driver. One way this can be done is to show that the driving range is now depleting less fast (for instance in a graph).
As a driver I would like to have information on the effect on driving range a decision *to follow through on an energy saving tip **will have***	With the tips on how to save energy to increase the driving range information must be shown with how much kilometers the driving range will be increased.

[6] Quote is translated from Dutch. See appendix D for original quote and translation.

Charging possibilities.

All participants wanted in some shape or form information about charging (stations). For this a connection between the navigational system and the dashboard is a must. Knowing where one can charge the electronic vehicle and how long this will take (named once) gives them a sense of security and eases anxiety. Table 3.8 states all the requirements with regard to charging possibilities.

“I would like to know where the charging stations are and that the car gives a warning when I am out of range with regard to the amount of kilometers that I still can drive in relation to where the electric pole is located. I prefer that my car just gives me a signal of come on dude you have to refuel, otherwise you will not make it.[7]*"* (Participant 8)

[7] Quote is translated from Dutch. See appendix D for original quote and translation.

Table 3.8

User requirements for charging possibilities. The requirements are ordered from the most towards the least important.

User requirement	***Implications for Design***
As a driver I would like to know the *distance to closest* charging station	In combination with the navigational system the distance until the closest charging station should be calculated. This should be presented in case the driving range is low or is not enough to reach the destination of the trip. For some drivers this information is always important so there should be an option to always show this information instead of when driving is low or not enough. The location of this information is also user dependent. They should have the choice to have the distance and warning signal in the dashboard or the signal in the dashboard a distance (route) in the navigational system or signal and distance in the navigational system.
As a driver I would like to know the *distance to the next station after closest* charging station	In combination with the navigational system the distance until the next to closest charging station should be calculated and presented in the same way as the closest charging station. Respondents want this information to make an informed decision to use the closest charging station or the next.
As a driver I would like to know *how long the car must be charged* to reach the destination.	Besides location of charging station information about the length of the charge to reach the destination is information that could help ease anxiety. For this information about the charging speed on the charging point and the distance to the destination have to be known (input from user or available for dashboard).
As a driver I would like to know the charging stations *in a range outside of current route*	Information about the maximal distance outside the route of the current trip to find charging possibilities should be known (input from user). The information can be shown in the same way as the distance to the (next to) closest charging possibility.

Historical data.

Most participants (five participants) would like to see the data from their trips afterwards. Mostly to get detailed information on why trips cost more than calculated when planning the trip or on which topics reduction of energy consumption of their trips is possible. Table 3.9 states all the requirements with regard to historical data.

"Yes in itself would be useful for when you find that you often notice that you consume more than what you expected. I would not want to see that in the car but that on your device just see what the causes were of that too high consumption.[8]" (Participant 7)

[8] Quote is translated from Dutch. See appendix D for original quote and translation.

Table 3.9

User requirements for historical data. The requirements are ordered from the most towards the least important.

User requirement	***Implications for Design***
As a driver I would like to have historical data of *my trips available*	It should be possible to have access to the data of previous trips. There should be an option to see all the data and an option to only show data of the trip on which the driver can influence their energy consumption because within participants that have the need for this requirement there are two groups. One that wants all the data and the other that only wants data that gives insight in how the driver can save energy. Users also would like to get pointers where they could save energy. For this a connection with the navigational system is necessary.
As a driver I would like to see the historical data on a *separate device*	The data of trips should be able to be downloaded to an external device (for instance app on tablet/phone or pc). This means the dashboard should in some way or form need to be able to send the information to a central database or directly to the device.
As a driver I would like to *compare* my historical data.	The data of drivers should be made available to a central database so that drivers can compare their usage with other drivers. Since not all respondents wanted this option and one was concerned with privacy it should be made clear for what the data is used the user must have the choice to share his data with the database

Discussion & Conclusion

The main goal of this study was to expand on the existing requirements for a dashboard in an EV that can preclude and/or ease range anxiety by looking into the needs of non-early adopters. In this study the focal point lied with user requirements analysis of the content of the feedback display of an EV. A feedback display in an EV is important because without it users become frustrated as the car will not perform as expected and they have insufficient information to deal with situations in which range anxiety could occur (Sovocool and Hirsh, 2009, Grahan-Rowe et al, 2012 and Rauh et al, 2015). The requirements were obtained via interviews with eight non-early adopters of EVs. This resulted in detailed user requirements regarding different topics for a dashboard. These results will first be discussed in relation to non-early adopters, after that the results will be compared to already known user requirements. This will be followed by a reflection on the limitations of the results, and finally a conclusion and recommendations.

Non-early adopters

As Graham-Rowe et al (2012) found, a distinction between early and non-early adopters is that non-early adopters cared more for mobility needs, as do the participants in this study. This combined with the fact that the participants did not own an electric car, and most were unlikely to do so, it is supposed that the participants in this study are non-early adopters of electronic vehicles.

User requirements.

Non-early adopters are not a group that is studied often when it comes to their needs and desires for a feedback dashboard EV. However, the study of Graham-Rowe et al (2012) does point to some requirements non-early adopters could have for a feedback dashboard and to some distinctions between early and non-early adopters, namely:

- A higher need to know the effect of their driving style on energy saving;
- A lower caring for environmental benefits, but more for mobility needs;
- A higher concern about the range they could cover; and
- A higher need for environmental feedback

This study also found utilisation needs and has expanded on these by adding requirements of non-early adopters to these needs. This study did not find the need for environmental feedback. This could be explained because non-early adopters care more about mobility needs than about environmental benefits (Graham-Rowe et al, 2012). Since in this study the main focus was on the requirements of non-early adopters to ease and/or preclude range anxiety the needs for environmental feedback never came up as this would be a broader need for a dashboard of an EV.

CRST.

Franke and Krems (2013) have stated that the lack of non-early adopters in their research is a limitation to their findings on the comfortable range of EVs. They suppose that because non-early adopters differ from early adopters in personality traits non-early adopters would have a lower comfortable range score than early adopters. The 75% to 80% average comfortable range of early adopters might be the upper limit and drop when non-early adopters would be taken into account (Franke and Krems, 2013). This would be significant because this would mean that non-early adopters would feel less comfortable with a certain distance than early adopters, who already accept more barriers than non-early adopters, putting even larger barriers on a further integration of EVs (Graham-Rowe, 2012). In this study however, the same average comfortable range is found in a group of non-early adopters.

User requirements and range anxiety

Rauh et al (2015) performed one of the first studies about user needs for a dashboard in an EV in a critical range situation. In that study however, there is no distinction between early and non-early adopters with regard to user requirements. To answer the question if non-early adopters have different/specific requirements for a display to ease and/or preclude range anxiety the results of this study will be compared to the findings of Rauh et al (2015). The topics that the participants named in this study correlated with, and expanded on, the broadly defined user needs that Rauh et al (2015) found in their study, see table 4.1 for a comparison between the two.

Table 4.1

Comparison between requirements in the study of Rauh et al (2015) and this study.

User requirement	***Present in Rauh et al***	***Present in this study***
Difference between remaining range and remaining trip length	+	+
Remaining range	+	+[a]
Remaining trip length	+	+[b]
Energy consumption	+	+/-
Recommendations on energy saving	+	+[c]
Buffer	-	+
Saving effects	-	+
Charging possibilities	-	+
Historical data	-	+

[a] Driving range in this study

[b] Energy necessity in this study

[c] Energy saving tips in this study

A +symbol indicates that a requirement is important according to that study (for the study of Rauh et al (2015) this was the case when it was mentioned in the article, for this study when a majority of the participants named this as a requirement). A +/-symbol indicates that it is named but that there is not a majority of participants that want this requirement (not used for Rauh et al (2015)). A –symbol indicates that a requirement was not present in that study. In comparing the two studies there are some differences in the user requirements participants state that they would like to have in a dashboard to cope with or preclude range anxiety.

Energy consumption.

The participants of the study of Rauh et al (2015) stated that they would find information about energy consumption helpful to reduce stress. In this study only a few participants would like to have this information in a dashboard. It is however important for all participants that this information is used in calculating, for instance, the driving range. This could be explained with the framework for understanding range anxiety (Franke and Krems, 2013). In a critical range situation, the outcome of the first appraisal will be that there is a threat/challenge regarding the comfortable range vs the range that is left for the trip. Participants in this study would like to get clear tips on what strategies they can employ in these situations instead of making a judgement call by themselves based on detailed information on energy consumption. This would explain why the participants in this study express a lower need for detailed information on the energy consumption than the participants in the study of Rauh et al (2015).

Charging possibilities.

In this study all the participants wanted a link between the navigational system of the car and the dashboard with regard to the network of and distance/route to charging stations. In the study of Rauh et al (2015) this requirement was not mentioned. The use of a charging station is a way of coping in the second appraisal in the framework for understanding range anxiety (Frank and Krems, 2013). For this it is essential to have a sense where charging stations are. Since the participants in this study are non-early adopters and therefore do not have an EV, all of them did not have an idea of the possibilities of charging an EV. So for them, to use the coping strategy to go to a charging station and charge the car, it is essential to have this information. In earlier studies regarding the framework for understanding range anxiety or requirements participants drove in an EV or were early adopters (Rauh et al, 2015 and Franke & Krems, 2013). This way they would have knowledge about the charging possibilities in general and on often travelled routes. The lack of knowledge on the possibilities of charging an EV would explain the need for requirements on charging stations in this study while in other studies these were absent (Rauh et al, 2015 and Franke & Krems, 2013).

Saving effects.

This study indicates that non-early adopters would like to get feedback on the (estimated) energy savings of a proposed tip to save energy. In the study of Rauh et al (2015) participants did not state this need. A possible explanation for this could be that non-early adopters care more for positive affective experience (for instance radio, air-conditioning but also driving itself) while driving than early adopters (Graham-Rowe et al, 2012). So, this indicates that this information is more important for non-early adopters because they have a greater feeling of giving something up and they have a higher need to know what the decrease in comfort gains them.

Buffer and Historical data.

In the study of Rauh et al (2015) participants did not state needs with regard to a buffer or historical data. However, in this study participants did mention a need for these topics. For historical data this can probably be explained by the setup of the two studies. In Rauh et al (2015) the participants were asked directly after a trip in which they encountered range anxiety what heightened and lowered their stress and how information in a dashboard could ease that. So, the focus was on the one trip while in this study one of the topics spoken about was historical data.

Rauh et al (2015) did not state explicitly that the participants in their study had a need for some sort of a buffer on the difference between driving range and range left as the participants in this study did. They did however describe that participants use the difference between driving range and range left as their main focal point to see if they would reach their destination or not, and an increase in this number would ease stress and a decrease would increase stress (Rauh et al, 2015). This would indicate that the participant in that study would compare the result of the difference between driving range and range left with an internal range they would feel comfortable with. This is in line with the framework for understanding range anxiety, in which a driver would compare the difference of driving range and range left with his or her comfortable range buffer (Franke and Krems, 2013). In agreement with this framework in this study participants explicitly stated that they required some sort of warning when the difference between driving range and range left would be lower than their comfortable range buffer. This might indicate that non-early adopters might not have a higher need than early adopters for the buffer per se, but they do for a warning system when the difference between driving range and range left is higher than the comfortable range buffer.

Limitations of results

In this study participants answered questions about their comfortable range and requirements for a dashboard of an EV to preclude and/or ease range anxiety based upon analytical thinking in a hypothetical setting. They had to think about unknown situations in a decontextualized setting than the one in which range anxiety usually occurs. As Frankish (2010) described these are all characteristics that would indicate that participants in this study used system 2 of the dual-processing system. In the dual-processing systems described by Kahneman (2011) this means that participants used slow, effortful, but also infrequently used processing to come to conclusions about user requirements they would like to see in a dashboard of an EV to ease range anxiety. While one would use the faster processing system for habitual behaviour (system 1) such as driving a car and using the dashboard while doing so (Frankish, 2010). This may have affected the results in this study since what participants have stated they would like to see in a dashboard would not be used, or that certain requirements that have not been named might arise.

This study relied on younger participants that are higher educated civil servants and therefore this group is not a cross section of society. It can therefore not be taken for granted that the results of this study are applicable to all non-early adopters, further research is needed.

Conclusion & Recommendations

This study has given an indication that the requirements for non-early adopters are on topic level not that different from what early adopters have as requirements. The framework for understanding range anxiety gives a clear indication of different topics on which users (early and non-early alike) would like to get feedback on (Franke and Krems, 2013). For some topics this was already found by Rauh et al (2015) on which this study expands. Not only with indications on additional topics non-early adopters have, but also by giving insights in how these needs can be transformed into user requirements and design implications. This study indicates that on the level of user requirements, even within a group of users can differ in what they want or do not want in a dashboard. These differences should be taken into account when design decisions are made with regard to future dashboards. The design implications this study yielded can be used as a first design for a dashboard in an EV. Based on the results of this study in table 4.2 a set-up consisting of the essential elements for a dashboard is proposed.

The limitations that the results of this study have make that further research is needed to concur the requirements that this study found. For this study it is advised that the participants reflect a wider perspective of society and that the participants experience a critical range situation in an EV. In that study a dashboard based on the requirements portrayed in table 4.2 can be used as a starting point.

Table 4.2

Proposal for first set-up for a dashboard of an EV to preclude and/or ease range anxiety

Topic	***Design***
Driving range	Central in the dashboard must be an indicator how much range the car has left on the current charge of the battery. It should come with predefined options for the driving style this is based upon (trip, this battery charge, a distance that can be chosen by the driver, and an option to have different drivers). Besides driving style, the driving range should be based upon the current weather conditions and the route profile. For the latter it is important that there is an option to get information on how this calculation is made.
Energy necessity	The dashboard must have an indicator how much energy it costs to reach the destination of the trip. This should be shown in kilometres. This should be based on the same sources and calculations as the driving range.
Energy consumption	There must be the possibility to easily access information in the dashboard about which tasks use energy and how they use it. It is not necessary to always have this information present in the dashboard.
Difference between driving range and energy necessity	A visual or auditory clue must be given when the energy necessity for reaching the destination is further than the driving range and there is some color-coded indicator which shows if the destination is reachable (green), the driver has to pay attention to reach it (orange) or is outside the range (red).
Buffer	The dashboard must have some indicator that the destination of the trip is further than the range that is left with a safety margin. This margin should be determined by the driver. Besides that, the calculation of the driving range should have the option to give it some slack (total range is a bit further than the range shown).
Energy saving tips	The dashboard must have the possibility to give tips on how to save energy. Drivers must have options when the tips are shown and when not (always/only when not or just enough energy is left to reach destination, and a possibility to switch it on). The tips should be clear and easy to understand, and should be able to be ignored or turned off after they are shown.
Saving effects	The dashboard should have an option to show what the effect of a saving tip will be. It should also have the possibility to show what the effect of following a saving tip was. It is not necessary to have this information always present, but it should be accessible in an easy manner.
Charging possibilities	Information about the charging network is a must. This means the distance to the nearest charging station, and the one after that. This information must come with an option to be always present, or only present when charging becomes a necessity.
Historical data	It should be possible to see data of previous trips. These should however not be shown on the dashboard, but be downloadable to a device.

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Appendix A

Part 1 interview scenario and response grids

Stel je voor dat je alleen een route met een elektrische auto aflegt. Het is zaterdag en je bent vertrouwd met de route omdat je deze vaker rijdt. Je reis brengt je door een landelijke omgeving zonder al te veel hoogteverschil. Het is een mooie, zonnige dag rond een graad of twintig en er is nauwelijks ander verkeer op de weg.

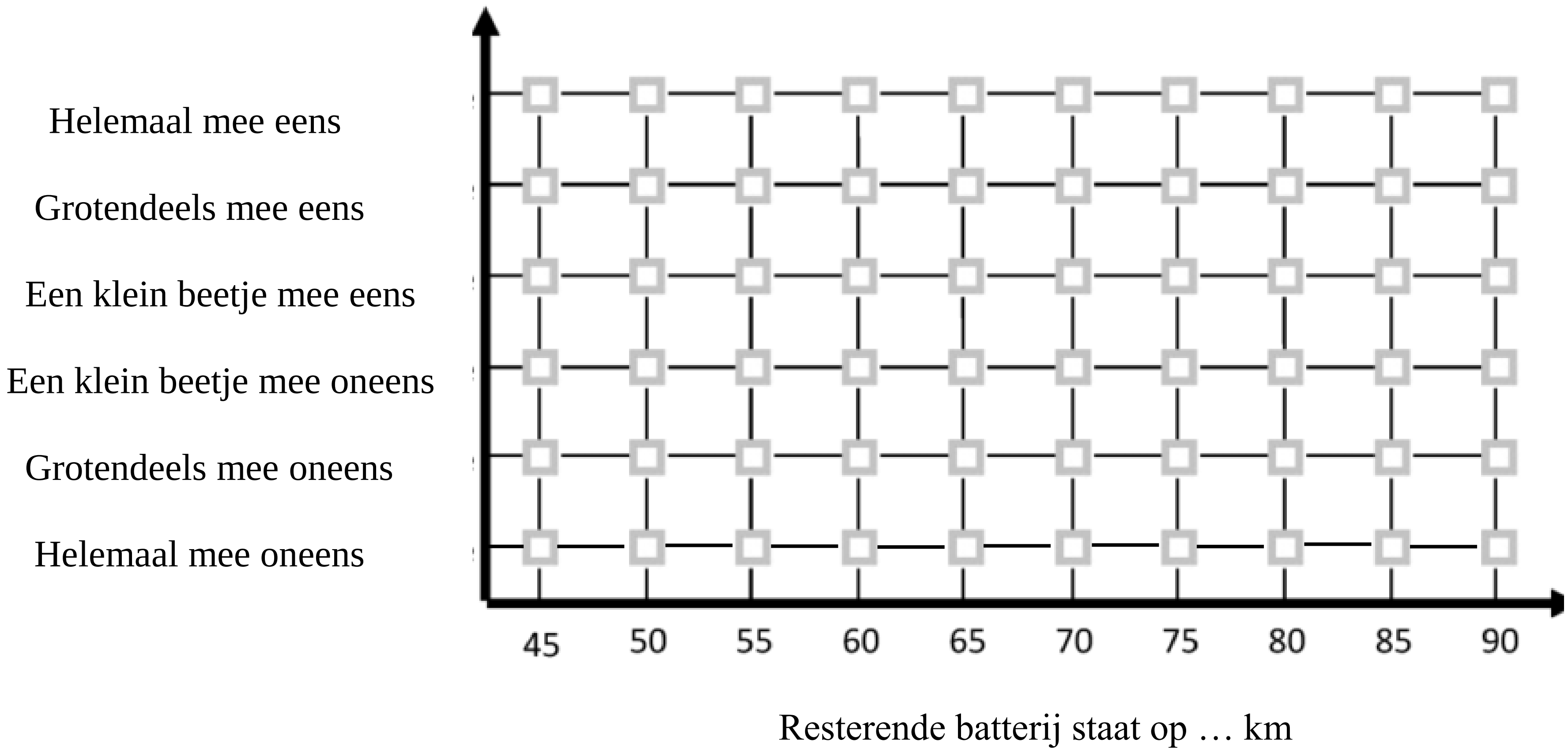
Je hebt al 30km afgelegd met je normale rijstijl voor deze omstandigheden. Voor dat je je eindlocatie bereikt moet je nog 60 km rijden. Onderweg kom je zeker geen oplaadpunten meer tegen. Op je eindbestemming is de mogelijkheid om de elektrische auto op te laden, waar je ook genoeg tijd voor hebt.

Houd dit scenario goed voor ogen bij de beantwoording van de vragen.

De onderzoeker zal je nu 4 kaartjes geven. Op elk kaartje worden 10 verschillende varianten van hetzelfde situatie beschreven. De afstand die je nog moet afleggen is altijd gelijk (60 km), echter de afstand die je nog kan afleggen met de elektrische auto verandert. De vraag is dus: als ik nog 60 km moet afleggen en de batterij heeft nog voor 90 km energie hoe comfortabel voel ik me in deze situatie? En hoe zeker voel ik me dat ik het haal als de batterij nog voor 85 km energie heeft etc?

Belangrijk: Voor de bepaling van de resterende afstand die je kan afleggen wordt zowel gebruik gemaakt van de status van de batterij als van de rijstijl van de afgelopen 30 km. Daarbij is er vanuit gegaan dat je de eerste 30 km met je normale rijstijl hebt gereden.

1. Ik ben er zeker van dat ik mijn eindbestemming met mijn elektrische auto haal



1. Ik zou willen dat ik een andere auto had (benzine) om deze reis te maken

Helemaal mee eens

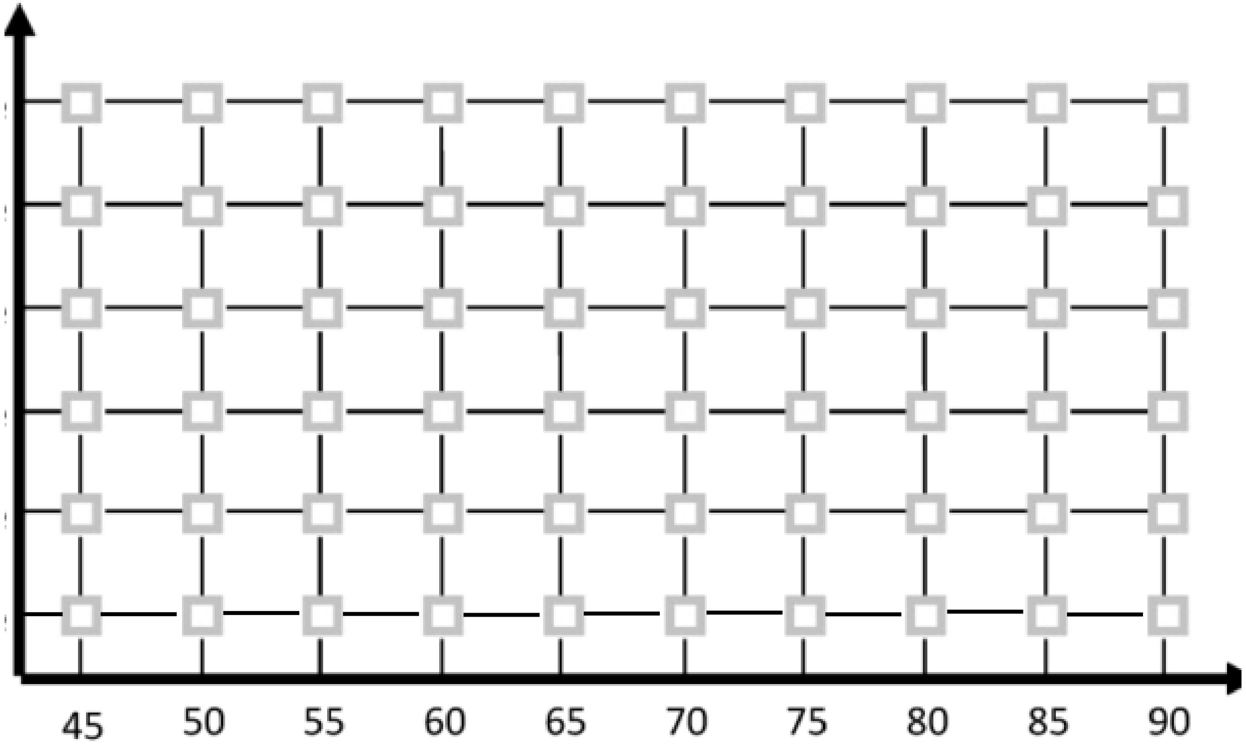
Grotendeels mee eens

Een klein beetje mee eens

Een klein beetje mee oneens

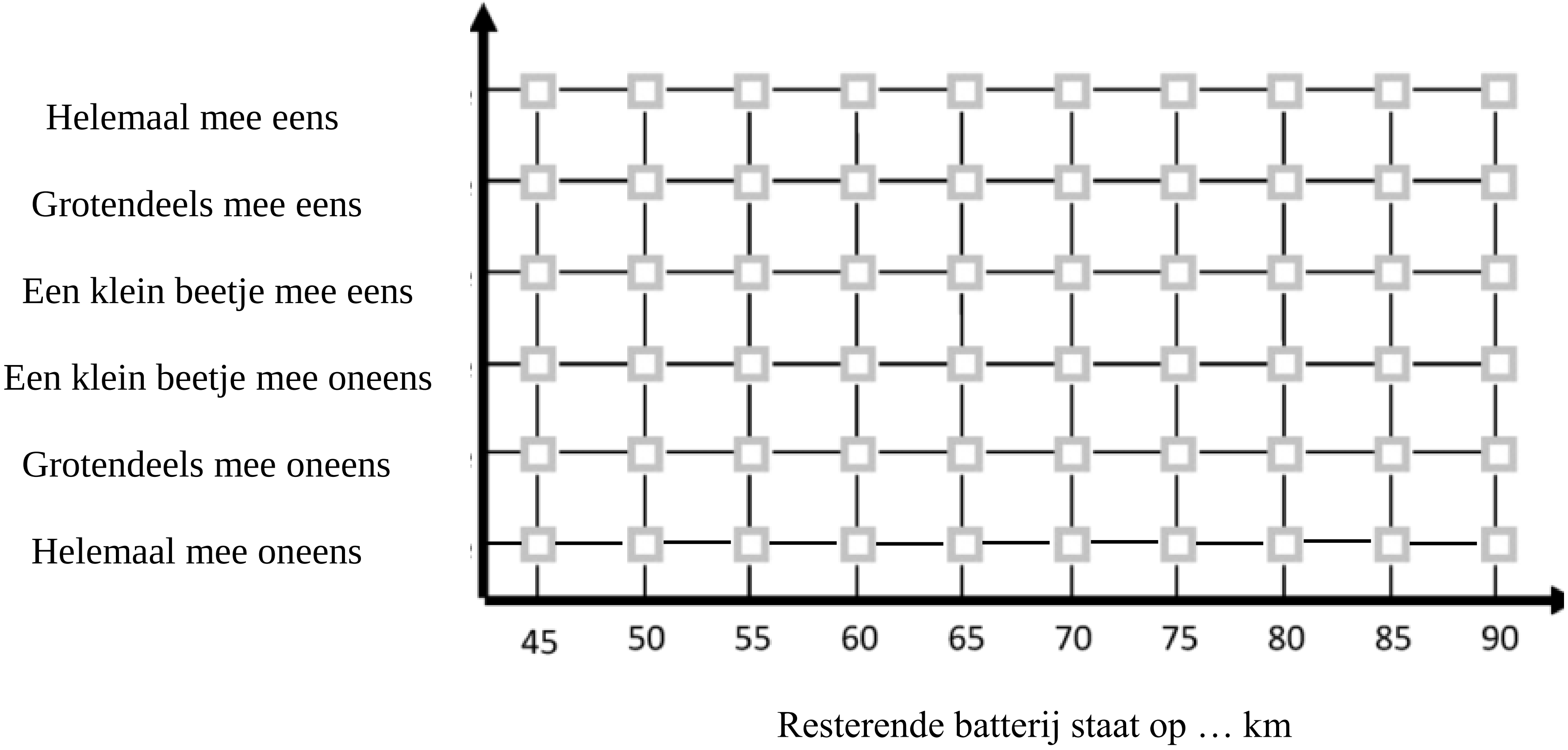
Grotendeels mee oneens

Helemaal mee oneens



Resterende batterij staat op … km

2. Ik ben bezorgd dat ik mijn bestemming niet haal



3. Tijdens deze reis denk ik geen stress te ervaren over de af te leggen afstand

Helemaal mee eens

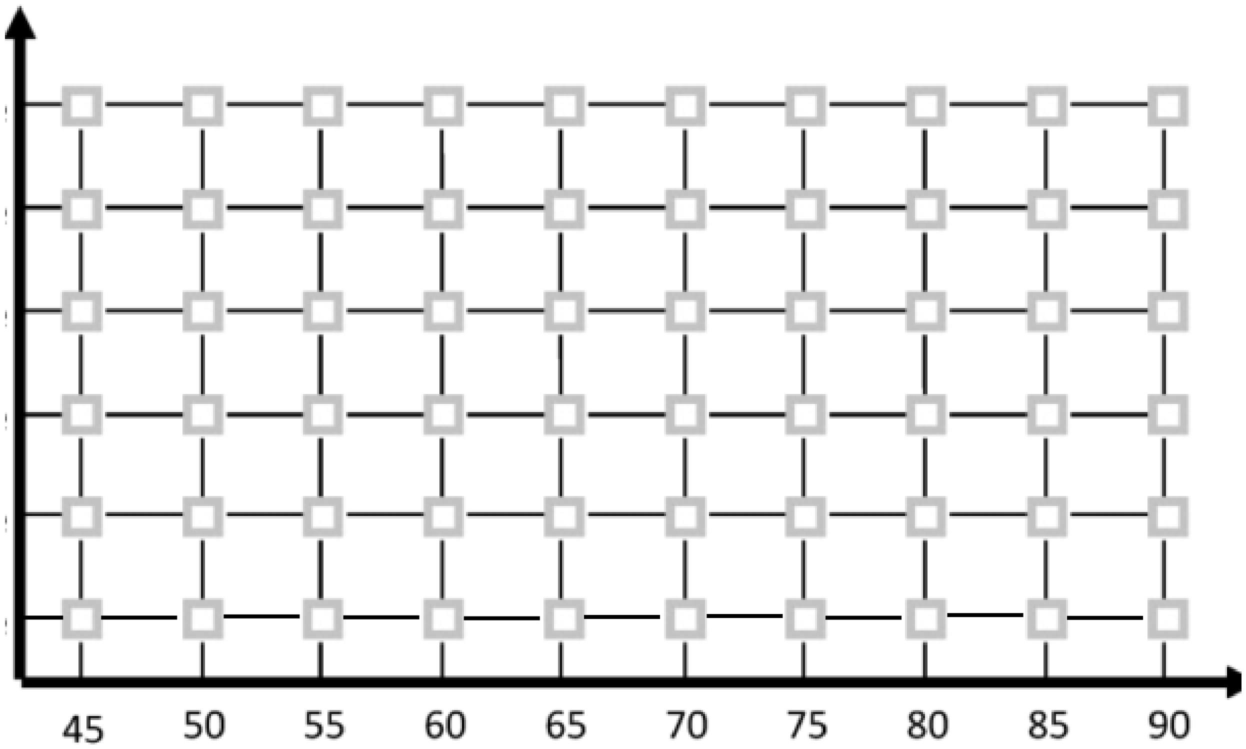
Grotendeels mee eens

Een klein beetje mee eens

Een klein beetje mee oneens

Grotendeels mee oneens

Helemaal mee oneens



Resterende batterij staat op … km

Appendix B

Part 2 interviewing scheme

Inleiding: In het scenario heb je gelezen over *'Range anxiety*' en hier vervolgens voor jezelf over nagedacht. In het vervolg van dit interview hebben we het erover welke informatie je graag zou willen ontvangen via een dashboard tijdens het rijden met een elektrische auto in relatie tot 'range anxiety'. Dit gaat zowel over informatie tijdens als na het rijden

Vraag: Zou je willen beschrijven welke informatie of functionaliteiten een dashboard in een elektrische auto tijdens het afleggen van je route zou moeten hebben om voor jou een goed inzicht te krijgen in, en te kunnen bijsturen op de mogelijke onzekerheid om je bestemming te halen?

Indien respondent er niet over begint of onderdelen niet noemt vragen naar
Resterende mogelijk af te leggen afstand zonder opladen

Vraag: Hoe belangrijk zou je het vinden om informatie te krijgen over hoe ver de elektrische auto nog kan rijden zonder op te laden.

Te behandelen zaken

Reden belang	Aan bod geweest	Prominent
Belangrijk: waarom belangrijk		
Niet belangrijk: Kan je me uitleggen waarom je dit niet belangrijk vindt		

Gebaseerd op welke informatie	Aan bod geweest	Prominent
Gemiddelde rijstijl over een willekeurige afstand		
Routeprofiel		
Weer		
Door respondent zelf genoemd		

Resterende afstand tot bestemming
Vraag: Hoe belangrijk zou je het vinden om informatie te krijgen over hoeveel energie het nog kost om je bestemming te bereiken?

Te behandelen zaken

Reden belang	Aan bod geweest	Prominent
Belangrijk: waarom belangrijk		
Niet belangrijk: Kan je me uitleggen waarom je dit niet belangrijk vindt		

Gebaseerd op welke informatie	Aan bod geweest	Prominent
Gemiddelde rijstijl over een willekeurige afstand		
Routeprofiel		
Weer		
Door respondent zelf genoemd		

De verwachte batterijduur bij het bereiken van de bestemming

Vraag: Hoe belangrijk zou je het vinden om tijdens het rijden inzicht te krijgen in de resterende batterijduur bij het bereiken van je bestemming?

Te behandelen zaken

Reden belang	Aan bod geweest	Prominent
Belangrijk: waarom belangrijk		
Niet belangrijk: Kan je me uitleggen waarom je dit niet belangrijk vindt		

Zou je hier en veiligheidsbuffer in willen zien?	Aan bod geweest	Prominent
Belangrijk: waarom belangrijk		
Niet belangrijk: Kan je me uitleggen waarom je dit niet belangrijk vindt		

Gebaseerd op welke informatie	Aan bod geweest	Prominent
Gemiddelde rijstijl over een willekeurige afstand		
Routeprofiel		
Weer		
Door respondent zelf genoemd		

Overschrijding bufferzone of bestemming niet kunnen behalen

A Vraag: Eerder heb je aangeven een buffer te willen zien tav status van de batterij bij het bereiken van je bestemming hoe belangrijk vindt je het om informatie te krijgen als je tijdens de rit deze buffer overschrijdt?

Buffer overschrijden belang	Aan bod geweest	Prominent
Belangrijk: waarom belangrijk		
Niet belangrijk: Kan je me uitleggen waarom je dit niet belangrijk vindt		

B Vraag: Hoe belangrijk vind je het om informatie te krijgen als er onvoldoende energie in de batterij zit om de bestemming te behalen?

Grens overschrijden belang	Aan bod geweest	Prominent
Belangrijk: waarom belangrijk		
Niet belangrijk: Kan je me uitleggen waarom je dit niet belangrijk vindt		

Oplaadpunten onderweg

Vraag: Hoe belangrijk zou je het vinden om informatie te krijgen over mogelijke oplaadpunten op je route.

Reden belang	Aan bod geweest	Prominent
Belangrijk: waarom belangrijk		
Niet belangrijk: Kan je me uitleggen waarom je dit niet belangrijk vindt		

Informatie over zaken handelingen op batterij
Vraag: Hoe belangrijk zou je het vinden om tijdens het rijden informatie te krijgen over welke factoren/handelingen effect (negatief of positief) hebben op je resterende batterij?

Reden belang	Aan bod geweest	Prominent
Belangrijk: waarom belangrijk		
Niet belangrijk: Kan je me uitleggen waarom je dit niet belangrijk vindt		

Gebaseerd op welke informatie	Aan bod geweest	Prominent
Rijstijl		
Apparaten in auto		
Routeprofiel		
Weer		
Door respondent zelf genoemd		

Uitgebreid verslag over gebruik na rit
Vraag: Hoe belangrijk zou je het vinden om na het rijden informatie te krijgen over welke factoren/handelingen effect (negatief en positief) hebben gehad op het batterijgebruik?

Reden belang	Aan bod geweest	Prominent
Belangrijk: waarom belangrijk		
Niet belangrijk: Kan je me uitleggen waarom je dit niet belangrijk vindt		

Gebaseerd op welke informatie	Aan bod geweest	Prominent
Rijstijl tips		
Apparaten in auto		
Routeprofiel		
Weer		
Door respondent zelf genoemd		

Appendix C

Part 3 questionnaire

Geslacht M/V

Leeftijd:

Heb je een rijbewijs? Ja/Nee

Hoe vaak rijd je auto (gemiddeld per week)?

Wat is je inschatting dat de actieradius van een elektrische auto is (met jouw gemiddelde rijstijl).

Hoe vaak schat je in dat je verder rijdt dan de actieradius van een elektrische auto (% van totaal)

Hoe waarschijnlijk is het dat als je een nieuwe auto koopt dit een elektrische auto zou zijn?

1 (zeer onwaarschijnlijk) – 2 (onwaarschijnlijk) – 3 (neutraal) – 4 (waarschijnlijk) - 5 (zeer waarschijnlijk)

Welke overwegingen spelen hier een rol bij?

Appendix D

Translation of quotations of participants

Quote in English	***Original quote in Dutch***
"The basis is of course, but I think that is obvious, that you want to see an estimate of how many kilometers you can drive with that car."	*"De basis is natuurlijk, maar ik denk dat voor de hand liggend is, sowieso willen zien een schatting van hoeveel kilometer je nog denkt te kunnen rijden met die auto."*
"Yes, if you assume a clear destination then it would not only be nice to see how many kilometers there are left but also a link with a navigation system or something where you then clearly see how many kilometers I have to drive so that you do not have to bet to reach your destination."	*"Ja als je uitgaat van een duidelijke bestemming dan zou het wat mij betreft niet alleen prettig zijn zoveel kilometer heb je nog maar ook een koppeling met een navigatiesysteem oid waar je dan duidelijk krijgt hoeveel kilometers moet ik nog maken zodat je dat niet alleen op de gok hoeft te maken."*
"For example, it would help me if you would see how much you have used in the last 30 km. And that you then see what was it that used that energy."	*"Het zou mij bijvoorbeeld helpen als je zou zien hoeveel je verbruikt hebt in de afgelopen 30km. En dat je dan ziet waar dat in zit."*
"Yes and that the car mainly makes the estimate am I going to get there or not if that is possible."	*"Ja en dat de auto vooral de inschatting maakt haal ik het wel of niet als dat toch kan."*
"I do not want that thing to calculate that, so I would not want to see you can still drive 10 km or you still have 10km left or so. It might be more convenient but I would still like to see you have to drive so many kilometers and you still have so many kilometers of battery based on your driving style left."	*"Ik wil niet dat dat ding dat al uitrekent, Dus ik zou niet willen zien je kan nog 10 km of je hebt nog 10km over of zo. Het zou misschien wel handiger zijn maar ik zou toch willen zien je moet nog zo veel kilometer rijden en je hebt nog voor zo veel kilometer aan batterij gebaseerd op je rijstijl."*
"That you can set that up, maybe I will reach it on the limit, but I want to leave something so I would like that warning."	*"Dat je dat in kan stellen, misschien haal ik het op de grens wel maar ik wil wat overhouden dus die waarschuwing zou ik wel prettig vinden."*
"I think at the very moment that you are going to get stress or anxiety that you will not reach your destination that you do not start thinking about things like that and that you will miss certain things. So it can certainly be of added value to get such notifications."	*"Ik denk helemaal op het moment dat je stress of angst gaat krijgen dat je je bestemming niet gaat bereiken dat je dan zelf niet zo snel gaat nadenken over dat soort zaken en dat je bepaalde dingen over het hoofd gaat zien. Dus dan kan het zeker van toegevoegde waarde zijn om dergelijke meldingen te krijgen."*
"Just like with your phone when you say I want to take an energy-saving measure that means that your speed is reduced, the screen reduced. That kind of information you want to see with regard to what that yields."	*"Net als met je telefoon als je zegt ik wil een energiebesparende maatregel nemen dat betekent dat je snelheid verminderd, het scherm verminderd. Dat soort informatie wil je dan ook kunnen zien met betrekking tot wat dat dan oplevert."*

"I would like to know where the charging stations are and that the car gives a warning when I am out of range with regard to the amount of kilometers that I still can drive in relation to where the electric pole is located. I prefer that my car just gives me a signal of come on dude you have to refuel, otherwise you will not make it."	*"Ik zou willen weten waar de oplaadpalen zijn en dat de auto een waarschuwing geeft op het moment dat ik uit range t.o.v. de hoeveelheid kilometer die ik nog kan rijden ten opzichte waar die elektrische paal staat. Ik heb het liefst dat mijn auto mij gewoon een signaal geeft van dude kom op je moet even gaan tanken anders red je het niet."*
"Yes in itself would be useful for when you find that you often notice that you consume more than what you expected. I would not want to see that in the car but that on your device just see what the causes were of that too high consumption."	*"Ja op zich zou dat handig zijn voor als je merkt dat je heel vaak merkt dat je meer verbruikt dan wat je had verwacht. Ik zou dat niet in de auto willen zien maar dat dan op je device gewoon terug kan zien wat de oorzaken waren van dat te hoge verbruik."*