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MASTER THESIS

The interaction between consumers and electrical cars - A longitudinal study

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Abstract

The aims of this study were twofold: first, to investigate how prospective customers of electrical vehicles (EVs) are influenced by the use of electrical carsharing cars and second, to investigate how they perceived using these EVs. We reviewed previous studies and found that three variables are decisive indicators of whether prospective customers would or wouldn't use EVs: (1) general EV acceptance, (2) usability and (3) range anxiety. Following this, we measured how using electrical carsharing cars influenced these variables within two groups of experienced and inexperienced EV users, respectively. Furthermore, we conducted semi-structured interviews to investigate how participants perceived using these cars. According to our results, general EV acceptance and usability showed low variability, while range anxiety showed high variability. In addition, participants perceived the sustainability of the EVs, having an extra car, and having low costs as main advantages of the electrical carsharing cars. In contrast, the limited distance range, the recharge infrastructure, and the inflexibility of booking the car spontaneously were perceived as the biggest disadvantages. According to our results, it is advisable to run electrical carsharing systems over long periods of time, in order to influence prospective customers' general acceptance of EVs of positively.

Samenvatting (Dutch Abstract)

Het doel van deze studie was allereerst het onderzoeken hoe potentiële klanten van elektrische voertuigen (EV's) worden beïnvloed door het gebruik van elektrische deelauto's. Daarnaast werd beoogd te onderzoeken hoe zij het gebruik van de elektrische auto's hebben ervaren. Volgens eerdere studies zijn de drie variabelen (1) acceptatie, (2) de gebruiksvriendelijkheid van EV's en (3) bereik-angst goede indicatoren van of potentiële klanten wel of niet gebruik zullen maken van EV's. Tijdens een volgende stap hebben we de deelnemers in twee groepen ingedeeld (ervaren en onervaren EV's gebruikers) en gemeten hoe de drie variabelen werden beïnvloed terwijl de deelnemers gebruik maakten van elektrische deelauto's. Verder werden er semigestructureerde interviews gevoerd met de deelnemers om te onderzoeken hoe ze het gebruik van de EV's hebben ervaren. Volgens onze resultaten was er een lage variabiliteit in algemene EV acceptatie en bruikbaarheid, terwijl er in bereik angst een hoge variabiliteit bleek te zijn. Verder worden het milieuvriendelijke van de EV's, het hebben van een extra auto, en de lage kosten als grootste voordelen van de elektrische deelauto's waargenomen. De beperkte reikwijdte, de laadinfrastructuur en het reserveren van de auto's werden als grootste nadelen waargenomen. Volgens onze resultaten is het raadzaam om elektrische deelautosystemen langdurig aan te bieden om potentiële klanten positief te beïnvloeden.

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1. Introduction

"I really do encourage other manufacturers to bring electric cars to market. It´s a good thing and they need to bring it to market and keep iterating and improving and make better and better electric cars, and that´s what going to result in humanity achieving a sustainable transport future. I wish it was growing faster than it is."

Elon Musk, CEO of Tesla Motors

1.1 Electrical vehicles as a key solution

Electrical carsharing systems like 'car2go' in Amsterdam or Berlin enable prospective customers to get accustomed with electrical vehicles (EVs) and promote EVs as attractive and environmentally friendly cars of the future. These carsharing systems are made available by various European car manufacturers, whose focus is on attracting customers, rather than on running economically profitable systems (Hüttl, Pischetsrieder, & Spath, 2010). Nevertheless, current state of the art EVs have a lot of weaknesses compared to conventional cars with combustion engines (VCE), such as limited range distances and long recharge times (Dijk & Yarime, 2010; Graham-Rowe et al., 2012; Kley, Lerch, & Dallinger, 2011; Pierre, Jemelin, & Louvet, 2011). This raises the questions: How are users' general evaluations about EVs influenced by using electrical carsharing cars and how are users influenced by the current weaknesses of the EVs? To our best knowledge, there is no empirical study that has investigated how users' perceptions about EVs are influenced by using electrical carsharing cars. The aim of this study is to fill this gap in current EVs research by conducting explorative research about how users are influenced by using electrical carsharing cars on an infrequent basis and to detect the influence of the current EV weaknesses (e.g. the limited range distance) on users' perceptions. To do this, we want to conduct an intensive longitudinal study with users of an electrical carsharing system. Intensive longitudinal studies are characterized by repeated measurements of a variable of interest, to analyze the change process of subjects or groups, as well as causes and consequences (Bolger & Laurenceau, 2013).

One might wonder why car manufactures make such great investments in promoting and developing EVs, despite the fact this does not lead to economic benefits. Their motivation is caused by new laws, consisting of CO^2 limits for an average fleet of a car manufacturer, adopted by the European Union (EU). In 2012, the average fleet CO^2 emission of the European car manufacturers was 143 grams of CO^2 per kilometer (European Commission for Climate Action, 2014). In order to comply with the new laws, European car manufacturers had to decrease their average CO^2 emission of their entire fleet down to 130 grams of CO^2 per kilometer by 2015 and down to 94 grams of CO^2 per kilometer by 2020. If car manufacturers do not reach the CO^2 target, they will be punished with financial penalties (European Commission for Climate Action, 2014). Accordingly, the development and sales rates of EVs have become increasingly important for the car manufacturers, in order to significantly decrease the average CO^2 emission of their fleet (Kroon & de Wilde, 2013). The overall goal, which led the EU to adopt these new laws, was to promote renewable energy solutions in Europe. Firstly, they wanted to decrease European dependency on fossil energy imports from Russia and different Arab countries (European Commission for Climate Action, 2014). The imports of fossil energy sources are inevitable, due to the limited fossil energy deposits in Europe. However, the political situation within these countries and between them and the EU are complex, thus demanding the sourcing of alternative energy supplies (Smith Stegen, 2011; Umbach, 2010). In addition, the EU wanted to counteract its greenhouse gas emissions, which are increased by the use of fossil energy sources. Greenhouse gas emission (especially CO^2) is related to both climate change and the fine particular pollution in several European cities (Allen et al., 2009; European Commission for Climate Action, 2014; Matthews, Gillett, Stott, & Zickfeld, 2009; Thiel, Perujo, & Mercier, 2010). In order to decrease the greenhouse gas emission in Europe, it is important to find alternatives for VCE, since they are one of the main greenhouse gas contributors in Europe (European commission for Energy and Transport, 2010). According to Thiel et al. (2010), using EVs instead of VCE would be a prospective alternative, because this would significantly reduce the greenhouse gas emission in Europe.

In addition to adopting new laws for car manufactures, different European governments, for instance the Dutch government, have approved new laws in order to establish tax advantages for citizens who are buying and using new EVs in place of a VCE (Rijksoverheid, 2011). The goal of the Dutch government is to achieve one million EVs in the Netherlands, by 2025 at the latest. The results of our study contribute to the understanding of how using electrical carsharing cars influences users' general perceptions of EVs. Furthermore, the results offer deeper insight into how users are perceive the weaknesses of current, state of the art, EVs. These results can be used as a basis for further research and in order to improve current efforts to encourage prospective customers.

1.2 Literature review

To investigate how using electrical carsharing cars on an infrequent basis influences users' general perceptions of EVs, we reviewed previous EVs research. Our aims were to understand both what influences EV users to form an opinion about EVs and how weaknesses of EVs influence the users' intention to use EVs. Two approaches were particularly suitable for our understanding. The first approach by Cocron and colleagues (2011) introduced a model that represents how users categorize their evaluations about EVs (Figure 1). According to the model, there are four factors (pillars) that are decisive for users' evaluation of EVs. The first pillar "mobility" describes the influence of the significantly smaller distance ranges and higher recharge times of EVs compared to VCE and whether this disadvantage influences users' evaluation of EVs. The second pillar, "Human Machine Interaction", describes how users' evaluation of EVs is influenced by the user friendliness of the EV, as well as by the usability of charging stations. Car manufactures often equip new EVs with novel displays, unfamiliar for the users, which provide them with information about the battery status.

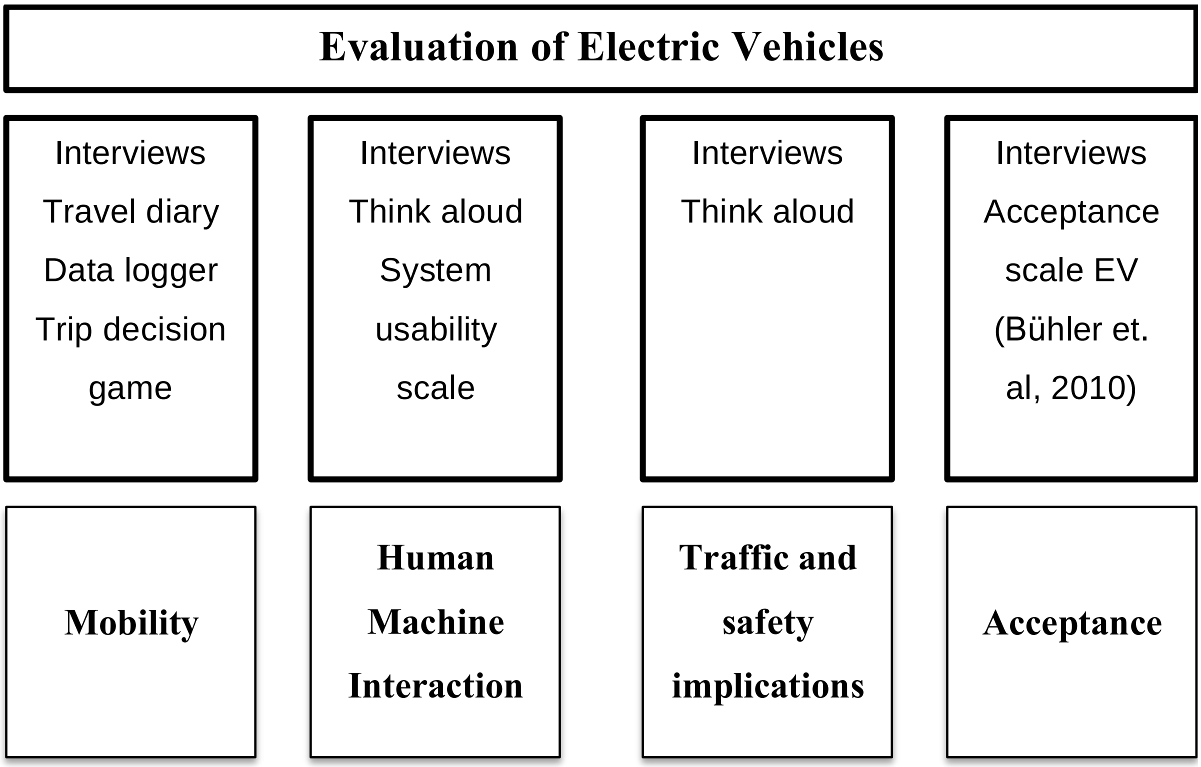


Figure 1. Four pillars in the psychological evaluation of EV, adapted from Cocron et al. (2011). The model represents the four pillars of user´ evaluation of EV (grey boxes at the bottom), as well as recommended measurement tools (in the white boxes).

Furthermore, charging stations are not standardized, in terms of different payment systems and interfaces. Users need to put more effort into using these new and unstandardized technologies. Subsequently, this can negatively influence their evaluations of the user friendliness of EVs. Pillar three, “traffic and safety implications”, describes how users’ evaluation of EVs is influenced both by the fact that EVs are generally relatively small and light compared to VCE and that the engine sound is absent. The small and light design of EVs can lead to feelings of anxiety, because users feel unsafe when considering the impact of a potential crash. The missing sound influences safety implications for users, because other road users (especially cyclists) can fail to notice the EV. The last pillar, “acceptance”, describes users' general perceptions of the EV. For example, users differ in their evaluation as to whether EVs are overestimated technologies or an opportunity to decrease air pollution. According to Cocron and colleagues (2011), the interplay between the four described pillars predicts whether users are satisfied by EVs or not.

The second approach, by Graham-Rowe and colleagues (2012) explores how users evaluate EVs after using them. The researchers conducted a qualitative study with 20 non-EV drivers, following a seven-day period of using an EV, in order to investigate how non-EV drivers evaluated EVs after having experienced them. The participants were provided with an EV for one week and were asked to use it in place of their normal car. At the end of this week, the researchers interviewed the participants about their experiences and their evaluation of EVs. The researchers used an inductive open coding approach and concluded that the responses of their participants could be allocated to six categories: (1) cost factors, (2) vehicle confidence, (3) vehicle adaptation demands, (4) environmental beliefs, (5) impression management and (6) EVs as progress in work. High acquisition costs, limited range distances and long recharge times were perceived as barriers to buying an own EV. Nevertheless, participants expressed feeling positively about the environmental benefits and perceived the EVs as a work in progress, believing that the main disadvantages, such as the limited distance range and long recharge times would be eliminated by technological development.

The studies by Cocron and colleagues (2011) and Graham-Rowe and colleagues (2012) both give insight into how users evaluate EVs and demonstrate factors that are decisive for the intention of users as to whether to make use of EVs or not. Nevertheless, in order to investigate the influence of experiencing EVs in a carsharing system, we need to define valid concepts of these factors that are decisive for user evaluation of EVs.

1.2.1 Towards a new definition of general EV acceptance

Previous studies used the term general EV acceptance as a variable to measure users' general evaluations of EVs. Hereby, general EV acceptance can be described as the sum of all perceived advantages and disadvantages of EVs and is decisive as to whether people wish to use EVs or not. Nevertheless, a standardized definition or concept of general EV acceptance has been missing from early EV research, as well as standardized measurement methods. Instead, users' attitudes towards EVs and purchasing intentions have been used as indicators for general EV acceptance (e.g., Gärling & Johansson, 1999; Gärling, 2001). Positive attitudes were associated with higher intentions to use EVs, whilst purchasing intention was equated with being satisfied with using EVs. Bühler and colleagues (2014) criticized that general EV acceptance was equated with positive attitudes and buying intentions and that a standard definition of users' evaluation of EVs was missing. Bühler and colleagues (2014) argued that one might have positive attitudes towards EVs as environmental friendly, but that this would not necessarily cause a person to use EVs (e.g., because EVs are not able to fulfill one's mobility needs or one might not have the financial resources to enable the desire to use an EV). Therefore, Bühler and colleagues (2014) introduced a new concept of general EV acceptance. According to this concept, general EV acceptance is the result of positive attitudes towards EVs (e.g., as an environmentally friendly means of transportation), as well as of perceiving EVs as useful and satisfying vehicles to meet one's mobility needs. Bühler and colleagues (2014) included positive attitudes in their concept because earlier studies have shown that attitudes towards EVs are decisive for users' evaluation of EVs. Furthermore, perceiving EVs as useful and satisfying were included, because these are decisive factors for one's decision to make use of a new technology or not (Van Der Laan, Heino, & De Waard, 1997). As a working definition, we can define general EV acceptance as users' perception of EVs as useful vehicles for everyday use, by satisfying users' mobility needs and bringing benefits for the environment.

Previous researches assumed that experiencing EVs would positively influence general EV acceptance (e.g., Bühler and colleagues, 2014). A main reason for this expectation was that people, who have never experienced an EV, often underrate the current "state of the art" and the usefulness of EVs (Jensen, Cherchi, & Mabit, 2013; Kurani & Lipman, 1995). Theoretically, these attitudes change when customers gain more experience with EVs in daily life situations (Jensen et al., 2013; Kurani & Lipman, 1995). Initial longitudinal studies by Gärling and Johansson (1999) and Gärling (2001) failed to measure a significant effect of time (experience) on users' evaluations of EVs (measured as attitudes and buying intention). Buying intentions were moderately high in pre and post measurements in both studies, while attitudes were more positive, but were not influenced by experiencing an EV. Bühler and colleagues (2014) argued that the EVs in the studies by Gärling and Johansson (1999) and Gärling (2001) were in a too early state of development, compared to modern EVs (e.g., significantly smaller distance range and longer recharge times). Therefore, it is possible that the participants did not reduce their prejudices, because these problems were valid and real.

In order to find evidence for their assumption that EV experience is positively related to general EV acceptance, Bühler and colleagues (2014) developed a scale to measure general EVs acceptance based on their concept of general EVs acceptance. They used the scale in the framework of a longitudinal study in Berlin, which included 40 families as participants. All families received a MINI Cooper E for a period of six months and were asked to implement it into their daily lives. General EV and acceptance was measured at T0 prior to the longitudinal study, at T1 after three months and at T2 after six months. The results showed that general EV acceptance was high at all three measurement periods. However, the researchers also measured a significantly positive change in EV acceptance after three months, between T0 and T1. Interestingly, EV acceptance decreased during the last three months, between T1 and T2. According to the interpretation of Bühler and colleagues (2014), bad weather conditions (extremely cold winter in Berlin), between T1 and T2 might have caused this decrease of general EV acceptance. The acceptance level at T2 was still higher than at T0, but no longer significant. Bühler and colleagues (2014) concluded that general EV acceptance increased after participants experienced EVs in real life situations. Nevertheless, the authors questioned how stable acceptance would be over short periods of time and whether short stimulation programs (e.g., giving interested customers the chance to test an EV for a couple of days) would positively influence customers' general EV acceptance.

1.2.2 Perceived ease of use (usability)

The studies by Cocron et al. (2011) and Graham-Rowe and colleagues (2012) showed that user friendliness, or in other words, usability of EVs is a decisive factor in whether users would use EVs or not. To date, there are only a couple of studies that have investigated the user friendliness of electrical cars. Before establishing new technologies on the market, customers of new products need to feel confident with the use of the products (Oreg, 2006). Otherwise, users won't purchase them. In general, the International Organization of Standardization (1998) defined usability as *„the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use."* In this definition, effectiveness is seen as the degree to which a user is able to reach his goal by using the product. Efficiency determines how much effort the users have to invest to reach their goal by using the product, while satisfaction describes the users' subjective perception of how satisfied they are by using the product.

Since EVs are new systems for most people, measurements of usability could explain how users interact with these new systems. Generally, EVs are able to fulfill their main task of taking a person from point A to point B, as well as conventional VCEs. Therefore, one might conclude that perceptions of effectiveness are not influenced if a person wants to use an EV to go from one point to another. Nevertheless, multiple factors can decrease levels of satisfaction. For example, the battery of EVs needs a lot of room, wherefore the trunk of EVs is often significantly smaller than the trunk of a VCE. This can become a great obstacle and can even make it impossible for users to transport large items with EVs. In turn, this can negatively influence users' perception about the effectiveness of EVs. Efficiency might be influenced by the fact that users need to put more effort into recharging the EV, if they want to reach a target that is far away (Graham-Rowe et al., 2012). Nevertheless, EVs might be perceived as efficient if participants use them for short distances, within the maximal range distance of the EV. Thereby, users can increase the limited range distances by driving slowly and economically, but in turn, this might influence the users' satisfaction, because they are unable to reach their targets, as fast as they could with a VCE. High satisfaction levels might be reached when EVs enable users to reach nearby targets, in the same way as VCEs, with the added benefit of achieving this in an environmentally friendly vehicle.

Moreover, it would be interesting to see whether experience of EVs would increase users' skills to use EVs in an effective, efficient and satisfying way and would therefore positively influence perceived usability. As discussed earlier, experience positively influences general EV acceptance, because users gain more experience about how to use the EVs effectively. Research by Mendoza and Novick (2005) about usability in human-computer interaction, found effects of experience on perceived usability. In their longitudinal study, Mendoza and Novick (2005) investigated participants' levels of frustration and found that they dropped during a period of eight weeks of using a website of interest. These results demonstrated positive effects of experience on perceived usability. It is of course not possible to compare a website with an EV, but nevertheless, it would help car manufactures and suppliers to get more insight about how users evaluate the usability of EVs over time.

1.2.3 Experience and Range Anxiety

The limited range distance of electrical cars is a widely discussed topic in scientific research (e.g., Franke & Krems, 2013; Neubauer & Wood, 2014; Rauh, Franke, & Krems, 2014). The main problem with the limited range distance is the anxiety about not reaching the target and the anxiety about being stranded on the highway or in other dangerous places, termed ‘range anxiety’. In general, range anxiety is a stressful feeling in a driving situation, because one might perceive the available battery resources as insufficient to make it home or to the next recharge station (Rauh et al., 2014). In turn, range anxiety could decrease customers’ willingness to buy EVs with low range distances (Neubauer & Wood, 2014; Rauh et al., 2014). Franke and Krems (2014) introduced the first scientific framework of range anxiety, including personal coping strategies, trait variables and current mobility needs (Figure 2).

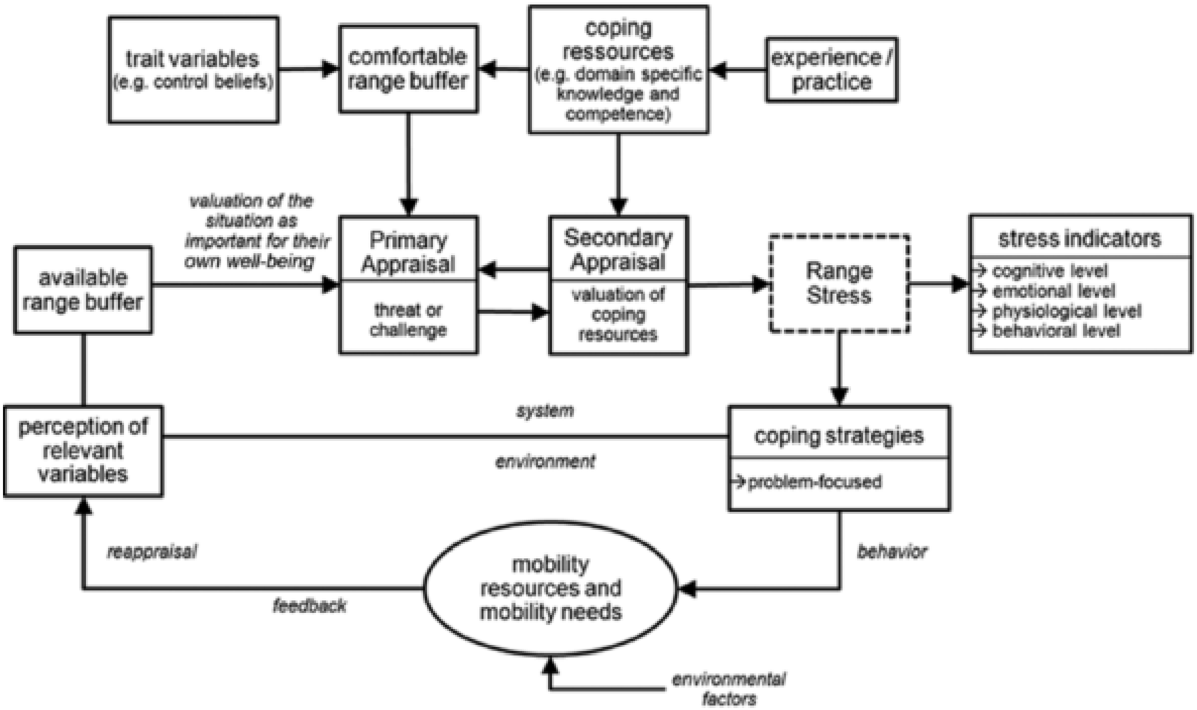


Figure 2. A framework of range anxiety, adapted from Rauh and colleagues (2014)

According to this framework, range anxiety is caused by the interplay of trait variables, the comfortable range, and the coping resources. Trait variables characterize individual differences between persons (e.g., risk seeking behavior). The comfortable range describes to which extent drivers are willing to use the maximal range distance of the car before they get stressed (e.g., driving 80 kilometers with an EV vs. driving 120 kilometers with an EV). Previous research shows that the comfortable range is approximately 80 percent of the total range distance. Drivers seem to avoid distances that are out of their comfortable range

(Franke & Krems, 2013). Nevertheless, they can encounter situations in daily life, in which they have to leave their comfortable range, in order to reach their target. Evidence has been found that the comfortable zone increases after drivers experienced an EV for more than three months (Franke & Krems, 2013). One explanation for this is that more experienced drivers improve their coping styles (e.g., drive in a battery friendly manner) and gain more experience of how far the EV can actually go (Rauh et al., 2014). In a quasi-experiment, Rauh and colleagues (2014) demonstrated that inexperienced drivers perceive higher levels of stress, compared to experienced drivers when they are confronted with a situation in which they run the risk of not reaching their target. Nevertheless, the researchers stated that further research should investigate range anxiety in real world settings, because participants were supervised, which might have given them the feeling of not being responsible for the car.

1.3 LochemEnergie and the concept of e-carsharing

LochemEnergie is citizens' association in the municipality of Lochem, which wants to produce and consume its own energy by using renewable energy sources. Furthermore, LochemEnergie is cooperating with several Universities and research institutes in multiple studies about new energy solutions or innovations. In order to develop a new concept of offering EVs in a cost efficient way, LochemEnergie introduced a carsharing system with a fleet of EVs. The primary idea of the e-carsharing concept is to supply EVs in a cost efficient way. As investigated by Graham-Rowe and colleagues (2012), a main obstacle for customers to make use of EVs are the high acquisition costs. This can be eliminated by the e-carsharing system because acquisition costs are taken over by the company. Furthermore, LochemEnergie produces renewable energy in the municipality of Lochem. Therefore, they can offer their customers an environmentally friendly car that is recharged with energy generated by renewable energy sources. LochemEnergie customers can rent the EVs via the company's website for four hours, eight hours or the whole day. LochemEnergie's total fleet consists of five electrical cars and is used by approximately 120 customers.

1.4 Purpose of the current study

The goal of the current study is to fill the gap in current EV research by conducting explorative research about how users are influenced by using an electrical carsharing car on an infrequent basis. In our literature review, we discussed the concept of general EVs acceptance and concluded that it is a general indicator for whether users are willing to use EVs or not. Furthermore, EV research to date has found evidence for the assumptions that experience has a positive impact on general EV acceptance. In contrast to our study, previous studies have measured changes of EVs acceptance over long periods of time and participants have been equipped with a personal EV (i.e., in a time interval of three months; e.g. Bühler and colleagues (2014)). It is impossible for car manufactures to stimulate and convince all interested users by providing a personal EV to them for three months. Our study will extend previous studies, by investigating how using electrical carsharing cars influences users' general perceptions of EVs. Bühler and colleagues (2014) highlighted the need for research that measures changes in EV acceptance over short periods of time, both to investigate how stable this variable is and to analyze whether short periods of experience are able to improve users' general EV acceptance. Furthermore, we discussed that perceived usability is another important variable for research, due to the fact that users of new products need to feel confident while using new products, or else will stop using them. To the best of our knowledge there are no empirical studies that have investigated how experience with EVs influences perceived usability. In our opinion, usability is a crucial factor for users in deciding whether to use EVs or not. Therefore, we decided to include usability in our explorative study. In addition to general EV acceptance and usability, we discussed how EVs' limited distance ranges could lead to range anxiety. Rauh and colleagues (2014) stated that research has to exceed the laboratory measurements, both by investigating how stable this range anxiety is in the real world and by investigating whether inexperienced EV users experience higher levels of range anxiety. Car manufactures and governments can profit from such research, because it demonstrates whether short projects, stimulating the general public to make use of EVs, can be successful or not. Furthermore, results would help researchers to select appropriate research designs for future research, because information about the variability of different variables could help to determine how to measure them.

This led us to the following research questions:

Research Question 1: How does experiencing an EV on an infrequent basis, over short time intervals of eleven days, influence general EV acceptance, perceived usability and range anxiety in both experienced and inexperienced EV users? Based on the small variability found by Bühler and colleagues (2014) we expected to find a small variability in general EV acceptance. Furthermore, we expected that the variability of perceived usability will be higher in the group of inexperienced users, because inexperienced users do not have any experience in which EVs can be used in an effective, efficient and satisfying way. Regarding range anxiety, we assumed to find higher variability for range anxiety, compared to general EV acceptance and usability, because the current driving situation usually causes range anxiety.

Research Question 2: What are participants' perceptions about using electrical carsharing cars with respect to general EV acceptance, usability and range anxiety?

Research Question 3: Is it possible to improve the carsharing system of our cooperation partner, LochemEnergie, based on our results?

2. METHOD

2.1 Participants

In total, the sample comprised 22 participants, 9 females and 13 males. The age of the participants ranged from 21 to 71 (M = 54.8, SD = 11.5). All participants were members of LochemEnergie and were either experienced users of the carsharing system or members who were interested in the carsharing concept, but had neither used the carsharing system, nor an EV, before. An additional requirement to participate in this study was that participants had to have access to the Internet and a valid email address. The participants were recruited in cooperation with LochemEnergie and were grouped into experienced (n=13) and inexperienced (n=9) users. We defined experienced participants as those who met two conditions. First, they had made use of the electrical carsharing system for at least six months and second, they were one of the top 50 most frequent users of LochemEnergie's EVs within the last 6 months. To acquire participants with experience, an email with information about the study and its aims was sent to the 50 most frequent users of LochemEnergie's electrical carsharing system. In total, 13 experienced members of LochemEnergie responded to this email and were willing to participate in this study. Inexperienced participants were defined as those who had never used EVs or the electrical carsharing system before. To acquire participants without experience, an information evening for all interested LochemEnergie customers was organized. Customers without experience of EVs were asked if they would like to participate in the intensive longitudinal study. Additionally, all questions the customers had were answered. Table 1 represents demographic information from both groups. Table 1 shows that asides from differences in the experience of using EVs, participants in the two groups did not differ significantly with respect to mean age, family members or cars in ones own household. All participants signed the informed consent form and the ethics committee of the University of Twente approved the study.

Table 1

General information about participants in both groups at T0

	Group 1 (experienced)	**Group 2 (inexperienced)**
Females/Males	6/7	3/6
Age	21 to 66 (Mean = 53.9, SD = 12.2)	39 to 71 (Mean = 56.2, SD = 11.5)
EVs experience (months)	6 to 12 (Mean = 10.68, SD = 1.87)	0 (Mean = 0, SD = 0)
Family members	1 to 4 (Mean = 2.2, SD = 0.93)	1 to 5 (Mean = 2.8, SD = 1.36)
Number of cars in their own households	0 to 2 (Mean = 0.92, SD = 0.49)	0 to 3 (Mean = 1.44, SD = 0.88)

2.2 Location

The intensive longitudinal study was conducted in the Dutch municipality of Lochem. Most of the experienced participants lived in the municipality's center, Lochem, whereas most of the inexperienced participants lived in the village, Gorssel. This is because the carsharing concept was first implemented in the center and afterwards in the village. In total, 32,546 citizens live in the municipality of Lochem. Both, the municipal center Lochem and the village Gorssel can be described as rural areas.

2.3 Electrical vehicles

LochemEnergie's carsharing system operated with two different types of electrical cars; (1) the Mitsubishi In-wheel motor Electrical Vehicle (MIEV) and (2) the Smart Fortwo electrical drive (Figure 3). Both cars had a distance range of approximately 70 km in the winter and up to 120 km in the summer. The main difference between both cars was the number of seats. The MIEV had four passenger seats, while the Smart Fortwo had only two passenger seats. Our study was conducted between February and April of 2015. The temperature increased significantly during this time period, with the result that the range distance of both cars increased during our study.

Figure 3. The Smart (left) and the MIEV (right)

2.4 Materials

2.4.1 Questionnaires

2.4.1.1 EV acceptance scale. General EV acceptance was measured with a seven-item questionnaire, developed by Bühler and colleagues (2011). The participants responded on a five-point likert scale to the seven items (1=Strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree). Previous research has shown that there was a lack of standardized questionnaires measuring EV acceptance (Bühler and colleagues, 2011). Therefore, researchers developed a new scale, in order to measure general EV acceptance in a standardized way (Table 2).

Table 2

Seven item scale to measure general EV acceptance by Bühler and colleagues (2011)

- *Electric vehicles are a key solution to solving air pollution.*
- *Electric vehicles are the means of transport for the future.*
- *I am convinced of electric vehicles.*
- *Electric vehicles should play a more important role in our mobility systems.*
- *Electric vehicle use results in driving pleasure.*
- *I think that as a sole vehicle, an electrical vehicle is suitable for a household.*
- *Electric vehicles are suitable for everyday use.*

The researchers used their seven-item scale in a longitudinal study where the scale displayed a Cronbach's alpha of .69. The original scale was created and used in German. For our study, the questionnaire was translated by a native Dutch speaking person and afterwards checked by two native Dutch-speaking peers. The Dutch scale showed Cronbach's α= .69.

2.4.1.2 Other scales. Perceived ease of use and usability were measured with eight items of the System Usability Scale (Table 3). This scale is a valid tool to measure the usability and perceived ease of use of an environment of interest (Brooke, 1996). The items "I found the various functions in this system were well integrated." and "I thought there was too much inconsistency in this system." were not included in the final questionnaire, because some participants reported that they were unable to associate these items with an electrical vehicle. Range anxiety was measured with three items from a scale by Rauh et al. (2014) (Table 3). Participants responded to both scales with a five-point likert scale (1=Strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree).

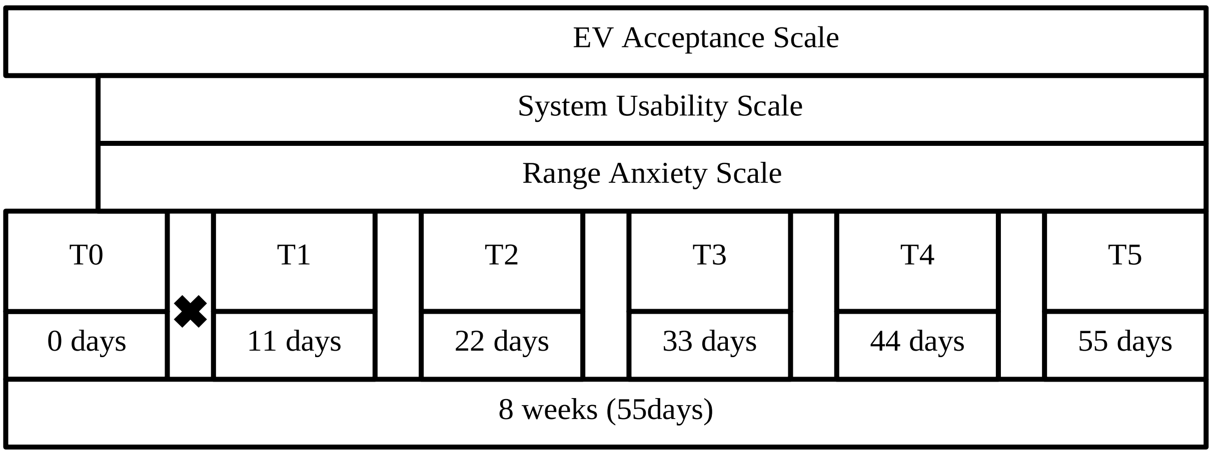
Table 3

Items from both (1) the System Usability Scale and (2) the Range Anxiety Scale

System Usability Scale, Brooke (1996)
• *I think that I would like to use this system frequently.* • *I found the system unnecessarily complex.* • *I thought the system was easy to use.* • *I think that I would need the support of a technical person to be able to use this system.* • *I would imagine that most people would learn to use this system very quickly.* • *I felt very confident using the system.* • *I found the system very cumbersome to use.* • *I needed to learn a lot of things before I could get going with this system.* • *I found the various functions in this system were well integrated.* • *I thought there was too much inconsistency in this system.*
Range Anxiety Scale, Rauh and colleagues (2014)
• *While driving, I was often worried about range.* • *With the electrical car, I was concerned about reaching the destination* • *With the electrical car, I was stressed by range.*

2.5 Design of the longitudinal study

To measure the influence of experience on general EVs acceptance, perceived usability and range anxiety, interval sampling, in an intensive longitudinal design of eight weeks, with two groups (experienced vs. inexperienced) was chosen. We made use of an intensive longitudinal design, as these designs are strong measurement methods that can capture individual change processes in their natural, spontaneous context. They allow the researcher to determine whether variable Y changes over time and in which ways variable X is involved in this context (Bolger & Laurenceau, 2013). In the current case, Y is defined by the three dependent variables: general EV acceptance, usability and perceived range anxiety, while X is defined as: influence of the designated group (experience vs. inexperience). Thus, this design enabled us to investigate changes in our three dependent variables over time and to analyze whether experience influenced these changes. The participants received an online link with the questionnaires at six different time points (Figure 4).



Note. The participants received the questionnaires at T0, T1, T2, T3, T4 and T5. Inexperienced participants used the EV for the first time after T0 (black thick X). In contrast to the group of experienced participants they did not receive the SUS and the range anxiety scale at T0, because they needed experience with the EV before they could fill in both scales.

Figure 4. Measurement points within this study

2.6 Interviews

After the participants used the electrical carsharing cars for 8 weeks, the interviews were conducted (after T5). The aim of the interviews was to investigate how participants perceived using LochemEnergie's electrical carsharing cars. We used a semi-structured interview approach to gather this information. To do this, we used two open questions: (1) "*What are, in your opinion, the main advantages of the electrical carsharing cars?"* and "*What are, in your opinion, the main disadvantages of the electrical carsharing cars?"* In addition, six categories were included that had to be discussed during the interviews: (1) range distance, (2) charging, (3) cost benefits, (4) environmental beliefs, (5) user friendliness of the EVs and (6) safety implications. If the participant did not say anything about one of these categories, the researcher guided the interview towards these categories.

2.7 Procedure

Stage 1: Individual appointments with all interested members of LochemEnergie were arranged. During these appointments, any questions related to this study were answered and participants were given guidance on how to complete the questionnaires. The questionnaires were provided via an online tool and therefore necessitated participants to provide a valid email address. After all questions had been answered, the participant and the researcher signed the informed consent form. Subsequently, appointments for the semi-structured interviews after T5 were scheduled.

Stage 2: Participants then received the first online questionnaires and were asked to complete these on the day of receipt. In contrast to the following questionnaires, the first questionnaires included additional questions about participants' demographic information. After this, participants received an email with a brief and gentle reminder to complete their online questionnaires every 11 days. The link to the online questionnaires was included in this email.

Stage 3: Semi-structured interviews were conducted after T5. These interviews mostly took place in a calm room within the participant's home. At the start, the researcher explained to the participant that everything that the participant said during the interview would be analyzed anonymously and asked whether the participant agreed to the interview being recorded. Following this, the researcher introduced the participant to the aim of the interview and answered any questions. The interview and the recording were then commenced. After the interview was finished, the researcher answered any remaining questions the participant had and repeated that all the data would be analyzed anonymously.

2.8 Data-analysis

2.8.1 Multilevel Model

We used a linear growth model to analyze group differences at T0 and group changes and variability over time. The linear growth model allowed each participant to have his own initial level of EV acceptance, usability and range anxiety, as well as his own change over time. Additionally, the strength of the chosen multilevel model was that it could deal with missing data, a common problem in intensive longitudinal studies like the current one (Bolger & Laurenceau, 2013). Three separate multilevel analyses were run with acceptance, perceived usability and range anxiety as dependent variables, respectively. In each of the three analyses we used group (experienced, inexperienced) and time (T0, T1, T2, T3, T4, T5 and T6) as independent predictor variables. Furthermore, we calculated the standard deviation of each participant for the three variables EV acceptance, usability and range anxiety, as well as the mean standard deviation of the whole population and the standard deviation of each group. Following this, we ran three separate t-tests to investigate whether the standard deviations of the three variables were different between the two groups and whether the standard deviation between the three variables of general EV acceptance, usability and range anxiety were different. The t-tests were included because the multilevel model did not analyze whether statistical differences existed between the standard deviation of our three dependent variables.

2.8.2 Interviews

To analyze the interviews we developed a coding scheme (Appendix D) with different subcategories for the six main categories: (1) range distance, (2) charging, (3) cost benefits, (4) environmental beliefs, (5) user friendliness of the EVs and (6) safety implications. With this coding scheme, it was possible to categorize participants' answers. All interviews were coded and subsequently analyzed with regard to how the participants responded to the questions. Subsequently, it was analyzed how many participants said something about a subcategory. This showed the general trend in our population, for example whether most participants perceived charging the car as simple or not. Furthermore, a second student (Research Master Student of Psychology and Methodology at the University of Amsterdam) coded two interviews and Cohen's Kappa was calculated to determine the inter-rater reliability. Results show, that the inter-rater reliability was almost perfect, with a Cohen's Kappa of 0.837 (Landis & Koch, 1977).

3. RESULTS

The purpose of our study was to analyze how the variables of general EV acceptance, perceived usability and perceived range anxiety fluctuate through the use of electrical carsharing cars over short periods of time. The results of our multilevel analysis are visually represented in Figure 6 and Figure 7. The thick lines in Figure 6 represent the fixed effects that can be described as the influence of the two different groups (degree of experience) and the effect of time. Furthermore, Figure 6 represents the upper level random effects that describe how the mean levels of general EV acceptance, usability and rang anxiety of each participant differ from the group average. The upper level random effects are represented by the difference between the individual regression lines (thin lines) and the group average (thick lines) in Figure 6. Furthermore, we plotted the raw data from three participants per group against the predicted time course data of the model (Figure 7). We chose to plot the data of the participant with the smallest SD, with the median SD and the highest SD for each variable, in order to visually represent how the variability differed within each group. The lower level random effects that describe how the individual data points differ from the values predicted by the model (lower level) are presented in Figure 7 by the difference between the raw data (measured) and the individual fitted regression line (created by the model).

3.1 Group differences

Our main findings regarding group differences in EV acceptance, usability and range anxiety are represented in Figure 6. The plot shows that both groups had a high initial level of general EV acceptance and that general EV acceptance stayed relatively constant in both groups over the 8 weeks. Visually comparing the initial levels of both groups shows that the group of inexperienced EV users had a lower level of initial EV acceptance compared to the group of experienced EV users. These visual findings are confirmed by the results of the multilevel model. According to the results of the model, the initial level (T0) of EV acceptance was 4.19 in the experienced group and 4.19 + (-0.28) = 3.91 in the inexperienced group (on a scale of 0 to 5). Nevertheless, looking more deeply into the results, the multilevel model showed that this difference was not significant (Appendix A). Furthermore, as visually detected, general EV acceptance increased slightly in the group of experienced users from 4.19 to 4.19 + 0.08 = 4.27 and from 3.91 to 3.91 + (0.08 - 0.049) = 3.94 in the group of inexperienced users. There was no significant difference between the slopes of the lines (t < 1).

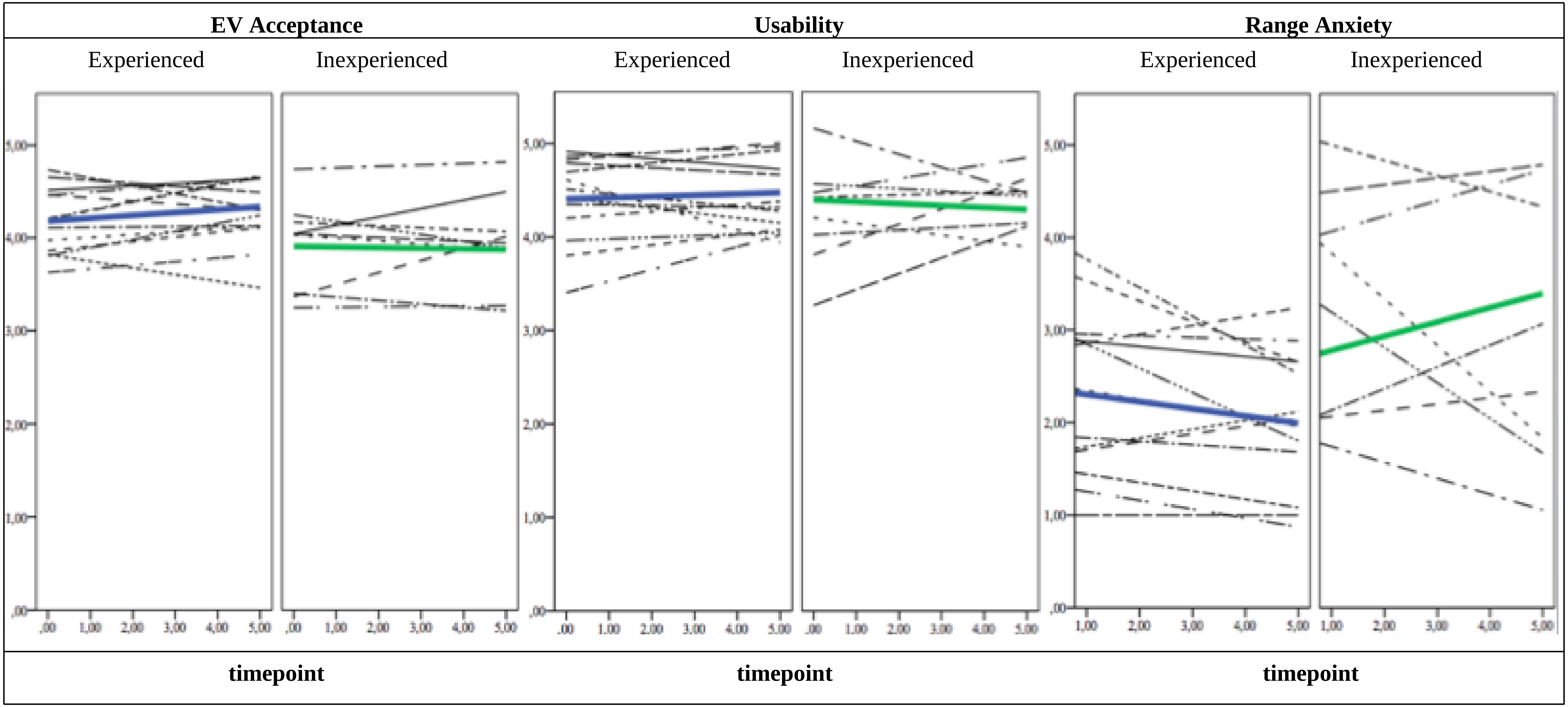


Figure 6. Spaghetti plot of average (heavy lines) and subject-specific (thin lines) changes in general EV acceptance, usability and range anxiety over time. The heavy blue lines represent changes of the experienced users over time, while the thick green lines represent these changes for the group of inexperienced participants.

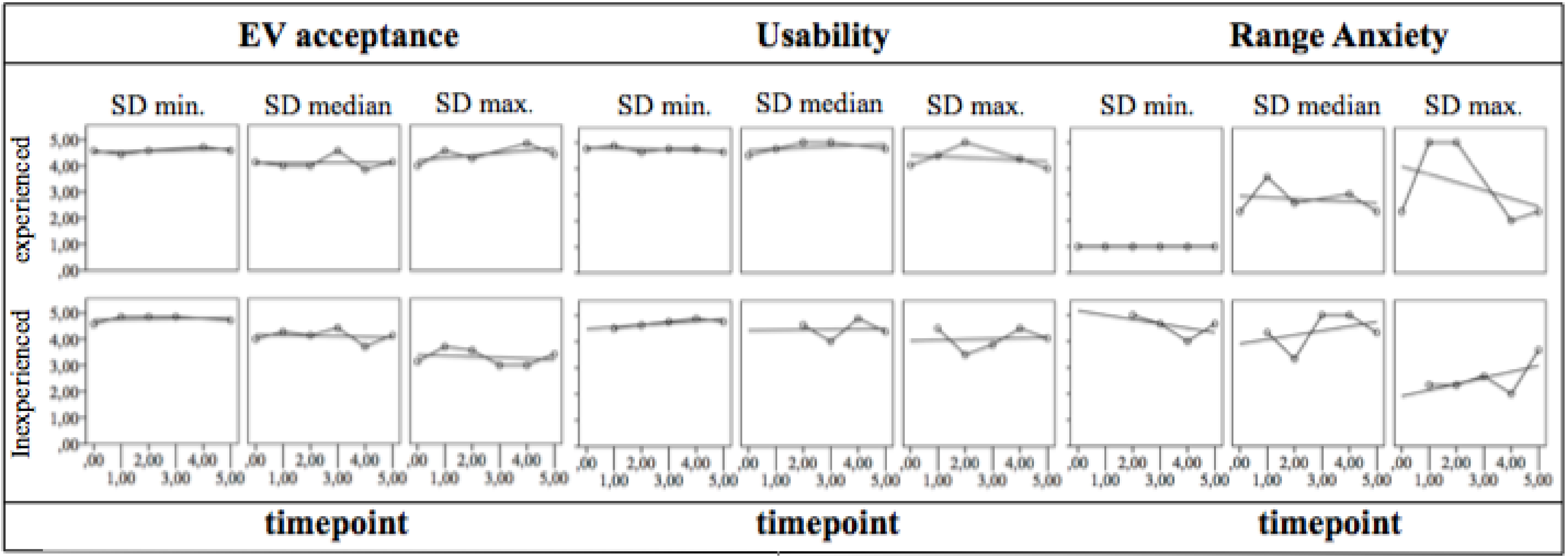


Figure 7. Raw data (measured) vs. fitted data (predicted by the model). The lines between the points represent the raw data while the lines without points represent the individual fitted regression line, predicted by the model.

Similar to general EV acceptance, no significant group differences in usability were detected. Figure 6 show that both group had high initial levels of perceived usability. Results of the statistical analysis showed that the initial level of usability was 4.41 in the experienced and 4.41 + (-0.16) = 4.25 in the inexperienced group (on a scale of 0 to 5). This descriptive difference between both groups at T0 turned out to be not significant (Appendix B). There was also no significant difference between the slopes of the lines during the 8 weeks (Appendix B).

Figure 6 shows that the initial level of perceived range anxiety was higher in the group of inexperienced users, compared to the group of experienced users. The two slopes in Figure 6 show that the perceived range anxiety of experienced users decreased during our study, while perceived range anxiety of inexperienced users increased. Running the multilevel model showed that the initial level of range anxiety was 2.37 in the experienced group and 2.37 + 0.80 = 3.17 in the inexperienced group (on a scale of 0 to 5). In contrast to the visually detected differences between the slopes of the lines, the results of the statistical analysis showed that this difference was not significant ($t < 1$).

3.2 Variability

In addition to group differences, we were also interested in the variability of general EV acceptance, usability and range anxiety. Figure 6 visualizes the variability of general EV acceptance, usability and range anxiety. Comparing the three spaghetti plots visually shows that the between-person variability (intercept variance) and the within-person variability (changes over time) in general EV acceptance and usability were more stable compared to range anxiety. This is in line with the results of the multilevel model, which demonstrates that the between-person intercept variance of range anxiety was more than twice as much than the intercept variability of general EV acceptance and usability (Table 4). Or in other words, levels of general EV acceptance and usability did not differ greatly between the participants of our study, while levels of range anxiety differed extremely.

Table 4

Intercept variance of the participants

	Intercept variance	Root (variance)	Intercept variance in units
EV acceptance	0.14	0.37	+- 0.74
Usability	0.15	0.39	+- 0.78
Range Anxiety	0.82	0.91	+- 1.8

To demonstrate the within-person variability we calculated the standard deviation of each participant, the mean standard deviation of the whole sample and the standard deviation of each group (Table 5).

Table 5

Within-person variability of EV acceptance, Usability and Range Anxiety

	SD mean	SD experienced	SD inexperienced
EV acceptance	0.23	0.23	0.24
Usability	0.23	0.22	0.27
Range Anxiety	0.56	0.60	0.49

Running a t-test showed that all standard deviation scores between both groups were not significant (all $p > 0.05$). Nevertheless, the mean standard deviation of range anxiety was significantly higher than the mean standard deviation of acceptance ($t(21) = -4.384$, $p < .001$) and the mean standard deviation of usability ($t(21) = -4.871$, $p < .001$).

3.3 Reliability of the questionnaires

To investigate the reliability of our questionnaires, we ran a reliability analysis with SPSS. The seven-item scale to measure general EV acceptance displayed a Cronbach's alpha of 0.69, the eight-item scale to measure perceived usability displayed a Cronbach's alpha of 0.74 and the three-item scale to measure perceived range anxiety displayed a Cronbach's alpha of 0.93. These results demonstrated satisfyingly high internal consistency (Vale, Silcock, & Rawles, 1997).

3.4 Results of the interviews

In analyzing the interviews, we did not distinguish between experienced and inexperienced users, because we were more interested in general perceptions about using electrical carsharing cars than to detect group differences.

3.4.1 Acceptance

In general, participants were positive about EVs as environmentally friendly and useful (in most circumstances), indicating high EV acceptance. The main reason of the participants for making use of the electrical carsharing cars was their pro-environmental beliefs. According to the participants, there are two main aspects that made the electrical carsharing cars environmentally friendly. First, sharing a car requires fewer resources and produces less waste that would need to be recycled in the future. Second, LochemEnergie's electrical cars are recharged with energy that is made from renewable energy sources. Therefore, using an electrical car has a significant influence on greenhouse gas emissions. These two positive effects of using electrical carsharing cars for the environment were crucial for the participants and positively influenced their attitude towards the electrical car.

"(*...) sometimes you are riding behind a car (..) and the smell is really disgusting and you think it would be nice if there were just electronic cars on the streets"* (Subject 1, p. 1).

Another point that made participants feel positively about EVs was that participants perceived the EVs as “work in progress” and believed that the main disadvantages of the electrical car will be eliminated in the future by technological progress. Furthermore, participants were enthusiastic over the cost advantages of the electrical carsharing car. Most participants stated that they have a high willingness to use electrical cars, but that the acquisition cost of having their own electrical car was too high. Therefore, sharing these costs as a community is an efficient alternative.

“(...) we do not want to not pay 400 euro per month to have an EV (..) which is the reason why an electrical carsharing system is so attractive (...)” (Subject 18, p. 2).

Participants who only needed a car occasionally were especially positive about this cost factor. They saw the electrical carsharing car as a cost efficient and sustainable alternative to their own (secondary) car that has a positive impact on their personal mobility. In addition to these positive points, some participants also had negative opinions about the electrical car. Besides the limited range distance that will be discussed later, some participants said that the car was very light and small, which led them to feel uncomfortable while using the electrical car on the highway.

3.4.2 Usability

Participants perceived the car as simple and not complex to use. They said that it worked in the same way as a car with a combustion engine. Some participants perceived charging the car at charging points outside of Lochem as difficult. This was because the different suppliers of the car charging stations use different charging and payment systems.

“I do not have a problem with this car. I think it is extraordinary and easy to use. I do not have any problems with the use of the car” (Subject 3, p. 1).

3.4.3 Range Anxiety

The limited range distances of both electrical cars were perceived as the main disadvantage. Generally, participants distinguished between using the electrical car for long distances that require recharging the electrical car to come back and using the electrical car for short distances that do not require recharging the car, while speaking about the limited range distance. Participants reported that using the electrical car for longer distances (>100 km) can lead to uncomfortable feelings and that they sometimes question themselves about whether they will reach their destination.

"(...) you are monitoring continuously how much(many) kilometers are still available with your car and how many you have to go (..) oh dear (..) and we have to go that(far) much (...)" (Subject 20, p. 2).

This disadvantage is especially increased by the fact that the range distance of the electrical car is very inconsistent, because it is influenced by a huge number of factors (e.g. temperature, headwind or traffic jams).

"(...) thus you are continuously uncertain about the energy consumption(..) and whether it is higher than originally was planned for a specific tour (...)" (Subject 4, p. 2).

Another increasing factor for feeling uncomfortable while using an electrical car is the charging infrastructure in the Netherlands. According to the participants, more recharge stations would give them more confidence in using the EV for longer distances, because they could always reach a charging station if the battery consumption was higher than expected (e.g., strong winds). Furthermore, even if participants reach a recharge station it is not guaranteed that they can immediately recharge their car because there are often more users than plugs for EVs. In contrast, using the electrical car for short distances (<100 km) does not lead to these feelings. Therefore, a huge number of participants reported that they would not choose electrical cars for long distances, but cars with combustion engines or trains.

“(...) it is a good car for the city (..) but I also used it on the highway and I think it is inappropriate for the highway(...)” (Subject 22, p. 2).

3.4.4 LochemEnergie’s carsharing system

As discussed previously, pro-environmental attitudes, cost-factors and increasing personal mobility were the main motivations to make use of the carsharing system.

“(...)it is a car that (...) that is interesting because of the price (..) and of course you do not pollute the environment” (Subject 2, p. 1)

Next, the participants reported several issues of the carsharing system that should be improved. First, the majority of the participants described the current reservation system as being too cumbersome. Participants stated that currently they need to fill in a form on the company’s website every time they reserve a car because there is no possibility to make an online account that users can log in to on the website. Furthermore, there is no opportunity to check whether the electrical cars are available and participants had to wait up to two days to get a message from the company about whether the car is available or not. Participants said that the reservation system is too time intensive and inflexible, especially when participants needed a car spontaneously. Therefore, the participants expressed their desire for having a mobile app where they can see online when electrical cars are available, and from which they are able to reserve the car.

Moreover, participants said that the electrical vehicles should be better distributed over the municipality of Lochem. Currently, there are only two places were participants can pick up an electrical vehicle. Participants who need to take their bike or the bus to get to the pick up points perceived this as a real obstacle.

4. DISSCUSSION

The first aim of the current study was to investigate the short-term variability (within 11 days) of the variables of general EV acceptance, usability, and perceived range anxiety of two groups-experienced and inexperienced EV users. The second aim was to investigate how participants perceived using these cars with respect to general EV acceptance, usability and range anxiety. The results of our multilevel model showed that the short-term variability of both general EV acceptance and usability was low, while the variability of perceived range anxiety was high. Furthermore, in line with expectations, both general EV acceptance and usability were higher in the experienced group than in the inexperienced group, whereas perceived range anxiety was lower in the group of experienced participants compared to the inexperienced participants. Nevertheless, statistical analyses did not confirm the differences between the experienced and inexperienced users as significant for any of the variables. Furthermore, with respect to general EV acceptance, participants reported that they saw the advantages in the environmentally friendly technology, in having an extra car, and in having low costs. Only the fact that the car was relatively small and light was perceived as a disadvantage. With respect to usability, participants reported that the car was very simple to use. Furthermore, they reported that the limited distance range and the recharge infrastructure in the Netherlands were perceived as the biggest disadvantages of current state of the art EVs.

4.1 General EV acceptance

In contrast to Bühler and colleagues (2014), who measured changes in general EV acceptance over long periods of time (three months), we investigated these changes over short periods of time (11 days). As a result, we found that general EV acceptance showed low variability over these short periods of time (11 days) and high initial levels in both groups. Furthermore, we investigated that general EV acceptance also showed low variability over the whole time course of our study (8 weeks). These results indicate that using an electrical car-sharing car for eight weeks on an infrequent basis is not enough to increase participants' general EV acceptance. Nevertheless, the experienced participants of our study, who had already used the EVs for at least six months, displayed a slightly higher initial level of general EV acceptance, compared to the inexperienced participants, who had no experience with using EVs. This difference turned out to be non-significant which was likely a result of this study's low power. However, this finding is in line with earlier research by Bühler and colleagues (2014) who found that general EV acceptance increased slightly but significantly after participants experienced an EV over long periods of time (3 months).

One might wonder why we did not find a small increase of general EV acceptance over the whole time course of our study (8 weeks), while Bühler and colleagues (2014) found a significant increase after 12 weeks. A favorable explanation is that our participants were not equipped with a personal EV. In contrast, participants in Bühler and colleagues' (2014) study had their own EV for the entirety of their study. Therefore, our participants did not have the possibility to use the car on a daily basis, but instead had to share EVs during the 8 weeks, which in turn could have decreased the extent of possible experience with the EV. Additionally, the inconvenience, caused by the carsharing context, of taking the car from a place relatively far away from the home and bringing it back there after use, might have negatively influenced general EV acceptance. Still, there was one point that may have had a positive influence on general EV acceptance: the costs. Participants of the other study, who were equipped with a personal EV had to pay approximately 400 Euros leasing fees per month, plus electricity. In contrast, the participants in our study only had to pay five Euros for four hours and ten Euros for eight hours, inclusive of electricity. Since the cost factor was one of the most frequently mentioned advantages in the interviews, one can expect that the low costs increased general EV acceptance. Nevertheless, comparing the results of the current study with the results from Bühler and colleagues (2014), it seems likely that having an own EV and paying for it might have a stronger positive influence on general EV acceptance than sharing an EV and not having costs. However, the slightly higher initial levels of general EV acceptance in our group of experienced participants (who used EVs for at least six months only within the carsharing system) indicate that using electrical carsharing cars for more than six months positively influences general EV acceptance. Thus, it can be argued that experience, indicated by the time participants have used the car, has an impact on general EV acceptance.

Further research should investigate how inexperienced users' general EVs acceptance is influenced over short periods of time (approximately one week) if they are equipped with a personal EV. It would be interesting to see whether the long-term influence of having an own EV would be measureable over such small periods of time. Based on the previous studies, it is impossible to predict whether this short, but intensive stimulation program would have an effect. However, if an effect were found, it would give car manufactures a new possibility to convince interested users by offering test weeks with EVs. Furthermore, it needs to be mentioned that both the sample in Bühler and colleagues (2014) and the sample in the current study are not representative for the whole population of potential EV customers of the future. Both studies used convenient sampling strategies because acquiring participants who are willing to integrate EVs into their daily lives, to pay for it and to invest time in online surveys and interviews is too difficult when using more valid random sampling strategies. Those participants who choose to participate explained their motivation for participation by their high pro-environmental beliefs and the chance to help decrease greenhouse gas emissions. The high pro-environmental beliefs of both samples might explain why participants in both studies showed high initial levels of general EV. Pro-environmental beliefs have a positive impact on the willingness to show pro-environmental behavior, even if this behavior requires the person to put a lot of effort into a certain task (Oreg, 2006). Additionally, pro-environmental beliefs have a positive impact on both users' attitudes towards EVs and users' buying intentions (Bühler et al., 2014; Pierre et al., 2011; Plötz, Schneider, Globisch, & Dütschke, 2014). For governments and car manufactures who are mainly interested in whether stimulation programs could increase general EV acceptance in average customers, further research should include participants with lower initial levels of general EVs acceptance. Research by Burgess, King, Harris, and Lewis (2013) offered an interesting starting point for such further research. Based on their qualitative approach, the researchers divided non-EV drivers into three categories with: (1) a traditional view (2) an ambivalent view and (3) a positive view towards EVs. According to this categorization, non-EV drivers with a traditional view are those who perceive EVs as overestimated technology without a future. Next, non-EV drivers with an ambivalent view are those who are uncertain in their judgments about EVs. The participants of the current study consisted of non-EV driver with a positive view before they made use of the carsharing system, since non-EV drivers with a positive view are those who perceive EVs as a solution for a sustainable future (Burgess and colleagues, 2013). Further research should include non-EV drivers with a traditional view and an ambivalent view, to investigate whether initial levels of general EV acceptance are smaller compared to the initial levels of non-EV drivers with a positive view. Furthermore, further research needs to investigate whether experiencing EVs in the context of carsharing would have an effect (or even a bigger effect) on the general EV acceptance of both non-EV drivers with a traditional and an ambivalent view. Results would deliver useful information about whether stimulation programs could increase sale rates of EVs by increasing general the "average" customer's EV acceptance.

To sum up, both the current study and the study by Bühler and colleagues (2014) provide evidence that general EV acceptance is a relatively stable trait, at least when participants have a high initial level. In turn, long exposure times are necessary to increase general EV acceptance of prospective customers that use EVs on an infrequent basis. These results also have implications for the suppliers of electrical carsharing systems. According to our results it is advisable for suppliers to run these carsharing systems over long periods to positively influence the general EV acceptance of their prospective customers.

4.2 Usability

The second dependent variable of our intensive longitudinal study was usability. To the best of our knowledge, there is no study that has investigated the influence of experience on usability in the context of EVs. According to the results of our multilevel analysis, usability showed low variability over short periods of time, as well as over the whole time course of our study. Furthermore, usability was high in both groups. This interpretation is underlined by the results of our interviews in that almost all participants reported that using the EVs was quite simple. These high perceptions of usability and its low variability are possibly caused by the context in which our participants made use of the EVs. Looking at the definition of usability illustrated in the introduction shows that the *specified context of use* is crucial for judgments of usability. Participants in our study reported to use the EVs almost entirely for short distances in the municipality of Lochem or to neighboring towns (approximately 30-40 km away from Lochem). In this specified context of use, participants have most probably perceived the EV as (1) effective, (2) efficient and (3) satisfying because (1) they were able to get from point A to point B (2) they were not forced to recharge the car and (3) they reached their target with effectiveness, efficiency and with an environmental means of transportation. Since effectiveness, efficiency and satisfaction are decisive for judgments of usability, this is a favorable explanation for the high scores of usability in our sample (ISO, 1998).

Further EV research about usability should investigate whether long distances influence the variability of perceived usability, because long distances force participants to recharge the EVs frequently and would therefore probably influence participants' opinions about the efficiency of EVs. Of course, further research about usability of the car is necessary when future EVs are equipped with new technologies, like regenerative breaking systems (e.g., used in BMW's EVs) because customers need to feel confident while using a new product (Oreg, 2006). Next, further research should investigate the user-friendliness of the different charging stations and systems offered by different suppliers. These different charging stations and systems led to frustration in our participants and were furthermore perceived as cumbersome.

4.3 Range Anxiety

As stated in our introduction, the limited range distance of electrical cars is a widely discussed topic in scientific research (e.g., Franke & Krems, 2013; Neubauer & Wood, 2014; Rauh, Franke, & Krems, 2014). We extended Rauh and colleagues' (2014) findings by investigating levels of range anxiety in real world interactions and changes of range anxiety over short periods of time. The variability of range anxiety was shown to be high in both groups and was furthermore systematically higher than the variability of general EV acceptance and usability in both groups. These findings are in line with our assumption that the current driving situation (e.g., bad weather conditions or traffic jams) causes ranges anxiety and is thereby relatively fluctuating, while general EV acceptance and perceived usability are rather stable EV perceptions. This assumption was based on the theoretical framework by Rauh et al. (2014). According to their framework, the current driving situation (e.g., kilometers to go, wind or traffic) can lead to range anxiety. The results of our interviews underline this assumption. The participants reported that particular events like strong winds or long traffic jams consume much of the battery and that this could lead to feelings of stress. Furthermore, they reported to have higher levels of stress when they were driving to neighboring towns, even if this was within the total distance range of the EV. In contrast, our participants reported that they were not stressed when using the EVs for short distances in the city. This matches the findings of a study where participants displayed higher levels of stress after leaving their comfortable range, approximately 80% of the total range distance of the EV (Franke & Krems, 2013).

In line with the theoretical work by Rauh and colleagues (2014), discussed in the introduction (Figure 1), we visually detected that experienced participants in our study had lower levels of range anxiety compared to the inexperienced participants. An explanation for this finding is that experienced participants have developed more effective coping strategies to manage critical situations, which can cause range anxiety compared to the inexperienced participants (Rauh et al., 2014). This interpretation is in line with the results of our interviews. Participants reported that gaining more experience with EVs is related to developing effective coping strategies (e.g., adapt driving behavior) and developing a higher understanding of factors (e.g., bad weather conditions) that influence the distance range of the EVs.

A limitation of our study was that our results of range anxiety were most probably influenced by our sampling strategy. We measured changes and variability of range anxiety with an interval sampling. Within this interval-sampling participants had to report their feelings of range anxiety retrospectively every eleven days. A consequence of this sampling method was that short distances influenced measurements of range anxiety within these 11 days. In other words, we did not distinguish between short and long distances. This might have influenced our results in the way that the mean scores of range anxiety decreased with drives within the participants' comfortable zone. Further intensive longitudinal studies about range anxiety should use event-sampling strategies (Bolger & Laurenceau, 2013). With this event sampling method, range anxiety should be measured when participants leave their comfortable zone or when participants are faced with special circumstances (e.g., long traffic jams or extremely cold temperatures). A possible method would be, to asked participants to fill in a range anxiety scale after using the EV for a distance that requires using more than 80% of the battery or after they were faced with special circumstances. As a result, measurements of range anxiety would not be influenced by drives within the comfortable zone and researchers could investigate the true variability of range anxiety and other underlining factors. Furthermore, it is advisable that further EV research about range anxiety should use the framework by Rauh et al. (2014) as a basis because the results by Franke and Krems (2013), Rauh and colleagues (2014) and the current study support the validity of this model. The results by Franke and Krems (2013), Rauh et al. (2014), and the current study showed that range anxiety is influenced by both the length of the current route and experience, two basic assumptions of the framework.

4.4 The e-carsharing system of LochemEnergie

As investigated by Graham-Rowe et al. (2012) the high acquisition costs are the main obstacles, which prevent interested customers from making use of EVs. According to our results this obstacle is eliminated by the carsharing system. Participants were very positive about the cost factor because buying an own EV would be too expensive. This is an interesting finding for car manufactures that want to decrease the average greenhouse gas emission of their fleets and governments who want to decrease global greenhouse gas emissions. E-carsharing systems might be a solution to increase sale rates and to develop and offer EVs in an economic and affordable way.

Looking at the current example in Lochem, participants were unsatisfied by the current reservation system, as it was too cumbersome. After first analysis of these results, LochemEnergie decided to hire a second student from the University Twente with a background in industrial design. The task of this student was to develop a concept for a new reservation system within the framework of his Bachelor thesis. To develop this new reservation system in a user-centered design process, results of our interviews were used in order to determine the needs of the customers. Furthermore, the student collected further data in the framework of a workshop with LochemEnergie customers and by conducting three interviews about the reservation system. To give the student useful information about users' needs of a new reservations system, we provided the student with the initial results of our interviews. The most important features of this new application are (1) the possibility to reserve an EV online (2) to see whether EVs are available and (3) to find recharges stations. The new prototype of the reservation system can be found by following the link in Appendix F, the full user-centered design process is in described in detail in Binnenmars (2015).

Next, participants who did not have an own car or who were hesitant to give up their own car stated that the EVs are suitable for every day use, but that they infrequently need a car for long distances. As a consequence LochemEnergie decided to include standby VCE cars for customers of their carsharing system. This solution makes it possible for their customers to drive electrical vehicle in their daily lives, but enables them to use a carsharing VCE car for long distances if necessary.

The pick up point of the electrical cars was another big issue for the customers. At the moment there are only two points in the municipality of Lochem were participants can pick up the EVs. Participants who lived far away from these two points reported that it is too cumbersome to first go to the pick up stations and then to bring the car back later. As a result, LochemEnergie will try to spread the EVs pick up points over the whole municipality. In sum, our study did not only investigate research relevant results, but was able to improve the services of our partner, LochemEnergie. It is hardly possible to draw conclusions for all electrical carsharing systems based on our findings in Lochem. Nevertheless, our results showed that suppliers of electrical carsharing systems should make the reservation platform as simple and flexible as possible, spread the pick up and return points as far as possible and organize a couple of VCE cars for long distances.

4.5 General conclusion

The global aim of our study was to investigate how using electrical carsharing cars on an infrequent basis influences prospective customers of EVs and how they perceive the weaknesses of the EVs while using these cars. We reviewed relevant literature and decided to investigate how general EV acceptance, the perception of electrical vehicles as useful, satisfying and environmental friendly, is influenced over short periods of time. Furthermore, we decided to measure usability and range anxiety of our participants while using the EVs. General EV acceptance and usability showed low variability over short periods of time, while range anxiety showed high variability. Nevertheless, taking together our results with the results of previous studies, evidence is provided that experiencing EVs over long periods of time has a positive impact on general EV acceptance. Furthermore, our results in combination with previous research results demonstrate that range anxiety is influenced by experience and the current driving situation. These results have implications on the strategy to offer electrical carsharing systems. Based on our results, it is advisable for car manufactures to run their electrical carsharing systems over long periods of time. Furthermore, including more groups of prospective EVs users in further research and eliminating the weaknesses of the EVs through technological progress can also increase the possibility of achieving a high number of EVs on the streets and in turn, to significantly reduce greenhouse gas emissions. It is likely that this will be a long and difficult process, but if car manufactures and governments continue to work on this concept, there is a real chance for a sustainable transport future. We should consider that new technologies, which are today used by nearly everyone, once faced the same problems and prejudices in the beginning of their development and were often perceived as overrated technologies without future.

"I think there is a world market for maybe five computers."

Thomas Watson, chairman of IBM (1943)

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6. Appendix

6.1 Appendix A - Results multilevel model: general EV acceptance

Table 3

Parameter Estimates for Linear Growth Model of EV acceptance as a Function of Group

				Cl95	
Fixed effects (intercept, slopes)	Estimate (*SE*)	*t()*	*p*	Lower	Upper
Intercept (level at week 1)	4.19 (0.12)	35.986	<.001	3.95	4.43
Time	0.08 (0.92)	0.860	.395	-0.11	0.27
Group	-0.28 (0.18)	-1.505	.149	-0.66	0.11
Group by Time	-0.049 (0.15)	-0.328	.744	-0.35	0.25
				Cl95	
Random effects ([co-]variances)	Estimate (*SE*)	*z*	*p*	Lower	Upper
Level 2 (between-person)					
Intercept	0.13 (0.06)	5.508	.000	0.045	0.091
Time	0.00 (0.00)	-	-	-	-
Intercept and time	0.00 (0.04)	0.064	.949	-0.068	0.072
Level 1 (within-person)					
Residual	0.06 (0.12)	5.508	<.000	0.451	0.092
Autocorrelation	0.18 (0.15)	1.189	.235	-0.126	0.459

Note. N = 22

All p-values are two-tailed expected the p-value of variance

Dependent variable: EV acceptance

6.2 Appendix B - Results multilevel model: usability

Table 4

Parameter Estimates for Linear Growth Model of usability as a Function of Group

				Cl95	
Fixed effects (intercept, slopes)	Estimate (*SE*)	*t()*	*p*	Lower	Upper
Intercept (level at week 1)	4.41 (0.12)	35.867	<.001	4.16	4.67
Time	0.02 (0.10)	0.196	.848	-0.20	0.24
Group	-0.16 (0.23)	-0.685	.499	-0.62	0.31
Group by Time	0.04 (0.22)	0.169	.867	-0.43	0.50
				Cl95	
Random effects ([co-]variances)	Estimate (*SE*)	*z*	*p*	Lower	Upper
Level 2 (between-person)					
Intercept	0.15 (0.07)	2.274	.023	0.063	0.358
Time	0.01 (0.00)	-	-	-	-
Intercept and time	-0.03 (0.04)	-0.578	-.578	-0.111	0.061
Level 1 (within-person)					
Residual	0.08 (0.02)	3.806	<.000	0.046	0.128
Autocorrelation	0.11 (0.25)	0.419	.675	-0.383	0.551

Note. N = 22

All p-values are two-tailed expected the p-value of variance

Dependent variable: usability

6.3 Appendix C - Results multilevel model: range anxiety

Table 3

Parameter Estimates for Linear Growth Model of range anxiety as a Function of Group

				*CI*95	
Fixed effects (intercept, slopes)	Estimate (*SE*)	*t()*	*p*	Lower	Upper
Intercept (level at week 1)	2.37 (0.29)	8.136	<.001	1.79	2.94
Time	-0.32 (0.25)	-1.294	.199	-0.81	0.17
Group	0.79 (0.52)	1.508	.132	-0.24	1.83
Group by Time	0.32 (0.52)	0.610	.543	-0.71	1.34
				*CI*95	
Random effects ([co-]variances)	Estimate (*SE*)	*z*	*p*	Lower	Upper
Level 2 (between-person)					
Intercept	0.81 (0.00)	-	-	-	-
Time	0.03 (0.00)	-	-	-	-
Intercept and time	-0.03 (0.19)	-.154	.878	-0.402	0.344
Level 1 (within-person)					
Residual	0.44 (0.07)	6.364	<.000	0.322	0.596
Autocorrelation	0.20 (0.00)	-	-	-	-

Note. N = 22

All p-values are two-tailed expected the p-value of variance

Dependent variable: range anxiety

6.4 Appendix D Coding Scheme

Codeerschema

De eindgespreken worden op volgende manier gecodeerd:

Stap 1: De wetenschapper leest alle interviews een keer globaal door.

Stap 2: De wetenschapper leest de interviews een tweede keer en markeert tekst passages in die de participant iets over een van de volgende categorieën verteld:

(1) beperkte reikwijdte van de elektrische deelauto

(2) opladen binnen de gemeente Lochem

(3) opladen buiten de gemeente Lochem

(4) gevoel van zekerheid tijdens het rijden

(5) uitspraken over eigen mobiliteit

(6) duurzaamheid

(7) gebruiksvriendelijkheid

(8) kosten

Stap 3: De wetenschapper gebruikt de bijbehorende codeerlijst om de uitspraken over de verschillende hoofdcategorieën te coderen.

Codering: uitspraken over de beperkte reikwijdte van de elektrische deelauto

Range-Distance-does-not-matter: Als deelnemers zeggen dat ze een auto alleen voor korte afstanden nodig hebben. *Bijvoorbeeld: "Ik heb alleen een auto nodig als ik naar Gorssel moet. Daarom vind ik het niet erg dat de elektrische deelauto zo een beperkte reikwijdte heeft."*

Range-Distance-perceived-as-no-limitation: Als deelnemers zeggen dat ze ook verdere afstanden met de elektrische auto rijden en het tussentijdse opladen en de beperkte reikwijdte niet als beperking waarnemen. *Bijvoorbeeld:* "*Ik vind niet dat de beperkte reikwijdte een limitatie is. Ik weet ervan, dus als ik grotere afstanden rijd plan ik het opladen in."*

Range-Distance-perceived-as-limitation: Als deelnemers de elektrische deelauto niet (of niet graag) voor verdere afstanden gebruiken omdat ze het onhandig vinden (te korte reikwijdte/opladen duurt te lang). *Bijvoorbeeld: "Voor verdere afstanden pak ik een andere auto of de trein."*

Range-Anxiety: Als de deelnemers zeggen dat ze tijdens het rijden vaak het gevoel hebben (of bang zijn) dat ze hun bestemming niet zullen bereiken of als ze de auto niet voor grotere afstanden gebruiken omdat ze bang zijn hun bestemming niet te zullen redden. *Bijvoorbeeld: "Tijdens het rijden dacht ik vaak dat ik het niet zou redden tot mijn bestemming".*

Codering: uitspraken over de laadinfrastructuur binnen Lochem/Gorssel

Charging-LG-perceived-as-simple: Als deelnemers het niet moeilijk vinden om de elektrische deelauto weer aan de laadpaal in Lochem/Gorssel aan te sluiten. *Bijvoorbeeld: "Het laden is heel makkelijk. Je steekt de stekker in de auto en de paal, pasje voor de paal houden en klaar."*

Charging-LG-perceived-as-difficult: Als deelnemers het moeilijk vinden de elektrische deelauto aan de laadpaal in Lochem/Gorssel aan te sluiten. *Bijvoorbeeld: "Ik vind het altijd een beetje verwarrend, moet de stekker eerst in de auto of in de paal?"*

Charging-LG-to-less-recharge-stations: Als deelnemers zeggen dat er te weinig laadpalen zijn en ze soms moeten wachten of een andere laadpaal moeten zoeken. *Bijvoorbeeld: "Je moet soms erg lang zoeken om een vrije laadpaal te vinden."*

Codering: uitspraken over de laadinfrastructuur buiten Lochem/Gorssel

Charging(other-places)-not-applicable: Als deelnemers zeggen dat ze geen gebruik maken van laadpalen buiten de gemeente Lochem. *Bijvoorbeeld:* "Ik gebruik alleen laadpalen binnen de gemeente Lochem."

Charging(other-places)-perceived-as-simple: Als deelnemers het niet moeilijk vinden om de elektrische deelauto op andere plekken op te laden. *Bijvoorbeeld: "Het laden is heel makkelijk. Je steekt de stekker in de auto en de paal, pasje voor de paal houden en klaar."*

Charging(other-places)-perceived-as-difficult: Als deelnemers het moeilijk vinden de elektrische deelauto aan laadpalen buiten de gemeente Lochem op te laden. *Bijvoorbeeld: "De laadpalen in andere steden zijn heel verschillend wat het soms lastig maakt."*

Charging-stations(other-places)-not-enough: Als deelnemers zeggen dat er te weinig palen zijn en ze soms moeten wachten of een andere paal moeten zoeken. *Bijvoorbeeld: "Als ik naar Enschede rijd staan er altijd andere EV aan de laadpalen."*

Charging(other-places)-problems-with-different-suppliers: Als deelnemers aangeven dat het voor hen een probleem is dat er zo veel verschillende laadpaal aanbieders bestaan. *Bijvoorbeeld: "Er zijn 100 verschillende aanbieders met 100 verschillende pasjes of apps."*

Codering: uitspraken over het gevoel van zekerheid

Missing-Sound: Als deelnemers zeggen dat ze het gevoel hebben dat andere verkeersdeelnemer ze niet waarnemen doordat de elektrische deelauto geen geluiden maakt. *Bijvoorbeeld: "Je moet extra opletten op fietsers, die horen je vaak niet aankomen."*

Small-Car: Als deelnemers zeggen dat ze bang zijn met zo een kleine auto te rijden. *Bijvoorbeeld: "Als je op de snelweg bent en voor en achter je zijn vrachtwagen is het niet zo een goede gevoel om in zo een kleine auto te zitten."*

Codering: uitspraken over invloed van de elektrische deelauto op eigen mobiliteit

Extra-Mobility: Als de deelnemers zeggen dat hun mobiliteit is verbeterd door de deelname aan het project. *Bijvoorbeeld: "Ik ben nu minder afhankelijk van openbaar vervoer."*

Maakt eigen (of tweede auto) overbodig: Als de deelnemers zeggen dat de deelname aan het project een eigen (of tweede auto) overbodig maakt. *Bijvoorbeeld: "We hebben nu geen tweede auto meer nodig."*

Codering: uitspraken over duurzaamheid

Sustainability-precondition: Als deelnemers zeggen dat het een absolute voorwaarde is dat de deelauto's elektrisch zijn. *Bijvoorbeeld: "Als ze hetzelfde project met gewone auto en dezelfde prijs zouden aanbieden, zou ik niet meedoen."*

Sustainability-pro: Als deelnemers zeggen dat het een voordeel is dat de deelauto elektrisch is, maar dat ze waarschijnlijk ook in het geval van duurzame benzine auto's mee zouden doen. *Bijvoorbeeld: "Het is natuurlijk een voordeel dat de aangeboden auto elektrisch is, maar als het een duurzame auto zou zijn, zou ik dat ook prima vinden."*

Sustainability-not-important: Als het voor de deelnemers niet belangrijk is wat voor een type auto het is of als deelnemers zeggen dat ze liever gewone auto's hebben voor dezelfde prijs. *Bijvoorbeeld: "Voor mij is het niet belangrijk dat het een duurzame auto is, ik doe gewoon mee omdat het goedkoop is en ik soms een auto nodig heb."*

Codering: uitspraken over gebruiksvriendelijkheid

User-friendly: Als deelnemers zeggen dat ze vinden dat de auto makkelijk te gebruiken is. *Bijvoorbeeld: "Het is een kleine auto die makkelijk te gebruiken is."*

Problem-User-friendliness: Als deelnemers zeggen dat ze problemen bij het gebruiken van de auto ervaren (Let op!: problemen met het laden horen hier niet bij). *Bijvoorbeeld: "Ik vind het moeilijk om in de auto te rijden omdat deze vanzelf remt als ik geen gas geef."*

Codering: uitspraken over kosten

Cost-factor-important: Als deelnemers zeggen dat ze meedoen omdat de elektrische deelauto goedkoop/goedkoper dan een persoonlijke (of tweede) auto is. *Bijvoorbeeld: "De kosten spelen ook een rol. Het is heel goedkoop om zo een autootje te huren."*

Cost-factor-unimportant: Als de deelnemers zeggen dat de kosten geen bepalende factor zijn in het al dan niet gebruiken van de auto.

6.5 Appendix E - Dutch and English quotes per subject

Translated quote (English)	Original quote (Dutch)
"(…) sometimes you are riding behind a car (..) and the smell is really disgusting and you think it would be nice if there were just electronic cars on the streets" (Subject 1, p. 1)	*"(…)soms zit je achter een auto (..) en die stinkt dan echt en dan denk je het zou fijn zijn als er alleen nog elektrische auto's rijden…"*(Deelnemer 1, p. 1)
"(…) we do not want to not pay 400 euro each month to have an EV (..) which is the reason why a electrical carsharing system is so attractive (…)" (Subject 18, p. 2)	*"(...) alleen zouden we niet 400 euro per maand daarvoor leggen om een elektrische auto voor te hebben (..) dus door deelauto system is het voor ons aantrekkelijk me te doen (..)"*(Deelnemer 18, p. 2)
"(...) I do not have a problem with this car. I think it is extraordinary and easy to use. I do not have any problems with the use of the car (...)" (Subject 3, p. 1)	*"(...) ik heb geen enkel probleem met die auto ik vind het uitermate een makkelijk (..) iets (..) nee geen enkel probleem met het gebruik van de elektrische deelauto(...)"*(Deelnemer 3, p. 1)
"(…) you are monitoring continuously how much kilometers are still available with your car and how many you have to go (..) oh dear (..) and we have to go that much (...)" (Subject 20, p. 2)	*"(...) dan let je ook altijd op hoeveel kilometers kunnen we nog rijden en dan zijn er nog zoveel kilometer (..) oh help (..) en we moeten nog zoveel (..) lukt dit? (...)"*(Deelnemer 20, p. 2)
"(…) thus you are continuously uncertain about the energy consumption(..) and whether it is higher than originally was planned for a specific tour (…)" (Subject 4, p. 2)	*"(...) dus je zit continu aan een onzekerheid (..) is de verbruikt harder dan ik gepland heb met mijn afstand (...)"*(Deelnemer 4, p. 2)
"(…) it is a good car for the city (..) but I also used it on the highway and I think it is inappropriate for the highway(…)" (Subject 22, p. 3)	*"Het is een prima stadsauto (..) maar ik heb hem ook voor langere afstanden gebruikt waar ik hem niet geschikt voor vind."* (Deelnemer 22, p. 3)
"(…)it is a car that (…) that is interesting because of the price (..) and of course you do not pollute the environment" (Subject 2, p. 1)	*"(...)het is een auto de mhm (..) mhm die qua prijs heel interessant is (..) je belast het milieu natuurlijk niet mhm (..) (...)"*(Deelnemer 2, p. 1)

6.6 Appendix F - Link to the prototype of the new reservation system

http://portfolio.io.utwente.nl/student/binnenmarsn/prototype