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Abstract. Disruptive eco-innovations that replace existing unsustainable modes of transportation could contribute to achieve substantial improvements in environmental sustainability. Electric vehicles (EVs) have the potential to provide a more sustainable means of individual mobility, but, thus far, customer adoption remains relatively low. Following disruptive innovations theory developed by Christensen, the disruptive potential of EVs can be realized if their performance on traditional attributes that customer's value improves. Here, information systems can play a key role. In this paper, we use a large scale (n = 1461) empirical investigation to examine which attributes must be addressed and assess the ability of existing mobile applications (apps) to do so. Our results indicate that apps contribute to a more reliable and convenient EV-user experience. We shed light on the role of apps in connecting the vehicle, the infrastructure and the user and in creating a digital eco-system that enhances the diffusion of EVs.

Keywords: Environmental sustainability, eco-innovations, disruptive innovations, mobile applications.

1 Introduction

Climate change, global warming, and increasing greenhouse gas emissions pose great risks for human and natural systems [1]. Environmental sustainability is one of the key challenges for today's societies due to the severe economic and social consequences of environmental deterioration [2]. Consequently, also the information systems (IS) research community has begun to think about its own contribution to achieving environmental sustainability under the theme of Green IS (e.g., [2-5]).

Of all the various challenges that the quest for "green" entails, the transportation domain is among the most important due to its enormous share of the world's greenhouse gas emissions [6]. Considering that the global number of vehicles is expected to increase to 2.9 billion in 2050, the transportation sector is accountable for a significant share of the increase in emissions from all sources [7-8]. One way in which sustainability in transportation might be reached is the development and adoption of new propulsion technologies that replace conventional, unsustainable ones [9-10]. EVs

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have been credited as a so-called eco-innovation, i.e., an innovation with a better environmental performance than its conventional counterparts [11-12]. Although major players in the automotive industry have introduced EVs into their product portfolio and policy makers have substantially supported their diffusion, customer acceptance has still remained at a relatively low level [10]. In order to achieve massive improvements concerning the environmental impacts of individual mobility, disruptive eco-innovations—leading to fundamental changes and replacing traditional, unsustainable modes of transportation—are needed [13], [14]. EVs are not a new development (e.g., [15]). Though numerous attempts to promote them have failed in the past, the ecosystem in which they are now being implemented is completely different. Today, IS are heavily integrated in everyday life, resulting in an enormous increase in information availability [16]. The diffusion of mobile devices, which has reached very high levels in modern societies [17], is particularly important when it comes to mobility. These technologies digitally connect users and supply them with information anytime, anywhere. As innovations—especially eco-innovations—are directly connected with novelty, inexperience, and uncertainty, these enhanced information possibilities have the potential to drive the disruptive impact of EVs.

Following the theory of disruptive innovations developed by Christensen [14], disruptive innovations bring along new attributes that customers value. The disruption, including the displacement of former technologies, occurs when the performance of the innovation in terms of the traditional attributes customer's value increases to a satisfying level. While technological progress of the innovation per se was described as the reason for these performance improvements in the past [14], it can be assumed that the use of apps can induce this effect in the case of EVs. In this paper, we therefore address the following research question: *What is the role of mobile applications concerning the disruptive potential of EVs?*

In order to investigate this topic, we present the results of a large scale empirical investigation (n = 1461) on the perceived attributes of electric and conventional vehicles. Moreover, we present a structural analysis of existing apps (n = 81) available for EVs. In a synopsis, we then discuss how apps address the characteristics of EVs and contribute to their coverage of traditional performance attributes.

2 Theoretical Background

2.1 The Need for Disruptive Eco-Innovations

Disruptive innovations are solutions that fundamentally change the rules of the game in established sectors [11], [18]. They lead to substantially different market settings and technologies employed [14]. According to disruptive innovation theory, the attributes customers value and use to rate a specific innovation, play a major role in explaining the disruption process [19]. Disruptive innovations bring a completely new set of performance attributes with them. However, in the beginning, they are rather unattractive for the mainstream market due to their disadvantages on traditional performance attributes, on which established technologies perform better. If this disadvantage can be managed and reduced over time, the disruption process occurs [20].

While disruptive innovations highlight the radicalness of the change an innovation causes, eco-innovations can be described as new solutions with a lower environmental impact than their conventional counterparts [12]. This impact can range from small improvements in the environmental performance of existing solutions to fundamental and systematic changes [6]. To achieve substantial improvements of environmental quality while ensuring a comparable level of mobility, along with political and regulatory initiatives, disruptive eco-innovations that build on new, eco-friendly technological trajectories, are needed. Incremental innovations that reduce the environmental downsides of traditional technologies have only a limited ability to contribute to achieving the ambitious sustainability goals [13]. For the case of individual mobility, EVs have been described as a potential disruptive eco-innovation [21]. Drawing on disruptive innovation theory [14], three prerequisites for EVs to achieve disruptive impacts can be derived: First, they must be able to ensure that the mobility demands of a substantial share of the population can be satisfied so that a substitution would be technically feasible. Second, they need to introduce to the market a new set of attributes that is valued by customers. Third, they must deliver a satisfying coverage of the characteristics that customers value attribute to established technologies. The fulfillment of the third prerequisite in particular can be seen as the key for achieving disruptions [14]. IS have recently been conceptually described as having the potential to play an important role in this regard: "For sustainable transport, pathway technologies might include emerging information technologies for automatic vehicle control, global positioning, booking and reservations, monitoring for mobility management, and congestion charging; that is technologies associated with important behavioral and institutional changes" [6]. By doing so, they might mitigate the disadvantages of potential disruptive eco-innovations by improving their performance on traditional attributes and thus drive the disruptive change towards sustainability.

2.2 Mobile Applications for Environmental Sustainability

According to Gartner [22], by 2017 apps will have been downloaded more than 268 billion times, which would make them one of the most accessible computing tools for users worldwide, resulting in personalized data streams to more than 100 applications and services every day [23], [24]. Watson et al. [25] describe this phenomenon as a form of U-Commerce, i.e., the use of ubiquitous networks for personalized and uninterrupted communications and transactions between an organization and its stakeholders that offers a value over, above, and beyond traditional commerce [17].

Prior research has introduced the topic of environmental sustainability to the IS domain and many scholars have been dedicating their work to this research field known as Green IS (e.g., [1-5], [26-27]). In this context, Chen et al. [26] argue that IS can help to develop environmental sustainability by achieving eco-efficiency, eco-equity and eco-effectiveness through automating, informating, and transforming organizations. Recent studies on apps as an integral part of Green IS has focused mainly on smart consumption, smart meter, and smart mobility (e.g., [28-31]). For example, Dada et al. [28] investigate the sustainable purchasing behavior through the use of an application during the shopping process, in which consumers can be informed about the CO_2 footprint of certain products with RFID tags. This enables the consumer to change their purchasing behavior in order to support more environmentally friendly products. Furthermore, Weiss et al. [30] examine the user acceptance of a specific smartphone application to monitor and control household energy consumption. In their findings, they explain the positive user acceptance of such application as an element of smart meter systems. Froehlich et al. [29] develop an application that examines the mobility behavior of users and offers them feedback on the environmental impact of their transportation choices. The application also suggests alternative means of transportation that are more environmentally sustainable. Moreover, Tulusan et al. [31] illlustrate in their study on eco-feedback technologies that apps can improve fuel efficiency even under conditions where monetary incentives are not provided. As these examples demonstrate, prior research focuses on app solutions in order to make consumption, energy and mobility more environmentally friendly.

2.3 Electric Vehicles and Information Systems

The introduction of EVs is seen as a vital contribution for reducing greenhouse gas emissions (e.g., [32]) and achieving government climate goals (e.g., [33]). The widely used term 'electric vehicle' describes any vehicle powered partially or entirely by electricity [34-35]. EVs have lower greenhouse gas emissions compared to conventional vehicles that are based on internal combustion engines (e.g., [32], [36]) and can even reduce these emissions by up to 50% and tailpipe emissions by up to 90% compared to conventional cars [37]. However, the power generation mix needs to be considered in order to assess the impact on ecological sustainability in a holistic contemplation [e.g., 36]). Despite the potential emission benefits of EVs and governmental support of electric mobility projects, the expected success is still pending (e.g., [38]). In 2012, EVs accounted for less than 3% of all new registrations in the European market [39]. The main barriers for user adoption are the high purchasing costs, lower average range of EVs, and insufficient charging infrastructure [40]. Generally, EV customers face higher initial costs but, under certain circumstances, lower running costs compared to conventional vehicles [41]. However, the lower operational costs cannot compensate for the high initial expenses [42].

The second barrier is the EV's limited driving range. Although most daily trips fall within today's battery capacity, potential EV users are unwilling to accept the limited range, even when a charging possibility is available on their private property [43]. In this context, the phenomenon of range anxiety is a common problem describing users' concerns about not reaching a planned destination with a limited range vehicle. As charging stations are hardly profitable with the low number of existing EVs, charging station providers demand a higher market penetration prior to undertaking infrastructural measures [44].

Increasing attention to IS in the context of EVs arises from the field of energy informatics, coined by Watson et al. [2], which includes electric mobility as integral part. Kossahl et al. [45] indicate that the EV's potential has yet to be addressed by IS researchers. First efforts include, e.g., IS-supported business models in the context of EVs and EV charging. Brandt et al. [41] present a decision support system that aids in pricing decisions in regulation energy auctions within the Vehicle-to-Grid concept by predicting maximum prices paid by independent system operator and continues by describing the corresponding business model for the players involved. Recently, the use of apps for EVs received attention from the IS community, as they can provide useful information for the user. Ferreira et al. [46] discuss a solution that integrates several sources of data in an app. This app provides information and recommendations for drivers about range autonomy, route planning, and charging infrastructure. - Lee et al. [47] propose an app service for EVs in order to facilitate car sharing services. Kim et al. [48] developed a comprehensive app to help users to promptly send a rescue request. This app makes it possible for EV drivers to overcome emergency situations mainly stemming from battery depletion. Finally, Mal and Gadh [49] present an app that enables EV smart charging, in which users are updated on the status of their EV and may set their charge parameters via web or native app. As these examples show, apps enable the physical mobility to be integrated into the digital landscape, changing the way cars are used and fostering new business models [50].

3 Methodological Approach

3.1 Survey

Attributes constitute a critical point in the analysis in a wide variety of contexts, such as consumer choice and motivation, and form the starting point of deeper investigation [51]. Moreover, attributes are a key concept in disruptive innovation theory [14]. We conducted a survey using structured interviews to retrieve both, EV-related attributes and attributes for conventional vehicles. We opted for a structured interview in terms of a quantitative approach because we had a clearly defined objective with the identification of the individuals' attributes [52-53]. Among the established elicitation methods, we decided to use the direct elicitation technique because we aimed for the intrinsically relevant attributes of the test subjects [51, 54], reflecting their personal perception of electric and conventional vehicles, without limiting their choices.

3.1.1 Data-Collection Procedure and Sample Characteristics

The survey took place from early November until the end of December, 2013. It was conducted in Lower Saxony, Germany, in public places (e.g., city hall, bus stops, shopping malls, and grocery stores) as a pen-and-paper, face-to-face, structured interview. This approach assured a decrease in uncertainty concerning the representation of the population by reducing the threat of excluding proportions of the population as can occur with online surveys [55]. Our sample comprises 1461 participants (54% females). The age of all test subjects ranges from 17 to 85 years (mean: 44 years). One-third of them (35%) hold a university degree as highest achieved education, 11% with a general qualification for university entrance, and 33% with a general certificate for secondary education. At the beginning of the interview, the test subjects were questioned about their mobility behavior and opinion about EVs, prior to the question about the attributes, in order to obtain insights about the sample. Table 1 illustrates the mean and median distance covered by the sample per week with the respective car usage. The percentage of the car use is related to the equivalent number of respondents (n) in terms of the purpose. The portion of the respondents owning a car comprises 83,7% of the total respondents, with seven of them possessing an EV.

Table 1. Weekly distance traveled by the test subjects

Purpose	*Use of car*	*Mean distance*	*Median distance*
Work (n = 1146)	56%	19 km	5 km
Shopping (n = 1222)	66%	40 km	2 km
Picking so. up (n = 577)	44%	9 km	5 km
Hobby (n = 1013)	57%	40 km	7 km
Other (n = 408)	29%	61 km	10 km

We asked the test subjects how long they park their vehicle at home and at work. Table 2 shows that almost one-third of the respondents leave their car at home for half a day. Based on an eight-hour working shifts, more than 40% of the test subjects leave their cars for this time at workplace. The test subjects showed an overall positive attitude concerning EVs as 77,4% have a generally positive opinion about EVs and more than half of them think an adoption would be reasonable for their mobility needs.

Table 2. Daily vehicle parking time of the test subjects

Parking time	*Participants (home)*	*Percentage (home)*	*Participants (work)*	*Percentage (work)*
0–3h	166	13,3%	373	31,6%
4–6h	404	32,5%	217	18,3%
7–9h	287	23,1%	490	41,2%
10–14h	387	31,1%	106	8,9%
Total	**1244**	**100,0%**	**1189**	**100,0%**

3.1.2 Data Analysis

The attributes named by the test subjects were stored in a database, followed by an operationalization process [56] of three independent researchers. In the first phase, 589 attributes for EVs and 665 attributes for conventional vehicles were collected during the interview sessions. This deviates from the total count of participants as some test subjects could not provide any attributes while others named more than one. The initial list included redundant and similar entries, which were gradually cut down to one. The reduction of the attributes took place in two steps: (1)all verbatim attributes were reduced to one attribute and labeled with their respective number of occurrences, then (2) the attributes were assembled into variables as logical sets of attributes [56]. In this process, attributes with similar meanings were grouped to a variable with the precondition that the inherent attributes were exhaustive and mutually exclusive and therefore form unique variables [56]. In the second phase, each individual researcher proposed a list of attributes matching to a variable. The three resulting lists were compared and discussed until consensus on the final variables was reached. The conformity between the individual lists reached a high level and only minor discrepancies regarding the wording occurred, which were clarified during the discussion. These two phases resulted in a reduced list of 58 variables for EVs and 92 for conventional vehicles, forming the foundation of the analysis of the apps. The emerging variables were ordered by the count of the nomination of the attributes they contain.

3.2 Mobile Applications Analysis

The present research incorporates data from 81 apps in the context of EVs, particularly electric cars. The application data was collected and analyzed from the Google Play Store and the Apple App Store from May until September 2014. We chose the following English and German key words for the app search: “electric mobility”, “e-mobility”, “electromobility”, "Elektromobilität”, “Elektroauto”, “electric vehicle”, “Elektrofahrzeug”. We identified 102 apps and eliminated in the first step all apps without a description in German or English. In a second step we dropped all apps we could not access, as these are special apps from research institutes or commercial apps. The remaining 81 apps were analyzed by their description and tested on a mobile device. Based on the functionalities of these apps, we derived clusters that describe a large scale of the app characteristics.

As a final step, we classified the apps based on our clusters. To get an impression of customer acceptance and the perceived quality of the apps, we included the download numbers and user ratings for each app. Table 3 shows an extract of the resulting evaluation matrix.

Table 3. App evaluation matrix (extract)

Nr.	*App name*	*R*	*Downloads*	*CSt*	*SP*	*CIS*	*ISH*	*RP*	*DS*	*CS*
1	Bluecub	4,4	100-500	x					x	x
2	BMW i Remote	4,4	5000-10000	x	x	x	x	x		
3	Chargelocator Global	2,1	100-500	x						
4	E.ON eMobil	5	100-500	x	x	x			x	
5	eM Analyse	3,5	100-500					x	x	
6	eMobility	5	100-500	x						
7	EV Charge Point	1	10-50	x			x			
…										
81	Zoe Quick Guide	4,1	1000-5000						x	
				50	8	11	22	11	31	4

Note: Rating – R, Charging Stations – CSt, Saving potentials – SP, Car Information System – CIS, Information Sharing – ISH, Range Prediction – RP, Decision Support – DS, Car Sharing - CS

4 Findings

4.1 Attributes and Substitution Potential

In Section 2.1, we defined three prerequisites for EVs to have a disruptive impact. In the following, we elaborate upon them.

Prerequisite 1 – Substitution potential. The disruptive potential becomes apparent as, (1) more than 83% of the respondents use a conventional vehicle for their mobility needs, (2) the majority of the weekly trips would be manageable with an EV (Table 1), and (3) parking times would be sufficient for charging purposes (Table 2).

Prerequisite 2 – New, alternative attributes that are valued by potential customers. Table 4 displays the most prominent variables, composed of the attributes mentioned by the survey participants regarding conventional vehicles and EVs. Concerning the latter, the most prominent variables and their attributes portray EVs as eco-friendly, quiet, and modern. These aspects can be described as the new, positive performance attributes perceived by potential customers. The vast majority has a positive attitude towards EVs and consider their use for their mobility needs as reasonable.

Prerequisite 3 – Satisfying coverage of attributes customers value for established technologies. Several negative attributes were also identified. Besides attributes such as small, unattractive, or slow, which depend on the EV model, there was a great number of people who mentioned short driving range and high costs. The importance of negative attributes becomes apparent when relating it to the attributes the respondents named concerning conventional vehicles. Many participants perceive them as utility vehicles, which are reliable, economical, comfortable, and flexible. EV-related variables like impractical or charging effort indicate the perceived gap of EVs to come up to those traditional attributes. Attributes such as roomy, fast, beautiful, or sportive depend on the car model. Interestingly, negative attributes of conventional vehicles, i.e., harmful to the environment, noisy, or old, are related to positive aspects that respondents attributed to EVs—another hint at the disruptive potential of EVs.

Considering these findings, it becomes clear that EVs would be a technically suitable alternative. Moreover, they deliver performance attributes that potential customers do value, e.g. eco-friendliness. The first two prerequisites can thus be regarded as being fulfilled for the technology of EVs.

However, in the eyes of the customer, the third prerequisite cannot be regarded as fulfilled. To achieve a disruptive impact, the perceived reliability, the comfort, and economic attractiveness of EVs must be increased. Here, apps can play a key role in providing users with information and functionalities that might mitigate the perceived disadvantages of EV usage.

Table 4. Attributes for electric (left table) and conventional (right table) vehicles

Operationalized variable	*Fre-quency*	*Percent-age*	*Operationalized variable*	*Frequency*	*Percent-age*
eco-friendly	150	25,6%	utility vehicle	88	13,2%
quiet	76	12,9%	reliable	53	8,0%
resource efficient	42	7,2%	economical	51	7,7%
modern	41	7,0%	polluting	44	6,6%
short range	35	6,0%	comfortable	40	6,0%
small	33	5,6%	fast	39	5,9%
economical	28	4,8%	roomy	38	5,7%
expensive	23	3,9%	flexible	27	4,1%
poorly conceived	21	3,6%	expensive	22	3,3%
utility vehicle	19	3,2%	small	18	2,7%
impractical	11	1,9%	mobility	17	2,6%
charging effort	11	1,9%	noisy	16	2,4%
slow	8	1,4%	high consumption	15	2,3%
uncomfortable	8	1,4%	high performing	14	2,1%
unattractive	7	1,2%	safety	13	2,0%
flexible	6	1,0%	long range	11	1,7%
			old	11	1,7%
			good cost-performance ratio	9	1,4%
			necessary	9	1,4%
			beautiful	8	1,2%
			sportive	8	1,2%

4.2 Mobile Applications

Table 5 shows the different functional clusters, their descriptions as well as the matching to the respective operationalized variables addressed in Table 4. Table 3 displays the associated user rankings and downloads. Google's Play and Apple's app store rating system are based on a 1-to-5 scale system, in which 5 stands for the most satisfactory. The average rating over all identified EVs' apps is 3,83. Over 22,2% (n = 18) of the ratings score 5 points and 9 apps have no rating. Only 4 apps are very frequently downloaded (between 10000-50000 downloads). Most of these apps cover the *Charging Station* cluster. The majority of the apps (n = 47) had a download rate of up to 5000. Of these, 23 apps were not frequently downloaded (up to 100 downloads).
Most of the analyzed apps (61,73%) represent the *Charging stations* cluster. These received an above average rating on their performance (3,68/5). Moreover, most of these apps were frequently downloaded (up to 5000 downloads). Further clusters addressing EVs' short range represent *Range Prediction* and *Car Information System*. Altogether, 31 applications address the *Decision Support* cluster. Many of these apps were highly rated, 6 of them were even scored with a rating of 5. Beyond that, this cluster is covered by 7 apps with a high download rate (median 1000-5000 downloads). In the *Saving Potentials* cluster, only few apps (n = 8) were found.

Table 5. Derived clusters and descriptions

Cluster	*Description*	*Matched attributes*
Charging stations	Provide information on charging stations. Some allow users to log into the charging station and pay with the app; others indicate the closest charging stations and navigate to them; some offer to choose how much energy is to be charged and/or how much it costs.	short range, charging effort
Saving potential	Provide information about the saving potentials that could be gained by using electric cars. These could be money, fuel and CO_2.	Expensive, economical, resource efficient, eco-friendly
Car Information System	Provide information about the car, such as charging status or the expected range that could be gained with this charging status. Others allow managing functionalities such as turning on the air conditioning or starting the charging process.	modern, resource efficient, charging effort short range
Information sharing	Allow the user to post information on social networks (e.g., new charging stations, free parking spaces). Suppliers for electric infrastructure use such apps to provide news to their customers.	modern, poorly conceived
Range prediction	Estimate whether the charging status of their car allows for driving to the desired destination.	short range
Decision Support	Support the user in decisions about choosing an electric car. Some apps analyze the driving habits of the potential new customer and evaluate whether the customer should buy an electric car. Other apps are more concerned with information about EV technologies and statistics.	economical, expensive, impractical, charging effort, unattractive, uncomfortable flexible
Car Sharing	Apart from conventional car sharing functions, apps further provide information about charging status and range prediction.	resource efficient, eco-friendly, economical

Most of the analyzed apps (61,73%) represent the *Charging stations* cluster. These received an above average rating on their performance (3,68/5). Moreover, most of these apps were frequently downloaded (up to 5000 downloads). Further clusters addressing EVs' short range represent *Range Prediction* and *Car Information System*. Altogether, 31 applications address the *Decision Support* cluster. Many of these apps were highly rated, 6 of them were even scored with a rating of 5. Beyond that, this cluster is covered by 7 apps with a high download rate (median 1000-5000 downloads). In the *Saving Potentials* cluster, only few apps (n = 8) were found. Nevertheless, one app was downloaded many times (median 10000-50000 downloads) and some of these apps were also highly appreciated by the customers. Only 4 apps represent the *Car-Sharing* cluster while *Information sharing* (n = 22) was among the most prominent clusters.

5 Synopsis and Discussion

The results of the survey indicate that, in order to increase EVs disruptive potential, their reliability, comfort and economic performance need to be improved. The findings of the systematic analysis of apps revealed that currently available solutions do already address these issues, at least partly. Considering that a substantial number of our test subjects are associating EVs to a short driving distance and to an uncomfortable charging process, the *Charging stations* cluster seems to be crucial for a broad acceptance of EVs. *Range Prediction* and *Car Information System* apps support the customers in the prediction of range, e.g., by using special algorithms for simulating an electric car drive during an operation of a conventional car. Additionally, these types of apps provide detailed information about electro mobility and hence enables customer to overcome knowledge barriers as quite a few test subjects associate EVs with poorly conceived. Other attributes resulting from the survey describe EVs as being too slow or unattractive. We believe that the *Decision Support* cluster may provide an appropriate basis to address these issues. This cluster supports potential users and actual drivers of EVs to gain more information about electric cars and additionally supports the decision process for users who are not sure if an electric car is suitable for them. Moreover, as shown in table 4, most test subjects describe EVs as eco-friendly and resource efficient. This positive association is strongly underpinned by the *Saving Potentials* cluster. The related apps analyze the individual driving patterns of the user and building on this calculate specific saving potentials in terms of greenhouse gas or money. Especially the ecological saving potentials stressed by the apps may push the awareness of the correlation between green thinking and EVs. EVs also enable app-controlled features like the regulation of the charging process or the recording of physical and electrical parameters (e.g., battery status) in order to communicate them directly to the mobile phone of the user. Apart from that, we believe that the cluster of *Information Sharing* may also support the modern aspect of EVs attributed by the survey participants. We also believe that the community functions within these apps (e.g., Facebook) may widen the knowledge of users of EVs and also enables to share their driving experiences.

Providing users with information about, e.g., the locations and availability of charging infrastructure, can be assumed to enhance the reliability of EV usage from a customer's perspective as it significantly reduces uncertainty. The same applies to apps targeting at range prediction. Apps that allow, e.g., for reservation of charging infrastructure or air-conditioning of the vehicle, increase the users convenience by automating tasks that otherwise would require manual work. Besides these applications that primarily aim to mitigate the potential disadvantages of EVs, there are apps that specifically account for the positive attributes that are newly introduced by EVs, e.g. their eco-friendliness. Here, apps, e.g., allow for calculating the environmental savings potential by using EVs. The aforementioned effects of the apps are delivered by three functions of IS that have been described in literature – automation, information and transformation [57]. This extends the aforementioned notion of Chen et al. [26], who described these functions of IS for achieving sustainability in organizations, to the context of modern, IS supported sustainable mobility. By the three functions, apps contribute to an enhanced connection of users with the vehicle and the infrastructure, thus creating a digital eco-system that allows for a more reliable and convenient use of EVs for personal mobility. Moreover, because consumers nowadays want to benefit from the combination of digital mobile services and physical mobility infrastructures, the physical mobility system is increasingly being connected to a newly emerging digital system of interconnected mobile users [58]. Nevertheless, as our analysis shows, especially the economic dimension of EVs still needs further improvement. Here, apps that drive cost savings or alternative business models might have a huge impact on the disruptive potential of EVs. Carsharing could pave the way for new electric car customers, as they provide the opportunity to drive an EV without the high initial costs. We found apps further drive the convenience of EV-carsharing, e.g., by using GPS and mobile booking and reservation. By doing so, apps may not only contribute to supporting new technologies but also modes of transportation within a digitally supported eco-system.

6 Limitations and Conclusion

The following limitations should be considered when interpreting the results. First, our study was conducted in Germany; therefore, cultural effects could not be measured. This aspect also applies on the provincial level, since the survey was solely conducted in Lower Saxony, it is uncertain if these results also prevail in other German provinces. Furthermore, most participants had no direct experience with any form of EVs. As experience can significantly change the perception and evaluation of EVs our findings should be supplemented with studies including experienced EV drivers. Our analysis did not encompass all applications in the context of EVs as we only considered applications with German or English descriptions and had restricted access to some applications. Further research should consider the practical testing of these applications and its potential influence on the reluctance of potential customers. We therefore suggest conducting an experiment with potential customers that have prevailing restraints concerning electric mobility.

In this study, we emphasize the importance of apps for the diffusion of EVs. Through our large scale empirical investigation on the perceived attributes of electric and conventional vehicles in combination with a systematic analysis of existing apps, we could observe that mobile applications contribute with information and functionalities that help (1) reduce the perceived disadvantages of EV usage, such as low range; and (2) emphasize the perceived advantages, such as saving potentials and green thinking. This means that through the support of IS, the disruptive potential of alternative forms of sustainable mobility in general could be increased. In summary, we suggest that a complementary perspective on the development of a digital eco-system which facilitates the diffusion of alternative means of transportation is urgently needed, given the growing importance of sustainable mobility in both research and practice.

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