Straight from the Horse's Mouth: "I am an Electric Vehicle User, I am a Risk Taker." [EV14, M, c. 30]

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Abstract. The car has become ubiquitous in late modern society. Electric vehicles (EVs) show potential to reduce environmental burdens of the transport sector. EV-niche market acquires more available and reliable charging infrastructure to support current and potential users. The location-allocation of the recharging facilities is not a new planning problem; however, the planning for newly-adopted low carbon emissions vehicles infrastructure has distinctive design requirements, sociotechnical and demographic factors. This paper reports on the end-user's insight and perceptions. Using ethnographic approach, an interview-based study was carried out addressing 15 EV-users in the North East of England. The sample covered a wide spectrum of active EV-users. Clustering analysis is employed as a dimensional technique for data mining and forming the participants' charging profiles. The model generated 3 clusters; each one is presented and discussed. This study presents a new way of capturing the social aspect of the EV-system and reports on qualitative techniques in EV-context.

Keywords: Electric vehicles · Charging preference · Clustering analysis · Recharging network · EV questionnaire · Narrative analysis

1 E-Mobility System

The reason behind the growth or the lack of the electric vehicle (EV) market is multi-faceted. Many factors are responsible, which vary between socio-technical and psycho-temporal. Individuals and families struggle with the decision of owning an EV due to the different issues related to limited range. Perception of EV-resources and in particular the limited resources (battery) shifts by time and differs between individuals. In recent years, the environmental burden of urban road traffic has been of concern to governments and authorities of developed countries [1] with an increasing interest in mitigating this [2] as well as to develop and (re-) design cities to make them greener [3].

Analysing current systems show cases of variant consumers' profiles and preferences, charging behaviour, and supply and demand records. It provides insights on prices, technologies, investment versus payoff perception, barriers, incentives, and standardization [4]. Moreover, coordinating the charging behaviour EV owners via the potential flexibility of charging time would assist with the great challenge the power system would accommodate with the large scale EV use [5].

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Despite major technological developments in various EV areas of research, there is a list of issues needs to be addressed. Among these, the need for a reliable and diverse recharging infrastructure, which meets different user mobility demand and charging needs, is placed at the forefront [6]. EV stakeholders have been investing in promoting and introducing EV in their fleets and early adopters [7]. Domestic charging (charging at home using 2.3 kW outlet) has positive values: (i) quiet operation, (ii) zero tail-pipe emissions, (iii) maybe green energy in case of solar panel, and (iv) ease of use. However, the minimum driving ranges that EV user should tolerate in order to obtain these positive attributes and prices are not always convenient and do not meet their everyday mobility demand.

Hence, the importance of non-domestic recharging system arose. The uncertainty of having a reliable and integrated recharging infrastructure (non domestic whether workplace or publically available charging points) slows down the growing trend of smart ecosystems and sustainable urban communities as whole. The strategic locations of charging points (CPs) will help with paving the way for a better electric mobility (e-mobility) market penetration.

2 E-Mobility in the Social Media

The current EV users see themselves as a community; they liaise with each other through Social media suggesting indispensable tools and many phone and computer applications that can help the driver to familiarise with the recharging network and all related issues to EV use. The social Media is used for posting updates and spreading news of interest for any other EV user. Passionate EV users tend to help others benefit from their experience and share pieces of information that can assist them in their daily trip, see Fig. 1.

Fig. 1. Twitter: #UKCharge, pieces of information that can assist other EV users and #UKCharge, a tweet shows owner cooperation

Due to the e-mobility network instability, immature monitoring systems and available database, EV drivers always tend to double-check the information from different sources. This happens if the driver is taking a non-routine journey, which requires further planning.

In order to deal with the EV technology, the user attempts to find a mean of communication or interaction with other users to gain reassurance. The use of social Media was and is still one of the tools that EV community uses to interact. It plays a major role in sharing knowledge and experiences among users.

The social mediation evolved by the emergence of EV. Users discuss the social practice especially over social Media. Social influence plays a key role in market dynamics [8], if the hurdles the current users are facing are not resolved, this would result in negative Word of Mouth (WoM) that could lessen EV diffusion in the market [9]. Innovative technology adoption is driven by motivation for purchasing and willingness to pay. Learning processes are a critical dynamic in the spread of new technologies [10]. To advance technologic diffusion beyond the early adopters, EV must appeal to the majority of consumers [11].

3 Methodology – The Interview

In this study we focus on the user's opinion regarding the use of EV. This includes the usability of the car and the infrastructure and preferences. We examine how different age, gender, years driving an EV, driving conditions and styles would affect the use of EV. In order to collect comprehensive opinions, the method employed in this study is an interview. A structured interview was designed and conducted (n = 15). This paper reports on the responses of Newcastle-Gateshead area, in the North East of England. The questionnaire is analysed using narrative analysis for qualitative data and data analytics for quantitative part. Qualitative data includes (purchase process, consumer's perception); whereas, the qualitative data includes (users' profiles, driver workload, and range occurrence).

The requirement process of the users was strictly monitored. The study was carried our in October 2014, it included 15 participants (7 male and 8 female) who live or work in the urban core of Newcastle-Gateshead Area. The selected sample covered a wide spectrum of active EV users who may have access to domestic, workplace or public CPs, users data is provided in Table 1. The selection criteria were developed to ensure that the sample would be representative considering the difficulties of reaching active end users especially when it is a niche market like the current e-mobility market. The participants have been using the EV (Nissan Leaf) for at least 12 months and living or working in the inner urban core of Newcastle. The sample size encompasses private users (own their EVs) and fleet users (maybe used for private purpose). The intention of including fleet users is to get insights into the use of EV from a different angle.

3.1 Sample Size and Recruitment of Participants

A questionnaire-based interview was designed to investigate the EV users preferences and their network spatial awareness of the existing charging infrastructure. Each interview takes approximately 35 min and consists of 4 sets of questions. The interview responses were analysed using content and clustering analyses. In the following lines, each set of questions is presented, followed by analysis. The second part of the article presents the clustering analysis investigating the users profiles and the main predictors that affect the users charging patterns.

Table 1. Participants summary

ID	**Ownership**	**Gender**	**Age**	**Home**	**Mile/day**	**Home**
EV1	Private Car	Male	c. 50	2 years	20 Miles	NE7
EV2	Private Car	Female	c. 30	3 Years	30 Miles	NE21
EV3	Private Car	Male	c. 50	2 years	30 Miles	SR2
EV4	Private Car	Male	c. 50	3 Years	30 Miles	NE25
EV5	Pool Car	Female	c. 30	2 years	30 Miles	DH3
EV6	Pool Car	Male	c. 50	3 Years	20 Miles	NE2
EV7	Pool Car	Female	c. 30	3 Years	10 Miles	NE6
EV8	Pool Car	Female	c. 30	3 Years	10 Miles	NE2
EV9	Pool Car	Male	c. 40	3 Years	40 Miles	NE38
EV10	Private Car	Male	c. 30	3 Years	10 Miles	NE7
EV11	Private Car	Female	c. 40	3 Years	10 Miles	DH1
EV12	Private Car	Female	c. 30	3 Years	20 Miles	NE3
EV13	Pool Car	Female	c. 30	3 Years	20 Miles	NE21
EV14	Private Car	Male	c. 40	1 Year	40 Miles	DL16
EV15	Pool Car	Female	c. 30	1 Year	10 Miles	NE6

3.2 EV Interview: Participant's Profile, Motivation and EV Use

The first set of questions investigated participant's profiles and purchase intention process. The set contains two questions:

1. *Profile: age, gender, home address and work location?*
2. *What motivated you driving an EV? (Private EV users)*

This section aimed at investigating the attitude toward willingness to use an EV. The first question addressed the participants' profiles, responses were tabulated, see Table 2. Gender and age are basic criteria addressing socio-demographic side of EV and non EV mobility studies. Understanding gender differences is essential to policy, marketing, and EV charging infrastructure deployment to ensure that sustainable mobility is appealing and accessible to all users [12, 13]. Gender has been an influential factor that determines the driving habits. The gender dynamics of consumer tastes in the context of EV was addressed in previous studies [14, 15]. In order to explore the possible nexus between the different dependent variables that affect use of EV, the

Table 2. EV participants' age versus gender (n = 15)

Drivers	Male	Female
c. 30	7 %	47 %
c. 40	13 %	7 %
c. 50	27 %	0 %

variables are assessed with respect to the gender. The first variable is the age, see Table 2. The majority of users are senior males and young females.

The second question addressed the decision of electric driving (particularity owning an EV referring to private users). Usually the main intention to purchase is a replacement of an old car or shifting to car as a primary form of mobility [7]. The participants (n = 15) responded to this question differently. Motivations ranged between the environmental concerns of conventional means of transport 40 %, the habit of being a technology geek 8 %, long-term based financial calculations 30 %, the self-satisfaction of being early adopters 12 % or a risk taker (social image) 10 %. The users indicated their opinions about purchase intention process.

"I had an accident and my car was a total loss. I had a road trip with my friend who has an EV, and guess what, the very next day I decided my next car is NissanLeaf."[EV 2, F, c.30]
"I am happy to use an EV but still will not buy my own."[EV 6, M, c.50]
"I would recommend the EV for those who commute short distances to work." [EV 12, F, c.30]
"I am very passionate about it. I work for a service provider and I can see a very positive future of charging points deployment." [EV 12, M, c.40]

The purchase decision takes time and passes through phases. Based on the interviewers' responses to this question and to the following "Access to charge" question, a flowchart was drawn to illustrate the process and the process may end up purchasing a conventional car. One of the key factors is to have access to charging (domestic) and workplace.

3.3 EV Interview: Access to Charge, Workplace and Charging Frequency

The second set of questions addressed charging preferences and daily trips. The set contains five questions:

3. *Do you have access to domestic charging? Workplace charging? If you do not have access to domestic charging, would you still consider having an EV?*
4. *What is the average of your daily destinations? (Number of destinations you reach-number of trips) Example: 2 destinations (xxxx and yyyy)*
5. *How many times (in days) you drive your EV/week?*
6. *How many times you charge your EV/week?*
7. *What is the usual SOC that you arrive to a charging point? Example: 20 miles left OR 10 % of the battery charge left*

The third question is associated with the purchase intention and process. All private users responded that they would not have contemplated buying an EV if there was no access to a domestic charging. However, this is not the case for all EV users, fleet users have a different opinion.

"I do not worry too much about the non domestic charging, I do the daily trip planning briefly on my head as there are only 3 or four destinations."[EV 1,M, c.50]
"My wife always asks me if I charged my car though she never voluntarily plug it in when both at home".[EV4, M, c.50]
"I drive my EV for everyday use. This does not mean I can only rely on domestic charging." [EV11, F, c.40]
"I am a fleet user, I never charged at home."[EV13, F, c.30]

The second milestone of the purchase intention process is the workplace charging which was reflected by the respondents' feedback. Recently, workplace charging has gained more attention by the stakeholders and the end-users. After checking the domestic access, the selection of the EV model takes place. By this the attitude phase finishes and the use of EV starts where the driving and charging behaviour commences [16].

"I live 3 miles away from work, I do not have kids at school, and Nissan Office is next my Office, so why to worry? However, if any of these parameters changes, I have no idea what to do." [EV2, F, c.30]
"I used to charge at home until I know that I may charge at work and even cheaper. Now my domestic charger is the workplace one."[EV14, M, c.40]

The fourth, fifth and sixth questions addressed the number of destinations per day and the use and charge frequency of the EV over the week, see Fig. 2 for a sample of visualization of two participants (private and fleet). The average of weekday-daily destination rate is two (work + school (drop-Off/pickup)); however, the school is on the way home, which does not consume more than two to four miles extra to the road trip.

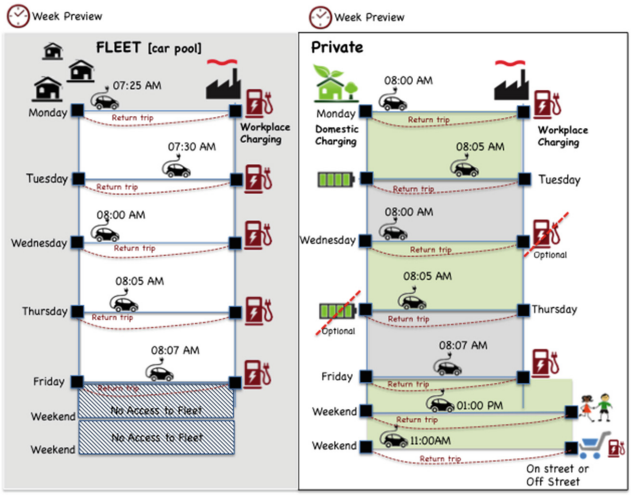

Fig. 2. Visualisation of fleet versus private EV users

The workplace charging practice has a different nature than public recharging network. Employers as public or private bodies, promote an environmental image by providing CPs (workplace CPs) and offers EVs to their employees. This refers to two other types of cars: i) fleet for work use only and ii) fleet for work and private use. The first type is the case of fleet users interviewed. Furthermore, community interest groups like public access car clubs, started to include EVs in their fleet [17]. Car sharing is becoming more and more common. The UK is the largest European carpool representing 12.1 % of the total EU fleet. Charging facilities shared by staff members and visitors requires an internal communication platform. EV4 is a participant who has access to workplace charging facility. There, the EV users communicate with each other to manage the shared charging facilities via internal system. The fifth question addressed the weekly charging frequency. The main differences arose between the private and the fleet users, see Table 3. The private users tend to charge from five to seven times a week (domestic + workplace). Fleet users charge only at workplace with a different frequency depending on the number of users charging the car and their locations. The gender had an effect on participants' responses to SOC related question, see Table 4. The seventh question regarded the usual SoC on arrival.

Table 3. EV participants' charging frequency versus ownership (n = 15)

Charge/W	Private	Fleet
2	0 %	10 %
3	5 %	20 %
4	0 %	0 %
5	15 %	10 %
6	0 %	0 %
7	30 %	10 %

Table 4. EV participants' SoC versus gender (n = 15)

SoC	Male	Female
Below 20 %	7 %	0 %
20 %	7 %	20 %
30 %	20 %	13 %
50 %	13 %	20 %

3.4 EV Interview: Participants' Charging Patterns

The third set of questions addressed charging patterns as follows:

8. *Do you commute across postal zones in NE to reach your work? (please specify the first part of your work address) Example: I live NE4 and commute to work in NE33)*

9. *How can you describe your driving comfort zone? (time, mileage, or area). Example: After commuting "XX" miles, I start to feel worried about my state of charge (Attitude)*
10. *What is the minimum SoC you can tolerate?*

The eight question aimed at identifying the daily-mileage commuted by EV users by counting the number of the postal zones the participants drive through from home (origin) to work (destination). The responses to this question are included in the clustering analysis, which is discussed later in the article. The ninth question is more attitude-oriented, asking the respondents about their range personal preferences. From this perspective, the higher the percentage the individual indicates, the more conservative they are in using their cars (less confident). A further 7 % (males) of respondents reported a wide comfort zone driving an EV. This means tolerating a very low battery (one to two cells charged out of 12 or below 20 % SoC). No occurrence of female respondents expanded their comfort zone to the same extent. The smaller the comfort zone (closer to the origin), the more the female drivers occur. At a small comfort zone circle (equivalent to 50 % charged or more), 20 % was female and 13 % were males, see Table 5.

Table 5. EV participants' charging behaviour versus gender (n = 15)

SoC % left	Comfort Zone	Male	Female
Below 20 %	(1-2 cells)/12 cells	27 %	13 %
20 %	(3-4 cells)/12 cells	13 %	13 %
30 %	(5-6 cells)/12 cells	0 %	20 %
50 %	(7-9 cells)/12 cells	7 %	7 %

The respondents indicated that they would experience severe anxiety by reaching this stage, but it is not on an everyday basis or even weekly. They reported that this only happens when:

"I have been driving my car for 3 years now, I usually reach 15 % charge on my third day on a raw not charging, this happens when I arrive at the workplace to charge. Yes, I do have anxiety by then, but manageable because I know where to charge."[EV4, M, c.50]
"Below 20 %? This never happened to me and I will make sure it does not happen. I will be scared to death."[EV8, F, c.30]
"My anxiety differs. It depends on where I am and how familiar I am with the vicinity (charging points/nearby home charger at friends."[EV11, F, c.40]
"Being down to 20 % SoC is not in my favour. This may take place only if I have strictly necessary trip and will prefer finding alternative charging solutions."[EV11, F, c.40]
"I do not see this possible, having said my routine and charging accessibility. But yes, I will be having a severe anxiety."[EV12, F, c.30]
"It happened once before I installed my domestic charger, and I promised myself it will never happen again. I can not even foresee this as I do not use my car that spontaneously, yet."[EV14, M, c.40]

The tenth question addressed the charging behaviour. The respondent was asked to indicate the minimum SoC ever reached. On the contrary, the lower the percentages the

respondents indicated, the more confident they are. This question is addressing their everyday patterns as what is the lowest state they reached spanning their driving experience. This question is different to the usual SoC when arriving at a CP. The latter would indicate when the user tends to charge (whenever possible or when needed). Fleet users didn't reach a low charge due to charging accessibility and limited distances commuted. Additionally, females (13 %) indicated that it was under very special circumstances that they reached this level.

> *"I didn't charge on Monday at the work, I went to pick a friend from Newcastle Airport on Tuesday and was having a meeting outside my company premises on Wednesday. On my way back home after the meeting I was a little bit worried as it was my first time seeing my carwings reading 20 % charged!"[EV 2, F, c.30] (Carwings software is Nissan user interface UI)*

The results showed how different the perception and the actual values can be with regard to minimum SoC, An inconsistency is observed when analysing the interviews. The records of some respondents, who indicated a tolerance to an expanded comfort zone, were inconsistent in terms of minimum SoC. A further 60 % of users have indicated a conservative experienced SoC compared to their indicated comfort zone values. However, two cases (EV2 and EV4) reported that they experienced EV range anxiety (EVRA) [18] as the minimum SoCs they reached were below their comfort zone values. The users justified that these two cases happened under special circumstances. Out of 15 users, 26 % (3 males and 1 female) have inconsistency in their attitude-behaviour process. Although it is based on direct experience (as being active users for more than one year), those users experienced different minimum SoCs than the tolerable values they indicated. This does not mean that the SoC Perception and Action percentages should have been identical. Users at the point of the interview may not have had the chance to experience full electric range although they were willing to. However, the inconsistency, which is referred to, pertains specific cases (EV6, EV9, EV10 and EV15), where the two values showed a significant difference.

3.5 EV Interview: Participants' Perceptions

The fourth set of questions explored the travel demand, flexibility of and willingness to spend time charging an EV over the course of a journey.

11. *In which road trip you usually charge your car? (maybe multiple)*
12. *EV Range: Does the confidence level improve by practice?*
13. *During weekdays, how much time are you willing to spend to charge?*
14. *Is there any time of the day at which you regularly struggle to find an empty CP?*

The eleventh question aimed at identifying (timing/road trip) of the non-domestic charging events made by the participants. The respondents were asked to identify in which trip purpose the charging event likely occurs. As for the non-domestic CPs', 90 % of respondents charge in the morning on their way to work or at noontime at the workplace. The twelfth question ascertained the relationship between the years of driving an EV and the user's confidence of driving an EV. The majority of the

Table 6. EV participants experience versus gender (n = 15)

Drivers	Male	Female
Newly Joined	14 %	13 %
Experienced	29 %	13 %
Early Adapters	57 %	75 %

participants have been driving an EV for 3 years (females and males). Only two participants (male and female) had been driving for one year, see Table 6.

The thirteenth and fourteenth questions were designed to identify the anticipated peak time of charging using the non-domestic network (to be included in the clustering analysis).

4 EV Study Clustering Analysis

The second part of the article discusses the clustering model. A TwoStep analysis was conducted to categorise the (n = 15) users into different groups based on the recorded attributes. Due to the mix of categorical (gender, locations, CPs) and contentious (state of charge, age, years of driving) data types, the TwoStep method was chosen instead of the other two approaches: the hierarchical and k-means. The TwoStep generates a report with some graphs and figures showing the cluster quality, see Fig. 3a. The clustering process took several iterations until the most coherent structure was reached. The decision is made based on the cluster quality, a reasonable number of clusters, and the ratio of clusters' sizes to each other (the biggest to the smallest). The quality should not be poor, and the ratio should not exceed three. As for the predictors (the influential factors affecting the clusters formation), willingness to spend time charging scored the first non-polar attribute that affected the clusters membership formation. The second most influential non-polar predictor was the number of charges/week. The third-ranked predictor was the number of destinations/day, see Fig. 3b.

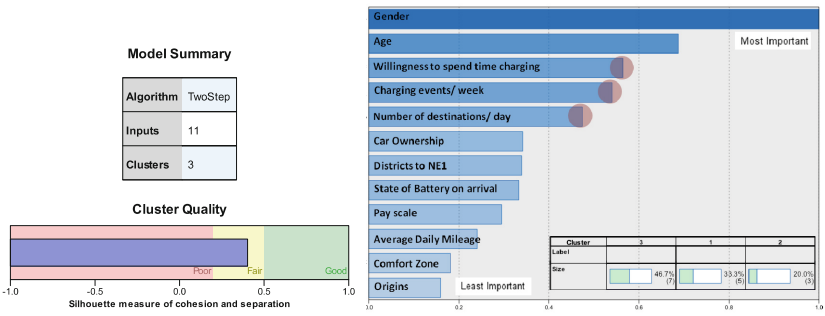

Fig. 3. (a) clustering quality bar, (b) clustering predictors

Frequency of use/week, willingness to spend time charging, domestic or non domestic, and willingness to use *on street* were the points of assessment and evaluation of the formation of the clusters membership. Spatiotemporal analysis of charging patterns was conducted using SPSS Statistics 21 [19]. The model output reflected the traits of the participants and managed to form a heterogeneous three clusters. The first group was termed, "The Risk Takers", see Fig. 4a. It is the second biggest cluster, and contains individuals in the age group of 50–59 years old who had been driving their own EV now for more than three years. The majority were males who usually commute around 30 miles a day. They preferred the *on street* CPs (such as the Grey street one, CP #20059). The number of destinations was two and they lived two miles away from the city centre. This group can tolerate up to 30 % left in their batteries. Users of this group are the lucky few who have access to CPs; however, they can tolerate low charge with a high confidence levels of getting back home safely. The records showed that they charge 5 times a week, however, they drive around the city and reach the CP with only 30 % charged. Those individuals are not happy and willing to spend more time charging; however, they see that investment in RFs is necessary. Compared to other groups, this group considered themselves as risk takers, they tolerate that their SoC being pulled down to 5 % and then they start to worry about finding a CP. The majority of this group lived and worked outside the study area, commuting and passing through every day.

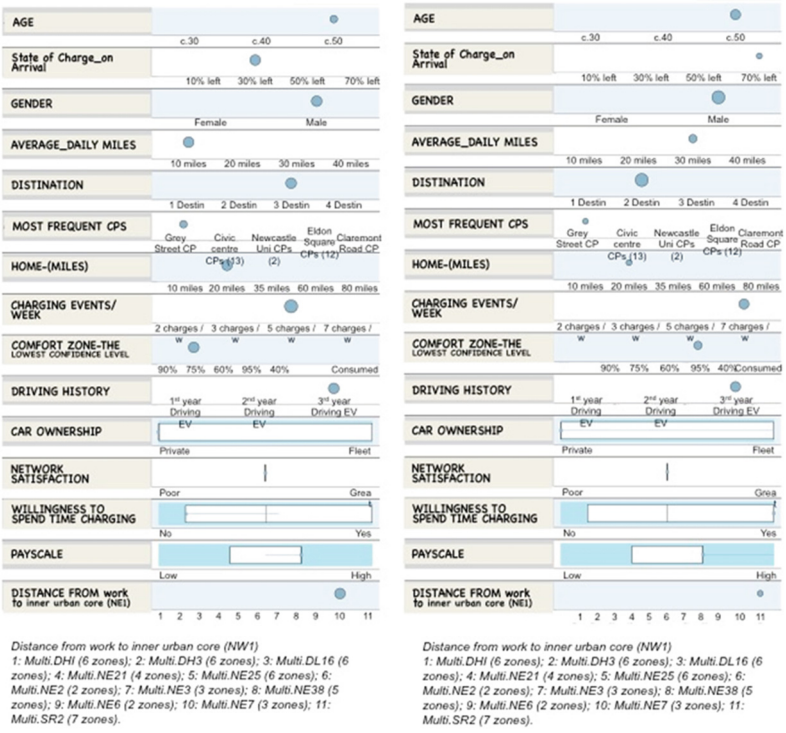

Fig. 4. (a) Cluster 1: "The Risk Takers"-SPSS, (b) Cluster 2: "The Old School"-SPSS

The second group was termed "The Old School", see Fig. 4b. The cluster contains individuals in the age group 50–59 who had been driving their own EV for 3 years. The majority were males and they tend to commute around 10 miles a day, two destinations a day and they live 2 miles away from the city centre. It is suggested that this group has low confidence levels. They charged seven times a week and their SoC is always relatively high when they arrive at the CP, 70 % charged. Those individuals are willing to spend more time charging their batteries within the day.

The third group was termed "The Opportunists". The cluster contains individuals in the age group 30–39 who have been driving an EV for three years. They do not own an EV; they go for the work-provided EV car pool option. The drivers of this group are females who commute 10 miles a day on average. The number of destinations was two and they live two miles away from the city centre. The car they use is usually charged at the workplace. This reflects the seven charges a week and explains why the state of charge when arriving at the CP is relatively high, 50 % full of charge. Those individuals were not willing to spend more time in charging their batteries within the day.

5 Commenting the EV Study's Clustering Results

The EV user study presented a new way of investigating the users' charging patterns, spatial awareness, and recharging network recognition. With the clustering analysis, the users' profiles were created and formed into groups with shared characteristics. These clusters may help the stakeholders to elicit the picture of the current system's users and work on satisfying their mobility and charging needs and demand. Each of the three-formed clusters has different paradigms. The Risk Takers are psychologically ready to deal with RA. They are willing to invest on infrastructure; however, they are not willing to spend time on charging especially the *On Street* option unless it is a quick charger. This means that the investment in slow chargers (types 1 and 2) is not in their favour or at least not to their preference, and may result in them not using slow chargers.

The Old School cluster has an issue with the driving pattern. It seemed that they do not expand their comfort zone. This zone is not metric measured; it is about the lowest state of charge at which they are confident to drive their cars. They can only consume up to 30 % of their battery and within the comfort zone. They do not go further than their home, workplace or the zones within which they know they have access to charging. This group is cautious and conservative and do not tend to practise the full electric range.

The third group is The Opportunists, which included those individuals who are the majority of current users. This cluster supports workplace CPs. The Opportunists are aware of the environmental burden of conventional means of transport, they were happy to take initiatives; however, they cannot afford owning a private EV. The way they contribute to the EV market is by car-pooling, using employers fleet and charge at workplace [20].

6 Conclusion

The paper reported on an EV user study. The interview aimed at investigating the users' charging patterns, profiles, each sub-set of questions focused on a particular facet of the e-mobility system of Newcastle-Gateshead area. The interview questions interrogated the driving confidence issue, EVRA, and the associated variables with the use of EV in its urban context. These variables were included in a clustering model, which generated three main clusters of EV users.

The clusters' assessment is articulated in Table 7. It presents the evaluation criteria of the three EV users clusters in relation to the size of each group. The assessment shows the imbalanced state of the e-mobility system of Newcastle-Gateshead area. As per the sample size, only 30 % of the users were happy to practice the full range of the EV and had high confidence level, the risk takers. Those users were not willing to spend time charging, which means they require quick charge (50–250 kw) and may relate to users who tend to top up their batteries on the go using *on street* CPs. Another suggestion is that they stay relatively longer using *off street* CPs (including workplace) in the case of using slow chargers while considering their available time to charge. The Opportunists cluster forms over 50 % of the sample size and this might be an explanation of the e-mobility low market penetration level. They use the non-domestic CPs; however, they tend not to use the publically available CPs as most of their charging events are made at the workplace.

Table 7. EV participants' clusters assessment table

Assessment	The Risk Takers	The Old School	The Opportunistic
Sample size %	30 %	15 %	55 %
Frequency of use/week	80 %	100 %	100 %
Willingness to spend time	Low	High	N/A
Domestic or non domestic	Domestic/On Street	Domestic,workplace,*Off Street*	Workplace
Willingness to use *On street*	Yes, quick charge	Yes	do not own EVs

This leaves only 15 % of the sample size, the Old School cluster, which uses the recharging network relatively more than others. They are willing to spend time charging and invest in installing more CPs. This group is widely spread and they are using both *on* and *off street* CPs alongside the workplace, if any.

To conclude, the paper discussed a selected sample of Newcastle-Gateshead area EV users. Those users vary in their charging preferences and demand, which were associated with their demographics. Although the sample size is statistically small, compared to the available EV owners it is reasonable. The sample covered private and fleet spectrum with different occupation, gender and age ranges. Studying existing

system while giving attention to the social aspect interrogates new correlations, provides insights, and justifies the system's dynamics.

For a better diffusion of EV, these clusters should not exist as the way they are. A mix of EV technology literates, who appreciate the long-term benefits of owning an EV and can trust the EV more, is the profile that we should be aiming to have. The Risk Takers need to be merged with the Old School and the Opportunists in order to have a reasonable and stable EV population who are willing to:

- *Pay for a privately owned EV;*
- *Use the recharging network more often and maybe amend their daily routine accordingly;*
- *Spend more time charging;*
- *Expand their comfort zone and experience the full electric range;*
- *Invest in installing slow chargers (quick chargers are too expensive in a larger scale);*

And finally, the contribution of this study can be formulated in two means:

- *Methodological approach: The study provides a methodological approach by employing the presented approach to analyse other existing e-mobility system*
- *Replication: The three clusters can be applied at a wider scale in another similar urban context. A similar urban system may refer to a city with (ex. an organic planned layout with EV population of both private and fleet, and with an existing system including on and off street CPs).*

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