Methodology for Studying the User Experience with New Mobility Systems:
The Cases of Electric Cars and Dynamic Car-pooling Use

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Abstract – **The use of emerging mobility systems in the city is a critical issue, and we propose in this paper a methodological framework, which is lived experience-centered, to study it. The methodology is illustrated with two studies: the first is about the way drivers deal with the limited autonomy of electric cars, and the second is about the use of dynamic car-pooling. We propose three steps: (1) studying a situation of reference, with interviews focused on the lived experience of specific situations of use, (2) studying the lived experience of a limited population in the emerging situation, with video recording and interviews based on the video and on diaries (3) generalizing some of the processes observed with quantitative data. We then discuss the pros and cons of this methodological approach, and we explain the resources it provides for designing technologies and services adapted to the users' activities and feelings in natural settings.**

Key words : methodology; natural use; lived experience; electric cars; dynamic car-pooling; interviews; reference situation

I. INTRODUCTION: STUDYING THE EMERGING USES

Mobility in the future cities is a crucial social issue because of the ecological, economical and traffic congestion impacts of the design of multi-modality systems. New modalities of mobility must be experimented to be adapted to the users' expectations, reluctances, and practical organization of their daily life.

We can find mostly global and statistical approaches looking at the flow of travels, at the profiles of the persons using new modalities of transport and macro description of the users' behaviour and motivations [1]; [2]; [3]; [4]; [5]; [6].

The approach that we present here is focused on analyzing how people deal effectively with the use of new mobility systems in their daily life (and not only on what they say about what they generally do or will do). It is focused on the situated activity [7] and on the lived experience of the users in specific contexts [8], [9]. We adopt a psycho-ergonomic perspective:

- A psychological perspective : exploring precisely the user experience with the new technology and service : their actions but also what they think during the use and how they feel [10];
- And an ergonomic perspective: proposing orientations for designing tools and services adapted to the user's situated activity.

The difficulty is that these new services and technologies are not developed yet in the city and we cannot really experiment them in the real context of the future city. It is then a matter of "prospective ergonomics" [11], of anticipating the future situation and the activities deployed in this context. We could base our study on the projective imagination of the future users, like it is often done in creativity sessions. But there is a potential gap between the intentions and the actions actually developed. We then prefer to study how people behave in a real situation. If this situation does not exist so far, maybe we can find an existing one, which is a reference (also for the users), and then develop a situation, which is similar to the future one, but on a smaller scale.

Our conception of User Experience is based on an in-depth analysis of the situated activity and lived experience, i.e., on what happens during the contextual use and how the user lives it: what are their actions and focus of attention; their mental activities for evaluating, reasoning, taking decisions; their sensorial perceptions and their affective feelings [8].

As examples of this methodological process, we will present two studies:

- The first study is about the initial use of an electric car and the specific issue of its limited autonomy [12], [13]; how do users deal with this new situation where the risk of breaking down is more important? (about 150 km of autonomy). Are they taking some risk with unpredictable routes or are they limiting their travels? How do they feel with the risk of running out of car energy, and how do they manage it when driving or before driving?
- The second study, which began recently, is about the use of dynamic car-pooling with service applications on smartphones. How do the users find another user

to share a personal car during a travel? Is the application satisfying? What is the relevant information about the other? Are they trusting the others or not, especially when they are strangers: their way of driving, their punctuality, their social behaviour? What type of social relation do they build during the travel?

We proceed in three steps:
- Studying a situation of reference;
- Studying the lived experience of a limited population in the emerging situation (with the new service or technology);
- Generalising some of the processes observed with quantitative data.

II. EXPERIENCE-CENTERED METHODOLOGY AND RESULTS

Our methodological framework is inscribed in the disciplines of psychology and ergonomics. It allows us to study the human lived experience and activity with its cognitive, emotional and sensorial aspects, with the ergonomic objective to design instruments and environments, which are adapted to the human needs.

A. Step 1: studying a situation of reference

In a first phase we study an existing situation of reference. This situation must be the most similar to the future situation that we aim at.

1) Situation of reference for the EV autonomy management

For studying the issue of how people act and feel regarding the limited range of the electric vehicle (EV), we first studied how people act and feel regarding the autonomy of *their traditional thermal vehicle*; we had no idea about this specific activity, which is adjacent to the driving activity but becomes very important with the EV.

14 in-depth interviews (half men/women, 23 to 63 years old) have been performed. After a general description of how they tend to manage the autonomy, we asked them to try to remember and describe the lived experiences of specific situations.

We then analyzed the interviews, and from this analysis we constructed a short questionnaire of 7 items to get quantitative data on specific points, which appeared to be relevant, filled by 344 drivers (21 to 65 years old).

We will not develop here all the results but only the main ones.

First of all, concerning the way people deal with the autonomy of their traditional thermal vehicle, the interviews and questionnaires allowed us to highlight different *styles* [12]: some drivers are more or less worried about running out of gasoline and consequently they anticipate and calculate more their refilling. The styles (anticipators, moderate anticipators, reactive to the signal, late refillers), which are a global tendency to act in a certain way, depend on personal determinant, but this global tendency can also be transformed by contextual determinants:

- Personal determinants are: (1) the affective relation to the risk of breaking down, some being anxious of breaking down and others being rather indifferent to this possibility; (2) the affective relation to the stations, some delaying the refilling because they feel the stations as disgusting and unpleasant places that they avoid.
- Contextual determinants are (1) the temporal priorities of the driver at that moment (refilling may be considered as less important as being on time at a meeting); (2) the trust in the reflexive instruments of their own cars indicate the remaining autonomy (such as the gauge); (3) the familiarity with the journey and station sites (for long and unknown trips, there is more anticipation); (4) the collective influence (when sharing a car with someone else, the refilling can be more systematic).

The more surprising results are the variety of reactions towards the uncertainty of the autonomy, and the diversity in terms of tolerance to uncertainty [14]. Also the emotional relation to the risk of running out of gasoline appears to be clearly linked to the proactive/reactive conduct, but models of risks surprisingly ignore this emotional dimension [15].

We also observed that, for dealing with the autonomy, drivers use instruments [13] of two types : (a) to anticipate and calculate in advance the risk, such as websites, and it is mainly done by those of the "anticipator" or "moderate anticipator" style (b) they also use reflexive instruments, which give them a dynamic feedback on their situation state (the gauge, the remaining kilometers, the econometer); some "late refillers", who are used to breakdown, can even have a can in the trunk and a pipe in order to cope with (and not anymore to avoid) the breakdown.

2) Situation of reference for the dynamic car-pooling

Car-pooling is defined as the sharing of a private vehicle between persons who may or may not know each other in advance, and who can meet by using a service on the web allowing them to find other persons to share a ride. Nowadays in France, this mapping is always performed in advance (we call it "planned" car-pooling); the planned car-pooling is mostly used for long trips (in Europe, the average is 200 km, [16]. The "dynamic" car-pooling implies that a system geolocates the potential users, identifying dynamically where they are. The matching between users is based on this geolocation. Consequently a person can go out of a meeting at anytime for instance, look on his smartphone at who is in the neighborhood and going in the same direction as himself. The mapping is then dynamic and users do not need any more to plan their ride in advance. Dynamic car-pooling services are not already functional in France, but some applications are used elsewhere, such as Avego Driver in Ireland.

We first studied the present services of car-pooling to have a clearer idea of why people do not use this type of service and if they do, how do they do. Some studies have already been conducted on this issue but with a more global perspective [17]; [18]; [5]; [19]; [20]. They indicate that, in France, car-pooling is occasionally used for holidays or for a special event, mainly by young users (60% are under 30

years) living in urban environment. The drivers are a majority of men (69%) and 34% of them are more than 40 years old; the passengers are rather women and 26% of them are less than 23 years old. Users say that the positive points are economic (low price of their travel), ecologic (reduction of greenhouse gas emissions) and social (meeting new people and creation of a social link). The negative points are the lack of flexibility in scheduling and journey [21], but dynamic car-pooling should respond to this problem.
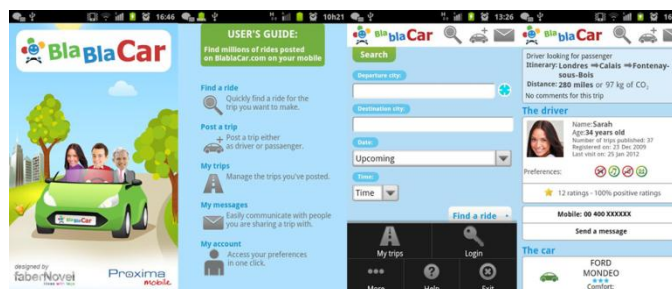

Figure 1 : Searching a travel and a driver/passenger on BlaBlaCar! (application of "planned" car-pooling available on App Store and Google play : [22])

Firstly, 25 interviews have been conducted with people who never used any car-pooling systems to know their motivations for not using it.

Then *25 in-depth interviews* have been conducted (with descriptions of real uses cases) with people using planned car-pooling. The objective was to specify the sources of reticence and appreciation but also the difficult or positive experiences they have had with this mode of mobility. The issue of trust/mistrust is particularly important: how do users construct a trust or mistrust in this service? Do they choose the persons with whom they share a car and how? What type of interactions do they have once in the car? What is the nature of the social interactions built in these circumstances? Do they feel a risk or not and which type of risk? This study is then questioning and completing the theories of risk-taking and trust [23]; [24]; [15]; [25]. The analyses of these data are in progress.

3) Interviews focused on the lived experience of specific situations

The in-depth interviews that we conduct for studying the situation of reference are based on a specific technique, called "explicitation" (or "elicitation") interviews, which has been developed by Vermersch [26]; [9]; [27]; [28]. First of all, the interview is focused on the description of real use cases, of effectively lived experiences.

The typical risks when getting verbalizations from subjects describing their activity are the rationalizations and re-construction. The more we take care of the recall process of the subjects, the more we limit this risk. The "explicitation/elicitation" interview aims at the phenomenological experience of the subject [29], and is very cautious on the recall process. One principle is to help the subject to get a vivid memory of the activity by asking questions about the sensorial context. Then, we ask questions always linked to the situation to avoid generalizations, and

taking care of their non-indicative format for not influencing the response of the subject. These techniques keep the subject in a position of talk which is focused on what he was living cognitively, perceptively and affectively during the past experience. It does not orient the subject to provide rational comments and explanations about it. The interviewer follows the temporal course of experience described by the subject and helps him to give more information about what happened in a specific situational context. With this interview technique, the subject has a vivid recall of the situation he describes (if not, he is invited to tell it) and can give more details about it and limit the rationalizations.

4) Transfer from the reference situation to the future situation

The situation of reference is a first basis to think about the emerging situation and to have indications and intuitions about how this future situation will probably be lived and acted by the users.

For instance, we observed different styles for dealing with the autonomy of the vehicle: some drivers being more worried and anticipating more than others who wait for the signal of energy stock or even far after it. These styles are tendencies to act in a certain way, more or less anticipative or reactive, more or less worried about a certain risk or indifferent to this risk. They could not totally change because the vehicle becomes electric, except if the infrastructure totally transforms the activity and the nature of the risk (if there is for instance plenty of electric charging points everywhere, or if we could exchange the battery everywhere). But it is not the case yet, and even then, the user will need to wait for the service (the charge will take some time) and will plan it (or not) in the course of his/her activity. Then these profiles will remain relevant for anticipating the lived experience in the future.

For the case of the 'planned' car-pooling, we intend to extract a lot of relevant information for the emerging 'dynamic' car-pooling; the situation is very similar except that the activity becomes more opportunistic and reactive than with the planned car-pooling, and may unable the users to get as much information about the car-pooler to build trust through his profile and the opinions posted.

B. Step 2: studying the lived experience of a limited population in the new situation

The second step is, according to us, the most important one; it is the core of the user experience research, the phase of analysis of the users' actions, perceptions, cognitive activities and feelings when using the new technology or mobility service.

1) Studying the lived experience with electric vehicles

For studying how people dealt with the limited autonomy of electric vehicles, electric cars have been lend to 9 subjects (7 men, 2 women, 24 to 55 years old, of the four styles). The lend cars are of three different types and trends, their official electric range is from 150 km to 160 km and the time needed to fully charge the battery is 7-8 hours. They used them during two weeks as they wished, without any constraint. The activity and user experience were studied by:

- Observing via *video recording* (3 cameras) the emerging use with the new technology in ecological settings (cf. fig.1);
- Asking the 9 users to fill a *diary* every day about (1) The journeys: destination, planification, unexpected events, renunciations and motivations; (2) The recharge: mode, place, impressions and others remarks (3) Others impressions or specific events with the EV;
- Interviewing the users, with explicitation *interviews* (after days 1, 8 and 14) based also on the *video* recordings and on the *diaries* (self-confrontation interviews) in order to know the subjective experience when using the new mode of mobility.
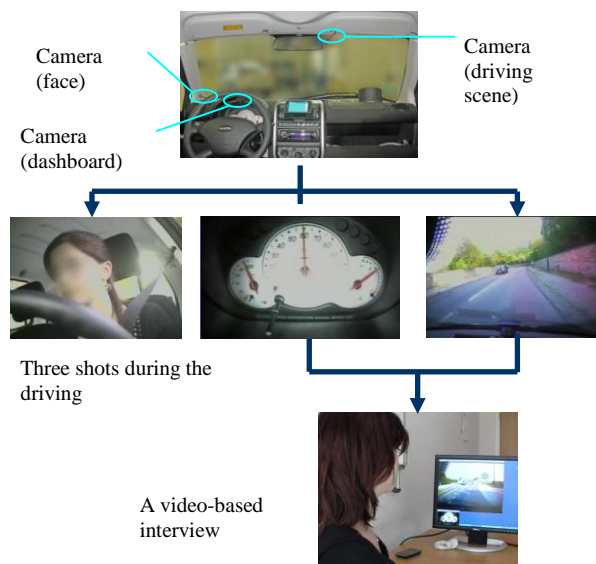

Camera (face)

Camera (driving scene)

Camera (dashboard)

Three shots during the driving

A video-based interview

Figure 2 .Illustration of the use of the video recordings

The main results are:

Most of the subjects limit the risky journeys and use the electric vehicle (EV) for well-known journeys such as from home to work. Only two subjects with the profile "late refillers" have taken the risk of driving the EV with very limited autonomy. This indicates that the styles of reactions with traditional cars are similar with EV and that we find again this differentiated styles of dealing with the autonomy issue.

The study indicates how the EV driving experience is situated and anchored in the context, and how it is emotionally embodied [12]. We showed how the activity and feelings of the driver depend on:

- The *reflexive instruments* available and their interpretation (gauge, econometer, other signals) ; the construction of their meaning depends on the style of anticipation and worry;
- The *geographic context* (hills, proximity of the arrival); the driver constructs a representation of it to anticipate the evolution of his autonomy, since some electric energy can be gained when going down hills and using the motor brake;

- It also depends on the co-drivers' reactions. When the car is shared by a couple for instance, the actions taking place are negotiated.

The use of the different "reflexive" instruments (gauge, econometer, remaining kilometers) have been studied in details, including the evolution of the use during the two weeks. For instance the econometer is often ignored at the beginning but finally used when critical situations arise.

Finally, we proposed two prototypes of instruments (developed by Renault) to the 9 subjects who had used the EV during two weeks. The prototypes proposed innovative applications for geolocating the places for charging, the distance and time to these places (from the present place of the driver), but also visualizations of their remaining charge and other information, which is relevant for the autonomy. We asked them about what would fit them and which other expectations they would have, projecting them in the future possibilities.

2) Studying the lived experience of the dynamic car-pooling

For studying how people act and feel with the dynamic car-pooling, we will soon disseminate an application with geolocation, which is not used in France but is developed in Ireland (Avego Driver) and a very new application, which is developed by a French start-up. We disseminate it in a zone of the south suburb of Paris, in several companies and engineer schools.

When a sufficient number of persons will use the service, we will ask some volunteers to videotape (using small wearable cameras like "glasses-camera") some moments of their natural activity, like the search of an adequate partner for the car-pooling, the arrangement of the meeting and the encounter. We will also put a video camera in the cars of some car-poolers to analyze the social interactions taking place with strangers.

Users will also fill in diaries and some volunteers will be interviewed with the techniques described above (explicitation interviews and interviews based on the video records and on the diaries).

Figure 3: Searching and matching on Avego Driver (application of dynamic car-pooling available on App Store and Google play : [30])

C. Step 3: generalising some of the processes observed with quantitative data

Our approach of the user's activity and experience is globally qualitative. Nevertheless it is interesting to quantify on a larger scale of population some of the processes put into light during the first two steps.

That was the case for the EV autonomy study. With a short questionnaire and 344 participants we could for instance specify the quantitative repartition of the styles

found in the qualitative interviews, and looked more precisely at the link between the anticipation tendency and the worry concerning the limited range of the vehicle.

The "*anticipators*" represented 17,4% of our population. To the question of the questionnaire "In general, in your daily life, you go and take some gasoline...", they responds "far before the signal of energy stock". 48,3% of them are "rather worried" or "very worried" "when the stock signal comes on". They are pro-active to avoid the stress of the failure risk.

The "*moderate anticipators*" represented 36,6% of the population; they tend to re-supply the vehicle "just before the stock signal". The autonomy management is more serene since 22,2% of them are "rather worried" or "very worried" when the stock signal lights on.

The drivers who are "*reactive to the signal*" represented 29,9% of the population; they generally wait "right after the stock signal (1 to 15 km)" for re-supplying. Only 6,9 % declare to be "rather worried" or "very worried" when it lights on.

The "*late refillers*" (16,3%) who get some energy "far after the signal (more than 15 km)" are also only 7,1% feeling "rather worried" or "very worried" when the signal lights on. They run out of gasoline sometimes.

It was actually interesting to know how these profiles are distributed in a larger population and to confirm the co-variation between the anticipative-reactive behavior and the affective relation to the risk of running out of energy.

The quantitative analysis is following the qualitative studies and completes the information on some specific processes. The in-depth qualitative analysis of the processes is a resource to build a relevant questionnaire.

III. DISCUSSION

Innovative modes of mobility such as the use of electric cars and car-pooling can be very efficient ways to build ecologic cities with less traffic and a better quality of life. Sharing cars is also a way of improving the economy of the households and of developing social conviviality. It is necessary to know how users deal with these new services and technologies, and our psycho-ergonomic approach is complementary to more macroscopic economical or sociological studies.

The perspective that we propose is focused on the real activity of the user during situations of use and their lived experience. Taking into account their lived experience of these new situations means that we are interested not only in their rational and strategic conduct but also in their emotional reactions and in their affective motivations to act. For instance the users' affective relation to a specific risk, their emotional tolerance to uncertainty, or their feeling of trust/mistrust built towards the instruments, services, and co-actors of the use, are very important phenomena, which impact their decisions and actions during the use, but they are not enough taken into account.

The methodology is mainly based on specific techniques of interviews (also based on video recordings and diaries) and may be completed by some questionnaires focused on the most interesting processes. There is a limit to these interview methodologies which are the core of our research: they are time-consuming (because of in-depth analysis of the psychological processes of use) and focused on a limited number of subjects. Nevertheless they are very useful for orienting the design; for instance the in-depth analysis of how drivers react to the various instruments helping them to control the car autonomy during the driving situations allows us to re-orient the design adequately. It is not the case through questionnaires for instance; we could not ask precisely how people react in such or such situation. With diaries we can ask people to describe specific use cases but generally they do it quickly and without many details. It is much more complete when an interviewer helps the subject to describe a specific situation of use. The global objective is actually to understand better the user lived experience in order to develop adapted services and technologies.

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