

Capture the Car! Qualitative In-situ Methods to Grasp the Automotive Context

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ABSTRACT

In terms of human computer interaction (HCI), the car interior is a space, which can be divided into three areas: the driver's area, the front seat area, and the back seat area. So far HCI researchers have primarily focused on the driver, and how in-car electronic devices can be designed to assist the driver in order to increase safety and comfort. We propose that for investigating interactive technology in the car in a holistic way, all three areas have to be taken into account. For that purpose we argue for an increased usage of qualitative in-situ studies, which have been hardly applied in automotive user interface research. So far the HCI community has mainly focused on laboratory studies utilizing driving simulators. Despite the broad range of available field study methods, such as ethnographic and self-reporting studies, the adaptation of these methods for the automotive context is challenging due to the specific characteristics of this environment. For instance, cars provide only very limited space, the environment is constantly changing while driving and the driver must not be distracted from driving safely. As a consequence, a lack of experience exists, on how in-situ methods should be applied to cars. In this paper we describe three qualitative in-situ studies, we conducted to research the driver, the front seat passenger, and the rear seat passenger spaces. All three studies used a different method tailored to fit these three areas best. To share our experiences and insights we discuss the strengths and pitfalls of each method.

Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces – *Input devices and strategies, theory and methods*

General Terms

Human Factors

Keywords

Ethnography, contextual inquiry, culturing probing, in-situ study,

1. INTRODUCTION

Personal and ubiquitous computing (UbiComp) technology such as sensors and actuators connected through wireless networks are commonly used to assist humans to perform a variety of tasks. Within the automotive context especially the driver has benefited from a variety of UbiComp technologies. Among others adaptive and autonomous cruise control systems, intelligent speed

adaptation systems, and lane departure warning and collision avoidance systems, are supporting the driver to drive safely. In-Vehicle Information Systems (IVIS) such as navigation and infotainment systems have been introduced to inform and entertain drivers and passengers as well. Additionally the need for integrating nomadic devices such as mobile phones and MP3 players into the car has increased. Thus modern cars have become a major playground for UbiComp technologies.

Despite the richness of such technologies in cars neither Mark Weiser's vision of UbiComp as a calm technology [18], nor Donald Norman's idea of the disappearing computer [14] seems to hold true for the automotive context—at least up to the present. Contemporary cars are often cluttered with buttons, knobs, and touch screens. Many IVIS still cause a high level of mental workload and distraction with more and more infotainment, entertainment and comfort functionality pervading modern cars [10]. When looking at the progress of interaction technologies within the car the design space for driver based automotive user interfaces became evermore complex. This trend contradicts to the vision of future vehicles with a minimalistic amount of user interfaces.

This is not only true for the driver but also for other users in the car. With more interactive technology pervading the vehicle, also rear and front seat passengers become users of UbiComp technology. Besides bringing nomadic devices into the car, passengers will use more integrated infotainment technology to assist the driver or to simply get entertained. Similar to the driver space, a negative side of this development can be the integration of an overwhelming amount of functionality.

To improve the situation of the driver and to avoid negative effects of UbiComp technology on passengers a comprehensive understanding of requirements, experiences, and contextual influences related to the car design spaces is necessary. Thus, we propose two things: First, we propose that the car should be divided into three areas, representing design spaces: the driver's area, the front seat area, and the back seat area. Especially the last two areas have not yet been sufficiently researched from an HCI perspective, although understanding the car in a holistic way required these areas to be taken into account as well.

Second, we claim that that in order move towards Mark Weiser's vision of UbiComp as a calm technology, qualitative methods need to be applied to investigate in-situ aspects of interactive system usage. The automotive user interface community so far has rather focused on laboratory studies, whereas qualitative in-situ studies have been rather neglected. Thereby often driving simulator studies are used to gain insights about driver interactions. The influence of in-situ experiences and related context factors have been rather ignored although the field of HCI offers a broad range

of field study methods to investigate user experiences and their related contexts. Nevertheless, due to the special characteristics of the car, the adaption of these methods for the automotive context is challenging. The car offers only little space and researcher in an ethnographic study might be perceived as intrusive. Self-reporting methods might distract the driver from his primary task and cause accidents. Measurement instruments and recording devices need to be attached safely and need power consumption. Additionally it is often not clear in advance, when the car is being driven. As a consequence a lack of experience how these methods can be applied to cars can be identified. Within the presented research activities, we will show how qualitative methods can be successfully applied in the car.

For that purpose we provide a description of three qualitative in-situ studies. The first study aimed to understand the driver, the second study researched the front seat passenger, and the third study targeted at the whole car with a special focus on rear seat passengers. For each of the studies we used a different methodological approach, tailored to fit best to each of these three areas. In the next section we present the three car design spaces. After a short overview on related literature, we present each study and examine strengths and pitfalls of each method. Finally, we share our experiences and insights and discuss best practices to research the automotive context from an HCI perspective.

2. THREE CAR DESIGN SPACES

In our research approach we divide the car interior into three design spaces: the driver, the front seat passenger as well as the rear seat passenger space (see Figure 1).

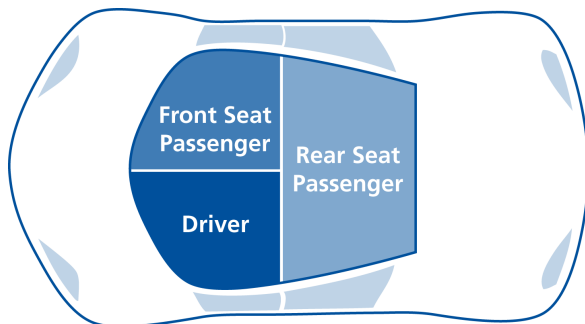


Figure 1: Design space areas for different roles in the car: driver, front seat passenger, and rear seat passenger. Although the automotive context is the same for each space users have different requirements in each area.

To understand each space and its characteristics, it is necessary to study the spaces from a user-centered perspective with the overall goal to achieve a grounded understanding of HCI and experience features. Each design space has to be studied with the overall goal of reducing human-machine interface limitations as well as uncovering optimization potentials. Beyond considering each design space separately, also synergies and interactions between the spaces need to be considered.

2.1 Driver Design Space

So far researcher and car manufacturers have been focusing on the driver interaction space. Nevertheless, there is yet room for improvement and interaction concepts, which have to be addressed by research. These include different ways of input and output systems (e.g. ambient interfaces) that enable new concepts of driver assistance such as persuasive elements. A persuasive acceleration pedal or speedometer for example can help to reduce speeding or can assist the driver in controlling the vehicle as fuel

saving as possible and potentially support driver behavior changes [17]. Nevertheless, the introduction of interactive technology requires a thorough understanding of the design space, related aspects of user experience and context factors, which influence the interaction of users with technology.

2.2 Front Seat Passenger Design Space

The front seat passenger interaction space is not sufficiently covered in state of the art vehicle interface solutions. Traditionally front seat passengers support the driver in their primary task but are also a potential source of distraction. The influence of a front seat passenger affects drivers' user experience (e.g., perceived safety), and therefore can be shaped by providing interactive technology for the passenger in the front row. In cases of driving with a front seat passenger navigation systems, for example, could be more oriented towards this front seat passenger. Front seat passengers could initiate complex search tasks, since they are able to use a screen and input and output mechanisms without major limitations such as distraction from the road. One possible implication is that front seat passengers therefore can use display solutions that include a much higher information load but still can be beneficial for the cooperation. Understanding those processes between driver and front seat passenger will allow the development of interactive technology for both driver and passenger space and make the passenger be a co-driver.

2.3 Rear Seat Passenger Design Space

Rear seat passengers are so far mostly addressed by equipping headrests with DVD players and gaming consoles for the purpose of entertainment. Unfortunately, car-producing companies only offer a very limited amount of personalization and adaption possibilities for the rear seat, compared to other aspects of the car. Therefore, users are often required to adapt the space for themselves in order to make it suitable for them and their children by bringing technology into the car, which is initially not made for this context. Future in-car technology can help in addressing negative aspects of the rear seat and support a positive user experience in that space. It will allow an interactive usage of Internet contents, games and TV. One of the main challenges will be the input and output modalities that can be used on back seats such as multi-touch displays or the utilization of facial input. New types of contextual interfaces can be developed based on taking the surrounding environment (for example by using the color or license plate of surrounding cars for popular children games). A major challenge will also be to keep the driver and co driver in control about what is going on in the back seats. Therefore also front seat passengers have to be included in research activities concerning the rear seat space, since they are directly affected by what happens behind them.

2.4 Holistic Perspective

Therefore we argue for a wider interpretation of the context car as social environment where the driver is engaged in driving as the primary task but also passengers are part of this social context (front seat passenger, other passengers). Our research activities add passengers to the in-car design space in order to get a holistic picture of the car and also to investigate how the other two user groups could influence the driver. The overall goal of our research activities is to investigate aspects of user experience and contextual influences in relation to interactive technology.

Taking the diversity of the design spaces into account, methods to research each space have to address its characteristics. We argue for applying qualitative studies for investigating each design space, as described in the next chapter.

3. QUALITATIVE STUDIES IN AUTOMOTIVE UI RESEARCH

Up to date qualitative in-situ studies have rather been neglected from the automotive user interface community. We have analyzed the proceedings of the 1st and 2nd international conference on automotive user interfaces and interactive vehicular applications (AUI 2009 [16] and AUI 2010 [2]). Among the overall 47 papers (AUI 2009: 22, AUI 2010: 25) only one paper reports on a qualitative field study [8]. The majority of the papers reports on lab based studies often analyzing a prototype by utilizing a driving simulator (44.68%) or other lab based studies (8.51%). 14.89% of the papers referred to field experiments (e.g., on road experiments) without studying participants. 21.28% of the papers do not include user studies at all. Additionally we counted two papers reporting on online studies and two papers provided a literature or picture analysis. Besides the AUI, only a very limited amount of CSCW and CHI publications applied qualitative research in the car, exceptions from that trend are for example the works by [6] and [12].

A potential downside of lab-based studies is the small focus on a certain design problem without addressing the design space as a whole. To design interactive systems for in car usage it is necessary to understand the context of use holistically. This should include all influencing factors such as environmental conditions, traffic conditions, constraints due to car abilities or internal social factors. Outside the HCI literature, there do exist qualitative studies most of them using analyses of video records [11] often on a large scale [3]. We have decided not to rely on video resources but use other approaches. The in-situ studies presented in the following, aim at generating a first understanding of the cockpit by addressing each design space and will aid in the generation of focused research goals for future activities.

Three types of qualitative studies were chosen, one for each design space. The following chapters report a contextual inquiry (CI) addressing drivers' conduction of tertiary tasks, an ethnographic study focusing on assistance in the front row and a probing study focusing on technology usage in the rear seat. We chose these different methods with respect to the special characteristic of the car. The CI was chosen to research the driver while driving including different contextual (e.g., road conditions) and user experience (e.g., satisfaction) factors. We used an ethnographic setup to investigate the social space between the driver and the front seat passenger. Due to space limitations within the car and to be less intrusive we investigated the rear seat space utilizing a method without researcher attendance, namely cultural probing.

In the following the study setup including reasoning for choosing the corresponding method and overview of study results are provided. In addition we elaborate strengths and pitfalls for each study method.

3.1 Driver Design Space: Contextual Inquiry

For researching the driver design space, the contextual inquiry (CI) method was chosen. CI is a qualitative user-centered research method, based on the idea of a one-on-one observation, traditionally aiming at observing a user's daily routines or activities [1]. The CI method follows a master-apprentice role model. Thereby the participant takes over the role of the "master" and the researcher is the "apprentice". The apprentice observes and tries to understand tasks the master conducts. If something is unclear the apprentice asks the master for clarification. The focus of this method lies in understating performed tasks. Using this

method researchers go to the users locations (e.g. offices, schools, hospitals, homes, etc.) to understand the context in which activities take place [15].

We chose to apply this method because of the benefits it offers in contrast to a pure interview or questionnaire: Due to the fact, that the inquiry takes place in the user's natural environment, it is possible to achieve a better sense of the context in which the inquiry takes place. Furthermore, information about user experiences, while interacting with an interface can be gathered, which helps the researcher to gain a deeper understanding of the user's actions. We chose the CI over the other two methods presented in this paper since we were especially interested in the driver tasks. Seeing the cockpit as workplace of the driver made the CI, which is traditionally applied in work settings, the most suitable method. In the automotive area, General Motors have successfully deployed a CI with 30 participants to study how drivers interact with entertainment, communication, navigation and information systems in their vehicles [8].

In our study we utilized the CI to investigate the interaction of drivers with a specific IVIS, namely multifunctional in-car interfaces such as rotary knobs located in the center stack. Examples for such interfaces are the BMW iDrive or the Audi MMI controller. The focus of this study was to understand in which way participants interact with the system. Additionally context and user experience factors were identified and analyzed towards their influence on the use of the system.

3.1.1 Study

The CI took place over a period of six weeks. Target groups for the study were people who own, and regularly use a multifunctional rotary knob in their car. Ten people (1f, 9m) from 24 to 63 years old took part in the study. All cars in which the CI took place were equipped with either the BMW iDrive, the Audi MMI, or the RNS-E System from Audi—a kind of previous model of the MMI.

For the CI a researcher was sitting in the front passenger seat taking notes regarding the conducted tertiary tasks, context factors (e.g., traffic, weather, road conditions), and user experience factors. An observation pattern was prepared and structured into the following categories: "function" (e.g. radio), "conducted task" (e.g. turn on/off the radio), "context factor" (e.g., highway, sunshine), "user experience factor" and "notes". In addition, the conversation between the driver and the researcher during the ride, as well as an optional interview after the ride was recorded with a voice recorder. For the interview a guideline was developed containing questions on the conducted tertiary tasks, the use of the IVIS in general, as well as requirements for the system. The route for the rides, which lasted at least one hour, was determined by the participants themselves to ensure natural driving conditions.

As mentioned before, our findings are based on the notes, taken during the drive as well as on the voice recordings. For analysis the data was transcribed and structured. Findings were grouped into similar categories (tasks, context factors, UX factors). Overall we were able to identify more than 15 different tertiary tasks performed with the IVIS. Most of them concern operation of the radio, navigation system and telephone. General attitude towards the particular IVIS was positive although participants had problems in conducting different tasks, especially when using the voice command functionality. In terms of user experience, comfort, safety and security where the most occurring factors in connection with the operation of the navigation system. Interestingly, the UX factor aesthetics in the sense of visual as

well as haptic quality was not mentioned at all by participants. The detailed findings of this study are currently under publication and not in the focus of this work.

3.1.2 Strengths and pitfalls

In the following part we provide methodological strengths and pitfalls of the CI in our study. The number of ten participants was appropriate for gathering a first view on the particular IVIS usage. Within the study no new or significant findings were generated after the observation of eight participants. The time effort for conducting the study was rather high but well invested, since the observer gained an in-depth understanding of the drivers' tasks in "real-time" and correlating influencing context factors. In one case, for example it was observed, that the driver barely realized that he was going to use the entranceway of the underground car park to leave it, when operating his navigation system. Episodes like that and the information gathered in these episodes are not replicable when only conducting an interview.

A high amount of input was gathered from audio recordings used, because during the drive it was hardly possible to note all information and impressions. The developed interview guideline was a valuable instrument to keep focused on the central research questions and the observation plan turned out to be practicable to roughly structure the data during the ride.

A major concern with the CI is that the observer might influence the driving situation (e.g., when asking questions during the ride) and therefore could distract the driver from operating the car safely. Additionally it was rather difficult to gather extensive data about the context factors that might influence the driver as well as the driving situation. Since the researcher could only focus on one aspect (e.g. the currently conducted task), other context factors were not recorded. Also taking notes during the drive was difficult, since the researcher has to write down his/her observations and simultaneously observe the driver and the ever-changing context. Additionally there is a threat of becoming motion sick during writing.

Another aspect is that one driver seemed to feel uncomfortable taking a person with him he does not know in the beginning. This could have had an influence on his behavior and the tasks he conducted during the ride. Another participant did not use the hands-free equipment due to privacy reasons.

Summarizing, the contextual inquiry for investigations in the automotive area was difficult but nevertheless successfully adopted. The drivers were open-minded and, according to their feedback, did not experience the observer as a source of irritation. The valuable information we gathered by riding along with ten participants encourage our team to further investigate driver interaction modalities.

3.2 Front Seat Passenger Design Space: Ethnographic Study

As stated above, over the last years an increasing number of driver assistance and driver information systems have pervaded the car. Some of these systems may be not only operated by the driver but also by the front seat passenger. Front seat passengers, for example, can undertake tasks to allow the driver to concentrate on the primary task (e.g., manipulating the radio), as well as support the driver (e.g., navigation). Thus collaboration in the car between the driver and passengers becomes more important [6]. To investigate this collaboration we performed an ethnographic study.

Within the HCI community ethnographic studies have gained considerable reputation as a technique for researching how individuals are working in groups or teams, and how they can be supported by information and communication technologies. The main characteristic of ethnography is that a researcher physically takes part in everyday life for an extended period in selected social environments with the goal of collecting data and description for further analysis [5]. Thus ethnographic studies provide knowledge of a context and the related experiences of users. Unfortunately only a few studies exist that advocate the benefits of studying car related aspects with an ethnographic procedure although driving a vehicle is a collaborative and social activity [9]. Esbjörnson et al. [4] mentioned the importance to perform in-situ studies of mobile phone use in cars in everyday traffic situation with an ethnographic fieldwork.

The main goal of our study was to research how an interactive system could support front seat passenger assistance (e.g. by presenting different kinds of information to the driver and the front seat passenger), and how an interactive system that assists the driver could learn from human assistance. For that purpose we conducted an ethnographic study aiming at collecting assistance situations and the context they happen in, as well as related aspects of user experience. The results are a collection of user experience factors and context factors interconnected with front seat passenger assistance as well as a deep understanding of the social processes involved.

3.2.1 Study

The study took place over a period of two months. Target group for the ethnographic study were people from car-sharing platforms, who are used in sharing their car with other people (in that case the researcher), and usually drive the same routes on a regular basis. 9 drivers and front seat passengers aged between 20 and 32 years old (mean: 27.9 years) were recruited and observed. The fact that those people spend a lot of time together enabled us to observe usual attitudes and real interactions. By being involved in the "everyday-life-driving-situations" the observer can take notes, describe the situation, and ask context related questions. The participants were 7 male and 2 female drivers, while 8 male and 1 female participant sat in the front passenger seat.

To generate detailed descriptions and information about the assistance situations a researcher joined the participants by sitting in the back row. Paper and pencil were used to log the situations. In addition, the driver was asked to answer a short questionnaire after the trip (e.g., demographic questions, UX questions about the current trip).

The data was evaluated with qualitative data analysis software. First all observations during the fieldwork were digitalized. Each assistance situation was classified into three areas: highway, national road and urban street. To organize the recorded information two researchers classified the data into attitudes and context factors that influence front seat passenger assistance. As a next step we compared defined categories to generate a picture of behaviors and thoughts classifications. Thereby it was possible to point out driver assisting actions to understand in which specific situation the front seat passenger assists the driver and what those situations looked like. Figure 2 shows a typical assistance situation from the researcher's perspective.

Within the study we identified about two hundred assistance episodes, most of them related to manage the driving task together. Results for example enabled us to divide assistance episodes into conscious/unconscious, explicit/implicit, or verbal/nonverbal dimensions. The results confirmed related

findings that driving a vehicle are a traffic common and social activity, where risks are handled in collaboration between the driver and (front seat) passengers [9]. Detailed of the study results are currently under publication and not in the focus of this work. Based on the ethnographic results we are developing new concepts for assistance in vehicle presenting different kind of information to driver and front seat passenger.



Figure 2: Ethnographic study in the car. The picture exemplifies the researcher's perspective on the driver and front-seat passenger.

3.2.2 Strengths and pitfalls

The ethnographic study is a promising method to research UX and context factors that have an impact on different forms of assistance. Our findings enabled us to connect the functional and technical aspects of driver assistance systems with social processes occurring in the vehicle. They enabled us to identify assistance situations and relate them to various traffic conditions (e.g. weather, driving during night or on the day, critical vs. non critical driving tasks).

A main advantage of the in-vehicle ethnography was that we could identify patterns of driving behavior, relationships of the driver and the front seat passenger, estimations of the traffic conditions, and decision-making processes for assistance. Our experience showed that it is helpful to recruit participants from car-sharing platforms, due to the fact that they usually drive with front passengers. Driving together was a common behavior for the participants, which could be observed in our ethnographic study. The selection of our participants allowed us to investigate different age groups and genders, as well as to observe behavior in variable contexts (e.g., highways, national roads, and urban streets).

A major disadvantage of the ethnography was the biasing of participants through the presence of the researcher. We observed a rather artificial behavior during approximately the first half hour. After this time normalization in behavior could be observed. This fact has to be considered, when analyzing the data. The longer the observation lasts (as in classic ethnographies), the least severe this effect will get. Another challenge was to find the right balance between detailed annotations and an overview of the situation. This was especially true in our study, since we investigated the influence of different context factors on the assistance episode. Nevertheless the ethnography is indeed useful for observing the front passenger as a main topic for adapting social assistance and for generating new design of in car technologies.

3.3 Rear Seat Space: Cultural Probing

As mentioned in the introduction, we guide our work regarding automotive user interfaces by dividing the design space into three areas. The rear seat space as third area has not been addressed sufficiently in automotive user interface research. Nevertheless, researchers and designers such as [13] already highlighted the importance of the rear seat as interactive space. We argue that researching implications for technology usage in the rear seat is highly relevant for user experience off all passengers in the vehicle.

Aiming at researching the usage and the potential of interactive technology on the rear seat, we chose families, whose children mainly travel on the rear seat, as target user group for our study. We acknowledge that the usage of the rear seat is more diverse than that but see the presented study with children as first step of investigating the rear seat space. Families with children were chosen for a first study since in relation to their total trips they were expected to conduct a high number of trips with children sitting in the rear seats.

We conducted a study in the rear seat, with the main research goal of investigating how families use the rear seat area and which implications for HCI exist when introducing technology in this area of the car. To address the research goal, we decided to apply the cultural probing method developed by [7]. The main idea of probing is to involve users in the design process by provoking them to reflect aspects of their everyday life. This is done by giving them tasks and tools to record relevant situations and artifacts, such as photos, diaries, and postcards and by supporting a creative approach to the study topic.

By letting the users collect probes, the researchers gain knowledge about the emotionally laden processes that evolve in the rear seat and within the interaction between passengers in the vehicle. Although not representative, probing results are highly relevant for the design of interactive technology since they inspire designers by giving them a direct view on the context and the experiences that evolve within the space.

3.3.1 Study

We invited 20 families with children using the rear seat to participate in the probing study. We asked at least one member of the family to take part in an initial one-hour workshop where we explained the study goals and the probing package. The participants kept the package for about four weeks, after returning it they were invited for a final workshop in order to discuss the probes and method related issues. The probing package was intended to inspire participants and to provide them with tools to take the probes. It included a roadbook (a metaphor taken from rally sports) with the probing tasks and free space for comments. Additionally the package included a disposable camera, postcards, pens, markers, glue, sticky notes, stickers and a large sheet of paper for a collage (see Figure 3).

17 families returned their probing package and were included in the interpretation. The families had 28 children in total with a mean age of 6.7 years. The probes were digitalized and separately commented by five researchers with different backgrounds. Each probe was analyzed towards its explicit and implicit content. The comments were collected, grouped and discussed in workshops. The results from these workshops were structured to areas of interest for the design of future interactive systems in the rear seat. We were able to gather input on the following aspects of the rear seat space: aspects of diversion, educational motivation, togetherness, food as activity, physical space, perception of safety

and mobile computing. Detailed results of the probing study are presented in [19].



Figure 3: Probing package including the roadbook, a disposable camera, postcards, pens, markers, glue, sticky notes, a large sheet of blue paper for a collage as well as a large paper cup for storing the items while driving in the car.

3.3.2 Strengths and pitfalls

Same as the CI and ethnography the probing method demonstrated to have strengths and pitfalls. Participants stated that almost all probing materials were used as shared activities with their children. The communicative aspect of probing was mentioned positively—participants liked to communicate about the probing and incorporated friends or other children into the idea generation.

All families that returned probing packages used the road book. Whilst one family mentioned that they would have liked a more diary-like structure, most participants liked the book a lot. Participants mentioned particularly clarity, guidance, fun illustration and compactness.

Using stickers for marking and rating objects of interest was described as a very good way to start brainstorming about the different parts in the rear seat area. Still, some families had difficulties to find appropriate photo motifs to express their ideas (e.g. a motif that expresses missing functionalities). Whereas some participants mentioned the disposable cameras as good and practicable idea, other participants dismissed them because they were not used to analog cameras or because of their environmental impact. Besides the disposable cameras participants sent us pictures taken with digital cameras and mobile phones.

A high amount of input was gathered from the collages as most participants invested a high effort in creating them. It turned out that the collage was the part of the provided package that best involved the children and triggered the most ideas. The participants liked the collaborative task and described it as *creative and inspiring*. The request to utilize self provided material (e.g. snippets from magazines) lead to a broad range of components for the “ideal rear seat”.

While some participants simply forgot about writing postcards, others liked them a lot (in total they sent back 27 postcards). An unintended effect of the postcards was that they constantly reminded participants of the study as while writing postcards to their friends and family the study postcards came to their mind. Calling our voice mail or text us was neither liked nor done by the participants. We did not receive any voice mails and only got one short message. Reasons for this were that participants feared saying something *trivial*, or that they just forgot to do so.

Overall the probing material inspired participants to creatively approach the rear seat areas in their cars. Feedback given by the participants showed that the probing study changed the way they saw their rear seat area. One participant left a handwritten note for the researchers saying: “(...) it was a lot of fun. Apart from that my husband finally put something for the kids into the car (e.g. reading light, drawer...)”

4. DISCUSSION

The previously described studies show that in-situ studies within the car are challenging but lead to valuable results. The set of contextual study methods in HCI provides a good base for researching the car. Nevertheless, the peculiarities of the automotive context have to be taken into account, when setting up and conducting field studies within the car. Table 1 gives an overview of challenges that have to be considered.

4.1 Safety and Distraction

To go by car is a dangerous undertaking. Year after year thousands of people are injured and killed on our roads. The tiniest distraction of the driver may lead to an accident. Therefore safety has to be the highest priority, when undertaking an in-situ study in the car.

Especially the driver must not be distracted from his primary task. Data collection has to use methods that do not sidetrack the driver from safely driving the car. The driver should keep his eyes on the road and his hands on the steering wheel. Questionnaires and self-reporting methods are excluded during driving unless it is possible for the driver to answer them verbally. If the driver is questioned or interviewed during the ride the specifically contextual situation has to be considered. As an example it would be unwise to ask the driver during a dangerous situation or in moments of stress. In case of researching the driver the presented contextual inquiry (CI) is a promising approach. The CI allows the researcher to react to situations dynamically, ask questions only in appropriate situations, postpone questions if a dangerous situation occurs, and observe the driver and his/her reactions instantly. The possibility of the researcher to adapt the method, even to unexpected events, makes the CI superior to technological solutions such as automated questionnaires.

Another safety related aspect is research equipment introduced brought into the car. For the both the CI and the ethnography we used paper and pencil to take notes during driving episodes, for the CI we additionally used a voice recorder. This equipment posed no risk, since the researcher carried these items near the body. When other equipment (e.g., video recorder, laptops) is deployed to record data, a secure attachment in the car has to be used. For the probing study we made sure that the probing material (e.g., through away camera, pens, roadbook, postcards, etc.) fitted into a plastic cup, which could be easily stowed securely in the cars cup holder. This did not only solve security issues but also saved space, which is usually rare in a car cabin.

4.2 Intrusiveness and Privacy

Another aspect, which has to be taken into account when investigating the car cabin, is intrusiveness and privacy. The interior of a car is relatively small, compared to other in-situ research contexts (such as for example homes). Therefore observers can barely keep themselves in the background. In field studies there is always the danger of influencing or biasing participants, this is even truer in the confined space within a car. Surprisingly, we did not experience tensions in that regard within our studies. In the CI, the researcher was very welcome and did not perceive to be a disturbance for the driver. One challenge

Table 1: Overview of challenges for each proposed in-situ study method.

	Contextual inquiry	Ethnographic study	Cultural probing
Safety and distraction	Relative safe and little distraction; allows researcher to react to situations dynamically and ask questions only in appropriate situations	Very safe and no distraction, researcher does not interact with the driver	Safety and distraction depends of the probing focus (e.g., driver vs. passengers) and the place and time in which the probes have to be handled (e.g. during a ride or after).
Intrusiveness and privacy	Researcher present and asking questions; researcher has to be careful not to be intrusive	Researcher not perceived as intrusive; privacy issues have to be handled with care	Since no researcher is present neither intrusiveness nor privacy play an important role; amount and type of information given to the researcher can be controlled by the participants
Organizational challenges and effort	Context factors, description of the situation and answers have to be noted; voice and video recorders could solve this problem, although effort for data evaluation is increased; planning and coordinating trips and motion sickness are challenging, effort for participants is low	Context factors, description of the situation have to be noted; again voice and video recording is an option, which in turn intensify analysis; planning and coordinating trips and motion sickness are challenging; effort for participants is very low	Effort for researcher is the preparing of materials and data analysis; effort for participants is higher

nevertheless was to try to keep the driver within his/her natural way of behavior. By asking questions about their tasks, the researcher unintentionally caused drivers to try out functions with their in-car systems, which they had never tried before. The study triggered their interest in new aspects of the system or caused them to give some sort of presentation of what their car was able to do. These episodes had to be excluded from the interpretation, since we wanted to research their natural usage of the systems.

In the ethnographic study, the researcher was not perceived as alien element, simply due to the fact that participants were recruited through a car sharing platform and therefore used to taking strangers with them. The researcher experienced that after a few minutes the front row had forgotten that someone was sitting in the back row and therefore acted naturally. In both studies we experienced it as extremely beneficial to carefully explain, what the goal of the research was. This supported the acceptance of the researcher and additionally motivated the participants to contribute to the study goals. In the ethnographic study no influence of the study goal explanation on the assistance behavior was observed.

When the presence of a researcher is impossible, due to the limited space in the car or social implications such as privacy, self-reporting methods such as probing are a promising approach. The only major downside of those studies, which we identified for the vehicle, is the lack of a trigger that clearly indicates for the participants, when to log something or when to take a probe. This is especially relevant during trips, when participants simply forget about the study. Future self-reporting methods in the car will benefit from a context aware trigger, such as traffic and driving situations, which elicits a study related action of the participant without reducing safety or causing annoyance.

4.3 Organizational Challenges and Effort

Since all studies addressed contextual influences, context factors, which affected the interaction in the car, needed to be observed. This may lead to a potential overload of the researcher, since both the observation and the related context factors have to be logged. We tried to address that issue by pre printing observation sheets. The sheets supported the researchers in structuring their notes;

they helped remembering aspects, which had to be logged. We also considered pre printing context factors (e.g. certain road conditions) to allow the present researcher to just check them off. We refrained from doing so due to the sheer mass of potential factors and the risk of biasing the researcher. For future studies we therefore highly recommend the support of the researcher with audio and video recording to reduce the pressure of logging every aspect of a situation. This would also reduce the problem of motion sickness. In both the CI and the ethnography, researchers reported problems in taking notes, simply due to sickness caused by the car movement. The main goal therefore has to be the reduction of notes that need to be taken through the support of other logging approaches. In the CI, we used a voice recorder for that purpose. Unfortunately we had to discover that although we used a microphone clipped on to the driver, the ambient noise made it hard to understand the recording. Special microphones and recording solutions will be necessary for future studies.

Other organizational challenges within the studies were the recruiting of participants and the actual conduction of trips. Especially within the CI, the target group was relatively small due to the requirements we had towards the cars. Finding participants who owned with multifunctional in-car interfaces was possible but required a high effort, also because our expense allowance was no incentive for participants owning expensive cars. Once potential participants were found, it was a long process to arrange the trips together with the researchers. Within the ethnographic study we tried to solve that issue by selecting a special group of drivers and passengers, which were easy to reach through the online car-sharing platform. While this does not pose a representative sample, we argue that our results lead to implications for a wider group of drivers and passengers than the one we researched, similar to [4]. In the probing study, recruitment was relatively easy. Again we reduced our target group to one specific group using the rear seat area, namely families. For probing, we supported the recruitment with the incentive we offered. The yearly passes for the local zoo addressed families who try to do many different free time activities. Those families saw probing as another leisure time activity and therefore participated actively in the study.

In general, the effort, which had to be invested in the studies, especially for collecting and interpreting data, was high. Regarding effort for the participants, both CI and ethnographic study were relatively effortless; the probing study on the other hand caused a high workload for the families.

4.4 General Implications

Generally it can be concluded that all three methods provided to be a reasonable approach to investigate the different areas of a car. Not surprisingly more context and UX factors were gathered, when a researcher is present (e.g. in the CI or the ethnography, compared to the probing study). On the other side these two methods were the most intrusive for participants. Additionally these methods were very time consuming and the planning of single observation episodes was difficult.

5. CONCLUSION AND FUTURE WORK

In this paper we have proposed to divide the car into the three spaces driver, front seat passenger and rear seat passenger. We argue that these areas need to be addressed by use of qualitative in situ methods. We have presented three different methodological approaches to research these areas. All methods have advantages regarding their intrusiveness, effort, and safety related issues but also suffer from disadvantages.

In the next step we will conduct the following activities: In a first step, we will use the results of the presented studies to develop interaction designs, matching the experiences and contextual influences, which we identified in each of the three design spaces. We are currently developing new input mechanisms for tertiary driver systems, novel front seat passenger assistance interfaces and prototypes for rear seat gaming. For example, based on the probing results we developed the rear seat entertainment application "RiddleRide", an educational riddle game for all passengers which takes the diversity of passengers and the dynamic context into account by asking questions about the surrounding and giving answers with a varied level of difficulty. Furthermore we will iterate the introduced study designs by conducting a second round of the presented studies in the vehicle. Supplementing those efforts, we will introduce other approaches such as self-reporting methods (e.g., experience sampling, or diary studies) into the car. The final goal is to create a method set, which allows the holistic understanding of in-car user experiences and their contextual influences.

6. ACKNOWLEDGEMENTS

The financial support by the Federal Ministry of Economy, Family and Youth and the National Foundation for Research, Technology and Development is gratefully acknowledged (Christian Doppler Laboratory, Contextual Interfaces).

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