Second Dashboard: Information Demands in a Connected Car

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Abstract

Traditionally automotive UI focusses on the ergonomic design of controls and the user experience in the car. Bringing networked sensors into the car, connected cars can provide additional information to car drivers and owners, for and beyond the driving task. While there already are technological solutions, such as mobile applications commercially available, research on users' information demands in such applications is scarce. We conducted four focus groups to uncover what kind of information users might be interested in to see on a second dashboard. Our findings show that besides control screens of todays' dashboards, people are also interested in connected car services providing context information for a current driving situation and allowing strategic planning of driving safety or supporting car management when not driving. Our use cases inform the design of content for secondary dashboards for and especially beyond the driving context with a user perspective.

1 Introduction

The classic focus of the automotive HMI is on design of in-vehicle interfaces. The aim is to inform the driver more effectively, providing ergonomic control and car-assistance systems matching humans' physiognomy and mental models to improve road safety and relieve drivers (Gkikas, 2012; Murata et al., 2013). In the last years, car experience design became a vivid research topic asking how to provide positive in-car experience to improve the quality of time e.g. by entertainment systems, in-car gaming or promoting social interaction (Alt et al., 2010). In this vein, also innovative modes of interaction are researched (Pfleging et al., 2012). The technological and societal progress towards connected cars offers new possibilities for automotive HMI (Swan, 2015).

Making a car a *connected car* is typically understood as a way of enabling car-to-car or car-to-infrastructure communication. Apart from new cars coming with such functionality, there are also upgrade modules / hardware to provide a remote access for current and older cars (Barcelos et al., 2014; Coronado et al., 2013). Mostly they use the on-board diagnostics (OBD) or controller area network (CAN) interface to access vehicle-specific data. In addition, such devices often have GPS and accelerometers to provide additional data on car movement and position (Al-Taee et al., 2007). Similar to what is planned for cars connected by default, data

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is then transmitted via GSM or LTE to be processed in a backend and finally visualized on common consumer devices.

By connecting the car and its multiple sensors to the internet, it becomes a cyber-physical system in the hand of non-experts, similar to what smart home systems. Research shows that such systems both provide means for improved management capabilities and knowledge about self-behavior, but also spark a need for awareness, such as for setting levels of privacy (Jakobi et al., 2017). Given that the connected car will soon be the default for newly built cars, we similarly expect that today's in-car dashboards will not be able to – and from a security and driver distraction point of view should not – display all data of interest to car owners. Instead, a second screen could extend the primary dashboard and provide additional car-related information. Similar to dashboards provided in Smart Homes or the second screen concept in media research, where users can receive additional information about a TV program via other devices (Hess et al., 2011), we define a second dashboard as follows:

> *The second dashboard is a device or application that allows extensions of the primary automotive experience on a second screen (e.g. smartphone or tablet).*

Whereas there are technological and market-driven commercial solutions such as smartphone applications available, research on what information users believe a connected car should provide, is scarce. We therefore conducted a user study to gain insights on how a second dashboard could support car owners in driving itself and make use of digitally available car data otherwise, such as improving car management or reflecting on their (driving-)behavior.

2 Designing for the Connected Car Data

Automotive UI is a research field, which investigates efficient visualization of relevant data for drivers (Schmidt et al., 2010). Research in this field typically aims at choosing and visualizing data in a way such that distraction from driving and thus potential dangers for road users is minimized (Pickering et al., 2007). At the same time, HMI (Kern and Schmidt, 2009; Schmidt et al., 2010) and interaction modes (Pfleging et al., 2012) in the car are targets of current research efforts.

In recent years, this challenge grew by a manifold of sensors, which are positioned in cars in the light of providing new features for drivers. More recently, manufacturers have started to put efforts in connecting the local sensing infrastructure within a car to a cloud backend (Häberle et al., 2015). The so-called "Connected Car" is not only foreseen to improve manufacturers' knowledge on car or vehicle parts performance (Bernstein et al., 2010), it is also often connected with the promise of autonomous driving, car-to-car and car-to-infrastructure communication becoming possible (Gerla et al., 2014). Also, from a technological point of view, cloud-based platforms for car data are researched (Bernstein et al., 2010; Häberle et al., 2015). The user largely profits from gaining higher comfort and security of driving by e.g. navigation services, automatic lane keeping, adaptive cruise control or other driver assistance systems (Kranz et al., 2008a). Research also investigates the potentials of integrating context information into HMI (Pfleging et al., 2013).

In light of increasing data visualization and potential distraction, Automotive UI seeks for an answer for the increasing gap between the visualization of potential and actual data (Green, 2004). Similarly, extending the car dashboard with nomadic devices when driving or integrating them into in-vehicle information systems is investigated from a technological perspective (Sonnenberg, 2010). For example, Kranz et al. built a tool to improve driver awareness via car-to-car communication (Kranz et al., 2008b). Nomadic devices are also investigated to find out of how users can benefit from such devices in the connected car (Lapoehn et al., 2014).

Designing for informing drivers beyond the actual driving task itself, however, has gained far less attention so far. Several manufacturers already provide mobile applications for their cars, such as the "BMW CarData", the "Mercedes me" or Volkswagens "Car-net" portal. However, the "Second Dashboard" lacks a systematic research of potential benefits from a user perspective: What would users want to know from their car? What do they need for handling a connected car? What do they envision to gain from car data becoming available to them? These are the questions, we turned to in our user study to better inform and motivate the design of applications extending the primary dashboard in connected cars.

3 Methodology

The aim of this study was to explore what information might be useful while using a second dashboard in general. Therefore, we conducted four focus group interviews as a well-established methodology for exploratory research to obtain as wide a range of responses (Mayring and Fenzl, 2014). Each focus group interview lasted on average about 30 minutes, based on the following script:

In the first phase, we as moderators introduced the topic connected car and the second dashboard. Then the participants were asked to write down on cards their ideas, information needs, and requests that might be of interest to them. To stimulate the discussion, the moderator gave some examples of possible ideas. Sometimes these ideas were taken by participants and inspired them to elaborate own ideas. This kind of trigger was often necessary as most participants had no relation to the connected car concept, some of them do not own a car, or rarely drive a car. In the second part, the cards were presented and discussed among the participants. In the last part, participants were asked to group cards that are closely related from their perspective. We asked them to give each group a title that summarize common issues and give it an expressive name.

The focus groups were quite heterogeneous in terms of age and gender. The age ranged from 24 to 57, with the majority of participants between 25 and 30 years old. The selection of the participants was deliberately chosen to be younger due to the high affinity to mobile devices. We interviewed participants with a different intensity of car usage and different household situations, meaning how many people live in a household. The car usage reached from several times a month to daily use and we interviewed people who live alone and up to four people in the household, this is particularly interesting in terms of car use or sharing and opens up new demands for connected car services. The mentioned ideas and categories were often similar

and largely matching each other. This indicates a kind of data saturation (Glaser and Strauss, 2009) – even if the mentioned list of ideas and information needs is certainly not exhaustive. To achieve a common category scheme with a greater interpretative strength, we comparatively analyzed and joined the results of all focus groups. This analysis was guided by the qualitative content analysis methodology (Mayring and Fenzl, 2014).

4 Findings

Our analysis reveals a set of information themes as well as presentation themes. Information themes are about the content our participant mentioned in the focus group interviews, means the information they would like to see on a second dashboard on i.e. their smartphones. Presentation themes are about how the information should be presented, means how can specific types of information be presented to the consumer, how they can be visualized and how can the car relevant data be combined with other applications.

4.1 Information themes

4.1.1 Defective Parts

An important theme often mentioned by participants was the desire to get informed immediately about vehicle defects or damages similar to existing car warning displays. In addition to the single information that something is broken, some participants suggested to get more information about the problem, the severity, and how it could be repaired. Concerning this, various options were discussed, how a second dashboard could support the *car repair literacy* e.g., by giving clear instructions for repairing the car by locating and giving detailed information about the defect part (e.g., with pictures, videos, and text), providing recommendations for buying or changing defect or wear parts. In addition, it was seen as helpful when information about spare parts, repairers, and approximate cost of the repair was provided. A recurring issue was that such information helps to feel safer driving a car and to save money by self-repairing.

4.1.2 Wearing Parts

Another often-mentioned theme was to get informed about vehicle components that are wearing off substantially when driving. In contrast to defective parts, they are not broken, but taking an eye on them is important for two reasons: (1) Legally binding safety requirements, such as a minimum tire profile, and (2) wearing components such as brake discs must be fixed or replaced in the future.

Currently, the wear condition must be checked manually and periodically, on suspicion, or on certain upcoming occasions, such as longer drives. In future, most participants perceive it as an advantage, when the conditions are checked automatically to display the information in the second dashboard. Besides the tire pressure, participants mentioned the condition of brake discs, clutches, spark plugs, starter, wipers, and level of oil, coolant, and washer fluid.

Being informed when to replace, repair, or refill them *before* a defect occurs, could help to avoid both stress and potentially repairs that are (more) expensive caused by collapse of one component while driving or prevent dangerous driving conditions. The primary demand of most participants was therefore a second dashboard to provide drivers an overview of the current state and evaluate the vehicle condition without having to rely on expert knowledge. Especially for older cars, such information was mentioned to increase the perceived safety of the driver. Overall, wear awareness was understood to allow planning ahead car maintenance. Being potentially critical, also the option was requested to get an alert when e.g., the brakes or cooling water has reached a critical state. In addition, such incidents should also made a corresponding entry in a task list (see below).

4.1.3 Remote Awareness and Remote Control

Remote car awareness refers to get informed about the car status nearby or outside the car. For example, information on whether the lights left on, a released handbrake, unlocked doors, or a detected intrusion attempt. On the one hand, this information was demanded for reassuring everything was okay with the car. On the other hand, knowing something was wrong before using the car the next time could reduce or prevent damage.

Additionally, some owners share their car with others– e.g., with their children, friends, or via private car sharing. These persons had an interest in various *surveillance* features. First, participants mentioned demands for controlling driving behavior as a means for assuring the car was being handled with care or driven economically. Another use case rather targeted what the driver did when using the car, by following its GPS location. For example, entering or leaving geo-fenced areas could be defined to raise a notification.

For some participants, it was enough to get notified. Others also were interested in remote control the car with their smartphone. This was either for reacting to a car-related issue, for example locking an unlocked door, or for comfort-purposes such as regulating the heating before entering the car.

4.1.4 Task List

Participants reported that keeping track of different checkup intervals for a car was burdensome. Primarily, most cars notify when e.g., inspection is due, instead of providing awareness in the run-up. The connected car could generate a task list to support a long-term car management. This list could contain tasks such as the next general inspection or oil change, as well as externally defined tasks such as the next MOT-test, or dates to check insurance.

Some participants suggested that the task list should include information about the nature of the task (repair a defect, regular or on-demand inspection), provide explanation, and inform when and where the work could be done or has to be done (e.g. replacement of brake discs due next week in an authorized workshop). Besides forthcoming inspections, wear and defect information should be integrated in the task list. Most participants like the idea of the connected car generating such a task list automatically. A perceived benefit was that such a list helps to get an overview of all upcoming dates, repairs, and tasks around the car easier. In addition, the

tasks should be ordered by urgency and recommendations for the best time and place to take action.

In addition, the idea was mentioned to synchronize the task list with the personal calendars to better be able to match dates with other appointments. The list should be linked with the financial overview (see below) to be able to forecast, plan, and evaluate future costs.

4.1.5 Overview about Financial Issues

Financial overviews were desired to provide past and future expenses related to the car. Issues requested were gasoline costs including average fuel consumption, tax payment, car repair costs, insurance costs, but also current market value of the car. Two ways of presentation were suggested: chronologically and in relation to the driven kilometers. The goal for the users should be to recognize at a glance what the car's costs amounted to in the last quarter. The hope is that connected cars could collect data of wear parts, defects, kilometer state, and other issues to make valid prediction about future costs. In addition to the costs, participants liked the idea of getting feedback about the current market value by comparing the actual state of the car with the price of related cars in online sales portals. Further, some participants consider that the car data could be used to get personalized recommendations about used cars and tuning products.

Several ideas were related to the connection with other applications, like logbook, tax, or business software. The data exchange, for instance, could be used to fill out forms, adapting depreciation to the actual residual value, and allow better financial planning. For car-sharing and carpooling, the car data can also be used for calculating fair, evidence-based, and transparent costs.

4.1.6 Location based Information

Another request was related to location-based information taking the car status and location into account. Among others, the second dashboard should inform about events, places, and services located in the area of the car. Examples mentioned include information about congestion, gas stations, car repair shops, free parking, speed trap warnings, upcoming construction zones, tractors, and heavy loads. Further information about the weather near and at the destination, and a kind of friends-radar were called. The collected data should be displayed in an enlarged map.

It should also be possible to retrieve details about the entries on demand. While such information can already be provided by map applications on mobile systems, advantages to provide live messages to the driver were discussed e.g., sending a push notification when a parking spot is getting free. In addition, the information could be improved, when the car context is taken into account (e.g., showing gas stations only if the petrol level is low).

4.1.7 Further Topics

Participants also mentioned other areas like environmental information including emission values, but also hints for ecological driving. Another topic refers to statistics like fuel consumption, speed, and most visited places, etc. One focus group also discussed the option of

including communication channels to manufacturers, repairers, and insurances to make it easier to ask questions, make suggestions, or provide feedback regarding the level of satisfaction with the car.

4.2 Presentation Themes

4.2.1 Information relevant for driving or security

There is a number of information over which our participant would like to be directly notified, to immediately react to certain conditions. By large, these circle around the actual driving context, but may extend the driving situation. Most importantly, when leaving the car, alerts should inform when the light was not switched off, a window is left open, etc. The same goes for attempted burglary and other suspicious events around the car. In contrast, information that refers to the actual driving, such as excessive speed, were deemed less important. This might be because these issues are already well supported by the first dashboard. Further, use cases for push notification had a stronger focus on other driving or location based information, e.g., leaving or entering a geo-fenced area.

Car push notifications could be characterized by three factors: (1) They are triggered when the car or one of its components reaches a pre-defined critical state or a user-defined state (2) they are pushed to raise the users' awareness, as (3) they usually call for immediate action.

Overall, users wanted to have control over pushed events. For instance, some car- or component states are pre-defined as critical in terms of driving or car security, while others may be defined individually, e.g., as soon as the fuel level drops below 30%. These subscription techniques, which are also used for RSS feeds, might be a useful design concept.

4.2.2 Information for car-related management

We also found that the connected car can support management activities of car-owners that go beyond the actual driving. Similar to other Smart Devices, such as Smart Homes and Smart Meters, users also seek to gain an overview about what the system is doing and what its state is (Jakobi et al., 2017; Schwartz et al., 2014). Moreover, a car needs explicit management, such as regular checkups or can be considered in tax declarations. Information regarding these management purposes should not be pushed, in order not to distract the user from ongoing activities. In particular, participants only called for specific information for a certain task such as planning a longer trip. Thus, the data is requested actively instead of being pushed. The presentation of such data should consider: (1) whether the data is retrieved regularly or on demand, (2) whether an overview about the most important indicators is needed or whether details about an actual issue, or the history of an issue is explored, and (3) to what extent informational demands vary depending on the particular context and task of the user.

Providing an overview, the dashboard design could adopt the long history of dashboard design in HCI (Few, 2006). To include tools for analyzing connected car data, existing InfoViz-techniques like "overview first, zoom and filter, then details on demand" (Shneiderman, 1996) should be adopted. This especially holds for the visualization of times and distance oriented data like fuel consumption, wearing parts, etc. For instance, common methods such as bar

graphs or scatter plots could be used, but also more advanced visualizations such as a spiral-shaped time axis or ThemeRiver technique might be used to support the detection of patterns and aesthetics of the graph (Aigner et al., 2011).

4.2.3 Providing Interfaces to other Applications

Finally, including data from the connected car into existing software was a feature desired by participants. For example, while the cost overview was considered interesting, some participants remarked that there already is software for managing a households' finances. The integration of the task list into a personal calendar is another example for the need to embed digital data of the connected car into the digital life of drivers and their loved ones.

5 Discussion and Conclusion

The connected car creates new possibilities to visualize enriched car-related information digitally. The concept extends existing research on telematics (Häberle et al., 2015) by a new perspective: It does not only seek to provide relevant data for the current driving situation, but also allows to take a management perspective considering the outside-car context. In this regard, we outlined a preliminary framework of categories for sensitizing designers in terms of what type of information users are interested in. Our study shows that the concept of the Second Dashboard needs a triangulation of data stemming from both within and outside the driving context to create innovative and useful connected car services from a user perspective. Processed data should 1) improve the driving experience, 2) improve management capabilities for owners, and 3) support reflection of driving behavior. Understanding the connected car as a complex cyber-physical system similar to Smart Home Systems makes apparent how these systems need transparency for the end-user in terms of what the system does and how it performs. Additionally, for security reasons, such newly available information will, when to be used during driving, spark new research demands regarding driver distraction, too. There are various attempts of business models for such services besides the solutions of car manufacturers, i.e. Pace (http://www.pace.car), which sell the OBD2 plug for a one time price or TankTaler (http://www.tanktaler.de), which raise a yearly fee for the usage of the OBD2 plug and the app. There are a lot of conceivable Second Dashboard business models like gamification or premium models. Moreover, especially data driven business models could be explored in further studies in terms of privacy and transparency.

Of course, our study is not exhaustive but rather open-ended, which is why it seems useful to understand the Second Dashboard as an ecosystem of related applications in the car context that needs further research. Concerning this, we plan to validate our findings by a survey and deepen the understanding of what information is relevant for different use cases and target groups. Further, we are going to conduct user studies where we equip test households in a living lab infrastructure with car sensing technologies, to develop user-centered connected car-applications, data visualizations and usable privacy management systems. What services are needed both in and outside the car? Which information should be pushed and which should be pulled? What is the role of privacy within these systems? For answering these questions, we

plan to conduct a design case study (Wulf et al., 2011) to shed light on different design concepts and outline basic design guidelines for visualizing connected car data not only, but especially in non-driving contexts.

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