Chapter 3
Driver and Driving Experience in Cars

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Abstract In connection with the automobile, user experience and emotion have always been contributing to a unique selling proposition and thus an important basis for the development of the product. In addition, requirements of traffic safety and usability have of course be taken into account. The corresponding trade-offs are not easy to solve; yet, existing premium products show that this is possible. While road safety provides a clear framework through basic requirements and regulations, the usability considered the interaction of a person with a technical system for a specific task in a given context, for example a navigation device in a motor vehicle. In this context, efficiency and satisfaction are optimized effectiveness. In addition, the emotional experience of users, as joy of use or user experience gain increasing importance. How these experiences can be translated into customer experiences in combination with current technology trends, for example in the area of perception of acceleration, electric mobility or automated driving is described in this chapter.

3.1 Introduction

In connection with the automobile, user experience and emotion have always been a unique selling point and thus an important basis for the development of the product beyond technical features. If we talk about the automobile we have to consider that, it was and is one of the most expensive and complex consumer goods that a heterogeneous user community experiences under again very heterogeneous circumstances.

Looking at the history of the automobile, we can see that from the beginning, it enabled its user to be mobile on an individual level at affordable cost. This individual mobility is not only rationally used to go to work or doing errands but also

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for leisure activities and in extreme for driving per se doing sightseeing trips. Bubb et al. (2015) give an overview over different trip types. Already the selection of a given vehicle type influences seating position, possible driving styles and experience of the traffic environment like the sketches of Otl Aicher visualize (Fig. 3.1).

A look at historic BMW advertisement banners shows that already in the early 1900s, the sporty character of this brand was a central point of communication besides aspects of economy and affordable mobility (Fig. 3.2).

The first trip in the Motorwagen done by Bertha Benz in the year 1888 is a good example to understand the potential for experience by individual mobility at a novel speed and range, which was impossible before. This shows that a discussion of user experience of automobiles should not be led on a too simplistic level if we want to understand the different influencing factors (Fig. 3.3).

In general, many different definitions of user experience exist, that cover in many cases aspects of human computer interaction or interaction with mobile devices also UX is highly related to the construct of acceptance but not identical with it. Körber et al. (2013a, b) give a good overview over different definitory approaches and the related measurement problems.

Frequently the UX definitions highly overlap with the term usability following ISO 9241 (Hassenzahl 2008; Nielsen 1999; Tullis and Albert 2013). Several definitions stem from human computer interaction and describe the emotional change that is initiated by an interaction between a user and a product or the expectations that initiate these emotional state changes. Only some of these definitory aspects can be easily be transferred to the automotive domain.

First, it makes sense to differentiate between driver experience and driving experience. Where driver experience defines the general perception and emotional states of the driver and driving experience is especially focused on the experiences effected exactly by and during the negotiation of the driving task. In addition, it has to be noted that the automobile is a one of most complex and expensive consumer goods that enables its user to produce enormous energy in a variant public environment. Therefore, beyond user experience requirements of safety and usability have to be taken into account. Car concepts and interaction solutions have to meet user expectations simultaneously they have to stay with the framework defined by official guidelines, standards and laws. Such the corresponding trade-offs to user experience are not easy to solve.

Moreover, the success and tradition of existing premium brands and their products show that this it is possible arrange the very differing requirements. Such the automotive industry possesses a long-term knowledge in the definition, design, engineering, manufacturing and distribution of user experience via the automobile. (see also Akamatsu et al. 2013).

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Compared the experiences with information systems and other artifacts that users are interacting with the automobile definitely provides an instant and ultimate multimodal feedback having the driver in dynamic environment.

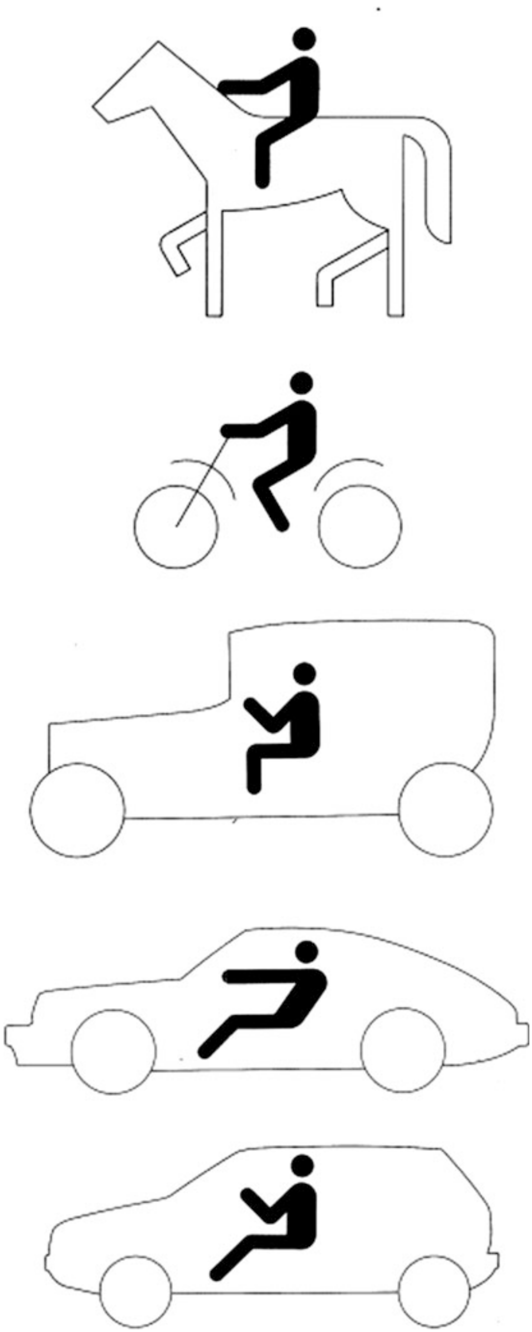

Fig. 3.1 Seating positions in different concepts for individual mobility (Aicher 1984)

Fig. 3.2 Advertising for BMW automobiles in the early years of the 20th century

Fig. 3.3 Daimler Motorwagen and concept vehicle. Picture taken at Frankfurt Motorshow IAA 2009

Looking closer at the related control cycle of this human machine system shows that very simple input activities at pedals and steering wheel lead to very instant kinesthetic, auditory, and visual feedback. This feedback is unique in the combination of sensory modalities, purely physical and therefore highly synchronized (Fig. 3.4).

The evolutionary development of the automobile consists of a continuous improvement of existing functionality and the integration of additional functionality. This definitely led to an increase of safety and usability. A closer look shows that this process was also driven by the need to provide additional experiences corresponding to the user needs of the current period.

Examples are the introduction of communication facilities like the car phone and information systems like navigation. It is remarkable that most of these integrations are discussed under aspects of safety, efficiency and comfort. Allowing the driver to stay connected while being mobile or to travel time using exact route guidance. On the other hand, especially the integration of more and more information systems led to the discussion whether this could lead to safety critical driver distraction.

A current challenge gets obvious if we consider user expectations that are generated by the experience with mobile devices that offer a magnitude of functionalities and access to huge contents. On the other hand these concepts cannot be transferred 1:1 to in-vehicle interaction as they would be in conflict with existing

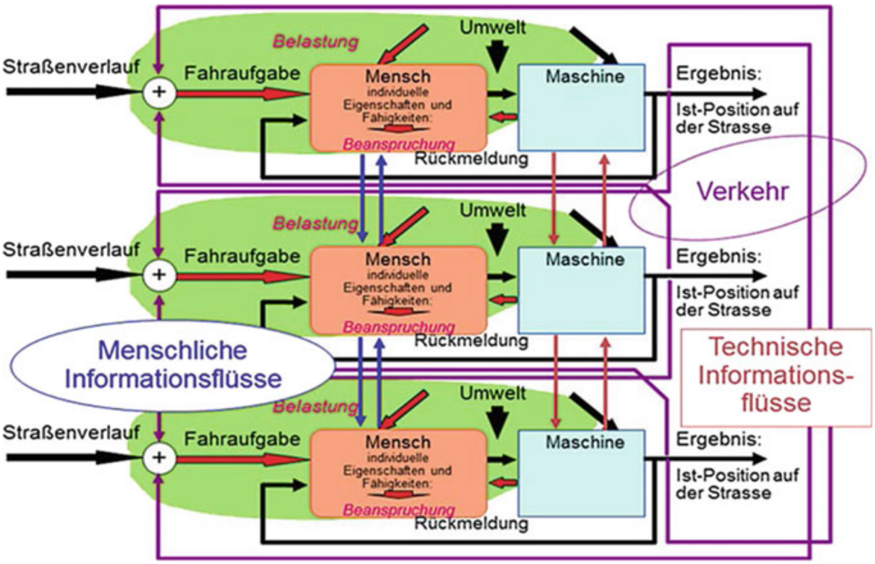

Fig. 3.4 Flow of information in the human-vehicle-traffic (Bubb et al. 2015)

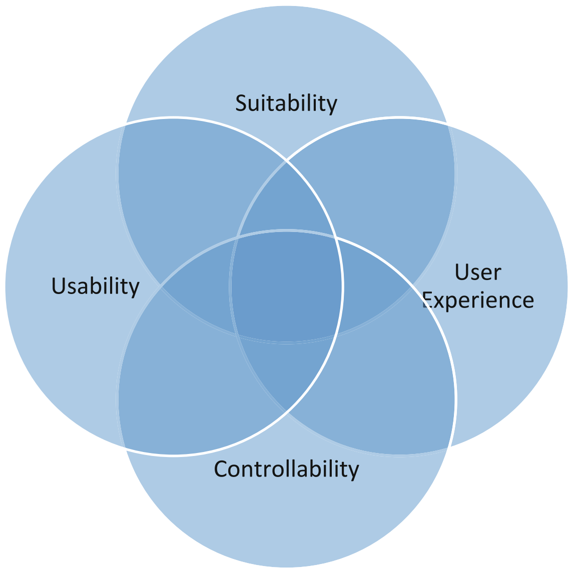

Fig. 3.5 Several requirements relevant for human factors in automobiles

guidelines and recommendations (European Commission 2008) that focus on driver distraction under the aspect of suitability (Fig. 3.5).

If advanced driver assistance systems are considered a further requirement comes into play. The driver has to be able to gain the control over the car and driving situation also in situations where the technical system fails or breaks down.

In addition to these interaction-related requirements, it has to be considered that a positive driver experience requires that the basic product requirements of quality, functional reliability, and mobility have to be fulfilled.

Following Bhise (2012) also the following product features contribute to acceptance and user perception:

Visual quality
Tactile quality
Acoustic quality
Harmony
Olfactoric quality
see also Bubb et al. (2015)

Additionally design, driving performance, and acceleration characteristic play a dominant role and a majority of drivers likes to experience the acceleration potential of their car. (Atzwanger and Negele 2008). Especially, longitudinal dynamic (acceleration) is an important factor for drivers and studies show that a majority of drivers like to experiment with it (Tischler 2013; Müller et al. 2012). Especially, this interaction possibility via the accelerator pedal makes the automobile a specific field of user experience. By a simple pedal activity, a very intense synesthetic experience can be produced by the driver him/herself.

3.2 Trade-Offs and Examples for Solutions

While road safety provides a clear framework in form of basic requirements and regulations, the usability considering the interaction of a person with a technical system for a specific task in a given context is an additional requirement. For example, the design of a navigation device in a motor vehicle needs to fulfil safety requirements considering the suitability of this device for use while driving.

The device also has to be usable to support with dedicated information the negotiation of the navigation task and the solution of potential traffic problems by the driver.

Compared to desktop systems implementations must be excluded that could for example lead to increased driver distraction by animation effects, an overflow of information or graphical effects that harm readability (Heinrich 2012).

For example, navigation information can be provided in different ways and it can be shown that design elements that contribute to user experience like animations do not necessarily suffer from suitability and usability requirements. Bengler and Broy (2008) show that animations in the GUI can increase the likeability of a system, be very helpful for the learnability of a menu system on one hand and non-distracting if the stay with given in-vehicle design rules for duration (below 300 ms) and dynamic of the graphical effect.

Several technological developments are influencing driver experience and driving experience. Three selected examples will be discussed in the following.

3.2.1 UX Und Advanced Driver Assistance Systems (ADAS)

The development and introduction of ADAS follows the logic that the human driver could benefit from dedicated support for subtasks of the driving tasks (Bengler et al. 2014). This approach leads to a new role model between driver and car. Due to technical feasibility this can lead to the situation that parts of the driving tasks are done by the ADAS being monitored by the driver and that the remaining parts have actively be conducted. Automatic cruise control manages longitudinal control and stays in a safe distance to preceding cars, the driver stays with lateral control. Parking assistance systems automate the lateral control (i.e., steering) the driver accelerates and decelerates the car.

Mainly drivers select ADAS mainly for comfort reasons but less following safety considerations. Planing (2014) reports that if users want to experience control they show a reduced motivation to use ADAS. However, the new role-play leads to a driving experience that can vary from an intense experience of comfort and support to an experience that is dominated by the permanent monitoring task. Because most ADAS are disabled if the driver takes over control, the interaction between driver and ADAS is limited to monitoring and parametrization. In case of ACC systems, the driver is able to change the set speed and distance to the preceding car. If the driver brakes, the system is switched off. In overtaking scenarios, the ACC system would try to always keep a safe distance to the preceding car and the driver has actively to accelerate by a dedicated pedal activity. For experience this means that the driver has to interrupt the ACC monitoring by active driving activities and turn back to monitoring again.

Totzke et al. (2008) show that by a minor change in the system logic it is possible to intensify the interaction with the ACC. In their setup, the input element for speed adjustments allows the driver to accelerate or decelerate temporarily but keep the set speed after this intervention. Some drivers describe the interaction as a kind of hand gas/brake. This adaption of the interaction concept establishes a driver experience active driving together with ACC that goes beyond monitoring the ACC versus driving without ACC. Interestingly drivers characterized this interaction concept as less demanding and more motivating although they had shown more motoric interactions but did not have to check the system state (enabled/disabled).

Popiv et al. (2010) and Rommerskirchen et al. (2014) give further examples that also use the information of driver assistance systems but tries to increase driver experience. Their concept focus on the fact that meanwhile several systems try to support the driver in longitudinal control: ACC, traffic sign recognition, navigation, congestion warning. The authors describe a system, which motivates an anticipative driving style by an integrated visualization of the upcoming events that are relevant for longitudinal control (Fig. 3.6).

In addition, the Kolibri app described by Krause et al. (2014) follows this approach with an app running on a mobile device (i.e. smartphone).

The presentation of additional information with a horizon of about 10 s motivates a more efficient driving behavior that is characterized by less braking and

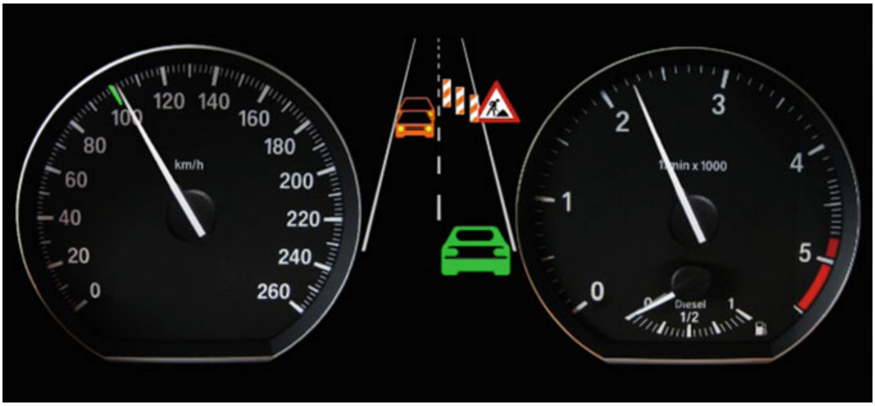

Fig. 3.6 Information for information integration in the cluster instrument to support driver anticipation (Popiv et al. 2010)

more sailing. The interesting effect is that drivers report very positive emotions and experience of competence and control compared to the usage of an automated system. It is evident that by the presentation of information instead of introducing an automated control system driving experience can be influenced sustainably. The studies show that although drivers received less automation support by control mechanisms they describe their driving behavior with the information system as more active and with positive emotions of control experience and system acceptance instead of being patronized by the system. Additionally by this self-initiated change of driving behavior efficiency gains in form of fuel savings go up to 20% (Fig. 3.7).

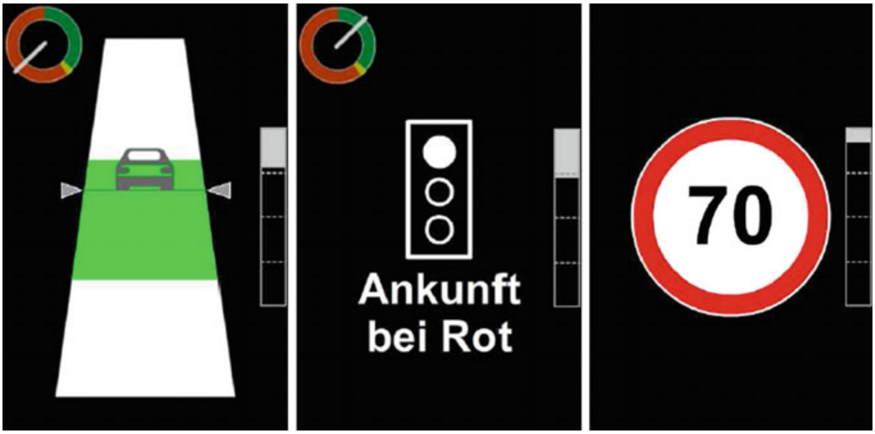

Fig. 3.7 Information concept of the KOLIBRI app to be displayed on an in-vehicle smartphone (Krause et al. 2014)

In subjective ratings in an ergonomic engineering process using the example of an in-vehicle information system.

Krause et al. (2014) compare different questionnaires (SUS, AttrakDiff, to investigate user acceptance and user experience related to above-mentioned information system.

This clearly shows that there is a remarkable potential to influence driving style in a positive way by information and connect it to positive user experiences instead of taking the driver out of the loop by automating the function.

3.2.2 UX und Automation

With increasing levels of automation the question arises, which driver experience can emerge from automated driving that goes clearly beyond assisted driving.

This question is highly related to the interaction concept that is implemented for an automated car. Different interaction paradigms have been realized. H-mode (Flemisch et al. 2014) and Conduct by Wire (Winner et al. 2006) represent two very different concepts how drivers could interact with an automobile that is capable of automated driving. Whereby H-Mode focuses on a permanent shared control interaction between driver and vehicle via driving elements like steering wheel or drivestick, Conduct by Wire allows the driver to instruct driving maneuvers to the car using a menu like concept. (see Kauer et al. 2010 for more details) (Figs. 3.8 and 3.9).

Fig. 3.8 Prototype of the CbW maneuver-interface (Kauer et al. 2010)

Fig. 3.9 H-Mode with trajectories displayed in the contact analogue head up. Display and active steering wheel/pedal. Application of H-Mode in the dynamic simulator with active sidestick. Flemisch et al. (2014)

Both concepts show that the integration of automation will lead to remarkable changes in driver vehicle interaction and especially driving experience.

Investigations by Albert et al. (2015) show that in addition driver and driving experience could move to the background and the interaction with non-driving related activities might get the main experience.

For automation levels 3 and 4 following the SAE taxonomy the driver will have to monitor the level 3 automated cars driving performance to intervene in critical situations. In case of level 4 to take over after dedicated take over requests given by the car without continuous monitoring.

Compared to active driving completely different experiences come to relevance that no longer benefit from direct interaction and continuous feedback but more from trust in automation (Gold et al. 2015) and mode awareness. Otherwise, the driver resources that are set free by an automation of the driving task would not be experienced with positive emotions.

For the design of the automated driving style, the experiments of Lange et al. (2015) show that the vehicle dynamics that play a central role for driver experience have to be treated very carefully in the automation case. First, an exact coordination of longitudinal and lateral acceleration is necessary to inform the driver about the maneuver that the automated car is going to execute. Therefore, the driver can differentiate a beginning overtaking scenario from an erroneous acceleration or a lane change with overtaking intention. This communication aspect between automobile and "driver" must not be underestimated in its value for the experience of trust into an intelligent machine. Furthermore, the experiments show that there is a remarkable difference in perception of driving dynamics dependent on whether the maneuver is conducted by the driver him/herself or by the automobile. The pure replication of driver patterns by an automated driving machine does not lead to the same experience like the "natural" human pattern.

3.3 UX and E-Mobility

Another technological development that heavily influences driver and driving experience of future automobiles is the introduction of electric mobility. The automobile offers in comparison to other products especially human computer interaction the potential to let the user experience dynamic via acceleration and deceleration in combination with different sound characteristics dependent on the drivetrain (i.e. combustion vs. electric engine).

First, vibration characteristics and sound level of an electric car are much lower. Electric vehicles are extremely silent in combination with a remarkable longitudinal dynamic. A second fact in combination with electric mobility is that many authors report the effect of "range anxiety" (Franke et al. 2011). Furthermore, users of electric vehicles positively experience the functionality of recuperation that allows them to gain control of their range if they replace brake pedal actions by releasing the accelerator pedal and thus fighting range anxiety. (see also Cocron et al. 2015)

Such due to the functional mechanisms of an electric drivetrain relevant perceptions and experiences differ significantly from a combustion engine vehicle.

On the other hand, these characteristics are combined with very specific longitudinal dynamics. Buyers and users of electric vehicles report that they prefer these cars, as they are innovative, green and economic. On the other hand, the experience of above-mentioned qualities might be the more convincing aspects.

Now the question is whether the absence of sound is perceived as a deficit and decreases the driver experience or it can lead to a new and specific experience. The driver and lead in combination with the low sound level to an experience of luxury can clearly perceive the remarkable dynamic qualities. The perception of dynamic is based upon the remarkable psychophysical sensitivity of humans to discriminate even small dynamic variations (Benson et al. 1986; Kingma 2005; Müller et al. 2013).

These effects show that not only amplification of sound can lead to more intense experiences. Especially the direct and instant feedback that the driver can achieve via the accelerator pedal contributes to an instant experience of control that can be combined with the luxury of a silent interior. Müller et al. (2012) gives very specific indications, which acceleration profiles are to be preferred. The studies of Helmbrecht show that drivers can easily and very quickly adapt to the different acceleration characteristic of an electric vehicle and the recuperation functionality. This adaptation and the related learning process is perceived with mainly positive emotions and shows no negative carry over effect if the drivers use intermittently a vehicle with combustion engine (Helmbrecht et al. 2014a, b).

3.4 Conclusion

The consideration of user experience in automobiles shows that there is an enormous potential and also need to take the challenge of an active design and engineering in this area. Important aspects of driver and driving behavior can positively be influenced via a successful experience design.

A closer view to different studies shows that there are not enough Methods to support especially automotive user experience engineering and evaluation. Still many approaches are transferred from the HCI domain or mobile device interaction importiert, but cannot cover all aspects of this complex product. The discussion mainly focusses on the integration von infotainment functions, while relations to existing knowledge around driving dynamic aspects is frequently addressed via acceptance and acceptability theory and methods.

The discussion in this chapter focusses on the driving task and here mainly on longitudinal control.

Important aspects like designing of shapes, selection, and combination of materials and interaction with infotainment systems have not been discussed but are of course in an important interplay with the driving task and the resulting experiences.

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