An Experiential Perspective on Advanced Driver Assistance Systems

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Summary  The objective of Advanced Driver Assistance Systems (ADAS) is to support drivers in mastering the driving task. Until now, the development of ADAS has mainly focused on technology, safety and comfort. This paper aims to complement this by a more experiential view. A study explored how Adaptive Cruise Control (ACC), as an example of ADAS, impacts people's driving experience. It showed that ACC creates a gap between the driver and her car. This gap can be interpreted in two different ways. It is negative, when the "joy of driving" is in the fore, because it removes the feeling of mastery, control, being in charge and being one with the car. It is potentially positive, when the "joy while driving" is in the fore, because it creates the freedom to engage in pleasurable activities beyond driving. Unfortunately, the current concept of "supervisory control" for ADAS does not allow for the disengagement with driving. Based on our findings, we discuss crucial aspects to consider when designing ADAS from an experiential perspective.

Keywords  H.5.m [Information Systems: Information Interfaces and Presentation: Miscellaneous] Driver Assistance System, supervisory control, experiential view

1 Introduction
Cars and driving are becoming more and more complex [9]. One reason are the rising demands of traffic. In Germany the number of cars has more than doubled since 1970 [2] to a number of 42 million – half a car for each German citizen. Advanced Driver Assistance Systems (ADAS) [1] typically aim at supporting the driver in dealing with an increasing number of problematic situations. They either support driving by providing specific information and warnings or even by automating parts of driving, such as speed control with cruise control or parking with fully automated parking assistants [8]. This paper focuses on ADAS, which automate whole parts of the driving task.

Legal requirements prescribed in the “Vienna Convention of Road Traffic” [15] allow the delegation of crucial parts of the driving to ADAS, given that the driver is still able to control the car. Therefore the driver typically has to supervise ADAS' performance, i.e., has to perform “supervisory control” [13]. While the locus of responsi-
bility (driver versus car) in case of accidents is certainly an important topic, this regulation nevertheless implies a substantial change in the meaning of driving: from something active (a performance) to something passive (watching others perform). This becomes especially apparent in the importance of trust. While without ADAS, a driver needs to trust in her own capabilities, with ADAS a driver must now trust in the car [10; 12]. Too much trust, however, will corrupt the legal goal set by the Vienna convention of the driver to always be in “supervisory control”.

ADAS are, thus, not only mere comfort and safety systems. They impact the whole driving experience, that is the feelings while driving and the meaning, people derive from driving and travelling with a car (see [3]). From an experiential perspective driving is not just a stressful and demanding physical and cognitive activity, which needs to be done to get from A to B. Driving is much more. It is an individual practice, a potentially meaningful and positive activity through competence experiences, i.e., feelings stemming from mastery and control of a challenging technology and situations (see [4]). It is no coincidence that for quite a few motorists driving a winding coastal road at some speed appears to be the essence of the “joy of driving”. The coastal road is a signifier for a pleasurable exciting driving challenge. But even more mundane activities such as parking the car can become a source of pleasure. In an unpublished study, Christina Sturm collected positive and negative experiences while driving in an urban area. Subsequent analysis revealed that the majority of 49 (of 84, 58%) experiences revolved around the theme of competence, mastery and control (or the lack of). The example of the coastal road exemplifies a further important aspect: most premium car brands understand the joy from challenging and competently mastered driving experiences as a core value of their brand.

An experiential perspective on the car and driving assumes ADAS to clearly impact the driving experience. Given the seeming importance of creating enjoyable competence experiences through driving, a better understanding of the experiential implications of driving with or without ADAS in addition to legal or safety implications seems merited. The present paper’s objective is to explore ADAS from an experiential perspective and to discuss the implications of according findings for the design of ADAS.

2 Our Case: Adaptive Cruise Control (ACC)

For an explorative study, it is appropriate to focus on a particular example of ADAS (rather than all potential ADAS) and to explore its impact on the driving experience in detail. We selected the Adaptive Cruise Control (ACC) for this purpose. ACC is a typical example for a comfort ADAS. It is a speed-regulating system, which tries to keep the car at a constant speed while controlling the distance to a car ahead. ACC relieves the driver of one of his presumably “greatest burdens” – the accelerating and braking due to staying in the flow of the traffic. ACC’s constant intervention crucially affects the driving task: Driving becomes distributed between driver and the car (i.e., ACC). In line with the Vienna convention, the driver is no longer executing the task by himself, but becomes a supervisor of the system, making sure that nothing goes wrong.

An experiential perspective on driving requires a particular methodological approach. Other than most traffic psychology, for example, we are explicitly interested in the phenomenology of driving, that is, the personal subjective constructions of drivers, and not so much what they objectively do. The core methods for obtaining these constructions are open, rather unstructured interviews – or better conversations – which explore the particular episodes participants found important, particular thoughts and emotions in those episodes and personal interpretations (i.e., meaning) (e.g., [14]).

The general leitmotif of the study was to explore how ACC impacts the driving experience and the perception of the car. We selected two from our perspective interesting situations for such an exploration: (a) the first contact with ACC and the immediately resulting impact on the driving experience of those “novices” and (b) a more long-term perspective of drivers, which successfully appropriated ACC. Obviously, other situations and people could have been studied as well, but those selected are crucial to get a glimpse of how experience changes over time (or not) – an aspect certainly important for a more long-term oriented technology, such as a car.

2.1 “Next Time, I do the Driving”: A First Contact with ACC

To study the first contact with ACC, we invited participants to an approximately two hours drive with an ACC-equipped car (BMW 5er). After having familiarized themselves with the car, we introduced ACC with the help of an in-built instructional video. Participants were then encouraged to use ACC as they would do it, when this would be their new car. They were prompted to “think aloud” about their experiences while using ACC and to provide more summary experiential descriptions when possible (e.g., when waiting at a traffic light). Each interview was video recorded and notes were made by the examiner.

Eight individuals participated in the study. Table 1 (upper section) describes the participants in more detail. The only precondition was that participants were supposed to have no prior experience with ACC.

The examiner’s notes were the primary source for analysis. After a screening of the emerging themes, we consulted the video material for a more specific understanding and according quotes. In the following, we present the emerging core themes of this analysis in a narrative form.
Not surprisingly, the change in locus of control was the major theme for first time users of ACC. One participant described:

“I hold the steering wheel tight ... only the steering wheel is reality, is the last thing that keeps me grounded ... through this, I release the tension created by not being able to do anything with my feet ...” (“Ich halte mich im Moment am Lenkrad fest ... und das ist mein letzter Punkt [an Realität], der mich auf der Erde hält ... ich lasse meine Anspannung darüber ab, weil ich mit den Beinen ja nichts machen kann ...”) (P3)

“Not doing anything” is obviously not experienced as comfort or safety, but rather as "tension", a blocked activity, which has to be "released" somehow else. In addition, without full control, driving becomes "unreal": “only the steering wheel is reality” (P3). A similar point was made by the following participant:

“It feels, as if the steering wheel is everything it needs to control the car. A little like in a computer game.” (“... ich habe das Gefühl, das Auto nur noch über das Lenkrad zu steuern. So ein bisschen wie beim Computerspiel.”) (P2)

Another participant explained:

“This is disconcerting. I drive towards this car in front and can’t do anything ... the tight feeling of potentially driving into the back of this car ...” (“Das ist befremdlich. Ich fahre auf den Vordermann zu und kann nicht eingreifen ... ein beklemmendes Gefühl, das ich dem gleich drauf fahre ...”) (P6)

Or more drastically:

“No, no, no, this is really horrible ... this feels totally uncontrolled ...” (“nein, nein, nein, das ist ganz schlimm ... das ist total unkontrolliert ...”) (P4)

The lack of control when driving with ACC led to a felt distance between driver and car. One participant stated:

<table>
<thead>
<tr>
<th>Participant</th>
<th>Profession</th>
<th>Own car</th>
<th>Driving</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-time user</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 male</td>
<td>24 Designer</td>
<td>–</td>
<td>Infrequently – several times a year with his parents’ car</td>
<td>Car enthusiasts – reads various car-related magazines</td>
</tr>
<tr>
<td>2 male</td>
<td>25 Designer</td>
<td>Ford Focus (2004)</td>
<td>Several times a week – he commutes a distance of 20 kilometres</td>
<td>The car is an object of utility</td>
</tr>
<tr>
<td>3 female</td>
<td>29 Photographer</td>
<td>Opel Astra (1993)</td>
<td>Extensive – The car is the central means of transportation</td>
<td>The car is a friend – strong emotional attachment to her own vehicle, it is a refuge</td>
</tr>
<tr>
<td>4 female</td>
<td>28 Welfare worker</td>
<td>Mercedes A (1998)</td>
<td>Several times a week – he commutes a distance of 20 kilometres</td>
<td>The car extends his personal mobility – it is a way to escape from the restrictions of the city</td>
</tr>
<tr>
<td>5 male</td>
<td>38 Lawyer</td>
<td>Opel Vectra (2007)</td>
<td>Occasional</td>
<td>The car extends his personal mobility – It is an important means to maintain social contacts</td>
</tr>
<tr>
<td>6 female</td>
<td>49 Government Employee</td>
<td>Renault Twingo (1999)</td>
<td>Several times a week – she commutes a distance of 30 kilometres</td>
<td>The car as a social place – where she can sing out loud along with her grandchildren</td>
</tr>
<tr>
<td>7 male</td>
<td>30 Designer</td>
<td>Nissan Micra (1998)</td>
<td>Several times a week – The car is mainly used for private journeys and daily errands</td>
<td>The car as a social place – he likes to come together with his friends in the car</td>
</tr>
<tr>
<td>8 female</td>
<td>32 Elementary School Teacher</td>
<td>Opel Corsa (2002)</td>
<td>Several times a week – he commutes a distance of 15 kilometres</td>
<td>The car as a social place – she enjoys socialising (e.g., telephone calls) while driving</td>
</tr>
</tbody>
</table>

Experienced user

<table>
<thead>
<tr>
<th>Participant</th>
<th>Profession</th>
<th>Own car</th>
<th>Driving</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 male</td>
<td>40 Physicist</td>
<td>BMW 530D (2008)</td>
<td>Several times a week – The car is mainly used for private journeys and daily errands</td>
<td>The car as a technical icon – he takes pleasure in the technical possibilities of a car</td>
</tr>
<tr>
<td>10 male</td>
<td>62 Realtor</td>
<td>BMW 530D Touring M (2007)</td>
<td>Extensive drivers – job-related driving in inner city</td>
<td>The car provides moments of fast driving and allows for relaxed travelling</td>
</tr>
<tr>
<td>11 female</td>
<td>45 Interpreter</td>
<td>BMW 330i (2007)</td>
<td>Several times a week – uses the car for trips to clients</td>
<td>The car as a symbol of her professional success</td>
</tr>
<tr>
<td>12 male</td>
<td>38 Engineer</td>
<td>BMW 535D M (2007)</td>
<td>Several times a week – he commutes a distance of 45 kilometres</td>
<td>The car provides moments of performance</td>
</tr>
<tr>
<td>13 male</td>
<td>53 computer scientist</td>
<td>BMW 335D 2006</td>
<td>Several times a week – uses the car for trips to clients</td>
<td>The car provides moments of fast driving</td>
</tr>
</tbody>
</table>
“... it feels like way back when my sister just got her driving licence ... I was the co-driver ... and I had a hard time trusting her ...” (“... ich fühle mich wie damals, als meine Schwester gerade ihren Führerschein hatte ... ich der Beifahrer war ... und ihr habe ich nicht vertraut ...”) (P3)

While the latter quote is relatively neutral, the following participant summarizes her felt lack of control and the emerging gap between herself and the car more emotionally:

“... it feels strange – as if the car becomes a person” (“... das ist so komisch, als ob das Auto zu einer Person wird ...”) (P3)

The gap blurs the border between driving and being driven. It further urges the driver to get a better understanding and assessment of the car’s capabilities. However, figuring out the car’s (actually ACC’s) capabilities proved to be difficult, resulting in a number of wrong expectations. For example, one participant implicitly assumed that ACC is capable of recognizing traffic lights and stops the car when the lights show red (which it doesn’t do). Another assumed that ACC can recognize standing cars as obstacles (which it doesn’t, too).

The contrast between expected and actual behaviour of ACC, or rather the difference between own competent driving and being driven by ACC, led one participant to the following statement:

“... I am convinced to be better able to drive the car than the computer ...” (“... ich bin schon davon überzeugt, dass ich besser fahren kann als der Computer ...”) (P7)

This quote directly refers to the feelings of competence derived from driving. But for this participant ACC does not only take the experience away, he cannot even submit himself to his car because he perceives the car’s driving capabilities as inferior to his own.

Note that there were participants (albeit only a minority), who did not necessarily experienced reduced control as negative. One said:

“... I would love nothing better than just let go of the steering wheel. Let him drive ... why do you want me to steer at all?” (“... am liebsten würde ich das Lenkrad loslassen und ihn komplett fahren lassen ... warum muss ich noch lenken?”) (P8)

This participant would happily give up control and forgo the competence experience of driving, if he would be completely released from this activity. But ACC is not fully autonomous driving, it requires supervision.

In sum, the findings illustrate the experiential costs of “supervisory control” embodied by ACC. Instead of being one with the car, competent in control, participant experienced a lack of control, resulting in primarily negative feelings and an emerging gap between themselves and the car. ACC takes away potential positive experiences derived from competent driving, but does not replace with the potential positive experience from delegating responsibility to a trusted confederate to be free to do other things.

It is obvious, that the negative feelings stemming from the lack of control are also due to the lack of expertise with ACC. While this is an important issue in itself – designing ADAS in a way that its capabilities become apparent through use – it seems possible that more knowledge about how ACC works and more long-term experience with it, may change its impact on the driving experience. To explore this, we complemented our observational interviews of first-time users with more seasoned users, who explicitly “liked” ACC.

2.2 “I Know When and How to Use it”:

Expertise of ACC

Despite the obvious interference of ACC with the driving experience for first-time users, ACC is nevertheless a successful system, bought, used and liked by drivers. We, thus, wanted to complement the experiential perspective of first-time use with the perspective of more experienced, “successful” users.

We conducted semi-structured, phenomenological interviews, which lasted about 90 minutes. The interviewer made notes and each interview was video recorded for later reference. Based on the findings from the first-time ACC users (i.e., car as own entity, gap between driver and car) we specifically focused our interest on how ACC impacts the perception of the car, its “character”.

Five individuals participated in the study (see Table 1, lower section). All participants owned a BMW 5er equipped with ACC. During recruitment we made sure that ACC is used and became an integral part of their driving. The general attitude towards ACC was positive.

Again, the examiner’s notes were the primary source for analysis. After a screening of the emerging themes, we consulted the video material for a more specific understanding and according quotes. In the following, we present the emerging core themes of this analysis in a narrative form.

We started the interview with discussing positive experiences the participants had with their cars. Not surprisingly, all participants reported recurring positive driving experiences, such as driving along serpentines or driving fast. Mostly, the enjoyment stemmed from the feeling of having mastered “extreme” situations. These competence experiences were marked by the feeling of becoming one with the machine, i.e., being in control.

This aspect of control and competence was especially well captured by the characterizations of the car. Participants described:

“... a blend of the speed of a cheetah and suppleness of a leopard.” (“... eine Mischung zwischen der Schnelligkeit eines Geparden und der Geschmeidigkeit eines Leoparden.”) (P11)
“... a cat lying in wait ... and when I drive the car, I become the cat to some extend ...” (“... Katze die auf der Lauer liegt ... “... wenn ich den Wagen fahre bin ich ein Stück weit Teil der Katze ...”) (P12)

“... like riding a Mustang, which gives everything ...” (“... wie jemand der einen Mustang reitet, der wenn man will richtig alles gibt ...”) (P10)

The car is an own entity, a supple beast with great powers, but the driver either becomes one with this beast or “rides” it, that is, exerts competent control. In enjoyable driving experiences the locus of control is internal, the participants become one with the car – its abilities become their abilities.

One participant said: “[without ACC] I am more inside, a part [of the leopard]...” (“... ich bin dann eher innen drin, ein Bestandteil (des Leoparden) ...”) (P11)

Another participant even more impressively stated:

“I never had the feeling of getting pushed out of the curve ... you feel it through the steering wheel, in the whole body so to say, you become one with the car ...” (“man hat nie das Gefühl der würde aus der Kurve fliegen oder so ... man merkt das ja auch im Lenkrad , auch im ganzen Köper sag ich mal, irgendwo wird man eins mit dem Fahrzeug ...”) (P10)

ACC clearly impacts this feeling. Participants explained that with ACC ...

“... it is less aggressive, the big cat was just fed ...” (“... Es ist weniger aggressiv, die Raubkatze hat gerade gegessen ...”) (P11)

“... the [supleness of the] cat is gone, it is more rough ...” (“... die Katze ist weg, es ist ruppiger ...”) (P12)

Contrary to the feeling of becoming one with the cat, cheetah, or mustang, the participants felt a separation between themselves and the car. One said:

“... it feels like sitting on the neck [of the cat] just watching ...” (“... dann sitze ich vielleicht hinten auf dem Nacken und guck in der Gegend herum ...”) (P9)

Note that he did not say that it feels like riding the cat. He is just watching, more like a spectator than an actor.

In sum, ACC seems to impact the driving experience for the more experienced users in a quite similar way as the experience of first-time users. Driving is a competence experience, the mastery of the machine, riding the beast, becoming one with the capabilities of the car. In contrast, ACC creates a substantial distance, tames the beast, and transforms the driver into a spectator. While the gap between driver and car (i.e., driving) does not result in immediate negative feelings of losing control as for the first-time users, there is still a more general loss of the sportive, active feeling – important to drivers at least of this type of car. ACC driving is not at the core of pleasurable experiences with or in the car.

2.3 Discussion

ACC requires surrendering control to the system. In the beginning this is problematic – as obvious in the reactions of the first time users – but can be mastered. None of the more experienced ACC drivers reported a negative feeling of lack of control. However, in both cases ACC created a distance, a gap between driver and car.

This distance can be interpreted in two different ways. If driving itself is in the fore, it is negative. It removes an important ingredient of the pleasure people derive from driving. It removes directness, the feeling of being one with the car. Instead of understanding the car as an extension of oneself, its capabilities becoming my own capabilities, ACC emphasizes the car as independent entity. Through this, driving challenges lose their power to create positive competence experiences, because a challenge is now mastered by the car not by the driver. However, the distance could also be positive. It potentially creates the freedom to disengage with driving and to engage in other pleasurable activities beyond driving. ACC driving was experienced as impoverished. People would like “to let go of the steering wheel” to simply do something else.

2.4 Designing ADAS: “Joy of Driving” versus “Joy while Driving”

Nowadays, an enjoyable driving experience is the core “product” sold by premium car manufactures. ADAS are designed with the intention to support this driving experience. However, through their focus on safety and their implicit technology-driven view of the human as being the weak element when it comes to safety, they overshoot this goal. Instead of supporting the activity of driving, that is increasing the driver’s possibilities, ADAS impoverish driving – they take the pleasure away. Our study revealed how ACC creates a gap between driver and car (actually, driving), resulting in negative feelings for first-time users and reduced emotionality for the more experienced users.

From an experiential perspective, the mismatch between what makes driving pleasurable, namely control and mastery, and the way modern cars are outfitted with competence-removing technologies is striking. Interestingly, engineers themselves or traditional human-factors specialists do not seem to care. It needs journalists to get to the heart of it. In a review of the BMW 535s GT in the Zeit magazine (10.3.2011) Wolfgang Büscher exclaimed: “Take care, that your love of technology is not destroying your style. A BMW driver does not want an intelligent sofa. He wants to drive, not to be driven – and now and then he even wants to bomb down the motorway. This is what he wants to focus on, not onto blinking, beeping, and displaying drive, park and other assistants”. What Büscher
means by “style” is simply the experience of competent driving.

Thus, ADAS to support driving (or other potentially competence-related activities, such as parking) need to be designed with competence experiences, that is, with the “joy of driving”, in mind. They must rather be thought of as empowerment than as assistance. The difference is obvious: While assistance implies a model of delegation and the removal of tasks, empowerment implies vesting new, exciting capabilities in the driver. One example is the Head-Up Display combined with Night Vision and pedestrian detection. Pedestrian detection is clearly a safety-related technology, however, through its particular design it is rather presented as a kind of “superpower”. The car enables its driver “to see in the dark.” This is clearly different from other potential designs, where the car more indirectly warns its driver about currently invisible obstacles. In the latter case, the car is the one who has the capabilities and it merely informs the driver.

While we primarily focused on driving, our study revealed a further way of framing ADAS. ADAS can be crucial in creating the freedom to engage in pleasurable activities beyond driving. It can be a precondition for the “joy while driving”. Central to this is the true delegation of driving or parts of it to the car. This seems to call for autonomous driving, which is clearly beyond current legal and technical possibilities. A closer look, however, reveals that even current technologies could be improved accordingly. ACC, for example, can control the distance to a car in front. This potentially releases the driver from constantly checking the road ahead, which frees resources to watch the landscape or engage in conversations with passengers or with friends on the phone. However, it is crucial that the “distance keeping” becomes a reliable, ever-present feature if the car. The driver must think of her car as the “car that can never collide”, and the technology must live up to this image to create the necessary trust to use this freedom. What is needed is a simple model (i.e., metaphor) of what the ADAS does as well as a clearly designed moment (in terms of situation and interaction) of transferring control to ACC and taking it back. Through this, ACC would act as a “hygiene factor”, which enables positive experiences beyond driving without being an experience in itself.

To more deliberately design the driving experience with ADAS, we must start with explicitly separating the “joys of driving” from the “joys while driving”. While the “joy of driving” is currently at the core of premium cars, the “joy while driving” is another, less developed story. Here, positive experiences stem from aspects beyond driving, e.g., through the stimulating landscape or through feeling related to others inside or outside the car. Kai Eckoldt explicitly collected positive experiences with or in cars and found that cars not only provide arenas for experiencing competence, but that they are meeting points (relatedness, social experiences), shelters (security), cloisters (autonomy), and explorers’ vessels (stimulation). Juhlin [6], for example, especially argued for taking social experience more into the focus. Following this, Knobel and colleagues [7] recently developed an in-car system called Clique Trip with the explicit purpose of creating “the experience of being one group even when being in different cars – as if the interiors of the cars unite”. While car manufacturers typically focus on positive emotions created through competent driving, positive emotions stemming from other experiences beyond the mere driving are becoming more and more important. The major reason for this shift of attention is today’s orientation towards experience as a source of happiness (e.g., [5]) and its economic implications [11].

Our study showed that neither view – neither the notion of empowering and enhancing driving itself, nor the notion of creating freedom for experience beyond driving – is compatible with “supervisory control”. Obviously, this metaphor borrows too much from automation and the work domain. But a car is not a power plant, and the driver’s seat is not the plant’s control room. Driving itself can be fun as well as anything else pleasurable we can do in a car beyond driving – supervising a car while it does the driving is not a likely candidate for enjoyment, though.

A final note: Through the experiential perspective, we want to inspire developers to create products, which satisfy the inherent psychological needs of its users (see e.g. [3; 4]). Accordingly, when bringing new technology into cars, we need to answer the question of which positive experiences could be created and mediated through its usage and the fulfillment of underlying psychological needs. User Experience is not primarily about designing a usable interaction between a product or parts of it and its user. A “good” experience is not the consequence of comprehensible icons or the efficient navigation through the menus of some in-car entertainment system. Good experience is about meaning and emotion created by fulfilling universal psychological needs through an activity and ultimately through a product. An experiential view on a technology, such as a car, takes the pleasurable experiences created through usage seriously. One may argue that this is self-evident. The case of ADAS shows: it is not.

References

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