Designing Adaptation in Cars: An Exploratory Survey on Drivers' Usage of ADAS and Car Adaptations

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Abstract. Current production cycle cars offer a wide range of driver assistance features spanning from Advanced Driver Assistance Systems to more established systems such as wing mirrors. All these features allow an increasing amount of adaptation enabling the driver to tailor all them to his or her requirements. However, drivers' usage of and attitude towards these features as well as their possible adaptations are largely unexplored and, as a consequence, not well understood. We present an exploratory survey on this topic and apply an inclusive design approach in order to accommodate the whole range of diversity in our population. The results indicate a low usage rate of driver assistance features as well as their possible adaptations. However, results suggest a high appreciation for a potential smart adaptation of driver assistance features.

Keywords: Advanced Driver Assistance Systems · Car Adaptation · Human Computer Interaction · Human Factors

1 Introduction

In current production cycle cars, a large number of different driver assistance features are supposed to support the driver in coping with the driving task and to make the driving experience more comfortable and enjoyable. These assistance features give drivers the possibility to adapt feature properties to their needs and wants and to save them in their assigned profiles. These profiles are then connected to the driver's car key or phone allowing an easy identification [1]. In a further development, the car interior will progress from this *customization* level, where adaptations, settings, and favorites are selected by the driver, to a *personalization* level, where all these adjustments are supported by and applied by the on-board artificial intelligence [2, 3]. With *customization* the user decides on product characteristics whereas with *personalization* information is gathered about the user and used for adaption. The online retailer, Amazon, utilizing user data to make personalized product suggestions, is a good example of personalization, while Dell, enabling their customers to choose components to customize their computer, demonstrates customization [2]. A highly personalized car tailored to the requirements of the user and smartly adapting during usage, as described and named Intelligent Driver Profiling System for Cars (IDPSC) in [4], can become reality.

Driver assistance features are defined as the whole range of assisting systems in the car from established adjustments; such as, seat, steering wheel, airbag, and wing mirrors, up to Advanced Driver Assistance Systems (ADAS); such as Adaptive Cruise Control and Lane Keeping Assistance (LKA). In general, driver assistance systems aim to increase safety [5] and support drivers by supplying relevant information about the environment, providing warnings in risky situations and automating some driving tasks to excuse the driver from manual control [6].

Unfortunately, only a minority of drivers enjoy these benefits. Low usage rates of these assistance features [7–9] reveal a poor market penetration and raise the challenge to tackle it. Trübswetter et. al. (2013) [8], for example, carried out 32 qualitative interviews with older car drivers and found several usage barriers to use ADAS. The Technology Acceptance Model (TAM) attempts to account for the uptake and use of new technology [10]. The main determinants in the TAM of whether a potential user will accept the technology in question are: ‘Perceived Usefulness’, ‘Perceived Ease of Use’, and ‘Intention to Use’. With the extension of this model, called TAM 2 [11], more determinants; such as, ‘Subjective Norm’, ‘Image’, ‘Output Quality’, and ‘Result Demonstrability’, were added. In the specific case of ADAS, the most decisive factors for acceptance are ‘Perceived Safety Benefits’ and ‘Perceived Comfort Benefits’ [12]. The TAM models aim to predict acceptance among potential users who are presented with the technology. However, actual usage is not recorded. Since these models do not ask for evidence of usage, the intended usage is likely to differ from the actual one [13]. A method to measure acceptance was introduced by [14] and uses nine 5-point rating scales to determine two scores denoted ‘usefulness’ and ‘satisfaction’.

A possibility to increase technology acceptance and consequently usage is the implementation of customization and personalization since by tailoring in-vehicle technology to users’ requirements and needs diverse customers can be addressed more effectively. All this will be of major importance with the shift to mass car sharing [15]. The history of the automotive industry has shown a shift from homogeneous mass production to mass customization [16], allowing customers to tailor their car to their requirements. The same trend has been observed in automotive interface design, for example, in the move from fixed to adjustable seating [17, 18]. Currently, the next step is being taken by developing smart, adaptive, and personalized interfaces which adjust to the user based on a variety of different measurements such as the driving context [19, 20] and the driver’s state [21, 22]. In one case [21], a range of notifications was scheduled based on the driver’s cognitive load which was estimated using CAN bus data. Although adaptation in cars has been available for a substantial amount of time, we lack knowledge and understanding of consumers’ usage and interaction with adaptive driver assistance features. Therefore, an exploratory online survey was conducted to gain knowledge about drivers’ usage of driver assistance features and their adaptations. By exploring users’ requirements, this lays the foundations for a highly tailored and adaptive car profiling system (IDPSC) [4].

2 Methods

2.1 Description

The survey questionnaire comprised of four groups of questions ensuring sufficient coverage to reveal drivers' interaction with ADAS and adaptive driver assistance features: (1) Demographics, (2) usage and adaptation of ADAS, (3) adaptation of driver assistance features, and (4) assessment of a potential highly tailored and adaptive car (IDPSC). Asking for demographic information delivers characteristics of the sample and, therefore, allows to evaluate the generalizability of the collected data. The aim of questions on the usage and adaptation of ADAS is to give insights on the requirements, needs, and wants of the users regarding these systems. The ADAS as safety enhancing systems with the potential for adaptation represent a crucial application area of an intelligent profiling system. In order to understand to what extent drivers already adjust other driver assistance features, and therefore to conclude whether there is a demand for adaptation, questions of group (3) were designed. Group (4) of the questions look at the attitude of drivers towards an IDPSC and, in that way, reveal whether drivers are interested in a potential IDPSC.

2.2 Sampling

The online survey aimed at gathering information about car drivers and, therefore, sampled people with a driving license. Although there are data indicating gender and age quotas based on driving license data [23], the institution releasing it clearly states that it does not mean these individuals actively drive. Due to this missing detailed demographic information about the actual driving population, it is hard to evaluate how representative a specific sample would be. Therefore, non-probability sampling, also called convenience sampling, was applied and allowed people encountering the survey on a website to decide whether to participate or not, called unrestricted self-selected survey [24].

2.3 Survey Instrument and Data Collection

Participants performed the online survey on the platform Qualtrics (see www.qualtrics.com), which was used to design as well as distribute the survey, and no monetary rewards were given for participation. All data was saved anonymously on Qualtrics' server. To reach a high number of responses the survey was, moreover, distributed via online mailing lists, social networks, paper advertisements, and specific survey websites, i.e., SurveyCircle (see www.surveycircle.com). Before distribution, the project had been approved by the Psychology Research Ethics Committee of the University of Cambridge.

3 Results

The collected data was analyzed using IBM SPSS Statistics 25 and NVivo 11.

3.1 Demographics

Country. Overall, 217 participants were recruited; 101 of them were from the United Kingdom, 45 were from Germany, and the remaining ones from various European countries and North America.

Age. The mean age calculated was $M = 30.35$ ($SD = 12.25$) for all participants. Concerning participants from the UK, the mean age was $M = 30.74$ ($SD = 12.77$).

Gender. Of all respondents 53.4% (47) were male, 44.3% (39) were female, and $.9\%$ (2) preferred not to answer. For the UK specifically, 49% (25) were males and 51% (26) were females.

Driving Hours. Overall, the mean hours of weekly driving was 11.66 ($SD = 12.47$). In the case of the UK, the mean was 10.28 hours ($SD = 10.88$).

Driving Experience. For all participants, the mean years of driving was 10.86 ($SD = 9.99$). For the UK, the mean was 10.31 years ($SD = 9.70$).

Car Sharing Usage. While only 24.42% (53) of all participants use mass car sharing services, a substantial number of 41.94% (91) regularly drives different car makes or models.

3.2 ADAS and Adaptation

Usage. Based on availability and market penetration nine ADAS were selected for inclusion in the questionnaire. The ADAS addressed are Adaptive Cruise Control (ACC), Navigation System (NS), Lane Keeping Assistance (LKA), Parking Assistance System (PAS), Night Vision System (NVS), Drowsiness Detection System (DDS), Blind Spot Information System (BSIS), Traffic Sign Assist (TSA), and Autopilot/Drive Pilot (AP/DP). For each system, a definition was given to the participants. The responses reveal that the NS is by far the most used ADAS followed with a big margin by ACC (see **Fig. 1**).

Attitude. For the attitude questions, participants were asked to select on a 7-level Likert-type scale [25] to which degree they agree or disagree to a number of statements (see **Fig. 2**).

A majority of 64.3% (139) agreed somewhat or strongly to the first statement indicating that people in general like using ADAS. Approximately 14.8% (32) were indecisive in their estimation. The results concerning the adjustment of ADAS (statement 2) reveal a high indecision and balanced views; while 32.9% (71) of the participants neither agreed nor disagreed, similar numbers either agreed, 30.1% (65), or disagreed, 37.0% (80). For statement 3, the eagerness to change ACC settings, participants again showed high indecision with 39.4% (85) neither agreeing nor disagreeing with the statement. However, there was a slightly higher agreement 38.8% (84) than disagreement 21.8% (47).

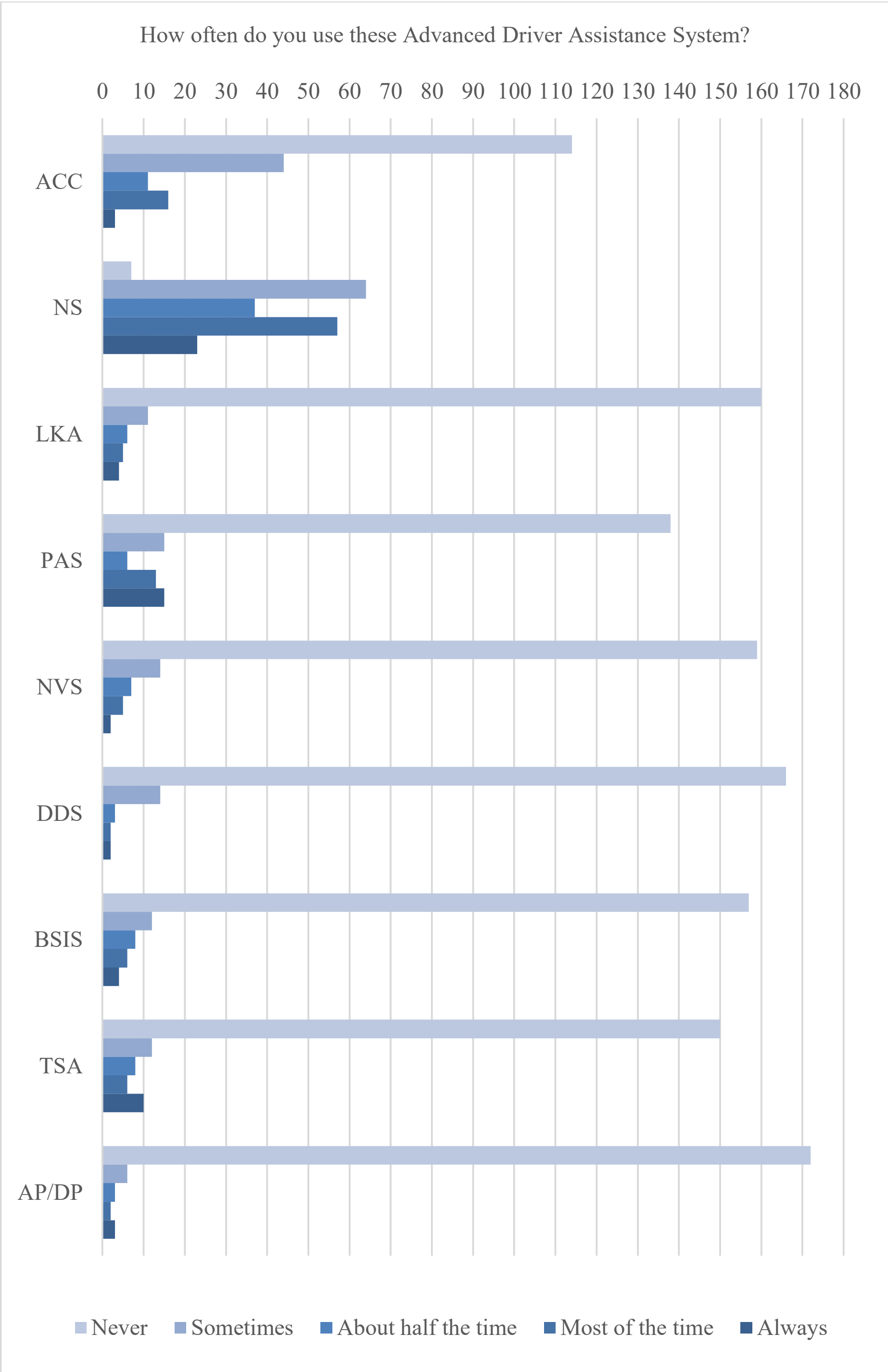

Fig. 1. ADAS: Usage.

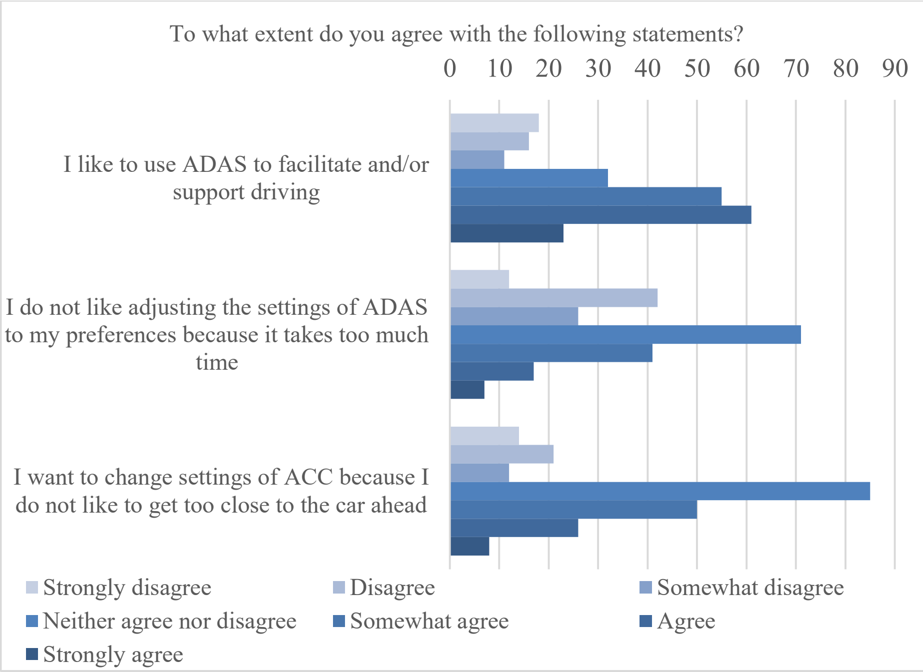

Fig. 2. ADAS: Attitude.

3.3 Driver Assistance Features and Adaptation

Usage. A number of driver assistance features supporting adaptation were selected for inclusion in the online survey ranging from seat position adjustment up to gearbox characteristic setting. The participants were asked the question "How often do you adjust car characteristics to your preferences after somebody else drove?" and were requested to select on a 5-level Likert-type scale in the time range "never" to "always". A big majority of 76.9% (166) stated that they either "most of the time" or "always" adjust the seating position after somebody else drove. For the headrest in contrast, 72.7% (155) of the respondents declare to only "sometimes" or "never" adjust the feature to their requirements. Moreover, for the steering wheel position 75.2% (161) of the participants indicate to "sometimes" or "never" check the feature for the right setting. **Fig. 3** gives an overview of all features and the participants' responses.

Tests of correlation revealed a significant positive correlation between rear-view mirror and seat position ($\tau_b = .585, \mathrm{N} = 207,\ p < .0005,\ \mathrm{two-tailed}$), and rear-view mirror and wing mirrors ($\tau_b = .560, \mathrm{N} = 207,\ p < .0005,\ \mathrm{two-tailed}$). A further significant positive correlation was found between headrest and steering wheel position ($\tau_b = .439, \mathrm{N} = 207,\ p < .0005,\ \mathrm{two-tailed}$). Moreover, there were significant positive correlations between suspension and engine characteristic ($\tau_b = .653, \mathrm{N} = 207,\ p < .0005,\ \mathrm{two-tailed}$), between suspension and gearbox characteristic ($\tau_b = .582, \mathrm{N} = 207,\ p < .0005,\ \mathrm{two-tailed}$), and between engine characteristic and gearbox characteristic ($\tau_b = .776, \mathrm{N} = 207,\ p < .0005,\ \mathrm{two-tailed}$).

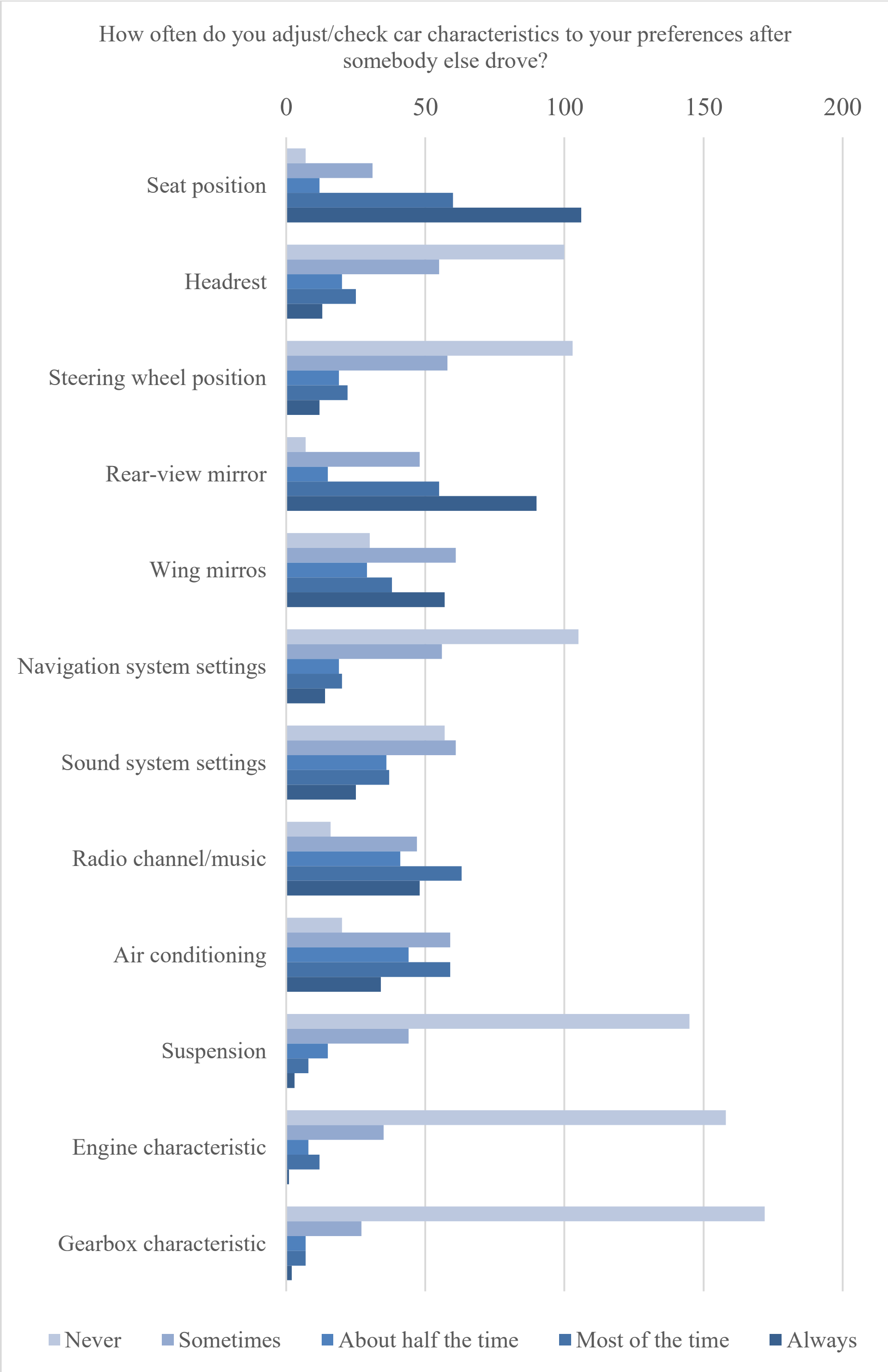

Fig. 3. Adaptation Usage of Driver Assistance Features.

Attitude. To evaluate participants' attitude towards feature adaptations, participants were given several statements and were asked to specify to which degree they agree or disagree using a 7-level Likert-type scale. All statements and the respective responses are given in **Fig. 4**. Overall, 77.8% (168) of the respondents disagree to some extent with the third statement that they have no interest in adjusting car characteristics. Concerning the enjoyment of adjustments participants are indecisive with 41.7% (90) disagreeing and 43% (93) agreeing to this statement. Big majorities of participants would like the car to adjust itself, 76.3% (164), and consider the memory function a helpful system, 79.6% (172). Approximately a third of the respondents, 37.7% (81), agreed to have experienced some safety hazard due to improperly adapted driver assistance features.

In addition to these statements, participants, who regularly drive different car makes or models or use mass car sharing services, were asked whether they face disadvantages or annoying factors when frequently changing the car make or model in private life or when using mass car sharing services. Approximately 27.3% (30) of these respondents indicated that they had experienced inconvenient circumstances. The qualitative data analyzed with NVivo 11 revealed that drivers particularly struggle with acclimatizing to the new interface, including confusion due to different alarms and icons:

"Learning where all the buttons and signals are."

Some users express frustration with necessary adjustments, such as seat position and mirrors:

"Constantly needing to readjust settings like seat."

3.4 Highly Tailored and Adaptive Car

For the questions about drivers' attitude towards a highly tailored and adaptive car, participants were faced with the following statements:

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It may be possible to create a driver profile which adjusts
car characteristics to your preferences across all car
makes.
 1. This would increase comfort.
 2. This would motivate me to use car sharing services.
 3. This would increase driving safety.
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A great support (somewhat agree, agree, strongly agree) was observable for statement 1, 87.9% (190), and statement 3, 80.5% (174). Approximately half of the respondents, 51.4% (111), thought such an intelligent profiling system would motivate them to use mass car sharing services.

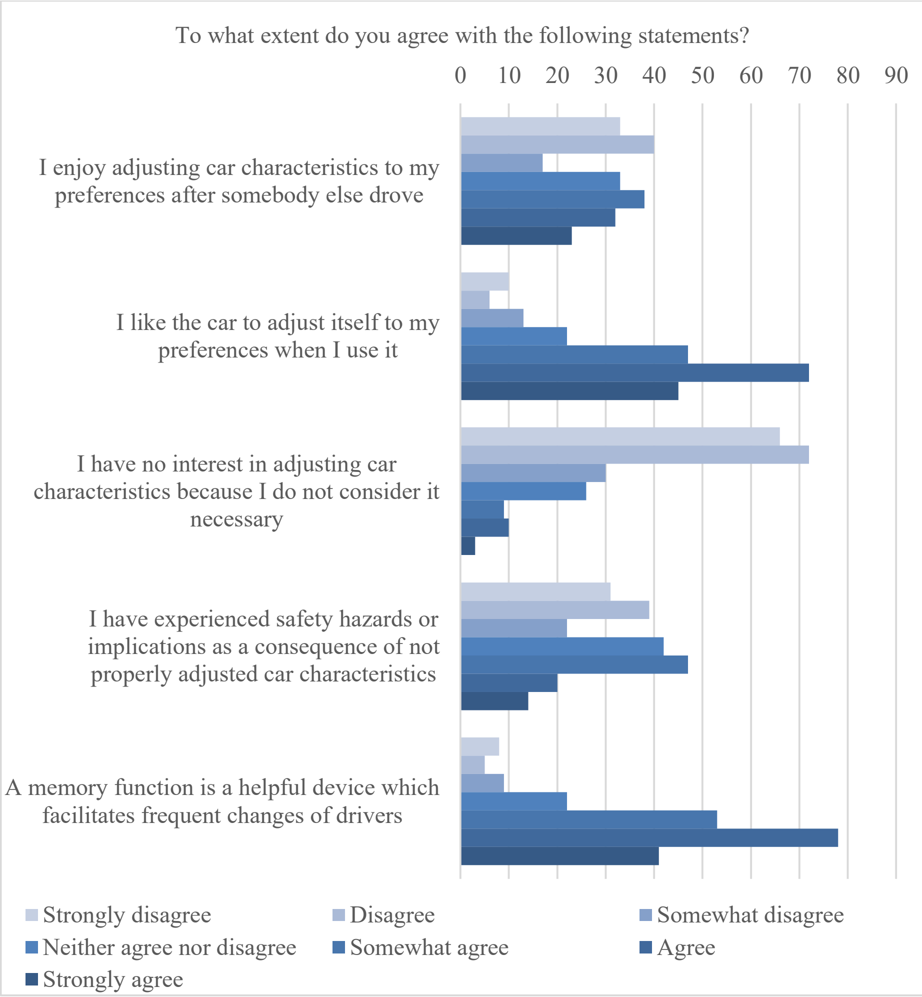

Fig. 4. Driver Assistance Features: Attitude towards Adaptation.

4 Summary and Discussion

The exploratory online survey collected data about the usage and adaptation of ADAS and other driver assistance features. Based on the demographics, the findings can be generalized for the younger technology-literate computer users in Europe but are not representative of the UK driving population. The survey offers interesting insights into drivers' interaction with car adaptations and ADAS. As shown in other work [7–9], this online survey also reveals a low usage rate for a majority of ADAS currently on the market. For example, the EU study [7] shows the contrast between attitude towards Lane Departure Warning Systems and the ubiquitous ABS. In the present survey, a possible reason for the low usage rate is the relatively low mean age of $M = 30.35$ indicating a high number of young drivers who might not be able to afford a car equipped with all these systems. The high usage rate of the navigation system demonstrates a substantial market penetration and implies wide acceptance among drivers. Potential explanations are universally perceived comfort benefits [12] and usefulness [10].

Based on the attitude questions, drivers seem to positively appreciate the idea of ADAS as supportive systems. The difference in appreciation and usage could be attributed to confusion about [26] or knowledge of [27] ADAS capabilities. It may also be due to, possible distraction and confusion due to ADAS interventions and warnings [9], or low perceived usefulness [8]. All these reasons could motivate drivers to completely stop using the ADAS [28]. Drivers seemed to be indecisive concerning the adjustment of ADAS settings and the willingness to adapt varied widely within the sample. This matches findings in other studies [28]. For example, factory settings were found not to be changed for complex ADAS, such as, rear cross-traffic alert [28]. However, research demonstrates that adaptive ADAS can be supportive and safety-enhancing features. In a study [29] developing an adaptive lane keeping assistant the researchers found that making adjustments based on the user's interaction with in-vehicle information systems improved safety as measured by lateral deviations. This represents a higher adaptation in the form of personalization in modern cars.

While a majority of drivers adjusts the seat position to their preferences, a surprisingly high number of drivers does not tailor the headrest and the steering wheel position to their preferences. The headrest as a passive safety system shows the biggest benefits in car crashes when adjusted appropriately for the respective driver [30, 31]. An improper steering wheel position can cause severe injuries in case of an airbag deployment [32]. Both features underline the necessity for adaptation to increase driving safety. The significant correlation between headrest and steering wheel position adjustment suggests that there is a group of customers who tend to associate headrest and steering wheel adjustment together. There may be a relationship between understanding of safety and use of driver assistance features. Therefore, a move away from customization to personalization would improve safety.

The online survey overall reveals a positive driver attitude towards memorized profiles and automatically adapting car features. Drivers are apparently convinced that such an adaptive intelligent profiling system will increase comfort along with driving safety. Both these aspects constitute important decisive factors for technology acceptance of car features and, therefore, could increase acceptance among these systems [12]. It is positive to have a strong support for an intelligent profiling system which; based on the participant sample, appears to increase their comfort and safety.

5 Conclusion and Future Work

ADAS as well as more established driver assistance features do not only increase comfort but also safety. However, the low usage rates limit the potential benefits for drivers substantially. This problem needs to be overcome to ensure that drivers get the optimal outcome from their assistance features. While research in technology acceptance provides decisive factors for users and drivers in particular, this research shows that these factors would be addressed and fulfilled by a highly adaptive and tailored car. All this makes focusing on customization and personalization of driver assistance features necessary and promising at the same time.

In future work, research in human-machine interaction needs to address the question of why possible adaptations available to drivers are not used. The reasons for the missing customization must be established to enable better interface design. The TAM gives us a model to understand the acceptance of the technology in terms of causal relationships. An analysis of the effects of memorized profiles, which already save a significant amount of settings, on users' customization usage would give further understanding. Furthermore, the potential interaction of users with smart personalization in cars should be examined and different methods of presentation should be designed and evaluated. In that way, it could be possible to avoid low usage rates of intelligently personalized driving features entering the market.

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