User Experience in Real Test Drives with a Camera Based Mirror – Influence of New Technologies on Equipping Rate for Future Vehicles

Corinna Seidler[1], Seda Aydogdu[2](✉), and Bernhard Schick[1](✉)

[1] University of Applied Sciences Kempten, Bahnhofstraße 61, 87435 Kempten, Germany
{corinna.seidler,bernhard.schick}@hs-kempten.de
[2] MdynamiX AG, Heßstraße 89, 80797 Munich, Germany
seda.aydogdu@mdynamix.de

Abstract. The variety of products on the market that are offered with advanced driver assistance systems is huge. Besides systems like the lane keeping assistant also camera based systems are more and more in the foreground. The Full Display Mirror (FDM), a camera-based hybrid mirror, is also being installed in vehicles. User experience in the sense of acceptance and peace of mind as well as benefit of the product are essential not only to know the systems are installed, but also to know how to use them. In a customer study with N = 60 persons, interviews and questionnaires were conducted during a test drive in real road traffic with various scenarios in order to test and evaluate the FDM. In comparison to the normal mirror, the FDM scored very well - especially in the field of view, the feedback was extremely positive. The increased safety with the use of the system, among other things due to the considerably larger field of view, is an absolute plus point of this camera-based mirror version. The fast familiarization with the system as well as the high user friendliness make the FDM a meaningful invention.

Keywords: User experience · Camera based mirror · Field of view · Customer acceptance · User friendliness · Trust

1 Introduction

Technological innovations are increasing more and more - what once seemed unthinkable, today is the most normal thing in the world (Stappenbeck 2017). A good usability of systems, task-appropriate functions as well as emotionally appealing user experiences are the goals of good human-computer interaction and thus also the basis for a successful innovation. Aspects such as attractiveness, user intention, and simplicity play a major role in capturing user experience aspects such as usefulness and user-friendliness (Reiterer and Geyer 2013).

In the ISO definition, usability is described as the extent to which products can be used in a particular context to achieve specific objectives effectively, efficiently and

H. Krömker (Ed.): HCII 2019, LNCS 11596, pp. 270–281, 2019.
https://doi.org/10.1007/978-3-030-22666-4_20

satisfactorily (DIN EN ISO D8241-11 1999; DIN EN ISO 9241-210 2010; Mentler 2018; Robier 2015). An evaluation of the system is therefore only possible after use. The user experience, on the other hand, is defined as "unique, subjective and individual experience that is evoked in the interaction with a system" (Körber et al. 2013, p. 14). Consequently, it is always about the interaction of a user with a system and can therefore be captured at several points in time, whether before, during or after use (Mentler 2018). The focus is therefore on the well-being of the user and not on the performance, as with the usability concept (DIN EN ISO 9241-210 2010; Mentler 2018). Due to this distinction of terms, in the following sections the focus will be on the user experience when using the product and less on the usability. User experience in this context also affects the equipment of vehicles with driver assistance systems and the development of automated vehicles. To ensure that the in the vehicle installed system is actually used, its development must be user-oriented. This means that in addition to cost, technical feasibility, standards, human capabilities and desires must also be included (Aydogdu et al. 2018; Held and Schrepp 2018; König 2015; Seidler and Schick 2018).

An interaction with different products and systems in vehicles is unavoidable due to the increasing digitalization, whereby the intuitive interaction has moved further and further into the foreground of research. This describes an interaction that is fast, unconscious and automatic (Blackler and Hurtienne 2007; Blackler et al. 2010; Macaranas et al. 2015; Ullrich and Diefenbach 2010a). However, the intuitive use of the system is also countered by its acceptance. This must be given, so that a use of the product comes at all. The technology acceptance model, an adaption of theory of reasoned action, served as basis to record the use of the product. This model is concerned that perceived usefulness and perceived ease of use influence the attitude towards use as well as the actual product use (Davis 1985; Davis et al. 1989; Venkatesh and Davis 2000). If, consequently, the comparison of actual performance in terms of experience in product use and the expectation, i.e. the target performance is compatible, customer satisfaction results. This in turn leads to confirmation and consequently to satisfaction (Nerdinger et al. 2015). The aim is therefore to keep the investigated product users satisfied by ensuring that the actual and target data of the product match. A supplement to this model is the KANO model, which examines the respective product requirements. These requirements are subdivided into enthusiasm, performance and basic requirements and classified according to the strength of the influence on customer satisfaction. It is also examined whether the characteristic is indifferent or questionable, in the sense of spending money on it. Thus, the KANO model can be used to analyze which problems exist with the product and which needs customers have in this respect (Hölzing 2007; Nerdinger et al. 2015). The market opportunity map also enables the structuring of customer wishes and requirements. In this representation, products can be classified according to importance and satisfaction. Among other things, this helps to classify the current acceptance stage of the product and how it is perceived by customers (Aydogdu et al. 2018).

The development of automation in the automotive industry is constantly progressing. Despite this, the rear-view mirror is still an integral part of vehicle equipment. The driver is accustomed to searching for information covering rear traffic at these points. However, the timely development away from a mirror towards a display is to be expected (Lee 2012). The development of a camera based mirror, following named as Full Display Mirros (FDM) starts here. The system will be installed in vehicles and may replace the mirror in the future, at least as a supplement or extension of it. The FDM operates as a standard mirror as well as display mode with streaming a video. Subjects can toggle the version manual by themselves. One of the advantages of the FDM is the mirror intergrade LCD for optimal rear vision. Thus, this paper presents the results of the evaluation and feedback of the users‘ experience by using the FDM. The results are to be evaluated statistically and presented with regard to the KANO model, the technology acceptance model and the market opportunity map. The goal is the investigation of human-computer interaction. The human being should be considered as the focal point in the use of the FDM in order to generate the best possible evaluation of the system.

2 Methods

2.1 Participants

In order to develop the Full Display Mirror (FDM) as a user-friendly system, it was tested in three studies with N = 60 to have a holistic view. The following criteria were taken into account when planning the experimental study:

- Different daytimes
- Different routes
- Different manoeuvres
- Interview
- Questionnaire
- Different methods
- Eye-Tracking.

The three studies included the following number of subjects

- Daylight study with n = 40
- Night ride study with n = 5
- Eye-tracking study with n = 15

In the following results, the contents of the test drive by daylight are described in more detail.

In total, n = 40 test drivers ($M_{Age} = 30.87; SD = 12.38$, $Range: 18 - 66$), 12 females (30%) and 28 males (70%), participated in the test drives. On average, the annual mileage was given as $M = 17,779$ km/$year$ ($SD = 8,378$). The technology affinity (from 1 = technology affinity very high to 7 = no technology affinity) was rather high in the sample ($M = 2.10$; $SD = 1.32$). The employment status of the sample was composed as follows: 19 subjects were college students, 13 full-time and three part-time employees, two officials, and in each case one pupil, apprentice and pensioner. Participants were not paid for completing the experiment. They were won through a call for tenders at the University of Applied Sciences in Kempten. Due to the central limit value theorem, the normal distribution is used as a basis for the following calculations (Döring and Bortz 2016).

2.2 Materials

Testing Equipment

The FDM installed in the test vehicle is a camera based mirror in a hybrid version. This means that mirror mode and display mode are combined, allowing the driver to switch between the two modes. The mirror mode operates as a standard mirror, whereas the display mode is streaming a video. The reason for this hybrid mode is to be able to distinguish between different driving scenarios, weather conditions and driver preferences. The test persons should be able to switch between the versions according to their preferences. This should facilitate a comparison of both modes. The following Fig. 1 shows the difference in looking behind in mirror mode versus display mode.

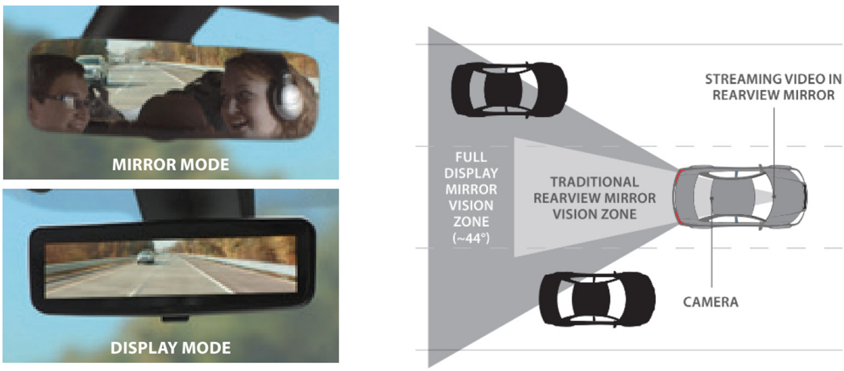

Fig. 1. Mirror mode versus display mode (see "Introducing the New Gentex Aftermarket Full Display Mirror (FDM)")

Interview and Questionnaire

Before and after the test drive on a public road, the subjects received a questionnaire. In addition to get information about user experience, the confidence in the system as well as the anticipated control and intended use was examined. The intuitive interaction questionnaire (INTUI) was used for this purpose. The questionnaire describes the factors "effortless" (5 items), "gut feeling" (4 items), "magical experience" (4 items) and "intuitive interaction" (1 item) (Ullrich 2014; Ullrich and Diefenbach 2010a, 2010b). In addition, questions based on the questionnaire of Gold et al. (2015) were used, especially the factors "trust in automation" with 12 Items and "safety" with four Items. The question about trust in automation included how reliably the system is evaluated, whether it offers security and whether one is confident in the system or whether there is distrust of it. The evaluation was made on a scale of 1 = absolute vote to 7 = absolute vote not to. The "safety" factor could also be answered on this scale and included, among other things, questions on support for hazards and road safety.

The product-specific criteria (“display”, “degree of relief”, “monitoring”, “feeling of safety”, “availability”, and “field of view”), which the subjects should evaluate, were developed in a preliminary workshop. These criteria were evaluated by the participants before the test drive according to importance on a scale of 1 = not important to 7 = very important. After the test drive these criterias were evaluated.

Furthermore, an interview with the subjects was carried out during the journey in order to obtain further information on specific driving manoeuvres, such as the overtaking process and lane change. Further questions were also asked, including the topics of focusing, positive and negative aspects of the FDM, its ratings and importance, comparison of FDM and mirror, purchase decisions and so on. All interviews both spoken and written were conducted in German.

2.3 Procedure

At the beginning of the study, the test persons were welcomed, their driving licence checked and a declaration of liability issued. An explanation of the procedure was given before the test persons received the first part of the questionnaire. As an introduction, a video clip was shown which demonstrated and explains the FDM. The following test drive was carried out with a premium vehicle in which the Gentex FDM was installed. First the test persons were instructed in the test vehicle, then they got accustomed to the vehicle in the sense of a running-in period.

In order to investigate the FDM in all driving situations, three driving speeds were included in the planned route as well as a parking situation was carried out. The distance travelled came to about 70 km per subject. The speeds varied from 80 to 100 km/h (B12, federal road), on the following section of the highway from 140 to 160 km/h (A7, highway) and in the city from 30 to 60 km/ h (City). During and after the test drive, the test persons were interviewed about the respective driving situations. Following the test drive, a new questionnaire survey was also carried out.

3 Results

The intuitive interaction questionnaire (INTUI) revealed that the product is equated to/with effortlessness, as well as with ease, simplicity ($M = 5.85$; $SD = 0.97$) - more than with effort, disorientation or high attention. Furthermore, the use of the FDM in terms of good feeling was neither thoughtless, unconscious or unreasonable, nor deliberate, conscious or justified ($M = 4.16$; $SD = 1.30$). The product is equated more to/with an enthusiastic, magical experience or stirring product ($M = 4.73$; $SD = 1.14$) – more than as insignificant or irrelevant. As well, the use of the FDM is rated as intuitive ($M = 5.90$; $SD = 1.01$). The reliability, which describes the reliability of the measurement method, indicates the degree of measurement accuracy (Döring and Bortz 2016). To measure the internal consistency, Cronbach’s Alpha was calculated. Acceptable to good values were achieved in all factors (effortlessness $\alpha = .86$; gut feeling $\alpha = .75$; magical experience $\alpha = .87$) (Field 2009).

The questions used on trust in automation included whether the system can be trusted in principle, to what extent its reliability is given or whether the system is deceptive. The twelve items of the factor trust in automation resulted in a high reliability (Cronbach's Alpha $\alpha = .90$). The values recorded on a scale from 1 = "high confidence" to 7 = "no confidence" resulted in an average high confidence in the FDM ($M = 2.59$; $SD = 1.07$). The experienced feeling of safety, which was recorded with four items, was also rated rather highly by the test persons using the FDM ($M = 3.32$; $SD = 1.35$). As in the trust in automation factor, good reliability could be recorded (Cronbach's Alpha $\alpha = .80$).

A comparison of the evaluation criteria of rear view mirror and FDM shows, that the FDM was rated better than the normal mirror in all criteria except "availability". The subjects stated that the field of view of FDM is 95% better or much better than the mirror. In all three route sections the category "field of view" of the FDM is rated significantly better than the normal mirror (B12: $t(39) = -9.21; p < .001$; A7: $t(39) = -5.42; p < .001$; City: $t(39) = -8.02; p < .001$). Like this, also the criterion "monitoring" was rated better in the FDM than in the normal mirror (B12: $t(39) = -3.31; p = .002$; A7: $t(39) = -2.87; p = .007$; City: $t(39) = -4.01; p < .001$). There were also significant differences in the sections of the route in terms of "display", "feeling of safety" and "degree of relief". If one now considers the differences in the information on the importance of the criteria versus the later evaluation, it shows that some factors, even if only minor, are rated significantly worse afterwards. Thus, the feeling of safety ($t39) = -1.73$; $p = .091$) and the display ($t(39) = -2.98$; $0 = .005$) as well as the overall factor ($t(38) = -1.79$; $p = .081$) of all evaluation criteria are rated worse after the test drive than its importance is indicated beforehand. The other criteria such as operation, field of view, monitoring, availability and degree of relief were not evaluated significantly differently after the test drive than the importance before the test drive. The following graphic illustrates this result (Fig. 2).

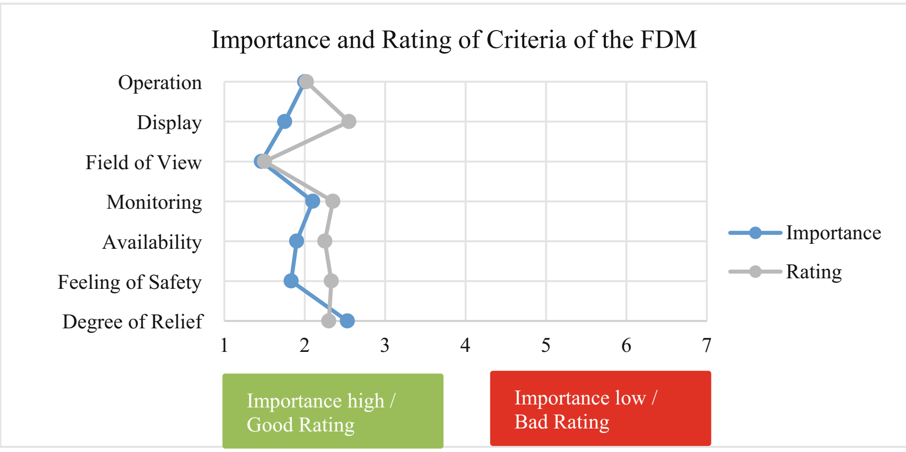

Fig. 2. Importance and rating criteria of the FDM

In addition, interesting customer statements could be recorded for the respective criteria, which enable further development with regard to increased customer requirement, acceptance and improvement of the actual use of the system. Looking at these results in the market opportunity map, the following graph illustrates this. The results of customer requests are divided into four quadrants with the axis cross importance versus fulfillment degree. The quadrant "Market Opportunity" defines requirements that are high in importance but low in satisfaction. The quadrant "Product Requirements", in which almost all evaluations can be mapped, contains product criteria that are very important and also record a high level of satisfaction. The graphic shows/demonstrates/reveals, that the mirror is rated worse than the FDM in all categories, no matter how important the criterion appears to be. The least important criterion is the degree of relief. The most important criterion is the field of view. The largest difference in the evaluation of mirrors and FDM is also reflected in this criterion (Fig. 3).

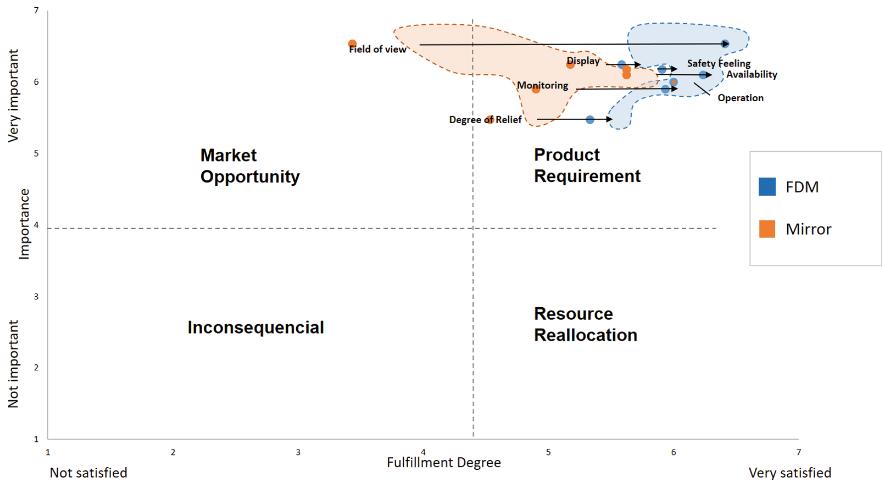

Fig. 3. Market opportunity map of evaluation criteria from FDM

Furthermore, the test persons were asked to describe the FDM with three words. The following entries were made: Safety (23%), clear and good overview (43%), field of view (13%), innovative (23%), picture quality positive (37%), comfort (13%), fun (13%), useful and intuitive (37%) as well as improvable (47%). In order to gain an even more precise insight into how the test drivers assess the FDM, it was recorded what was particularly positive or negative. The following evaluation gives an exemplary overview of which entries the field of view received (Fig. 4).

To obtain a subjective recognition of the field of view with the FDM versus the rear-view mirror, the test persons were asked to make an entry in a drawing. Here they could indicate how broad the field of view is perceived in the respective versions. The following figure shows the result. A total of 85% more field of view with the FDM

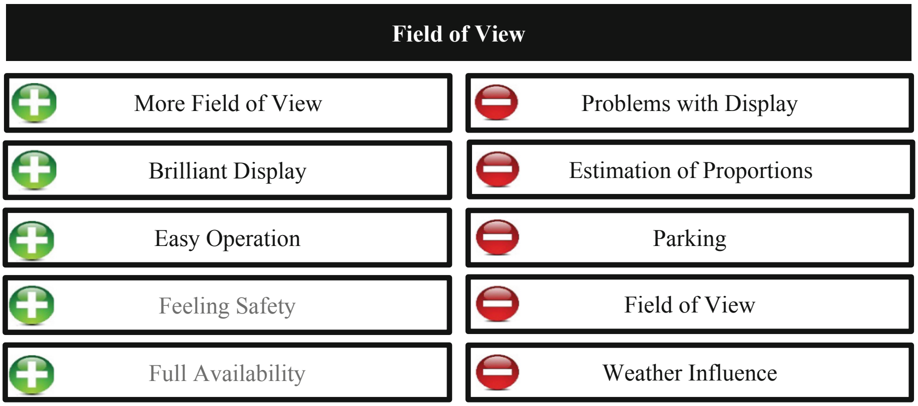

Fig. 4. Positve and negative aspects of field of view with FDM

instead of the rearview mirror was given. The subjects also stated that on average, the hidden area when using the mirror was given as 35.3% (Range: 7% to 60%).

In order to dispel the concerns that problems of focussing might occur, the question was asked whether the subjects had problems with this. A total of 75% of the respondents stated that they had no problems to focus on the FDM. A total of 10% reported focusing problems, 15% of the participants had partly problems. Further wishes regarding further development of the FDM towards design as well as additional features, could also be derived (Fig. 5).

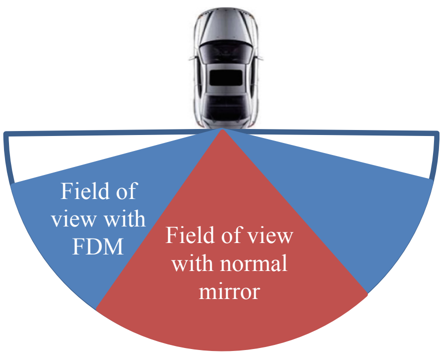

Fig. 5. Field of view with normal mirror versus FDM

In order to capture user-friendliness and usefulness, the questions were based on the technology acceptance model. The users rated the FDM on a scale of 1 = very user friendly with 7 = not user-friendly on average very positive ($M = 2.08$; $SD = 1.56$). Feedback on user-friendliness such as idiot proof, super easy, intuitive to fold etc. supported this result. Also the usefulness was rated very good on a scale from 1 = very useful to 7 = not useful with $M = 2.60$ ($SD = 0.55$). Here, however, it was shown that usefulness is rated most useful in the city ($M = 2.13;\ SD = 1.64$) compared to federal road ($M = 2.48; SD = 1.24$) or even highway ($M = 2.98; SD = 1.98$). The following Table 1 shows the paired t-tests of the respective track sections.

Table 1. Usefulness on the different route sections in comparison

Usefulness of the FDM	t	df	p-value
City – Federal road	–1.236	39	.224
City – Highway	–2.199	39	.034
Federal road – Highway	–1.936	39	.060

Overall, the FDM was not perceived as disturbing by the test persons. The recommendation rate was also very high at 75% in the hybrid version versus 12.5% FDM without the possibility of folding into the mirror versus no recommendation 12.5%. The purchase decision for the tested hybrid version was 57.5% (pure FDM 15% and no version, i.e. normal mirror 27.5%). The assessment of the degree of maturity also revealed that this was rated relatively high by the test persons ($M = 71.5\%; SD = 15.56$; range 0–100%), which illustrates a high product quality. The evaluation of the questions on the KANO model showed that the FDM was an enthusiastic feature. 22 of the test persons stated that it would make them happy if an FDM was installed in their next vehicle. The following Table 2 gives an overview of the respective response categories. The question was once asked what would happen if the FDM was installed and once if it was not installed.

Table 2. Results from questions from the KANO model

Answers KANO model	Installed	Not installed
That would make me happy	22	1
I presuppose that	0	4
I do not care	10	18
I could accept that	7	16
That would bother me a lot	1	1

4 Discussion

The aim of this study was to gather customer feedback on the FDM. End users should be involved as they will and should use the system in their vehicles in the future. Therefore, this large-scale customer study was carried out to involve users and get feedback on how the use of the system is perceived. The evaluation of the interview using theoretical models and existing questionnaires is intended to show how the customer's requirements and wishes affect opinions regarding the product and evaluations of them.

Results showed that there are significant differences in the evaluation of FDM and normal mirror. Based on this, it can be determined, that the FDM as a new technology is already positively evaluated and accepted after a short test drive. A comparison of the FDM and the mirror clearly shows that the broader field of view of the FDM, in particular, receives many plus points in the evaluation. Automation in the sense of using an FDM offers great potential for improving safety, since the field of view is much larger and thus offers more detection potential for hazards. The possibility to switch manually from FDM to mirror by means of a folding mode, even increases the confidence in the system. The occurrence of failures has a strong impact on confidence in automation, but the hybrid version can compensate for malfunctions or technical failures (Feldhütter et al. 2016; Gold et al. 2015).

The low proportion of subjects with focusing problems shows that this affects only a few. Possibly this problem could be excluded with long-term use. If the subject becomes accustomed to the system, it is easier for the test persons to focus, which could reduce the problems. In order to generate further information in this respect, it would be possible to record the accommodation moderation and adaptation. The data of the eye-tracking study will be used for this purpose.

Further results from the study show similar tendencies in user experience. This suggests the conclusion that FDM as an extension of the mirror is an important system. The user experience was rated very positively. The usability and usefulness of the FDM also show, how well the system already works. The test persons' desire to expand the system shows that there is a desire for digitisation. With a further development of the system, the rear traffic could be detected by vehicle detection. A possible extension would be to add a warning system, including information on the time to collision or a colour marking in relation to the speed of the vehicle (Sun et al. 2012). However, this question can be examined further and in more detail. Further research is suggested, to analyze whether added information in the display could be helpful for the monitoring and to increase the benefits for the driver.

In the future, the installation of driver assistance systems in new cars will become more and more important. The trend is towards supporting the driver with these systems. More and more vehicles will be equipped to increase safety in traffic (Köllner 2018). However, the basis for this must be the customer acceptance of the systems, which are only then also used (Schick et al. 2019). In the future, driver assistance systems will certainly be available, but the implementation and use of these systems by customers is currently doubtful. For the actual use of the customer-oriented application, however, a further development of the systems with the involvement of the end users is indispensable.

References

Aydogdu, S., Schick, B., Wolf, M.: Claim and reality? lane keeping assistant - the conflict between expectation and customer experience. In: 27 Aachener Kolloquium Fahrzeug- und Motorentechnik (2018)

Blackler, A., Hurtienne, J.: Towards a unified view of intuitive interaction: definitions, models and tools across the world. MMI-Interaktiv **13**, 36–54 (2007)

Blackler, A., Popovic, V., Mahar, D.: Investigating users' intuitive interaction with complex artefacts. Appl. Ergon. **41**, 72–92 (2010). https://doi.org/10.1016/j.apergo.2009.04.010

Davis, F.D.: A technology acceptance model for empirically testing new end-unser information systems: Theory and results (Dissertation). Massachusetts Institute of Technology (1985)

Davis, F.D., Bagozzi, R.P., Warshaw, P.R.: User acceptance of computer technology: a comparison of two theoretical models. Manage. Sci. **35**, 982–1003 (1989)

Döring, N., Bortz, J. (eds.): Springer-Lehrbuch. Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften. Springer, Heidelberg (2016). https://doi.org/10.1007/978-3-642-41089-5

DIN EN ISO 9241-21: Ergonomie der Mensch-System-Interaktion Teil 210: Prozess zur Gestaltung gebrauchstauglicher interaktier Systeme. Beuth, Berlin (2010)

DIN EN ISO D8241-11: Ergonomische Anforderungen für Bürotätigkeiten mit Bildschirmgeräten Teil 11: Anforderungen an die Gebrauchstauglichkeit. Beuth, Berlin (1999)

Feldhütter, A., Gold, C., Hüger, A., Bengler, K.: Trust in automation as a matter of media influence and experience of automated vehicles. Proc. Hum. Factors Ergon. Soc. Ann. Meet. **60**, 2024–2028 (2016). https://doi.org/10.1177/1541931213601460

Field, A.: Discovering Statistics using SPSS: and Sex and Drugs and Rock 'n' Roll. SAGE Publications Ltd, London (2009)

Gold, C., Körber, M., Hohenberger, C., Lechner, D., Bengler, K.: Trust in automation – before and after the experience of take-over scenarios in a highly automated vehicle. Procedia Manufact. **3**, 3025–3032 (2015). https://doi.org/10.1016/j.promfg.2015.07.847

Held, T., Schrepp, M.: UX-Professionals im Spannungsfeld zwischen Nutzern und Entscheidern. In: Hess, S., Fischer, H. (eds.) Mensch und Computer 2018 - Usability Professionals, pp. 427–436. Gesellschaft für Informatik e.V. und German UPA e.V, Bonn (2018)

Hölzing, J.A.: Die Kano-Theorie der Kundenzufriedenheitsmessung: Eine theoretische und empirische Überprüfung, 1st edn. Gabler, Wiesbaden (2007)

Introducing the New Gentex Aftermarket Full Display Mirror (FDM). http://www.gentex.com/media-kit-files/Aftermarket-FDM/Aftermarket-FDM-Flyer.pdf

Köllner, C.: Immer mehr Assistenz für Fahrer (2018). https://www.springerprofessional.de/fahrerassistenz/automatisiertes-fahren/immer-mehr-assistenz-fuer-den-fahrer/15544504

König, W.: Nutzergerechte Entwicklung der Mensch-Maschine-Interaktion von Fahrerassistenzsystemen. In: Winner, H., Hakuli, S., Lotz, F., Singer, C. (Eds.) ATZ/MTZ-Fachbuch. Handbuch Fahrerassistenzsysteme: Grundlagen, Komponenten und Systeme für aktive Sicherheit und Komfort, 3rd ed., pp. 621–632. Springer Vieweg, Wiesbaden (2015). https://doi.org/10.1007/978-3-658-05734-3_33

Körber, M., Eichinger, A., Bengler, K., Olaverri-Monreal, C.: User experience evaluation in an automotive context. In: 2013 IEEE Intelligent Vehicles Symposium Workshops, pp. 13–18 (2013). https://doi.org/10.1109/IVS.2013.6629440

Lee, E.: Der Rückspiegel als Display. ATZ **7**, 108–113 (2012)

Macaranas, A., Antle, A.N., Riecke, B.E.: What is intuitive interaction? balancing users' performance and satisfaction with natural user interfaces. Interact. Comput. **27**, 357–370 (2015). https://doi.org/10.1093/iwc/iwv003

Mentler, T.: Usability engineering and user experience design sicherheitskritischer systeme. In: Reuter, C. (ed.) Sicherheitskritische Mensch-Computer-Interaktion: Interaktive Technologien und Soziale Medien im Krisen- und Sicherheitsmanagement, pp. 41–60. Springer Vieweg, Wiesbaden (2018). https://doi.org/10.1007/978-3-658-19523-6_3

Nerdinger, F.W., Neumann, C., Curth, S.: Kundenzufriedenheit und Kundenbindung. In: Moser, K. (ed.) Wirtschaftspsychologie, 2nd edn, pp. 119–137. Springer, Heidelberg (2015). https://doi.org/10.1007/978-3-540-71637-2_8

Reiterer, H., Geyer, F.: Mensch-computer-interaktion. In: Kuhlen, R., Semar, W., Strauch, D. (eds.) Grundlagen Information und Dokumentation: Handbuch zur Einführung in die Informationswissenschaft und –praxis, pp. 431–440. De Gruyter Saur, Berlin (2013)

Robier, J.: Das einfache und emotionale Kauferlebnis: Mit Usability, User Experience und Customer Experience anspruchsvolle Kunden gewinnen (Online-ausg). EBL-Schweitzer. Springer Fachmedien Wiesbaden, Wiesbaden (2015). https://doi.org/10.1007/978-3-658-10130-5

Schick, B., Seidler, C., Aydogdu, S., Kuo, Y.-J.: Fahrerlebnis versus mentaler Stress bei der assistierten Querführung. ATZ **121**, 74–79 (2019)

Seidler, C., Schick, B.: Stress and workload when using the lane keeping assistant: driving experience with advanced driver assistance systems. In: 27 Aachener Kolloquium, Fahrzeug- und Motorentechnik (2018)

Stappenbeck, B.: Technologische Innovation wird die Weltwirtschaft umwälzen (2017). https://www.bertelsmann-stiftung.de/de/themen/aktuelle-meldungen/2017/april/technologische-innovation-wird-die-weltwirtschaft-umwaelzen/

Sun, C., Ma, G., Dwivedi, M., Zeng, Y., Song, X.: A rear view camera based tailgate warning system. in society of automotive engineers of China & international federation of automotive engineering societies. In: Proceedings of the FISITA 2012 World Automotive Congress: Volume 9: Automotive Safety Technology, pp. 449–460. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-33805-2

Ullrich, D.: Intuitive Interaktion: Eine Exploration von Komponenten, Einflussfaktoren und Gestaltungsansätzen aus der Perspektive des Nutzererlebens (Dissertation). Technische Universität Darmstadt, Darmstadt (2014)

Ullrich, D., Diefenbach, S.: From magical experience to effortlessness: an exploration of the components of intuitive interaction. In: Hvannberg, E.T. (Ed.) ACM Digital Library, Proceedings of the 6th Nordic Conference on Human-Computer Interaction Extending Boundaries, pp. 801–804. ACM, New York (2010a)

Ullrich, D., Diefenbach, S.: INTUI exploring the facets of intuitive interaction. In: Ziegler, J., Schmidt, A. (Eds.) Mensch & Computer 2010, pp. 251–260. Oldenbourg Verlag, München (2010b)

Venkatesh, V., Davis, F.D.: A theoretical extension of the technology acceptance model: four longitudinal field studies. Manage. Sci. **46**, 186–204 (2000)