

To whom does the driver's seat belong in the future?

A case of negotiation between gender studies and automotive engineering

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ABSTRACT

This article provides an experience report on an interdisciplinary cooperation between two gender researchers and two automotive engineers at a German technical university. It focuses on the negotiation processes around a joint research proposal, dealing with the question of how to create concepts for a trustworthy human-machine interaction in automated driving systems that satisfy the requirements of different user groups. These systems aim to offer the choice of automobility to groups of users who have so far had rather limited access, or have had reasons to refuse usage. Discussions in the interdisciplinary team are still ongoing. Their substantial shifts and their expected methodological and epistemological effects are analyzed from a feminist science and technology studies (STS) perspective. The general objective of this paper is to provide insights about the contributions and challenges of integrating approaches from gender studies into the field of automotive engineering in order to support interdisciplinary dialogues that foster a socially fair and inclusive digital transformation.

CCS CONCEPTS

• *Human-centered computing-Empirical studies in HCI*

KEYWORDS

Automated Driving, feminist STS analysis, interdisciplinary collaboration, case study, autonomous driving

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1 INTRODUCTION

Automotive engineering is an interesting field of study for gender studies scholars because of the close connections between men and technology [26], [55], [57], [71] and men and cars [3], [46]. Automated driving systems such as adaptive cruise control, parking assistance, or lane keeping systems, actively support and progressively take over the driver's actions. Ongoing sociotechnological developments will change the driver-car relationship in a fundamental way that also affects traditional entanglements of masculinity, cars, and driving [18], [68]. Drawing on science and technology studies that focus on the mutual shaping of society and technology [18], [46] these systems are 'technologies in the making' [11] that currently 'materialize' technically and socially. For this reason, the initial question "to whom does the driver's seat belong in the future?" is not yet decided.

In the following, we examine automated driving systems and research from gender research and STS perspectives. That means that we inquire how different (social) actors, interests, and positions influence relationships between humans and cars. In this context, gender researchers particularly consider marginalized actors and aspects within the process of technological development. We do not, therefore, only explore the concepts and interests of automotive engineers, but also take gender and diversity dimensions into account by paying attention to current attitudes, needs, and desires of different user groups.

The article is structured as follows: After this introduction, in the second part, we describe current visions, paradigms, and developments that constitute the field of automated driving systems in automotive engineering and contrast these with results from empirical investigations in the social sciences and humanities. The latter identify several drivers' use cases and

motives, their often non-functional, affective relationships to cars, and attitudes towards the future vision of self-driving vehicles, which have not yet been sufficiently considered in automotive engineering. This second part of the paper provides insights into problems and limits of current technological developments and explains the increasing interest of engineers in gender studies and the social sciences. In the third part, we describe and analyze our collaboration at the interface of gender studies and engineering science at a German institute of technology. Our case study investigates the negotiation process between two gender researchers and two automotive engineers. This process is still ongoing and aims at the development of a joint research proposal for one of the major German funding agencies. The proposal deals with the question of how to create trustworthy automated driving systems for different user groups. Referring to concepts of feminist science and technology studies (STS) that describe how society, technology, and gender mutually shape one another, we analyze concepts such as users, technology, agency, human-machine configurations, and the overall research design explicitly or implicitly used in the negotiation process, and evaluate how they contribute to a socially fair and inclusive technological outcome. We thus describe how our interdisciplinary discussions led to a) a substantial differentiation of user groups to be included in the research design of the proposal, b) a consideration of emotional dimensions of driver-car relationships and, c) methodologically, to an overall change of the proposal's research focus, from questions about how to design user-appropriate and trustworthy technological artefacts, to questions about general methodological approaches and tools that meet design requirements for safe real-time human-machine systems which satisfy different users' demands. In the conclusions we reflect on our experiences and discuss what we have learned about the benefits and challenges of interdisciplinary negotiations between gender studies and engineering.

2 DIFFERENT PERSPECTIVES ON CURRENT AND FUTURE AUTOMOBILITY

2.1 The vision of automotive engineers: Driverless cars

Researchers in automotive engineering at universities and in the car industry are currently working hard to provide driving systems that enhance the driving experience and support challenging traffic settings for everyone. Adaptive cruise control, parking assistance, or lane keeping systems already belong to the standard equipment of today's vehicles. These efforts culminate in the vision of driverless cars. This vision is guided by a model that includes six levels of automatization ranging from level 0, no automation, level 1 ("hands on"): driver assistance, level 2 ("hands off"): partial automation, level 3: ("eyes off"): conditional automation, level 4 ("mind off"): high automation to level 5: driverless [67]. Automotive engineers see this model as the roadmap for automated driving systems aiming at a complete substitution of humans by machines. This means that autonomous cars need to be designed so that the complex tasks of driving,

which are so far assigned to human drivers, will be carried out by the cars themselves.

The main discourse in automotive engineering promotes autonomous cars with arguments such as increasing traffic safety, efficiency, and comfort in general [18]. These systems are also expected to solve the current problems in western industrialized countries caused by mass motorization, urbanization, and ageing societies and the negative consequences of traffic jams in congested urban areas for the environment and health [28], [31], [72]. Automated cars also promise to provide individual mobility and independence for people with limited cognitive, physical, or experiential capabilities [9], [47].

Despite the possible benefits, we take into account empirical investigations that give reasons to expect that automated driving systems run the risk to fail. According to such findings, available driver assistance systems are rarely used [47]. Moreover, market research and acceptance studies reveal that consumers have very ambivalent feelings towards the future of automobility [1], [27], [33], [34], [39]. Social sciences and humanities researchers in particular point out that non-functional, especially emotional, aspects of driving play a crucial role in the relation between humans and cars [3], [9], [49], [60], [68], [72].

As we will discuss more extensively in the next section, such results make automotive engineers realize that a technological development focusing mainly on the functionality and efficiency of the machine/car instead of on users is too limited to succeed. Therefore, they become increasingly interested in gender and social science research, which is expected to provide important insights and approaches for a user and use-oriented development of future automotive systems that have better chances of being accepted by the users.

2.2 The vision of gender researchers: Automated driving as technology of inclusion

For gender researchers, automated driving systems are especially interesting because they may change relations between humans and cars in a fundamental way that affects the traditional connection of cars and driving with masculinity, in which men's passion for the automobile often follows heterosexual patterns of desire [49]. Driverless cars turn the active human driver into a passive passenger. Thinking through human-machine configurations with the gender and technoscience studies scholar Donna Haraway [40], whether the structural-symbolic gender order will change when the human driver is (at least partially) replaced by a technological system [9], [18] is an open question. Will the driverless car symbolically disconnect driving from masculinity? Or will men refuse to use autonomous cars, since it threatens masculine identity? Will the vision of the driverless car, therefore, fail socially, rather than technically? Whether automated driving systems reach their potential for inclusion might depend on such issues and the related question of how will agency be shared between people and their cars.

Following this line of argument, what automated driving systems will mean in the future and how these systems will matter

does not only result from engineering efforts. In terms of science and technology studies, meaning and matter is rather an ongoing process of emerging socio-technical interpretations, stabilizations, and destabilizations by different actors who co-produce or co-materialize these artefacts [4], [19]. Gender researchers can contribute to technological developments by introducing knowledge of how gender and technology are co-constructed, in order to create or modify artefacts that are socially fair and inclusive. With such an agenda, gender studies researchers have already been successful since the 1980s in such fields as informatics and computer science [14], [35], where they provided methodologies for technological research and development based on gender studies and other theoretical approaches critical of inequality and power regimes [5], [6], [7], [24], [25], [30], [48]. Automotive engineering is not yet familiar with this extensive body of knowledge. Moreover, it has its own disciplinary culture that embodies specific challenges to the integration of the knowledge and approaches of gender studies. As a case study, in the following part we explore the negotiation processes between gender researchers and automotive engineers in our own context of work.

3 DEVELOPING A JOINT RESEARCH PROPOSAL FOR THRUSTWORTHY AUTOMATED DRIVING

In the following, we examine the interdisciplinary collaboration between two gender and STS researchers and two engineers from the institute of automotive engineering at the Technische Universität Braunschweig. The first two and one of the latter researchers are authors of this paper. We aim at developing a joint research proposal that intends to explore methods of designing trustworthy automated driving systems.

In this section, we first present the concepts we refer to for our case study analysis. Then we briefly illustrate how the two research groups involved got in touch, and outline the preliminary motivation for a joint research project.

3.1 Feminist STS concepts as analytical tools

For the purpose of analyzing our own interdisciplinary discussion in the group, we use concepts from feminist science and technology studies in order to examine how the ontological and methodological assumptions negotiated change. We particularly draw on Lucy Suchman's understanding of technological development. In reference to Judith Butler, she emphasizes the performative character of objects or technologies and states: "(...) that sexed and gendered bodies are materialized over time through the reiteration of norms is suggestive for a view of technology construction as a process of materialization through the reiteration of forms. Butler argues that 'sex' is a dynamic materialization of always contested gender norms: similarly, we might understand 'things' or objects as materializations of more and less contested, normative figurations of matter." [65].

On this basis, gender and automated driving systems are not considered as pre-existing entities, but co-materialize in a process

in which traditional gender norms, as well as forms of the technology, are contested. Following Karen Barad's approach to "ethico-onto-epistemology" [4], we cannot assume ourselves as researchers to be outside of these processes of co-materialization. Rather, we play an active part in shaping the world. This implies responsibility. By turning this inevitable involvement into an explicit commitment of mutual engagement between gender studies and automotive engineering, we strive for "agential cuts" [4] by (re-)negotiating concepts of humans, machines, and agency. We consider these cuts as accountable when they shift automated driving systems towards a more socially fair and inclusive technology. By aiming at interventions in technology design, our approach transcends analytical research and thus goes further than most feminist STS work.

3.2 Initializing interdisciplinary cooperation

Both research groups first met at an invited talk organized by the gender and STS studies researchers. The invited researcher presented an analysis that carved out the relevance of masculine connotations for the relationship of drivers and (autonomous) cars. This caught the engineers' attention. In first encounters both groups identified questions of gender and automated driving as research lacunae. We decided to develop an interdisciplinary research proposal in order to fill this gap. As already mentioned above, we shared a common interest in users, although for different reasons. Whereas the engineers saw a chance to reduce the risk of future economic failure by increasing possible user acceptance and trust, the gender and STS researchers took the opportunity to explicitly focus on users and aspects of use that are usually not the focus of engineers' attention. In this respect, the latter followed the concepts of technological democratization, emancipation, and user empowerment. They aimed at demonstrating that gender and STS studies provide profitable knowledge and methods for technological research and development. The interest in users can, therefore, be regarded as a "boundary object" [45] that mediates between the different research parties' intentions.

4 CASE STUDY: THE PROCESS OF INTERDISCIPLINARY NEGOTIATIONS

In the following, we focus on and analyze the process of negotiation from the perspectives of the two gender researchers involved, asking which contributions, challenges, and difficulties foster a socially inclusive, gender- and diversity-sensitive technological development.

4.1 Starting an interdisciplinary discussion: The first draft of the research proposal

The engineers offered a first draft of the research proposal that provided the basis of our negotiation process. In this sketch they described a research setting which aimed at a detailed exploration of the interactions between human drivers and automated driving systems, methodologically based on extensive usability tests in driving simulations and demonstrator vehicles. The overall intention of the first draft was enhancing and adapting concepts

of human-machine interactions for automated driving systems according to empirically gathered insights into the drivers' informational needs and representational preferences. The engineers argued that there is a need for such adaptations and optimizations by referring to results of present usability studies, which show that systems such as adaptive cruise control (ACC) or lane departure warning systems (LDW) are rarely used or even switched off [47]. In the draft these results were interpreted as evidence for an inappropriate design of the human-machine interface (HMI), which led to users' suspicion and mistrust in such systems and might limit their future acceptance and use. The engineers assumed that their own professional practice fosters such failures because of their focus on functionality and efficiency. They suggested that in the next version of the research proposal individual users' needs should play a more crucial role.

4.2 Negotiating the 'user'

The first draft allowed deeper insights into engineers' understanding of 'users'. Users were principally seen as subjects with different informational and representational needs that have to be considered within the development of appropriate human-machine interaction (HMI) concepts of automated driving systems. The proposal described users in terms of situational conditions such as tiredness, distraction, stress, mental over- or underload, and personal aspects. In this respect, the engineers focused on age and driving experience, and recommended taking elderly and novice drivers into account. In contrast to the engineers, the gender and STS researchers referred to inquiries from social sciences that investigate the socio-cultural aspects of automobility and its changes in conjunction to contemporary social developments. They agreed with the engineers that the research proposal in progress should focus on elderly and occasional drivers, who are supposed to have less established driving routines. Additionally, both categories represent growing user groups with regard to ageing populations and a saturation of individual mass motorization as an effect of urbanization in western industrialized countries [66], [72]. Especially young urban citizens, who can use alternative mobility services, often have neither a car nor a driving license [72].

The gender researchers also took studies about the changing attitudes of people towards new technological developments into account. Acceptance studies show that users have very ambivalent feelings towards automated driving systems. On the one hand, they appreciate technical progress in terms of the increased comfort and efficiency promised [1], [12], [13], [27]. On the other hand, they mistrust the systems' technical reliability and safety [34], [37] or fear the loss of the drivers' power and a reduction in driving pleasure [9], [36]. Most of the respondents explicitly ask for the possibility to override the system at any time. This suggests that they do not yet trust in automated driving systems [34], [37]. Men and well-educated people with higher incomes tend to be more open towards automated driving technology than, e.g. women [34]. Young respondents seem to be less skeptical than elderly [17], [34].

Subjective motives of use especially influence how users evaluate the future technology of automated driving systems:

When respondents emphasize aspects of comfort and flexibility, they evaluate automated driving much more positively than those who regard driving as an expression of individuality, self-determination, and fun [36]. Such subjective, emotional aspects can moreover cause resistance against the change towards a more sustainable, posthumanist mobility [42] [50] [73].

These insights are additionally underpinned by studies from the social sciences and humanities that investigate the historical change of meaning and current media discourse about automobility from a socio-cultural perspective [43], [63], [68], [72], [60]. Cars are, according to these studies, much more than just means of transportation. Subjective and emotional motives of use, aspects of age, gender, and education, as well as socio-cultural values and norms, influence the relationship between drivers and cars. Emotions in particular are important with regard to the aspect of trust in these artifacts, which have to work reliably under real-life conditions. With these results, the gender and STS researchers convinced the engineers to consider socio-cultural aspects in the research design. Both parties agreed on focusing on drivers who might represent exceptionally demanding user groups for this kind of technology, for instance passionate and risk-oriented drivers.

Empirical insights suggest that people who claim that driving, especially driving fast, is a crucial part of their identity, – and these are mostly young and male drivers [3], [60], [68] – have a tendency to reject automated driving systems [21]. Such systems turn the driver's role from an active and self-determined subject into a passive passenger, which affects particularly negatively those who seek to express power, freedom, and self-control through driving. The social scientist Lena Berscheid [9] even assumes that the future vision of self-driving cars threatens masculinity. Simultaneously, this aspect can be regarded as a chance to redefine the gendered human-car relationship. This is in line with the gender and STS researchers' intention to turn automated driving systems into a socially and gender-fair technology. The gender and STS researchers, moreover, recommended considering the target group of people who are – professionally or personally – responsible for care work. Empirical investigations show that care workers take shorter and more cross-linked routes than people without any support obligations [8], [10], [51]. The gender and STS researchers argue that users who frequently drive in the service of others – and these are mainly women [29] – are supposed to be a very demanding target group with regard to safety requirements.

4.3 Considering users' diversity and emotional subjectivity

To summarize, the gender and STS researchers used inquiries from the social sciences and humanities to identify and argue for different user groups and aspects of use that should be considered within the design of automated driving. These insights and arguments convinced the engineers, who completely agreed with their suggestions. Thus, integrating knowledge from gender studies, the social sciences, and the humanities led to the following substantial modifications of the research proposal:

- Interdisciplinary work contributed to a concrete definition of target groups for automated driving systems according to contemporary and future social developments, as well as subjective aspects of use.
- It sensitized to the relevance of aspects of gender and diversity according to different life conditions and contexts of use.
- It contributed to a general expansion of the research focus, embracing non-functional, emotional aspects of use, which is an essential amplification within the research and development of automotive engineering that is mainly guided by criteria of functionality, rationality, and efficiency.

Finally, the negotiation on relevant target groups for automated driving systems contributed to an overall elaboration and concrete diversification of the concept of “users”. In contrast to the first draft of the proposal, users are now conceptualized as rational as well as emotional subjects, who relate to certain life conditions, social roles, and gender images that influence their functional and non-functional attitudes and demands towards automobility now and in future. On this basis, we can say that the negotiations resulted in a more pluralistic and comprehensive view on users. However, recognising different user groups and understanding that their different relationships to cars and driving are deeply socio-culturally and individually influenced is neither sufficient to predict the future acceptance of automated driving systems, nor does it provide information about concrete user requirements for the design of appropriate HMI concepts. This problematizing led us to questions of how to mirror the manifold individual and socio-cultural aspects of users and use contexts in the development of automated driving systems. These questions in turn gave rise to discussions on appropriate methods and tools for user involvement in order to produce appropriate and reliable technical solutions. We will focus on this shift in the next paragraph.

4.4 Negotiations about user involvement

In the first draft of the research proposal, the engineers proposed the following research design: They planned to conduct extensive usability tests within driving simulations and demonstrator vehicles, depending on the risk factor of the respective driving maneuvers. Within these test scenarios, the driving behavior of the respective test user should be measured according to certain parameters of the system. Afterwards, the test users should be interviewed and statements on their experiences and impressions in interacting with the system should be recorded, which can later be related to the collected data and the corresponding design. Using this kind of approach provides user insights about the given HMI-concepts, the technical infrastructure, and the necessary functional and technical adaptation to increase the users' confidence. This take, however, neither informs on the respective user's daily life, nor on his or her emotional concerns, which are crucially important in understanding different design preferences and demands. In

respect to our previous negotiations and their results, e.g. the extended and elaborated concept of users, we were in need of new methods that included drivers' subjectivities in a more comprehensive way and made their context of use and their subjective and affective reactions visible. For this purpose, the gender and STS researcher suggested a Participatory Design approach. In contrast to usability tests, which integrate users at a very late stage of the development process, Participatory Design requires that people who are directly affected by the technology in question have to be involved in the research and development process from the beginning. The question here is not which approach is generally better. Instead, we have to ask: What would we like to know? Which results do we expect? How do these results affect the technology we want to design? And finally: How do these results satisfy the different research questions of the engineers and gender and STS researchers within our research team?

The gender and STS researchers emphasized that Participatory Design has already been successfully applied to the development of user-appropriate, gender- and diversity-sensitive software within the context of computer science and informatics [22], [23]. They explained that this approach is capable of making highly subjective, socio-emotional user requirements visible, considerable, and transferable to design ideas and technical solutions.

One essential part of this approach is to sensitize users to their own behavior. Such awareness increases the significance of the research and design results. Especially daily routines – and driving often belongs among them – are based on tacit knowledge that has to be made conscious and expressible [62], [64]. Participatory Design offers manifold tools and techniques that enable users to reflect on their needs and demands, express them to technicians, and enable them to visualize ideas and design solutions together with them [21], [63]. In contrast to usability tests, this approach is open to the development of completely new ideas, use scenarios, and design concepts essentially inspired by the users. The gender and STS researchers admitted that they did not question usability tests in general, but within a participatory design framework they would employ them in a more contextualized manner at a later stage of the design process. So, Participatory Design seemed capable of tying both research parties' intentions together by enhancing the user-appropriateness and future acceptance of automated driving systems on the one hand, while providing socially fair, gender- and diversity-sensitive technical solutions on the other. In respect to the latter, the gender and STS researchers refer to the Scandinavian roots of Participatory Design that originates from the movement of workplace democracy and strives for a 'democratization of innovation' by the empowerment of those users who are directly affected by the technology, but are often not heard because of their marginalized and powerless positions [15], [44]. The development of autonomous cars affects all of us, since it will change mobility in fundamental ways. For this reason, it is crucial to consider very heterogeneous users and use aspects, as reflected within the modified concept of users we negotiated before. The engineers were convinced to follow this kind of

approach that implies new roles and relationships developing between all participating people. This led to negotiations about how to name the 'users' within the next version of the research proposal. While the engineers talked about "test subjects" and "proband", terms that fit into their former research model of usability testing, the gender researchers pointed to a necessary change. Participatory design approaches consider users as experts in their life and practices. Hence, they are no longer test subjects, but partners who work with the engineers on an equal level. That turns users into co-designers and shifts the role of engineers, who are now responsible for the users' involvement. As a consequence, engineers additionally become moderators, facilitators, and "change drivers" [32], [61]. The discussion within the research team ended with a joint decision of talking about 'participants' or 'participating users'.

4.5 From usability tests to user participation

The discussions on an appropriate approach that is capable of reflecting the socio-cultural complexity of automobile use contexts led to an overall participatory turn of the research proposal. This affected the entire research design and entailed the definition of new work packages to deal with the recruitment of representatives of the preliminary defined user groups, whose subjective mobility habits, resources, patterns, and explicitly studied non-functional and subjective driving motives and safety demands should be investigated by using qualitative methods and tools. Both research parties agreed on involving users closely in the research and design phases, but there is still disagreement about the composition of the participating users' group. Whereas the gender and STS researchers advocate for selecting users according to the criteria of qualitative diversity, the engineers would prefer to select them according to the criterion of representativeness, without specifying what the user group should be representative of. Nevertheless, the methodological negotiations turned the whole research and development process from a technical into a more a socio-cultural and user-driven approach that promises to produce the following results:

- Receiving heterogeneous insights into different life conditions and subjective driving motives and considering functional and non-functional aspects with explicit reference to subjective and emotional demands
- Developing concrete use scenarios, design and safety requirements, new ideas, and design concepts directly with users, according to their individual mobility habits, conditions, and demands, with an explicit focus on non-functional and affective aspects
- A contextualization of design preferences and safety demands according to different life context and use conditions, in conjunction with aspects of gender and diversity
- Modification of power relations within the research and design team and process to the benefit of users

The discussions about the appropriate methodological approach caught the engineers' attention more broadly. During

the discussions that led to the participatory turn of the research proposal, they realized that there is a general lack of methodological procedures, and tools, which allow for a user-centered development of technological solutions in the context of automotive engineering. The preliminary question of how to create user-appropriate and trustworthy automated driving systems came to be regarded, not as a design problem anymore, but as a methodological one.

4.6 Methodological negotiations: From participatory design concepts to participatory approaches for user-driven technologies

Consequently, the engineers advocated for a complete shift of the research design. Instead of focusing on gathering user requirements for reliable design concepts of automated driving systems, the proposal should rather aim at the development of a participatory design procedure that provides an appropriate knowledge, which generally allows producing real-time technological solutions that satisfy different users' design requirements and safety demands. The gender and STS researchers eagerly supported this shift for several reasons. They regarded automotive engineering as a new and particularly interesting field of investigation and application that offers great potential for enhancing participatory procedures, methods, and tools. This approach addresses the challenging question of how to capture user insights during real-time interactions with new technological systems and features. In this respect, the gender and STS researchers saw automated driving systems as extremely suitable research objects for exploring how far virtual simulations or real-time demonstrations can be used as Participatory Design tools that provide an experiential basis the participating users can refer to in order to estimate and evaluate the chances and risks of future technologies. Finally, the engineers reacted to the social scientists' recommendation of Fraedrich und Lenz [36] who had already emphasized the need to provide to users experiences of future automated driving systems in order to get more reliable and significant feedback about their demands. This introduced the last, and so far final, modification of our proposal. It now describes a research project that aims at the development of a participatory design procedure that provides the basis for the design of reliable human-machine interactions, with particular emphasis on considering subjective, socio-cultural, and affective aspects of use. In this new version, the automated driving systems act as a model field of investigation and application for the progression of participatory design methods and tools. An essential part of the proposed research project is developing criteria that allow the evaluation of the overall procedure and the methods and tools applied, with regard to their contribution to increasing the users' trust in the developed systems.

5 SUMMARY AND CONCLUSION

5.1 Shifts and changes during interdisciplinary collaboration

Looking back to the beginning of the cooperation between gender and STS researchers and automotive engineers, we claim that the changes from the first draft to the current version of the research proposal can be appreciated as a success story for both parties involved. The process illustrates that interdisciplinary negotiations are worthwhile, since they reveal disciplinary shortcomings and offer possibilities for a substantial sharpening and adjustment of concepts and for methodological improvement. In our case, we have passed through the following modifications and achieved the following results:

- A broadening and diversification of user groups, including considerations of gender and other categories of inequality
- An inclusion of users' different functional as well as non-functional demands of current and future automobility
- Understanding users as situated subjects in contexts of daily life with certain mobility habits, resources, and conditions under which they live.

Conceptualizing users this way differs from traditional technological projects in a number of respects. Against the underlying assumption of alleged neutral technology development and the risk of designing according to male engineers' assumptions and interests [69], [70] – a design practice that has already been criticized as I-methodology [2], [58] – gender researchers called for integrating gendered perspectives. This call is in other contexts, however, often misunderstood as “designing from stereotypes” [59], where stereotypes about women are implemented in technological products and, thus, fail to address users (e.g. women) because of their misrepresentation [56]. Our approach, on the contrary, involves users directly. Moreover, we aim at overcoming binary gender concepts, which risk essentializing gender, by not only involving a variety of users, but also relating user requirements to their daily life contexts instead of their alleged sex.

Two further changes in the course of our interdisciplinary negotiations were:

- Enhancing rationalist function-driven technology development by taking non-functional and emotional aspects of technology into account
- Moving from a technology-driven to a user-driven development

For decades user-centered approaches have called for a shift, from a technology development that only follows questions of functionality and objectifies user models, to addressing the needs and demands of users by recognizing their subjectivities [52], [54]. Particularly, proponents of the field of user experience (UX, a branch of human-computer interaction) pointed to emotional and affective relations users create when interacting with technology

[41], [53]. Our approach draws on this scholarship, which is, however, not well known in the field of automotive engineering so far. Emotions and affect are already considered in designing certain features of (traditional) cars, such as the sound of closing a car door. Such rather subjective aspects, however, are not yet taken into account in the first stages of technology/car design, i.e. in the phase of identifying user requirements. In order to achieve these two changes some more shifts in the proposal were necessary:

- Shifting the concepts of technological adaptation to users' demands closer to a concept of socio-technical co-creation by users and designers
- Shifting the research proposal's focus from new user interfaces to new methods of technology design

From the latter shifts we expect the most substantial and sustainable changes. If our research proposal is approved, it is likely, not only that the research project will result in a more trustworthy technology of automated driving, and will not only answer the initial question “to whom does the driver's seat belong in the future?”, but will also produce socially fair and inclusive technology. It will, moreover, hopefully show that the new concepts and methods we have chosen, more adequately address the intended user groups and their subjective, affective relationships with technology than the concepts and methods used before. The shift towards a methodological research proposal, through which we have passed, will also have ontological and epistemological consequences, since it fundamentally affects the basic knowledge from which engineers think and work as well as the world and daily life of those who will live with the new technology. In this sense, the question “to whom does the driver's seat belong in the future?” turns out to be “ethico-onto-epistem-ological” [4]. It affects knowing-in-being and being-in-knowing. Having this in mind, we – the researchers changing the proposal – aimed at making decisions about shifts and modifications ethically, or rather politically. Drawing on the theoretical feminist STS framework, the shift from the initial research question of how to design trustworthy automated driving systems to questions about appropriate methods and tools that provide a suitable knowledge base for designing in a reliable, socially fair, and inclusive way, can be read as a series of accountable “agential cuts” [4].

5.2 Open question and problematization

This obviously productive process of interdisciplinary negotiations, however, did not proceed without any contradictions, tensions, or missing links. There are, for instance, several unquestioned ontological concepts and scientific paradigms with which we work, but have not yet discussed critically in the development of our joint research proposal. This includes fundamental concepts about humans, technology, science, and research that differ between engineers and gender studies scholars because of their differing disciplinary cultures. An example in which such differences become relevant is the 6-level model of automated driving culminating in driverless cars.

The automotive engineers take this model as an unquestioned development guideline, whereas the STS scholars consider it problematic, since it is based on the assumption that machines might substitute humans and, thus, erase any human agency in driving. The STS researchers, to the contrary, refer to concepts of distributed agency and cooperation between humans and machines [20]. This understanding implies thinking about distributed accountability [65]. The 6-level model of automatization, however, has never been problematized in the group. Working with concepts of distributed agency and accountability might change onto-epistemological assumptions of the whole research setting, again, fundamentally. This can result in new understandings and methods of technology design.

Furthermore, the conceptualization of gender needs to be critically discussed, particularly because of the current shift in the research proposal from user involvement to a methodological research project. If we get funding for our project, the involvement of the gender researchers ensures that we will employ current gender studies approaches, which move beyond binary assumptions about women and men. If our project is successful, it is likely that the outcome – the methods we will have used effectively – will also be employed in other technological development projects, which is something we generally appreciate. In this case, however, there is a danger that only the methods and not all attitudes underlying them will be transferred – a problem that was already addressed by some HCI researchers as the gap between method and methodology [16], [38]. Particularly the critical stances towards gender blindness as well as towards gender stereotypes or the general criticism of the binary system might get lost when methods get adapted to a new field without inviting gender or social science researchers with such expertise into the research and development team.

Last, but not least, there is another gap in the discussion within the group responsible for developing the research proposal. Although we have advocated integrating drivers who are strongly opposed to the idea of driverless cars, we did not fundamentally question whether we will need automobility at all in the future or which alternatives exist. Neither did we ask which forms of mobility people want to use, nor did we discuss the status of cars (including driverless cars) within current national and global economies. Substantial social and economic criticism is missing in our project, since we started with the assumption that driverless cars will doubtlessly be present and we only have to care about how this technology will materialize socially and technologically. A more fundamental criticism might, however, run in conflict with constructive engineering approaches and hence, prevent engineers from interdisciplinary collaborations with gender, social science, and humanities researchers. We are, to the contrary, convinced that only interdisciplinary translations between these fields can support building better social-technical futures responsibly. Openness towards the others' disciplinary culture and willingness to blaze new paths – substantially, methodologically, epistemologically – are central prerequisites for such endeavors.

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