Required Service Characteristics for Automated Mobility as a Service: A Qualitative Investigation

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REQUIRED SERVICE CHARACTERISTICS FOR AUTOMATED MOBILITY AS A SERVICE: A QUALITATIVE INVESTIGATION

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Abstract
Automated and shared mobility promises to be the new trend in transportation. But, in order to be successful, automated mobility as a service (AMaaS) providers need to convince future customers to adopt their services. While existing research mostly investigates which factors influence adoption intentions for either car-sharing or automated vehicles, this study elaborates relevant AMaaS service propositions. Based on 23 interviews with the general public, we derive user requirements and perform a card sorting exercise to conceptualize the expected AMaaS characteristics: traffic safety, information privacy, cybersecurity, regulations, flexibility, accessibility, efficiency, and convenience. We reveal how autonomous driving and shared mobility research results can be combined for AMaaS and we create construct clarity regarding the scope of each service characteristic. An assessment of code frequencies from our interviews with the general public in comparison to experts’ relevance ratings provides insights which service characteristics are most relevant to promote AMaaS user adoption.

Keywords: Automated Mobility as a Service (AMaaS), Autonomous Driving, Shared Mobility, Service Proposition, Value, Adoption Intention, Construct Clarity.

1 Introduction
Today’s rapid developments in sensor-based technologies and intelligent real-time data processing enable new types of individual mobility. Accordingly, the industry invests heavily in vehicles that are going to be connected, automated, and shared between users (Möller et al., 2019). These investments are supported by market forecasts that predict increasing user numbers for shared mobility (Peter, 2020) and an automated driving technology market for cars worth $270bn by 2030 (Weber et al., 2019).

On a societal level, shared mobility is associated with a sustainable way of life with less hyper-consumption and pollution (Hamari et al., 2016). Simulations demonstrate that it can fulfill the mobility needs with a fleet size of approximately one-third of the vehicles currently in use (Spieser et al., 2014). At the same time, connected cars should improve the vehicles’ efficiency, safety, and comfort by analyzing massive amounts of data (Papadimitratos et al., 2009). Moreover, as 94 percent of today’s traffic accidents are due to human error (NHTSA, 2018), self-driving vehicles are expected to reduce traffic deaths by entirely removing human driver interventions.

A convergence of the two mobility trends of shared mobility and autonomous driving, i.e., automated mobility as a service (AMaaS), is beginning to develop with multiple pilots emerging worldwide (Stocker and Shaheen, 2018). Based on Pangbourne et al.’s (2020) conceptualization of mobility as a service, we define AMaaS as a “provision of on demand door-to-door mobility being offered by self-driving cars, which can be requested via an online platform for individual or shared rides”. However, to be successful in the market, society must be willing to adopt the new concept of AMaaS. Even though...
both underlying research streams of shared mobility and autonomous driving have independently studied the adoption factors in detail, it remains unclear (1) how and whether we can integrate the extent adoption research results for the context of AMaaS, (2) which of these mobility concepts dominate the user’s perception when being combined, and (3) which factors might become obsolete or additionally relevant in order to promote high user adoption rates.

To understand the factors that account for customer shifts from their current, product-based mobility to automated and shared mobility, only a few studies have been published (Wiefel, 2020). These studies focus mainly on the participants’ latent beliefs and feelings towards the new mobility offering (Chen and Yan, 2019; Jing et al., 2019; Nordhoff et al., 2018b) or on their demographics or habits (Hassan et al., 2019). As a result of this, they lack to assess how intrinsic AMaaS service characteristics that build the service’s value proposition influence the users’ adoption intention. Contrary to beliefs and demographics, service providers can easily design, implement, and adapt the service offering so that it is particularly relevant in practice to know the service characteristics required by users. In the same vein, user-derived service requirements can guide design science research in actively building and improving AMaaS services instead of only explaining the adoption factors (Iivari and Venable).

A comprehensive literature review on car-sharing services supports our line of argument as it identifies "one of the biggest lacks in the literature: the absence of studies related to [...] the value proposition" (Ferrero et al., 2018, p. 507). We think it is of utmost importance to identify and specify the service attributes defining the value proposition as they can affect the user’s value-in-use, which is the evaluation of the service offering during consumption (Edvardsson et al., 2010). Eventually, high perceived value positively influences the adoption intention (Kim et al., 2007). Consequently, a better understanding of the expected service characteristics is needed (Kim et al., 2019).

Due to the gap in extant literature, this study gets underway to investigate relevant AMaaS characteristics in an explorative fashion. To do so, we first introduce the theoretical background on automated and shared mobility. Afterward, we outline our methodological approach. We derive user expectations regarding AMaaS from 23 qualitative interviews. Based on these, automotive experts familiar with the latest market trends and customer demands rate each statement’s importance and perform a card sorting exercise to conceptualize the service characteristics. Finally, we present and discuss our results, followed by a critical evaluation of our work's contributions and limitations.

2 Theoretical Background

In the following sections, we summarize insights from AMaaS adoption research as well as traditional car-sharing and automated vehicles (AVs) literature. Furthermore, we introduce a theoretical constraint called construct identity fallacy (Larsen and Bong, 2016) that is present in the AV research stream (Bornholt and Heidt, 2019).

2.1 Automated Mobility as a Service

AMaaS represents a service system, i.e., a dynamic configuration of resources (people, technologies, and shared information) that interact with each other to co-create value (Maglio et al., 2009). In the automated mobility service system, the passenger and the automated car can be considered the interacting entities. Opposed to this, the passenger and the taxi driver have been the entities within traditional taxi service systems. While previously the human taxi driver controlled the technology, the autonomous vehicle now controls itself. Hence, the service encounter, i.e., the moment of interaction between a customer and a service provider, becomes increasingly technology-mediated (Bitner et al., 2000), and "this change has implications for the way the entire system works” (Storbacka et al., 2016, p. 3010). This development requires service systems designers to identify new ways to attract customers by exploiting the system's opportunities and managing its complexity (Glushko, 2014).

Although the adoption of automated driving is generally intensely researched, studies on the context of AMaaS remain scarce (Bornholt and Heidt, 2019; Wiefel, 2020). In their comprehensive literature review on shared autonomous vehicle services, Narayanan et al. (2020) also report that a large number...
of pertinent studies either try to optimize AMaaS components (e.g., fleet size or vehicle distribution) or investigate the expected impacts of shared automated vehicles (e.g., traffic and safety, land use, or travel behavior), but less is published about the factors affecting the adoption of AMaaS services. Those studies that investigate the adoption of shared and automated vehicles identified the context (Wang and Akar, 2019), socio-demographics (Becker and Axhausen, 2017; Acheampong and Cugurullo, 2019), and user attitudes (Jing et al., 2019; Dowling et al., 2018; Lee et al., 2019) to be relevant.

However, with this study, we aim to uncover service-related adoption factors. After searching1 and reviewing the literature diligently, we can only identify the following intrinsic AMaaS characteristics that influence user adoption: First, AVs need to guarantee high traffic safety standards (Nazari et al., 2018). Besides, exact pick-up and arrival times seem to be relevant in order to choose AMaaS (Philipsen et al., 2019). Last, the presence of strangers in a ride-sharing setup could limit user adoption – especially in a leisure context (Lavieri et al., 2017).

As extant results regarding AMaaS adoption factors are relatively scarce, we continue to investigate literature concerning shared mobility and automated driving.

2.1.1 Shared mobility

Literature regarding shared vehicles affirms that satisfaction with car-sharing service characteristics can explain the customer's usage intention (Kim et al., 2019). Kim et al. (2015) distinguish between attributes of the vehicle, the booking and payment process, the availability, and the economic perspective. The vehicle's most relevant attributes are speed, comfort, noise, and cleanliness (Kim et al., 2015). Further vehicle attributes related to the consumers’ usage motives are vehicle variety, design, size, and fuel efficiency (Lindloff et al., 2014; Schaefers, 2013). Customers value flexible booking and payment processes with a reservation via an app (Hildebrandt et al., 2015), a pay-per-use fee structure (Schaefers, 2013; Hildebrandt et al., 2015), and price transparency (Lindloff et al., 2014). While the availability of shared cars is one of the most relevant adoption factors (Lindloff et al., 2014; Cervero et al., 2007; Habib et al., 2012), further convenience related service characteristics have been found to be relevant: guaranteed parking spaces (Shaheen and Cohen, 2007), flexibility, and interoperability between various car-sharing providers (Lindloff et al., 2014). Regarding the economic perspective, customers value reasonable prices (Schaefers, 2013) and time savings (Lindloff et al., 2014).

We deem that these insights can inform our work but might not directly be transferred because AMaaS is different from traditional car-sharing in multiple ways. First, the occupant of an autonomous car gives up control when riding in the vehicle because the driving task is fully automated and cannot be intervened (SAE International, 2018). This can create stress for the user, requiring specific service attributes that address the passenger's emotional well-being. Second, as the autonomous car drives independently, this can raise questions regarding the liability in the case of a traffic offense (Bruckes et al., 2019). Last, current requirements like car-sharing station accessibility or guaranteed parking spots might become obsolete when the cars pick-up/deliver the customers at any given place and then drive on independently to the next available parking space until they collect the next customer.

2.1.2 Automated Driving

Extant studies investigating the adoption of automated driving identify political/societal conditions, the users’ characteristics, and vehicle characteristics to influence the adoption intention (Bornholt and Heidt, 2019). Focusing on vehicle characteristics, we see users expecting higher efficiency in terms of being able to perform other things while driving (Hein et al., 2018). Reduced travel time compared to manually driven cars is another significant adoption predictor (Hohenberger et al., 2017; Nordhoff et al., 2018a). Closely linked is the users' expectation that riding an autonomous car will be more environmentally friendly (Wu et al., 2019; Liu et al., 2019a). Congruent with other services, self-driving cars need to be

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1 The search term was (automated OR autonomous OR self-driving OR driverless) AND (vehicle(s) OR car(s) OR driving OR mobility) AND (shared OR “on demand” OR "as a service") AND (adopt* OR accept* OR intention)
reliable (i.e., continuously operate properly and flawlessly) in order to be adopted by the passengers (Bruckes et al., 2019; Tussyadiah et al., 2017).

Next to these practical adoption factors, scholars find emotional aspects to be significant for the adoption of AVs. In this regard, traffic safety is a relevant adoption factor (Hohenberger et al., 2017; Lee et al., 2018; Cho et al., 2016). Furthermore, people are concerned that an autonomous car could be hacked because of sophisticated information technology. Hence, passengers require cybersecurity assurance before adopting this new technology (Woisetschläger, 2016; Hein et al., 2018).

Although the AV adoption research stream already developed a large body of knowledge, we cannot directly use the results for AMaaS, either. Most of the research examines AVs as privately owned cars, but users have different expectations for autonomous vehicles, based on whether the vehicle is owned or consumed as a service (Wießel, 2020; Amanatidis et al., 2018). In a service context, users create value by utilizing the providers' resources (Ranjan and Read, 2016), which puts them in a dependent position. This poses the question if other service characteristics become relevant. Last, existing research falls victim to construct identity fallacy (Bornholt and Heidt, 2019), an issue we outline in the next section.

### 2.2 Construct Identity Fallacy

Construct identity fallacy can arise two-fold (Larsen and Bong, 2016). In the first case, called jingle fallacy, two constructs have identical names but describe different phenomena. In the context of automated driving, perceived risk is affected by this fallacy. While one author operationalizes perceived risk as financial loss, reliability issues, and general risks (Jing et al., 2019), another includes items regarding safety, privacy, and time constraints (Chen and Yan, 2019). The second case, called jangle fallacy, is characterized by two constructs being named differently but referring to the same phenomenon. For example, cybersecurity is referred to as data risk in one study (Hein et al., 2018) and as security in another (Kaur and Rampersad, 2018). Nevertheless, both studies include items regarding the risk of being hacked. These inconsistencies make it difficult to compare and build on existing knowledge.

Almost all vehicle characteristics identified in earlier adoption research are used both as an item to measure latent constructs and as a construct itself (Bornholt and Heidt, 2019). The different layers of abstraction lead to varying scope conditions (Suddaby, 2010), which also prevent researchers from working effectively with these factors. Even in cases where the vehicle characteristic is used as a construct from two researchers, boundaries vary as they are formed by the researcher's assumptions (Bacharach, 1989). Coming back to the cybersecurity example, we found that the first study only refers to cybercrimes and hacking (Hein et al., 2018). In contrast, the second study also includes software failures and connectivity with infrastructure and other cars (Kaur and Rampersad, 2018).

### 3 Methodology

This unsatisfactory situation makes us use an explorative research approach to identify all relevant user expectations regarding AMaaS and set clear boundaries between the inherent service characteristics. Instead of using a theory-driven approach, we first want to discover any generalizations leading to a deeper understanding of the concept at hand (Stebbins, 2001). Thereby, the concept boundaries should not be derived from the researcher's view to facilitate a user-centered design of AMaaS.

We leverage concept mapping, a methodology that provides a representation of the group’s thinking relative to the domain in focus (Trochim, 1989). This approach involves three steps building on each other (see Figure 1): In the first step, we conduct interviews with the general public and gather high-level paraphrases about their expected AMaaS service attributes. In phase two, we ask mobility experts who are familiar with the general public’s demands and with its implementation feasibility to cluster and rate these paraphrases so that the domain of AMaaS service characteristics can be conceptualized and prioritized from a practitioner's perspective. In the last step, we apply hierarchical cluster analysis to identify the AMaaS service characteristics.
**3.1 User Interviews**

Concept mapping begins with the generation of statements, i.e., high-level paraphrases derived from the interviews which represent the entire domain of expected AMaaS service attributes. We recruit a convenience sample of interview participants mainly living in Germany and sporadically in Great Britain, France, and the Netherlands with different backgrounds and mobility habits to represent the largest possible share of potential AMaaS consumers. The candidates include laypersons as well as IT experts, court personnel, and an ethicist. This way, the resulting concept map will be generalizable to the population of interest (Trochim, 1989). The group includes a larger share of young respondents living in urban environments (see Table 1 for demographics) as they are likely to be early adopters (Rogers, 2003) and in a relevant age when AMaaS is going to hit the markets.

Table 1. Demographics of interview participants (n=23)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Male</th>
<th>Female</th>
<th>Place of living (no. of residents)</th>
<th>Rural (&lt;5,000)</th>
<th>Urban (5,001-100,000)</th>
<th>Metropolis (&gt;100,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13%</td>
<td>39%</td>
<td>48%</td>
</tr>
<tr>
<td>Age</td>
<td>15-24</td>
<td>26%</td>
<td>Education</td>
<td>Secondary school</td>
<td>Bachelor's degree</td>
<td>Master's degree</td>
</tr>
<tr>
<td>25-34</td>
<td>34%</td>
<td></td>
<td></td>
<td>48%</td>
<td>18%</td>
<td>30%</td>
</tr>
<tr>
<td>35-44</td>
<td>9%</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>45-55</td>
<td>9%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55-64</td>
<td>13%</td>
<td></td>
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<tr>
<td>&gt;64</td>
<td>9%</td>
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</tbody>
</table>

While interviews with users are useful to capture their desires, it often comes to problems when investigating new and latent product requirements. They do not mention attractive product features because they do not expect them (Matzler and Hinterhuber, 1998). Thus, it is necessary to reveal the users’ current needs and problems to be solved by conducting outcome-focused interviews (Ulwick, 2002). As automated driving is not existent yet, and research has proven the quality of current transportation modes to be influential for mode choices (Kim et al., 2017), our interview guide contains questions regarding AMaaS as well as current mobility offerings. For example, we ask the participants: (1) What do you like/dislike about today’s mobility offers? (2) In which situations would you use AMaaS and why? (3) How would a value-adding AMaaS service look like for you in order to adopt it? (4) Which hopes and concerns do you have regarding AMaaS? This way, we can explore both which benefits and sacrifices influence the adoption of present transportation forms and how they form the expectations regarding automated mobility services. We conduct and transcribe 23 interviews lasting, on average, 26 minutes. We transcribe each interview verbatim and paraphrase relevant user requirements before conducting the next one until we notice a saturation of information. The final number of interviews is in line with Griffin and Hauser (1993), who state that 20-30 interviews reveal 90-95% of the needs.

**3.2 Card Sorting**

Building on our interview results, we conduct a follow-up study in which we approach 98 German mobility experts (sales representatives, consultants, and researchers) from our network, via LinkedIn, and at their business premises. We ask them to rate the derived user expectations by relevance and
cluster them by conceptual similarity. Each aspect can be categorized as either (1) "not relevant", (2) "important, but not essential", or (3) "essential" for the implementation of AMaaS. While we receive 52 relevance ratings (a response rate of 51%), only 41 experts (a response rate of 40%) sort the quality statements into piles based on conceptual similarity (Weller and Romney, 1988). The lower response rate for the sorting task is due to the higher time requirement and no offered compensation for study participation.

We exclude two responses from the relevance ratings, as the subjects rated less than 50% of the available quality characteristics. Besides, we remove three sorting exercises as two sorters grouped the quotes by relevance, and one only sorted those statements categorized as important in the previous step. Nevertheless, the resulting 38 sortings are still sufficient for analysis as results stay stable with sample sizes above 30 (Tullis and Wood, 2004).

3.3 Cluster Analysis

Based on the resulting piles, we construct a matrix for each sorting. Cell values represent if a pair of statements are in the same group (1) or not (0). The individual sort matrices are added to obtain a combined group similarity matrix shown on the left-hand side in Figure 2 (Jackson and Trochim, 2002). From the aggregated matrix, multi-dimensional scaling (PROXSCAL) creates two-dimensional coordinates for each statement. Instead of using the original similarity matrix, these coordinates serve as input for hierarchical cluster analysis using Ward’s algorithm (Trochim, 1989; Jackson and Trochim, 2002). This algorithm is most suitable for identifying categories if the structure is not already known (Afifi and Clark, 1999). The algorithm proposes eight clusters representing the user-required AMaaS service characteristics. The average silhouette value equals 0.6, which indicates good cluster separation.

![Card sorting serves as basis for group similarity matrix](image1)

PROXSCAL calculates two-dimensional coordinates

![Ward's algorithm identifies eight clusters](image2)

Figure 2. Steps followed for cluster analysis

4 Results and Discussion

Looking at the statements in each cluster, we identify eight service characteristics required for AMaaS services to create adoption intentions: Traffic safety, information privacy, cybersecurity, regulations, flexibility, accessibility, efficiency, and convenience. At first glance, one could assume that the first four characteristics stem from autonomous driving studies and the last four from the car-sharing literature. However, a closer look reveals that the attributes that are presumably car-sharing related, like convenience and accessibility, include elements that are specific to automated vehicles. For example, convenience includes performing hedonic activities during a ride, and automated re-location strategies should provide accessibility. In order to equip practitioners and researchers with a more detailed understanding and clear boundaries of each identified AMaaS characteristic, we discuss our insights from the interviews in comparison to earlier research results in the following paragraphs.

Before we do so, we want to highlight that the two mobility trends of automated and shared mobility are not equally present in the general public’s and the experts’ minds when they think about AMaaS. To show this, we create a code matrix representing the code frequencies from our interviews with the general public in relation to each service characteristic across various demographic groups (see Figure [Figure 3])

3). In addition to that, we calculate the average experts’ relevance rating for each user requirement to identify the overall characteristic’s importance (shown in the inner circle in Figure 4).

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Place of Living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Female</td>
<td>15-24</td>
</tr>
<tr>
<td>Traffic Safety</td>
<td>Privacy</td>
<td>25-34</td>
</tr>
<tr>
<td>Security</td>
<td>Regulation</td>
<td>35-44</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Accessibility</td>
<td>45-54</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Convenience</td>
<td>&gt;65</td>
</tr>
<tr>
<td>Rural</td>
<td>Urban</td>
<td>Metropolis</td>
</tr>
</tbody>
</table>

**Figure 3. Interview code matrix showing number of codes per group**

**Figure 4. Experts’ relevance ratings (1-3) and exemplary attributes per AMaaS service attribute**

While all interview groups (except the oldest ones) talk a lot about traffic safety, the remaining autonomous driving related characteristics of information privacy, cybersecurity, and regulation are less often mentioned when people think about the new mobility service. Contrary to the low number of codes for these categories, the experts’ relevance ratings for traffic safety, but also for cybersecurity, information privacy, and regulations are very high. The experts assigned even higher numbers to these service attributes than to the remaining service characteristics (i.e., flexibility, accessibility, efficiency, and convenience), although the latter show higher code frequencies across all user groups.

The disparate weights that we find associated with the quality attributes comparing the interviews with the experts’ relevance ratings highlight that potential users initially mostly demand service attributes that are already known from existing services (i.e., car-sharing) and can be experienced actively. The diverging experts’ view could be interpreted in two ways. Either the experts do not know the users’ demands as well as expected, or people only start valuing how a service is delivered as soon as they know more about the service’s functionality. The second explanation would be in line with Grönroos’ (1984) observation that it is more important for experienced users how a service is delivered than the mere service outcome. This interpretation reveals the vital insight that mobility providers need to focus on different service attributes depending on whether they want to attract new customers or increase the quality perception of AMaaS for an experienced target population.

4.1 Traffic Safety

Perceived traffic safety is mentioned most frequently during the interviews and is also rated with a high relevance score of 2.52 out of 3 by the experts. It is the extent to which the consumer feels safe and not in danger or at risk while participating in traffic using AMaaS. While vehicle safety seems not to be
relevant in public transport (Andreassen, 1995), the willingness to use autonomous vehicles has already shown to increase with higher levels of perceived safety (Hohenberger et al., 2017).

Like Salonen and Haavisto (2019), who examined privately owned AVs, we experience that all our interview participants are concerned about traffic safety in a shared context, too. Thereby, the participants do not only care about their own physical integrity but also about others: "If a child runs into the street, and you suddenly have to brake - I don’t know if the car can see that" (Gender = F, Age= 84). Consumers are hesitant in trusting the automated driving systems to properly integrate into mixed traffic situations because the engineers face complex challenges when constructing systems that react safely and effectively to every situation (Linehan et al., 2019). Our study participants are concerned that the “technology misjudges the environment or surroundings” (F, 30) or how the car will behave in “any unusual weather conditions” (F, 33). Some even suggested letting the vehicles drive detached from other traffic, “maybe like a taxi or bus lane. Then it would be a little bit separate” (F, 31).

The above concerns are related to the technical capabilities and reliability of the system. Reliability enhances trust in driverless cars (Kaur and Rampersad, 2018), but the consumers are used to technical failures from other areas "like a cell phone, that breaks down" (M, 63). Consequently, "equipment failure" (F, 59) is one of the biggest concerns that potential future users have regarding traffic safety. Thus, a provider “who takes care of the maintenance of these cars” (F, 48) should actively communicate its efforts.

Particularly in cases of technology breakdowns, passengers wish to regain control over the vehicle: "But if the technique fails and I cannot intervene, then it would not be good" (F, 25). Hegner et al. (2019) showed that concerns about handing over control to a self-driving vehicle are strongly linked to the trust that passengers have in the system. However, our study participants seem not yet to be ready to give up control and trust the car. "If I now assume that I really don’t have to intervene at all, I can't imagine that at the moment. Now, I would still think that I still want to be able to intervene” (F, 31). Hence, researchers and practitioners should investigate the levers to improve the passenger’s trust in automated vehicles.

4.2 Information Privacy

Perceived information privacy is defined by the consumer’s beliefs about a provider’s ability and willingness to protect his/her personal information from improper use, disclosure to third parties, and secondary use without consent (adapted from Pavlou et al., 2007). Up to now, information privacy has shown to have only a non-significant influence on the autonomous vehicle passengers’ trust and perceived usefulness (Kaur and Rampersad, 2018; Hein et al., 2018). In line with these results, most interview participants in our study do not mention privacy at all. However, if they do, they say that “privacy is definitely a big concern.” (F, 31). Experts generally rate the relevance of privacy as high (2,34 out of 3).

The interviewees make the provider’s trustworthiness dependent on its transparent handling of the data: "Well, I think it would also have to do with what kind of provider it is and how transparent it is. So basically, how trustworthy he is” (F, 22). If they mention privacy in our conversations, people are anxious about individual analyses: "What worries me is if someone knows where I’m going. Maybe even associate driving patterns of me as a person" (M, 29). While this person was especially concerned about personalized advertisements, participants from earlier research were worried about data shared with insurance companies (Linehan et al., 2019).

Nevertheless, our participants support anonymized analyses to improve the vehicle’s performance and traffic safety: "... but only to analyze the driving behavior of the car [...] in the sense that the car has recognized everything correctly. To minimize the error rate, it's okay” (F, 33). With this, value is created for the user and the provider, who can enhance the capabilities of the automated vehicle.
4.3 Cybersecurity

Information security is the degree to which the customer believes that protective measures are taken to make the AMaaS information systems safe from intrusions, unintentional corruptions, or breaches (Bruckes et al., 2019; Hein et al., 2018). Technical protection generally increases trust in technologies (Gefen et al., 2003) and self-driving vehicles (Bruckes et al., 2019).

Foremost, security is the least often mentioned quality characteristic in our interviews. Only a few participants require security measures against hackers. For them, the protection should include data security measures to address concerns like the following one: "If there are any hackers who can hack in. Get access to the credit card, that they'll just sort of mug you." (F, 22) Another participant is even afraid to get hijacked and physically harmed: "Especially if such a car is hacked, probably the doors are also locked somehow electrically, and so, you can't get out of it anymore, you'll be trapped like this, right?" (M, 26). To enable cybersecurity, providers need to ensure that preventive measures are taken to avoid vulnerabilities being exploited (Benlian et al., 2011).

Although extant AV research has only paid little attention to cybersecurity so far (Wiefel, 2020), and our participants do not care much about it, the experts rate information security with 2.56 as the most relevant service characteristic for AMaaS. A reason might be that hacker attacks are a salient threat not recognized by the general public. Experts, however, already know that exploits can be perilous when causing severe traffic accidents. Hence, future AV research should investigate information security from a technical perspective and more closely from a user’s view.

4.4 Regulations

“Considering [the] fragility of trust, governments should establish efficient regulations […] since the initial stages of the automated vehicle technology” (Liu et al., 2019b, p. 366). Maybe because of the unavailability of AMaaS in the current development stage, experts who are concerned about a quick market introduction of autonomous driving desire guiding boundaries and rate regulations with 2.54 out of 3 as highly relevant. Legal protection refers to the extent to which traffic regulations and government regulations enforce passenger’s welfare when applied by the AMaaS provider (Bruckes et al., 2019).

While most study participants were less interested in regulations, some interviewees demand a robust regulatory solution to resolve liability issues: "This should perhaps be properly anchored in the law, what if something should happen? Who's liable?" (F, 48). Earlier research already provided evidence that legal bonds help consumers trust new technologies (Pavlou, 2002). The liability is also strongly related to the question if a driver’s license is still needed: "When it's all about autonomous driving, then we wouldn't need a license anymore" (F, 24). However, Ro and Ha (2019) have already shown that licensing requirements do not significantly affect the intention to use self-driving vehicles.

While liability plays an essential aspect after an accident, ethical decisions can become essential during the accident situation: "There's this dilemma, are you knocking down the grandma or the kid? That is the question, isn't it? […] But the third option would also be there. Do you kill your driver? That's a big question for me" (M, 24). To avoid manufacturers always to save the passengers’ lives, this decision-making should be regulated by law: "Something like that can only work if it has been discussed by committees and of course expert commissions. That rough rules have already been laid down, which are then legitimized again by the parliament" (F, 33). By having the government approve the ethical decision-making, we would obligate the algorithms to act in line with our social norms and not deliberately harm other people in favor of the driver (Salonen and Haavisto, 2019).

Although the mobility provider cannot implement legal regulations on its own, we think that these aspects are still relevant to inform future discussions with the regulators.

4.5 Flexibility

Flexibility, the second most important characteristic according to our code matrix, defines the capability of AMaaS to support the individual passenger's mobility requirements. Providing users with flexible
mobility offerings is essential because compatibility with daily life is the most important factor for users to adopt or reject new mobility forms (Burghard and Dütschke, 2019).

According to our qualitative investigation, a service that offers customer value is available whenever the passenger requests a ride, collects him/her at an arbitrary pick-up place, and drives the passenger to the defined destination. If all of these fundamentals can be fulfilled, a feeling of independence will be present: “Absolute flexibility [...]. Not to be bound to anything or anyone” (M, 35). As part of this, the frequency of departures is an important quality aspect of public transport (Andreassen, 1995) and also for AMaaS. Users want to be “[...] as flexibly as possible. So don't be dependent on fixed departure times” (F, 59).

In addition to that, the personalized route arose as being an essential factor (Salonen and Haavisto, 2019). Most desired, however, is the ability to choose any discretionary location as either starting point or destination: "Because I can drive right from the front door and reach my destination directly and drive right up to the door” (F, 59). This requires a sufficiently large business area. While today’s car-sharing offerings are mostly restricted to the city centers, automated driving could enable mobility providers to enlarge the business district as the cars are able to re-locate themselves after each ride.

While pooled car-sharing is promoted to reduce greenhouse emissions, our study reveals that some interviewees want to decide themselves flexibly if they drive alone and who can join their car: "The problem is, you never know who is going to get on. If I drive myself, I can decide who gets on” (M, 63). In contrast, more environmentally concerned participants require a forced pooled car consumption: “Because you still have the environmental factor in the background. It makes a lot of sense to say, no, it's not just for me, but also for others if someone happens to want to drive in the same direction” (F, 33). Overall, our interviewees show a tendency to prefer flexibility over environmental protection, which is in line with Stoiber et al. (2019), who realized that specific push and pull mechanisms need to be in place to encourage people to a pooled usage. For example, our participants demanded a cost reduction and the least possible detour when picking up other passengers.

4.6 Accessibility

Interestingly, users of AMaaS still demand accessibility. We define this service characteristic as the extent to which an individual perceives that the AMaaS is easily available for use when needed. According to our participants, an accessible service offering needs to comprise multiple aspects:

First, the automated cars need to be at the user’s disposal quickly: "So, that means that if you call a taxi [...] you might wait an hour, and if you have your own car, you can drive directly” (M, 57). Consistent with this participant’s concern, access time has already been shown to be significant in traditional car-sharing services (Li and Kamargianni, 2019; Ko et al., 2019). Car-sharing customers are generally concerned that the car might not be quickly available when needed. Thus, availability significantly affects membership decisions (Kim et al., 2017; Yoon et al., 2017; Ko et al., 2019).

Contrary to these findings, the experts rated accessibility only as medium relevant (1,94 out of 3) for AMaaS. A reason might be that AMaaS offers multiple ways to improve accessibility. First, people could share privately owned cars to increase the number of vehicles available: "An example of start-ups [...] was a platform in which every user can offer his vehicle” (M, 35). Alternatively, the vehicle can be automatically re-located based on active requests: "If the software notices that somewhere there is no more car, then this car can drive back on its own” (F, 25). Accordingly, current research already tries to improve the self-driving cars’ availability in car-sharing offerings by optimizing the relocation algorithms (Kek et al., 2009; Herrmann et al., 2014).

Besides, our participants put particular emphasis on the availability in rural areas: "I'd like to see it work in small towns, too” (M, 46). However, they also recognized different availability levels in larger cities when they were asked for their car-sharing quality requirements: "Car availability. But even within cities, there are differences” (F, 30). While today's car-sharing offerings are mainly located in urban areas, first studies investigate the feasibility of car-sharing in municipalities. The authors find that inter-urban car-sharing service may be adopted, but only if the service is guaranteed and efficient (Luca and Di Pace, 2015).
To be easily accessible, also an easy booking process needs to be in place. While younger participants 
"imagine that the cars will be booked and called via an app in the future as well" (F, 28), older interviewees think that "you somehow have to call a switchboard" (F, 84). Besides being able to request a car on demand, users were also interested in pre-ordering a ride for a defined time. Simulations show that a reservation system can help to reduce delays (Lamotte et al., 2017) and significantly increase vehicle use rates (Ma et al., 2017) so that service customers and operators can benefit from a pre-reservation feature.

Last, in case of damage, our interviewees would value service recovery. They imagine that the automated and connected car calls a replacement, which is routed to the current location so that the ride can continue without any major interruptions. This could be a key differentiator compared to present car-sharing services, and we are the first to identify this value proposition of AMaaS.

### 4.7 Efficiency

Both experts and the general public only gave efficiency a medium relevance. It refers to the degree to which a passenger perceives the autonomous ride as less time- and energy-consuming. While regular car-sharing presents an effective antidote to mitigate increasing traffic congestion and air pollution (Jian et al., 2017), autonomous car-sharing could be even more efficient "because the autonomous cars drive more disciplined, perhaps even coordinated with each other, the traffic flow becomes very regular and fluid" (M, 29). Being connected to the internet, automated cars can receive real-time traffic information, exchange their current locations, and coordinate among themselves at intersections. This results in fewer traffic congestions and less energy consumption, which is important as reduced travel times entail higher usage levels (Hohenberger et al., 2017).

However, the expected benefits (i.e. fewer cars needed, lower energy consumption, a quieter driving style leading to shorter traffic times) will not materialize if more vehicle kilometers are traveled as soon as automated driving is introduced. Wadud et al. (2016) expect an increase of 57% of vehicle kilometers driven, which will then still clog the roads. According to their research, replacing transit journeys with automated vehicles will furthermore double household greenhouse gas emissions.

In addition to a smooth driving style, our participants expected electric engines to protect the environment: "Yes, I mean electric is better than diesel. [...] I mean for the environment" (F, 84). Having electronic vehicles in the car-sharing fleet already increases the probability of switching today (Cartení et al., 2016). Moreover, as a consequence, "maybe we don’t even need a car for everyone anymore" (M, 29). However, to purely rely on car-sharing services is more likely for individuals who value minimizing environmental impact (Spurlock et al., 2019; Wu et al., 2019).

To enable the expected efficiency gains, technical infrastructure needs to be expanded. Currently, the limited number of charging stations lead to car-sharing users avoiding limited-range electric vehicles, even if those vehicles still have sufficient range for the user’s trip (Zoepf and Keith, 2016). "Putting coils into the tar, so that the car is automatically reloaded successively and slowly while driving" (M, 32) was proposed to reduce the need for long charging stops.

### 4.8 Convenience

Convenience relates to if consumers perceive AMaaS as a facilitating mobility option that minimizes the driving efforts and provides well-being. Our experts rate it as the least relevant (1,92 out of 3) in comparison to the other service characteristics in our framework. Opposed to this, in the interviews, convenience was the third most often mentioned aspect. Hence, potential future users of AMaaS show different expectations than current public transport passengers, for whom Guirao et al. (2016) conducted a ranking of service attributes and identified comfort to be less relevant than frequency and accessibility.

In addition to the above utilitarian aspects, Sweeney and Soutar (2001) have shown that it is also essential to include hedonic elements when assessing consumer service evaluations. One participant sums it up as: "Grab me a book, and the car will drive me. Or I close my eyes. Like I'm on a train, only I'm driving on my own" (F, 59). In addition to that, most interviewees required an Internet connection to
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either work or surf the web. Some desired it for entertainment purposes: "Netflix or so can be quite interesting that you watch some videos when you are on the road for a long time, but for short distances, Spotify would be enough" (F, 25). These instrumental benefits can positively influence the occupants’ perceived usefulness in an autonomous vehicle (Hein et al., 2018).

Autonomous cars can also offer a solution for the inconvenience related to perceived parking availability: "$I always have this wasted time of parking [...] Of course, you could save yourself by just getting off where you want to go and not bothering about the rest because the vehicle then automatically takes the next car park" (M, 35). Research regarding traditional car-sharing already emphasizes the influence of perceived parking availability in short-term mobility decisions (Yoon et al., 2017; Stoiber et al., 2019). We expect this to become more relevant for autonomous car-sharing as the occupant does not need to park the car anymore.

Last, AMaaS can be a convenient form of transportation for physical or cognitive impaired people (Salonen and Haavisto, 2019). This includes the elderly: "We are not the youngest anymore, right? I mean, my husband can't even drive a car anymore" (F, 69) and also the younger generation: "when I'm drunk and want to come home" (M, 26). Especially for the old ones, the physical design can increase the convenience in comparison to today’s mobility options: "Put a sliding door in the car, and then you can fix the walker. Now, I need to fold it up and carry it inside the trunk" (F, 84).

5 Implications, Limitations, and Further Research

By identifying and specifying user-required AMaaS service characteristics, we advance IS research in an area where little prior research has been done: Exploring the value proposition required by users in order to adopt AMaaS offerings. Our results not only shed light on the general public’s view but also on the experts’ perceptions, and we observe large differences between both. Thus, our work entails important insights for mobility providers. Thereby, we break away from traditional acceptance theories like TPB (Ajzen, 1991) or TAM (Davis, 1989) and instead focus on the less abstract, intrinsic characteristics of the service proposition.

Our results show how the existing insights from the well-researched autonomous mobility and car-sharing contexts can be combined for AMaaS. Factors from both streams influence the adoption of AMaaS. Stronger are the factors known from shared mobility services like accessibility, flexibility, or efficiency. They are especially relevant before the general public is willing to use AMaaS. On the other hand, according to the mobility experts traffic safety needs to be guaranteed, cybersecurity measures need to be in place, and regulations should define ethical behavior and liability - like it was observed for privately owned AVs.

Besides, our results highlight that the sum (i.e., AMaaS) is more than its parts (i.e., automated vehicles and shared mobility). We can observe expanded boundaries of characteristics initially relevant for car-sharing users. For AMaaS, convenience can only be achieved when passengers do not need to concentrate on traffic, accessibility is now provided by autonomously re-locating vehicles, and future efficiency gains are expected from vehicles communicating with each other at intersections.

By means of our mixed-method research approach, we were able to propose a new delineation of the services characteristics’ scope from a practitioners’ view. With this, we hope to make a first step in unifying the assumptions guiding researchers when investigating the phenomenon at hand. According to Suddaby the achieved construct clarity has three advantages (Suddaby, 2010): First, by demarcating service characteristics, we propose construct boundaries that can facilitate communication between scholars in the future. Second, our work enhances researchers’ ability to empirically explore the phenomenon of AMaaS adoption as the service-related characteristics can be easier operationalized if all scholars share the same understanding. Finally, our contribution allows for greater creativity and innovation in research because our elaboration might stimulate insights that lead to new theories.

With our work, we support the microfoundation movement in strategic management (Barney and Felin, 2013) as we uncover service-related AMaaS adoption factors. The microfoundation movement wants to make theory more relevant to managers as it provides explanations on multiple levels. For the AMaaS...
service system, three levels of analysis can be applied: "micro (actor engagement), meso (sets of actors and their resources), and macro (ecosystem and institutional logic)" (Storbacka et al., 2016). This study focuses on the micro-level where manageable conditions, i.e., the service value proposition, lead to observable actions, i.e., user adoption (Coleman, 1994). As a result of this, practitioners gain an understanding of the service characteristics that potential future customers expect from AMaaS in order to adopt the service offering. Furthermore, the relevance ratings of each service characteristic helps to steer the investment of scarce resources.

First, manufacturers of automated vehicles need to ensure high traffic safety standards, and automated mobility providers have to guarantee the perceivable service benefits like flexibility and convenience. Only if these most relevant functionalities are available the broader society will start to adopt AMaaS. Next, the focus needs to be on such service characteristics as security or privacy. Furthermore, from the experts' view, legal assurance is a prerequisite for AMaaS service providers to leverage automated cars. Despite our contributions, we have to acknowledge that our conceptualization lacks operationalization. Still, it can serve as the first step in a scale development effort. Valid and reliable measuring instruments are needed to enable specialized scholars and mobility providers to statistically assess the influence of each AMaaS characteristic on the adoption intention. Thus, we propose a large-scale quantitative survey as the next necessary step to develop and evaluate this instrument in line with the procedures proposed in the literature (MacKenzie and Podsakoff, 2011).

Furthermore, our results are likely to be time-sensitive. As AMaaS offerings are not existent yet, the identified service characteristics are especially relevant for new users. Experienced users, however, might place less emphasis on, e.g., traffic safety requirements but could develop a stronger need for a hedonic experience. At least Distler et al. (2018) could observe changed passenger perceptions after a ride in an experimental autonomous shuttle. Thus, we propose to repeat the effort with experienced users as soon as AMaaS is publicly available.

Besides, future research should investigate the observed discrepancy between the general public’s and the experts’ priorities. It would be interesting to see if more experienced users develop the same or different priorities as the experts did in our study. Discrete choice experiments could assess which service attributes are most relevant when people choose from various providers. Furthermore, structural equation modeling can be used to statistically assess the effect sizes of the identified service characteristics on both initial adoption intention and the quality perception after a ride in a real car.

Last, future research should investigate how to improve the identified service characteristics. While scholars already try to increase the accessibility of shared vehicles, additional efforts could focus on creating a feeling of flexibility and convenience. Overall our results can serve as a basis for the development of various new theories in the context of automated mobility as a service.

Acknowledgments

This research work has been funded by the German Federal Ministry of Education and Research and the Hessen State Ministry for Higher Education, Research and the Arts within their joint support of the National Research Center for Applied Cybersecurity ATHENE.
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