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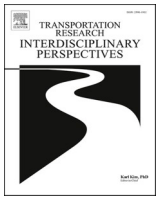

# Pool more, drive less: An investigation of barriers and motivators of ridepooling in autonomous vehicles

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ABSTRACT

The integration of on-demand ridepooling services provided by autonomous vehicles into transportation systems offers a solution to mobility challenges in the future. If such services effectively enable travellers to share a vehicle instead of driving alone, higher vehicle occupancy rates would lead to a more efficient use of existing road infrastructure. This in turn could help alleviate traffic congestion and its associated drawbacks. The acceptance of such autonomous ridepooling (aRP) services by prospective users is essential for their successful adoption. Therefore, this qualitative study aims to uncover the relevant factors that determine aRP acceptance and to better understand the drivers and barriers of aRP acceptance using a user-centered approach. Through 18 semi-structured in-depth interviews with a diverse range of participants, the study revealed the significance of performance expectations with regards to safety, comfort, flexibility, sustainability, and social aspects in shaping acceptance for aRP. Notably, ambivalent attitudes and controversial perceptions of these factors as well as differences between public transport and private car users underscore the importance of customer segmentation and tailored strategies for the design and promotion of aRP services. Findings emphasize the need for aRP services to prioritize user-centric approaches to enable the adoption and facilitate the integration of aRP as a more sustainable option into future transportation systems.

## 1. Introduction

The transformation brought about by digitization has a profound impact on future transportation. The introduction of autonomous vehicles (AV) opens new opportunities but also challenges for policymakers, manufacturers, and users alike. AVs are anticipated to enhance traffic safety and optimize road network utilization by reducing gaps between vehicles (Fagnant & Kockelman, 2015). In addition to providing opportunities for alternative activities during travel (Hamadneh & Esztergár-Kiss, 2022), AVs will broaden access to transportation services for a wider audience due to lower requirements for driving competences (i.e., independent access for children, elderly and disabled) as well as decreased costs (Shen et al., 2018). As a consequence, single occupancy of AVs could potentially result in an amplification of travel demand and in an escalation of empty vehicle kilometers, resulting in large infrastructure costs, increases in noise emissions, congestion, and accidents (Hörl et al., 2019). Ridepooling in AVs is likely to mitigate these negative effects. Ridepooling per se facilitates passengers sharing segments of their journeys without a fixed schedule or predefined stops. The service thereby uses an algorithm for optimizing overall travel routes and minimizing detours for each individual (Shaheen & Cohen, 2018). Ridepooling distinguishes itself from single occupancy rides that are usually not shared with other passengers, such as carpooling (a service wherein private individuals offer a shared ride, see Sonneberg et al., 2019), or ride hailing (a service that connects customers with private driver for specific trips, e.g., UBER or Lyft, see Shaheen, 2018). While ridepooling services have primarily been tested with traditional vehicles (i.e., non-automated), their limited adoption is partially attributed to the significant portion of operating costs dedicated to driver salaries (Bösch et al., 2018). It is clear that the highest benefit for the transportation system in terms of a reduction in congestion, pollution, or the number of vehicles/distances traveled, can be achieved through an integration of AV technology with pooled services. In the remainder of this paper, this type of transportation mode will be referred to as autonomous

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ridepooling (aRP). From a user perspective, integration of AV technology with ridepooling holds the potential to combine the advantages of both public transport (lower costs) and private vehicles (direct trips), allowing for significant accessibility improvements, particularly in areas and during times of the day when conventional public transport services face operational challenges (von Mörner, 2019). Consequently, designing aRP in a way that is accepted by its potential users is essential for their success on both the individual and the societal level.

Previous research on the acceptance of aRP is still scarce. While psychological factors influencing the acceptance of AV have been extensively studied and consolidated in literature reviews (Becker & Axhausen, 2017; Golbabaei et al., 2020), research on factors impacting the intention to use aRP is currently limited to a few qualitative and quantitative studies (Nordhoff et al., 2018; Sanguinetti et al., 2019; Schuß et al., 2021; Zubin et al., 2020).

Against this background the present research aims to fill this gap in the literature by conducting an exploratory investigation specifically on the determinants of aRP acceptance from a user perspective.

To this end, the paper first summarizes insights from previous research that investigated acceptance of AVs in general and ridepooling in AVs specifically. Second, methods and procedures of an in-depth qualitative exploration of acceptance of aRP are explained and the respective findings are described in the third section. The final section discusses these findings in light of the previous research in order to derive propositions for future research as well as recommendations for practical implementation of aRP services.

## 2. Previous work

The literature review summarizes findings form previous investigations on user acceptance of non-autonomous ridepooling and ride hailing, as well as of autonomous vehicles (AV).

### 2.1. Framework of determinants of aRP

To systematically organize the psychological determinants influencing the acceptance of autonomous ridepooling (aRP) as identified in the literature, we used the extended version of the Unified Theory of Acceptance and Use of Technology (UTAUT2) (see Fig. 1). developed by Venkatesh et al. (2012). UTAUT2 integrates different theoretical models about user acceptance, while also incorporating a range of psychological constructs. This allows for a comprehensive understanding of the acceptance of new technologies such as aRP. It is a well-established framework to describe technology acceptance in a consumer context and its application has been previously demonstrated in studies on the acceptance of AV (Madigan et al., 2017; Nordhoff et al., 2019; Yuen et al., 2020). UTAUT2 states that multiple constructs, which present users' perceptions and attitudes, as well as sociodemographic characteristics, influence the intention to use a novel technology. Behavioral intention then influences actual user behavior, that is the adoption of aRP. Since aRP presents a future transport mode and actual use cannot be measured, acceptance is here defined as behavioral intention to use aRP.

Behavioral intention is determined by a set of seven constructs (Venkatesh et al., 2012). In the context of aRP these seven constructs are defined as: (1) *performance expectancy,* referring to the utility of aRP, including considerations of safety, environmental benefits, time-savings, and cost-savings; (2) *effort expectancy*, describing the ease of use of aRP, including the simplicity of planning and booking, and the effortless interaction with the vehicle; (3) *social influence*, measuring the significance of aRP use to others; (4) *facilitating conditions*, accounting for the availability of resources to use aRP; (5) *hedonic motivation*, capturing the enjoyment or pleasure derived from aRP; (6) *price value*, considering monetary travel costs and the pricing structure of aRP; and (7) *habit*, behavior that is performed automatically, e.g., regular use of aRP (Venkatesh et al., 2012). The model also proposes moderating effects of gender, age, and prior experience. The framework has further been extended by the authors by the construct *social aspects*, as literature indicates the presence of factors related to aRP that can be subsumed under this category (Dolins et al., 2021), referring to the interactive character of ridesharing, as vehicle are potentially shared with other users at the same time, similar to conventional public transport.

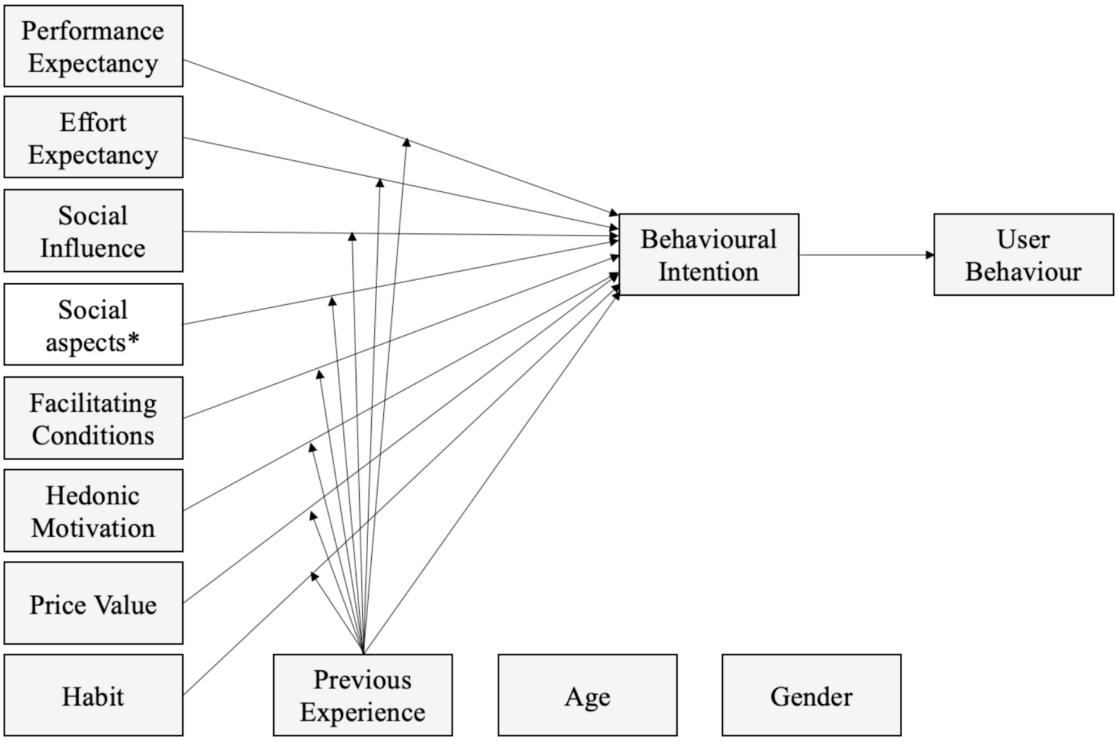


**Fig. 1.** Adapted version of UTAUT2 (Venkatesh et al., 2012).

Additionally, the adapted framework includes moderating factors of gender, age, and prior experience with aRP.

### 2.2. Factors influencing the acceptance of aRP

The adapted version of the UTAUT2 serves as a framework to structure the more general constructs and the more specific factors that determine behavioral intentions to use aRP. Thereby, the constructs form broader categories that comprise of the contextualized factors (see Table 1).

The construct of *performance expectancy* encompasses the largest number of factors influencing the acceptance of aRP. Notably, safety and comfort of the vehicle emerge as the most frequently investigated factors within this construct. Safety is defined in terms of the passenger's perceived safety regarding the technology of AV, speed, or safety measures such as emergency buttons or external control centers (Nordhoff et al., 2018, 2020; Zubin et al., 2020). Comfort of the vehicle includes aspects such as a welcoming and comfortable atmosphere, vehicle exterior and interior, disability friendliness, personal space provided by seat arrangements, and cleanliness (Etminani-Ghasrodashti et al., 2021; Sanguinetti et al., 2019; Schuß et al., 2021). Other factors within the construct of performance expectancy are time, availability, reliability, and flexibility. Time is composed of different elements, such as waiting time, pick-up time and total journey time (Merat et al., 2017). Availability comprises access during different business hours and to recreational destinations, as well as the capacity of the service (Etminani-Ghasrodashti et al., 2021). The perception of reliability is influenced by the predictability of travel time, waiting time, punctuality, and precise information about pick-up and drop-off locations in advance of the trip (Etminani-Ghasrodashti et al., 2021). The factor flexibility includes the ability to change routes and stops, adjust stops, modify pick-up and destination points, have flexible booking options, and the spontaneous availability of a ride (Schuß et al., 2021). Performance expectancy also includes the factors trip purpose, social equity, environmental considerations, privacy, activities during the journey and parking space. Trip purpose can be associated with work, shopping, education, home, leisure, or other activities (Hamadneh & Esztergár-Kiss, 2022). Social equity refers to ensuring that individuals with limited mobility also have access to the service (Paddeu et al., 2020). Environmental considerations involve assumptions about the impact of aRP on the environment, such as reduced traffic, electric vehicles, shared vehicles, decreased need for parking, improved air quality, and reduced emissions (Paddeu et al., 2020). Privacy encompasses concerns about the use of personal data by companies, including user locations and facial recognition (Gurumurthy & Kockelman, 2020), as well as potential risks associated with disclosing personal information, such as home and work locations, to co-riders (Sanguinetti et al., 2019). Activities during the journey, such as reading, writing, talking, using social media, gaming, eating/drinking, or doing nothing (Hamadneh & Esztergár-Kiss, 2022), and the need, availability, and cost of parking spaces (Stoiber et al., 2019), are among the least investigated factors within the construct of performance expectancy.

*Effort expectancy* is a construct that includes various factors related to the ease associated with the use of aRP: the trip planning process, information provided on the app, interaction with the AV, perceived control, liability (questions regarding who is liable and responsible when AVs fail), and payment methods. The process of planning a trip (short-term or long-term) and the tool a consumer uses to plan a trip (own definition) determine the ease of use. Information on real-time positioning of the AV and its near-future trajectory, pricing, and payment. Interaction with the AV involves the communication with the vehicle (information about travel, details on shuttle behavior, auditory shuttle information (Nordhoff et al., 2018)), and the recognition of groups by the AV, or a welcoming voice for passengers (Schuß et al., 2021). Ease of use is also related to the feeling of having the ability to control something (Sanguinetti et al., 2019). This construct also includes the payment method, e.g., cash or credit card (Etminani-Ghasrodashti et al., 2021) or the possibility of direct booking and payment (Merat et al., 2017). Finally, liability in case of accidents (own definition) is assumed to influence ease of use perceptions.

Several constructs of the adapted version of UTAUT2 are unidimensional: *social influence* (i.e., norms regarding whether using aRP is accepted by significant others), *facilitating conditions* (knowledge and available resources to use aRP), *hedonic motivation* (the fun or pleasure derived from using aRP), *price value* (including perceived travel cost, e.g., student free cost, registration cost, unified cost, and perceived cost savings, e.g., reduced fares, prices (Paddeu et al., 2020)) and *habit*, which represents current mobility habits like using public transportation or private cars.

The additional construct *social aspects*, encompasses the factors security, comfort in social situations, and opportunities for socializing. Security is described as safety concerns related to other passengers in a shared driverless vehicle (Dolins et al., 2021). Comfort regarding the social situation describes the psychological or social comfort/discomfort caused by close interpersonal space between passengers (Merat et al., 2017). Socializing describes the interaction between two or more passengers in a shared vehicle (Sanguinetti et al., 2019).

UTAUT2 also includes moderating effects of age, gender, and prior experience. Similarly to habit, previous experience refers to using public transport or private cars, since aRP is not yet available in Switzerland, where the current study has been conducted.

In summary, there is a wide range of influential factors that have been explored in previous research. Some factors, such as safety, reliability, flexibility, and availability, have been researched more extensively than others, such as planning, interaction with the vehicle, perceived control, payment, and norms. However, there is still a lack of in-depth understanding of all factors, and there is a need to comprehensively examine which factors are relevant from a user's perspective.

### 2.3. Objectives of the present research and research questions

In sum, various approaches have been utilized to investigate the factors influencing acceptance of either AVs, ridepooling, or a combination of both, resulting in a wide range of proposed determinants that might influence the acceptance of aRP. However, the meaning of these factors in the context of aRP has not been thoroughly explored. Our research aims to fill this gap in the literature by conducting an exploratory investigation specifically on the determinants of aRP acceptance. The goal of this study is to gain a better understanding of the determinants of aRP acceptance, exploring their perception as motivators and barriers from a user-centered perspective. Additionally, we examined the influence of current mobility habits, such as the use of public transportation versus private cars, as potential mediating factors for the acceptance of aRP. Habits play a crucial role in the adoption of new behaviors (Verplanken et al., 1997), particularly in transitioning from car driving to shared and thereby more sustainable forms of mobility (Semenescu et al., 2020).

Therefore, the present research sets out to answer the following research questions:

1. What are the underlying meanings of the factors that influence the acceptance of aRP from a user perspective?
2. In what way are these meanings perceived as motivators or barriers concerning the acceptance of aRP?
3. In what way do the perceptions of individuals that primarily use public transport differ from the perception of individuals that primarily rely on private cars for their individual mobility?

The findings of the presented previous research are the starting point for the qualitative exploration of future users' of aRP services.

**Table 1**
Potential psychological factors influencing the acceptance of ridepooling, structured according to an adapted version of UTAUT2 (Venkatesh et al., 2012).

| Construct | Description | Psychological factors | Description | References |
|---|---|---|---|---|
| Performance expectancy | Extent to which aRP provides benefits (i.e. perceived usefulness) | Usefulness (general) | Perception of usefulness to fulfill daily travel behavior (Nordhoff et al., 2018) | (Nordhoff et al., 2018) |
| | | Safety | The extent a passenger feels safe regarding the technology, speed or safety measures (Nordhoff et al., 2018, 2020; Zubin et al., 2020) | (Barbour et al., 2019; Dolins et al., 2021; Etminani-Ghasrodashti et al., 2021; Fan et al., 2022; Irannezhad & Mahadevan, 2022; Nordhoff et al., 2018, 2020; Nordhoff et al., 2021a; Paddeu et al., 2020; Schuß et al., 2021; Zubin et al., 2020) |
| | | Comfort of the vehicle | Aspects like atmosphere, vehicle exterior and interior, disability friendliness, personal space due to seat arrangements and cleanliness ( Etminani-Ghasrodashti et al., 2021; Schuß et al., 2021) | (Dolins et al., 2021; Etminani-Ghasrodashti et al., 2021; Fan et al., 2022; Nordhoff et al., 2018; Sanguinetti et al., 2019; Schuß et al., 2021; Zubin et al., 2020) |
| | | Social equity | Availability of mobility for people who are less mobile (Paddeu et al., 2020) | (Etminani-Ghasrodashti et al., 2021; Fan et al., 2022, p. 22; Paddeu et al., 2020; Zubin et al., 2020) |
| | | Time | Time as in travel time, walking time, waiting time, pick-up time or total journey time (Merat et al., 2017) | (Dolins et al., 2021; Nordhoff et al., 2018; Sanguinetti et al., 2019; Schuß et al., 2021; Stoiber et al., 2019; Susilawati & Lim, 2021; Zubin et al., 2020) |
| | | Environmental considerations | Considerations about the impact of aRP on the environment (e.g., less cars, better air quality, less emissions) (Paddeu et al., 2020) | (Nordhoff et al., 2018; Paddeu et al., 2020; Zubin et al., 2020) |
| | | Reliability | Aspects of predictability of travel time, waiting time, punctuality and exact information about pick-up and drop-off locations in advance ( Etminani-Ghasrodashti et al., 2021) | (Barbour et al., 2019; Etminani-Ghasrodashti et al., 2021; Irannezhad & Mahadevan, 2022; Nordhoff et al., 2021b; Sanguinetti et al., 2019; Stoiber et al., 2019; Susilawati & Lim, 2021) |
| | | Flexibility | The flexibility of changing routes and stops (pickup and destination), flexible booking options and spontaneous availability of a ride ( Schuß et al., 2021) | (Etminani-Ghasrodashti et al., 2021; Irannezhad & Mahadevan, 2022; König & Grippenkoven, 2020; Schuß et al., 2021; Stoiber et al., 2019; Susilawati & Lim, 2021) |
| | | Availability | Access during different business hours and to recreational destinations, but also the capacity of service (Etminani-Ghasrodashti et al., 2021) | (Etminani-Ghasrodashti et al., 2021; Irannezhad & Mahadevan, 2022; Nordhoff et al., 2020; Paddeu et al., 2020; Schuß et al., 2021) |
| | | Privacy | Concerns about the use of personal information, such as the user's locations and facial recognition (Gurumurthy & Kockelman, 2020) | (Fan et al., 2022; Sanguinetti et al., 2019) |
| | | Trip purpose | The specific reason or objective for undertaking a journey or travel e.g., work, shopping, education, home, leisure or others (Hamadneh & Esztergár-Kiss, 2022) | (Barbour et al., 2019; Hamadneh & Esztergár-Kiss, 2022; Irannezhad & Mahadevan, 2022; Paddeu et al., 2020; Zubin et al., 2020) |
| | | Parking Space | The need, availability and cost of parking spaces (Stoiber et al., 2019) | (Barbour et al., 2019; Stoiber et al., 2019) |
| | | Activity during journey | Activities during journey, e.g., reading, writing, talking, using social media, gaming, eating/ drinking or doing nothing (Hamadneh & Esztergár-Kiss, 2022) | (Hamadneh & Esztergár-Kiss, 2022) |
| Effort expectancy | The degree of ease users associate with aRP (i.e. ease of use) | Interaction with vehicle | Communication with automated vehicle ( Nordhoff et al., 2020) | (Nordhoff et al., 2018, 2020) |
| | | Information on the app | Information on real-time positioning of the AV and its near-future trajectory, pricing, and payment (Merat et al., 2017) | (Merat et al., 2017) |
| | | Perceived control | The feeling of having the ability to control something (Sanguinetti et al., 2019) | (Sanguinetti et al., 2019) |
| | | Planning | The process of planning a trip (short-term or long-term) and the tool a consumer uses to plan a trip (own definition) | (Etminani-Ghasrodashti et al., 2021; Nordhoff et al., 2018) |
| | | Payment | Includes the payment method, e.g., cash or credit card (Etminani-Ghasrodashti et al., 2021). Possibility of direct booking and payment (Merat et al., 2017). | (Etminani-Ghasrodashti et al., 2021; Fan et al., 2022) |
| | | Liability | Liability in case of accidents (own definition) | |
| Social influence | Extent to which users perceive that important others (e.g., family or friends) believe they should use aRP (Venkatesh et al., 2012) | Norm | Extent to which users perceive that important others (e.g., family and friends) believe they should use the service (Venkatesh et al., 2012) | (Nordhoff et al., 2018) |
| Social aspects | Response to interactions and presence of other people (own definition) | Security | Safety concerns related to other passengers ( Dolins et al., 2021) | (Dolins et al., 2021; Fan et al., 2022; Nordhoff et al., 2018; Sanguinetti et al., 2019; Stoiber et al., 2019; Zubin et al., 2020) |

(*continued on next page*)

**Table 1** (*continued*)

| Construct | Description | Psychological factors | Description | References |
|---|---|---|---|---|
| | | Comfort / discomfort social situation | Psychological or social comfort or discomfort caused by close interpersonal space between passengers (Merat et al., 2017) | (Fan et al., 2022; Nordhoff et al., 2018; Nordhoff, Malmster, et al., 2021; Sanguinetti et al., 2019; Stoiber et al., 2019; Zubin et al., 2020) |
| | | Socializing | Interaction between two or more passengers on a shared vehicle (Sanguinetti et al., 2019) | (Sanguinetti et al., 2019) |
| Price value | Cognitive tradeoff between perceived benefits and costs of using aRP (Venkatesh et al., 2012) | Travel cost | Travel cost and cost saving from a consumer's perspective (Paddeu et al., 2020) | (Barbour et al., 2019; Etminani-Ghasrodashti et al., 2021; Fan et al., 2022; Irannezhad & Mahadevan, 2022; König & Grippenkoven, 2020; Paddeu et al., 2020; Stoiber et al., 2019; Zubin et al., 2020) |
| Facilitating conditions | Users' perceptions of resources and support available to use aRP ( Venkatesh et al., 2012) | Skills | Requirements for the users (own definition) | |
| Hedonic motivation | Fun or pleasure derived from using aRP (Venkatesh et al., 2012) | Hedonic motivation | The fun or pleasure derived from using the service (Venkatesh et al., 2012) | (Nordhoff et al., 2018) |
| Habit | Extent to which people perform behaviors automatically due to learning processes or previous experiences (Venkatesh et al., 2012) | | Performed behavior based on learning processes and previous experiences (Venkatesh et al., 2012) | (Barbour et al., 2019; Irannezhad & Mahadevan, 2022; Nordhoff et al., 2018, 2020) |

## 3. Methods

To answer the research questions, the study at hand used an exploratory approach involving semi-structured qualitative in-depth interviews to explore psychological factors in the acceptance of aRP. The use of qualitative interviews allows for a detailed exploration of attitudes and behavioral tendencies (Brinkmann, 2014).

### 3.1. Procedures and measures

In total, 19 in-depth interviews were conducted. Each interview took between 45 and 60 min and was conducted remotely via a video communication application. Trained interviewers followed a pretested semi-structured interview guideline throughout the sessions, all of which were recorded and transcribed for the analysis.

The present research adopted the technique of narrative storytelling to identify implicit attitudes and perceptions. Narrative storytelling facilitates the exploration of implicit aspects by focusing less on cognitive rationalization and more on emotional expression, complexity, and conflicting attitudes (Lugmayr et al., 2017). This approach is especially helpful in overcoming the challenges of investigating hypothetical scenarios in the future – such as using aRP (Sools, 2020).

The semi-structured interview guide is structured as follows (for the full interview guide see Appendix A). In the introduction, the concept of AV and RP was explained using a simple description with a few bullet points and a visualisation. Additionally, the participants were asked whether they have previously heard of or used this mode of transport. The participants were then asked to imagine a fictitious journey with an aRP. They were free to choose the type of journey. By applying the narrative storytelling approach, they were told to imagine and report on the whole journey, i.e. how they got to the vehicle and what the actual ride entailed, up until to the arrival at their endpoint. The participants were then asked why they would use – or not use – aRP. With additional questions a more thorough understanding of the relevant factors could be gained.

### 3.2. Sample

Participants were recruited through various channels, including existing ride-pooling service user databases, social media platforms, and a professional recruitment service. This recruitment approach allowed for a broad range of perspectives. Due to the qualitative nature of the study, participant recruitment followed an iterative process (Negrin et al., 2022). Initially, individuals with and without previous ridepooling experience were recruited. Initial insights revealed that participants with ridepooling experience were exclusively public transport users. Considering the influence of mobility habits on new travel modes, the recruitment strategy was adjusted to ensure adequate representation of car users.

Participants were categorized according to their mobility habits (public transport or car users), either based on information provided in the interviews or data from a screening questionnaire. An inclusion criterion was a medium level of innovativeness regarding new mobility services (2 *Little* – 4 *Rather a lot* on a 5-point scale) to ensure that participants were generally open to such services yet do not belong to the small group of highly innovative so-called early adopters (Rogers, 2003). Screening questions were used to ensure a balanced sample with respect to age and gender.

The total sample consisted of 18 participants. While 19 interviews were conducted, one participant was excluded because for not being a user of public transport or a car.. The sample consisted of residents of the German-speaking part of Switzerland and comprised individuals with different employment status and household types. The sample was balanced in terms of gender (male, n = 8; female, n = 10), and dominant mobility mode (mostly public transport users, n = 9; mostly private car users, n = 9). Participants were aged between 21 and 59 years (M = 35, Median = 33). A detailed overview of the participants' characteristics is listed in Table 2. The interviewees received a monetary incentive of 50 Swiss francs for their participation.

### 3.3. Data analysis

The transcribed interviews were analyzed according to the procedures of a structured content analysis (Nielsen et al., 2015; Radke et al., 2011). The narrative storytelling, including the questions about specific

**Table 2**
Sample characteristics.

| | Total | Public transport users | Car users |
|---|---|---|---|
| Gender | | | |
| Male | 8 | 3 | 5 |
| Female | 10 | 6 | 4 |
| Age | | | |
| 21–40 | 10 | 6 | 4 |
| 40–61 | 8 | 3 | 5 |
| Previous experience with RP | | | |
| Yes | 5 | 5 | 0 |
| No | 13 | 4 | 9 |
| Total | **18** | **9** | **9** |

factors, was analyzed in a two-step procedure. In a first step, interview-transcripts were coded by two independent coders along the constructs and factors based on the findings from the literature (UTAUT2) using the software MAXQDA. New codes were given to additional factors when necessary (inductive category development). Overall, the coding system comprises seven constructs and 23 psychological factors (see Appendix B for full coding system).

In a second step, different statements within a factor were classified either as a motivator, a barrier or as neutral. This resulted in a three-level structure of the coding system: (1) constructs, (2) psychological factors and (3) motivators and barriers (or neutral arguments) for using aRP (see Table 1). We differentiated between statements from public transport users and statements from car users. In an additional step, we examined differences between individuals with and without ridepooling experience.

## 4. Results

The results are reported along the constructs of the adapted version of the UTAUT2. To explore the most relevant factors from a user perspective, all factors that feature ten or more motivators and barriers are reported. Table 3 provides an overview of these factors, their superordinate category as well as the number of motivators and barriers. The motivators and barriers thus reflect the variety of statements. As soon as one person mentioned the factor, it is listed in the tables. If the same arguments were reported by several participants, they were subsumed within the same motivator or barrier. Conversely, one person could state multiple motivators and barriers. The motivators and barriers of all factors are listed in A ppendix A.

The motivators and barriers of these factors are explored following the structure of the according constructs from UAUT2. Further, motivators and barriers as mentioned from public transport users versus private car users are differentiated.

### 4.1. Performance expectancy

Safety.

Participants reported to trust the technical functionalities of aRP and considered it to be safer than human-driven vehicles as AVs are less susceptible to human errors (see Table 4). The trust in technology is exemplified by the following statement:

> *"I would trust it more than human reliability. Humans make mistakes." (P15, car user)*

Participants trusted the safety standards a vehicle needs to pass before being allowed on the streets. Despite this, using aRP would feel new and unfamiliar at the beginning, yet repeated use and growing familiarity was said to increase trust. This is shown in the following statement:

> *"I think I am going to feel insecure, to have these doubts whether you can trust it. … I think with repeated use and experience, when you really know this works, then this would be a completely different feeling" (P03, public transport user)*

However, participants also mentioned that they would feel insecure when using aRP. Further concerns were skepticism towards the technology, fear of accidents, and the inability to intervene if the automatic steering mechanism fails.

Public transport users further said that they want additional information about safety standards before using aRP, e.g., information about the accident rate. Furthermore, autonomous driving was perceived as feeling safer when other passengers are present, i.e., it is used in a shared mode.

Car users considered it helpful to still have a steward present when first launching aRP. Initially, it might also not be clear how the vehicle works. Additionally, some car users also stated a general anxiety about autonomously moving vehicles or were concerned about technical issues and then being stranded somewhere. If an accident happened, one might even feel liable.

**Travel times**.

Travel time with aRP was considered to be shorter compared to public transport due to direct trips and shorter waiting times (see Table 5). A participant elaborated on the relationship between travel time and advanced technology:

**Table 3**
Number of motivators and barriers for the most relevant psychological factors.

| Construct | Psychological factor | No. of motivators | No. of neutral arguments | No. of barriers | Total |
|---|---|---|---|---|---|
| Performance expectancy | Safety | 7 | 2 | 7 | 16 |
| | Comfort of the vehicle | 5 | 3 | 3 | 11 |
| | Time | 6 | 1 | 6 | 13 |
| | Environmental considerations | 6 | 1 | 5 | 12 |
| | Flexibility | 9 | 1 | 4 | 14 |
| | Availability | 9 | 0 | 4 | 13 |
| Effort expectancy | Planning | 8 | 0 | 2 | 10 |
| Social aspects | Socializing | 6 | 4 | 3 | 13 |
| Price value | Travel cost | 8 | 2 | 2 | 12 |
| Total | | 64 | 14 | 36 | 114 |

**Table 4**
Motivators and barriers concerning the factor safety.

| Motivators and barriers | | PT users | Car users |
|---|---|---|---|
| Motivators | Less susceptible to human errors | X | X |
| | Trust in technical functionalities | X | X |
| | Trust in safety standards | X | X |
| | Trust with increasing familiarity | X | X |
| | Information about safety standards | X | |
| | Presence of other passengers | X | |
| | Presence of steward during initial drives | | X |
| Neutral | New and unfamiliar at the beginning | X | X |
| | Open questions about how the vehicle works | | X |
| Barriers | Feelings of insecurity and uneasiness | X | X |
| | Skeptical about technical functionalities | X | X |
| | Fear of accidents | X | X |
| | Not possible to intervene when automated driving fails | X | X |
| | Fear of technical issues | | X |
| | General fear of AV's | | X |
| | Liability in case of an accident | | X |

**Table 5**
Motivators and barriers concerning the factor time.

| Motivators and barriers | | PT users | Car users |
|---|---|---|---|
| Motivators | Shorter travel time due to direct journey | X | X |
| | Shorter waiting times | X | X |
| | Time savings if current public transport | X | |
| | connections are not convenient | X | |
| | Flexibility in travel time is rewarded with cost | X | |
| | savings | | X |
| | Indication of maximum travel time | | |
| | As fast as public transport | | |
| Neutral | Slightly longer travel time is ok | | X |
| Barriers | Longer journey due to detours | X | X |
| | Travel / waiting time difficult to estimate | X | X |
| | Occasional delays due to technical issues | X | X |
| | No time savings compared with current public | X | |
| | transport | | X |
| | Slow speed of aRP vehicle | | X |
| | Fixed departure times are stressful | | |

*"If you have an algorithm that really works, then there are no delays. Occasional technical problems can happen […] But […] I'm not at all worried about being delayed. On the contrary, it usually works like clockwork." (P08, public transport user)*

However, participants also had concerns related to longer travel time due to detours when picking up other passengers. The travel and waiting time for aRP was regarded as difficult to estimate and occasional delays due to technical issues were presumed.

Public transport users further considered travel time to be shorter due to improved public transport connections. Flexibility in travel time was expected to make the service financially attractive, i.e., longer travel time due to more drop-offs should be cheaper. Additionally, it was assumed that a maximum travel time could be indicated. However, as existing transport connections were sometimes deemed sufficient, no further time savings were expected.

Car users also draw comparisons to conventional public transport and considered travel time in an aRP to be similar compared to public transport. However, some car users expected the vehicle to drive at slow speed, resulting in longer travel times. Furthermore, fixed departure times were perceived to be stressful. A slightly longer travel time was accepted under certain circumstances, e.g., for leisure trips. The difference in travel time for different trip purposes is exemplified in the following statement:

*"I only use public transport for private journeys, because then I have enough time and I don't care if I have an extra 10 min because I'm stuck in a traffic jam. […] I would use [aRP] for private trips, but to drive to work, that's not possible." (P16, car user)*

**Environmental considerations**.

When it comes to environmental aspects, participants reported the following motivators for aRP (see Table 6). They deemed it environmentally friendly due to better use of its vehicle capacity and the use of alternative propulsion technologies, e.g., electric motors. ARP was sometimes seen as generally sustainable. Further, aRP was seen to reduce the number of privately owned vehicles and traffic volume. It could also reduce trips without any passengers due to intelligent routing. This is shown in the following statement:

*"I think it can strongly minimize the number of journeys. Not only by taking smarter routes, but also combining journeys. We currently have a lot of empty cars on the road and there is often only one person in a taxi." (P06, public transport user)*

However, sustainability wasn't a relevant factor for all public transport users. Public transport users saw a drawback of aRP as being less environmentally friendly than conventional public transport because of lower capacities and because aRP could lead to an increase in traffic. An additional analysis between individuals with and without ridepooling experience revealed that all barriers were mentioned by public transport users with ridepooling experience, while public transport users without such experience did not express any negative concerns.

Car users mentioned different arguments against aRP compared to public transport users. They considered the negative environmental impact of the propulsion technology, either because of conventional combustion engines or the implications of electric driving (e.g., large batteries). Additionally, it was seen problematic if aRPs did not operate at sufficient capacity.

**Availability**.

Participants mentioned a large number of motivators concerning the availability of aRP (see Table 7). ARP was deemed a service that complements public transport network, e.g., during off-peak hours or in areas with a less dense network. It was also perceived as a service particularly suitable for urban areas. One participant elaborated on the advantages of aRP as follows:

*"It would be very convenient if it complements normal service. [Where I live], public transport doesn't run after 9 PM. […] If autonomous vehicles were able to offer a 24-hour service, this would be a huge progress." (P13, public transport user)*

Enough vehicles was seen as important to enable spontaneous and flexible use of the service, while an insufficient number was perceived as a barrier. An extensive network was perceived positively as it would allow for direct trips in an aRP. Additionally, the vehicle should be appropriate for the intended use, e.g., when one travels with a lot of luggage.

Public transport users considered aRP not as appropriate for urban areas as the existing public transport network is sufficient. Furthermore, a weather-dependent service was deemed an option.

Car users saw aRP also as a replacement for public transport instead of being an addition. A barrier to using aRP was seen if no instant or connecting service was provided. Additionally, car users saw the availability of a private car at any time as a deterrent for using aRP. One person discussed the advantages of a private car:

*"I would miss my car. For example, for leisure activities, where I can just pack my car that sits in the garage. I can throw everything in it and leave. Ridepooling can never offer me that." (P18, car user)*

**Flexibility**.

Participants mostly mentioned motivators when it comes to the flexibility of aRP (see Table 8). They appreciated the possibility of door-to-door transport and direct trips without any transfers. A further advantage was seen in the spontaneous use without being restricted by a timetable. The vehicle stops were seen as clearly defined and easily accessible. An ambivalence is observable about the directness of trips:

**Table 6**
Motivators and barriers concerning the factor environmental considerations.

| Motivators and barriers | | PT users | Car users |
|---|---|---|---|
| Motivators | Higher use of vehicle capacity | X | X |
| | Alternative propulsion technologies | X | X |
| | Reduction of car ownership | X | X |
| | Reduction of traffic volume | X | X |
| | Smart routing | X | X |
| | Sustainable (general) | X | X |
| Neutral | Sustainability is not an important argument | X | |
| Barriers | Conventional public transport is more sustainable | X | |
| | Increase in traffic volume | | X |
| | Use of vehicles with combustion engines | | X |
| | Negative effects of electric vehicles, e.g., battery | | X |
| | Insufficient use of capacity | | |

**Table 7**
Motivators and barriers concerning the factor availability.

| Motivators and barriers | | PT users | Car users |
|---|---|---|---|
| Motivators | Service for off-peak hours | X | X |
| | Service for areas with insufficient public transport network | X | X |
| | Service for urban areas | X | X |
| | Sufficient vehicles | X | X |
| | Addition to public transport | X | X |
| | Extensive network to enable direct trips | X | X |
| | Appropriate vehicles, e.g., for transport of luggage | X | X |
| | Weather-dependent service, e.g., snow | | |
| | Replacement for public transport | | |
| Neutral | | | |
| Barriers | Insufficient number of vehicles | X | X |
| | Service not suitable for urban areas | X | |
| | Private car is always available | | X |
| | Service is not immediately available | | X |

**Table 8**
Motivators and barriers concerning the factor flexibility.

| Motivators and barriers | | PT users | Car users |
|---|---|---|---|
| Motivators | Door-to-door travel | X | X |
| | Direct trips without any transfers | X | X |
| | Well-defined, easily accessible stops | X | X |
| | Spontaneous use | X | X |
| | Fewer stops / detours | X | X |
| | Booking in advance | | X |
| | Regular schedule | | X |
| | Combination with public transport | | X |
| | Exclusive booking for a group for direct trips | | X |
| Neutral | Short walk to vehicle / destination is acceptable | | X |
| Barriers | Detours due to pick-up / drop-off of passengers | X | X |
| | More flexibility with private car | | X |
| | No short-term booking or changing of journey | | X |
| | Long distance to destination | | X |

On the one hand, participants considered an aRP to choose a more direct route with less stops, yet, on the other hand, it was also thought to be doing detours as passengers have different destinations. This is exemplified by the following comment:

> *"Several people need to be [in an aRP]. And they all have their individual journeys and yet you must bring the journeys down to a common denominator." (P04, public transport user)*

Car users reflected on further motivators and barriers concerning the flexibility of aRP. While spontaneous use was a motivator for some and not being able to do short-term changes in the booking was perceived negatively, others preferred booking in advance or a regular schedule. ARP was also seen as being used in combination with conventional public transport. Furthermore, the possibility of an exclusive booking of a vehicle when traveling in a group was appreciated. While for some car users a short walk to the vehicle or destination was acceptable, some considered it a barrier if the drop-off destination was far away from the destination. Another barrier for car users was that a private car was seen as more flexible in general, which is shown in the following statement:

> *"I'm very flexible with the car, with [ridepooling] you're not. For example, when I get off work, I can just get into the car. You can't do that with [ridepooling]. If I say the bus has to be here at this time and then it's 5–10 min late […] and I have an appointment right then." (P16, car user)*

**Comfort of the vehicle**.

Participants mentioned the following motivators and barriers concerning the comfort of the aRP vehicle (see Table 9). They imagined the vehicle to be clean and to provide sufficient space, e.g., for luggage and comfortable seating. The vehicle should provide easy access for elderly or disabled people. One participant contemplated the issue of inclusive design:

> *"Another question would be how the vehicle is designed for people with disabilities. With a wheelchair, can I use it without help or do I need assistance? […] Train platforms have been adapted so boarding is handicapped accessible. How is it [with an aRP]? If someone has a walking stick or a wheeled walker, how is it then?" (P14, car user)*

Different ideas were expressed about additional services in the vehicle, e.g., the option for charging a phone or a snack machine. As a barrier was seen a small vehicle with little space or standing places.

Public transport users mentioned that the comfort of the vehicle was dependent on the length of the journey. In this context, standing places were sometimes considered an adequate option. Furthermore, the vehicle was perceived to be easily recognizable from the outside, e.g., via some kind of identification. A comparison between individuals with and without ridepooling experience showed that, except for one argument, all arguments were raised by participants with ridepooling experience. Car users mentioned two additional barriers for using aRP. They were worried about bad air quality and poor performance of the vehicle, e.g., if it rides uphill.

**Table 9**
Motivators and barriers concerning the factor comfort of the vehicle.

| Motivators and barriers | | PT users | Car users |
|---|---|---|---|
| Motivators | Spatial design of vehicle, e.g., standing places or luggage space | X | X |
| | | X | X |
| | Interior design of vehicle, e.g., comfort of seats | X | X |
| | Access for elderly or disabled people | X | X |
| | Services in vehicle, e.g., phone charging or snack machine | X | X |
| | Cleanliness | | |
| Neutral | Standing places and seats | X | |
| | Identification of vehicle | X | |
| | Comfort depends on length of journey | X | |
| Barriers | Spatial design, e.g., small vehicle, room for luggage or standing places | X | X |
| | | | X |
| | Bad air quality | | X |
| | Poor vehicle performance | | |

## 4.2. Effort expectancy

**Planning**.

Regarding planning an aRP journey, participants mentioned several motivators (see Table 10). They imagined that planning can be easily done via app or online. One person describes the process as follows:

> *"I imagine that I have an app. And then I can plan that I would like to order [an aRP] and it shows me that there is one 10 km away and it is picking up two other passengers and I know, it will be here in 15 min. [….] then I expect a travel time, so I have a rough idea of how long it will take." (P09, public transport user)*

While some participants explicitly wanted to plan in advance, others favoured short-term planning. Additionally, a feature for planning a group journey with different pick-up points was seen as a motivator.

Public transport users considered a motivator if real-time data of the vehicles was available. They further wished that the planning process accounts for multimodal journeys, i.e., the combination of different vehicles. However, uncertainty in planning because pick-up and drop-off times were not reliable was perceived as detrimental to planning an aRP journey.

Car users mentioned as a barrier for using aRP that travelling by private car was seen as easier because it requires less planning. Furthermore, they appreciated if extras could be added in the booking process, such as additional luggage space.

## 4.3. Price value

**Travel costs**.

**Table 10**
Motivators and barriers concerning the factor planning.

| Motivators and barriers | | PT users | Car users |
|---|---|---|---|
| Motivators | Planning via app / online | X | X |
| | Possibility of short-term planning | X | X |
| | Possibility of planning ahead | X | X |
| | Easy planning | X | X |
| | Group travel | X | X |
| | Real-time data of vehicles | X | |
| | Multimodal journeys | X | |
| | Booking of extras, e.g., luggage | | X |
| Neutral | | | |
| Barriers | Uncertainty in planning | X | |
| | Private car requires less planning | | X |

Participants reported several motivators and a neutral argument regarding travel costs of aRP (see Table 11). Even though different ideas about the pricing of aRP prevailed, comparisons with public transport and a private car were often made. The comparison with different transport modes is exemplified in the following statement:

> *"It should be slightly below the yearly price of a GA [Swiss subscription for unlimited public transport use] or in the range of what public transport usually costs. It certainly has to be below the average cost of a private car. I think a maximum of CHF 200 per month" (P11, car user)*

ARP was thought to be either similarly priced to public transport, or slightly more expensive due to the additional services provided. Several users also anticipated that travel card subscriptions would be available for aRP use. ARP was also perceived as cheaper than a private car; sometimes it was generally seen as a cheap mode of transport. Flexible pricing was also considered a possibility.

Public transport users further made comparisons with using a taxi. While high costs were perceived as a barrier for using aRP by some participants, they were sometimes seen as not being the main criterion, especially in this comparison, as taxi prices are usually very high in Switzerland.

For car users, higher prices than conventional public transport were seen as a barrier for using aRP. While some car users saw flexible pricing as an option, equal pricing for all users was also considered important by some. The possibility of travelling with luggage without any extra costs was mentioned. Additionally, cheap offers for testing the service without the need to buy a subscription were motivating to try aRP.

### 4.4. Social aspects

**Socializing**.

A balanced mix of motivators, barriers, and neutral arguments were mentioned when it comes to socializing in an aRP (see Table 12). Some participants said that they were open to socializing and found an aRP an opportunity for making new acquaintances. The shared experience of using an aRP was seen as a possible conversation starter. However, others said they do not want to talk to other passengers when travelling; or it depends on the mood, context, and time of day. Thus, one person differentiated:

> *"In the evening, when I'm tired, I don't really want [to talk]. But during the day it might be quite nice." (P01, public transport user)*

Participants imagined the interaction in an aRP to be similar to interactions in conventional public transport: some people talk to each other; others are quiet and on their phones.

Public transport users considered an aRP vehicle as conducive for socializing as it is smaller than conventional busses. It was thus seen as a new social space where different rules for interaction might apply. Differences in personality were deemed relevant to whether socializing was appreciated. Hence, giving and reading the signs if passengers are open to socializing were perceived to be important.

Car users also reflected on the impact of the small vehicle size and considered aRP less anonymous as a result. To travel this way regularly with the same people, was on the one hand perceived as positive because it might lead to a familiar atmosphere. On the other hand, it was also evaluated apprehensively as it might lead to awkward social situations. This is exemplified by the following statement:

> *"If it's a one-off, then it's not a problem. If it's a regular thing, then it depends very much on what kind of people I'm travelling with. For example, I'm not the most talkative person in the morning. In such a vehicle I would be forced to socialize." (P18, car user)*

Due to different needs for socializing, differently themed vehicles were proposed, such as a quiet vehicle or a sociable vehicle.

**Table 11**
Motivators and barriers concerning the factor travel costs.

| Motivators and barriers | | PT users | Car users |
|---|---|---|---|
| Motivators | Generally cheap | X | X |
| | Similarly priced to public transport | X | X |
| | Cheaper than a private car | X | X |
| | Slightly more expensive than public transport | X | X |
| | Cheaper than a taxi | X | |
| | Equal pricing for everyone | | X |
| | No extra costs for luggage | | X |
| | Test offers without subscription | | X |
| Neutral | Flexible pricing | X | X |
| | Price is not the main factor | X | |
| Barriers | High costs | X | |
| | More expensive than public transport | | X |

**Table 12**
Motivators and barriers concerning the factor socializing.

| Motivators and barriers | | PT users | Car users |
|---|---|---|---|
| Motivators | Open to socializing | X | X |
| | Possibility to make new acquaintances | X | X |
| | Using aRP as a common feature | X | X |
| | Small vehicle is better for socializing | X | |
| | Growing familiarity when regularly meeting same passengers | | X |
| | Differently themed vehicles | | X |
| Neutral | Social interaction similar to public transport | X | X |
| | Depending on personality type | X | |
| | (Non-verbal) communication about willingness to socialize | X | |
| | Different social space | X | |
| Barriers | No need for socializing | X | X |
| | No need for socializing depending on context | X | X |
| | Awkward social situation in small vehicle | | X |

## 5. Discussion

The purpose of the present study was to explore determinants of aRP acceptance from a user-centered perspective. A content-analysis based on 18 semi-structured in-depth interviews revealed perceptions of potential users. The results contribute to existing research by shedding light on psychological factors of aRP acceptance along the constructs of the UTAUT2 framework. Exploring these psychological factors contributes to a better understanding of their meaning in the context of aRP. Additionally, the study's results suggest that mobility habits (i.e., regular car use versus public transport use) influence acceptance of aRP through different perceptions of psychological factors that determine behavioral intention of aRP. In consideration of these results, we discuss the findings in light of previous literature and derive implications for the design of future aRP-services.

### 5.1. Discussion of results along the research questions

Addressing Research Question 1, this section discusses the meanings of the underlying factors influencing the acceptance of aRP. Alongside, for each factor motivators and barriers are explored (attempting to answer Research Question 2) from the perspective of car users versus public transportation users (addressing Research Question 3).

The study generally confirms the relevance of the constructs of the UTAUT2 framework for aRP acceptance. In the present study, factors that are related to the construct of performance expectancy are the ones discussed in most detail. This is similar to the finding by Nordhoff, Madigan, and colleagues (2021), which identified performance expectancy as one of the two most important predictors of the intention to use AV shuttles.

Within the construct of performance expectancy, the factors safety, comfort of the vehicle, time, environmental considerations, flexibility,

and availability played an important role. When it comes to safety of aRP, participants generally revealed ambivalent attitudes. They expressed high trust in autonomous driving while also feeling insecure. A study by Paddeu (2020) also showed that safety is an important issue and passengers expect high standards of safety levels. However, in a different study, participants were hesitant about trusting the technology or the service provider and mentioned concerns about the readiness of AV-technology (Dolins et al., 2021). Car users expressed more diverse arguments about safety concerns. A possible explanation is that car users might be less used to handing over control (Sweet & Laidlaw, 2020). Consequently, it might be that there are more psychological barriers for car users to adopt aRP. In addition, the presence of other passengers is thought to mitigate feelings of insecurity, as they might be competent to solve or to deal with safety issues. Concerns about the absence of a human operator were also mentioned in the study by Etminani-Ghasrodashti and colleagues (2021). Furthermore, in a study by Nordhoff and colleagues (2018), participants stated that they appreciate supervision, either via an external control room or with a steward on board. Thus, shared use such as ridepooling could actually lead to better acceptance of autonomous vehicles.

Comfort of the vehicle is associated with a clean, spacious vehicle which also enables the elderly and people with disabilities to travel. This is line with other studies that found cleanliness was an important issue (Dolins et al., 2021; Schuß et al., 2021) as well as spaciousness (Dolins et al., 2021; Nordhoff et al., 2018). Furthermore, a study by Etminani-Ghasrodashti and colleagues (2021) showed that people with disabilities and without emphasized that aRP services should be inclusive. This not only concerns the vehicle (e.g., boarding), but also the general access to the service (e.g., the app). Since autonomous driving holds the promise of improving mobility of people with impairments (Harper et al., 2016), careful attention should be paid to the vehicle's service design when implementing aRP in practice. The perspectives of users with different needs should be identified and integrated in the development of an inclusive aRP (Miller et al., 2022; Severs et al., 2022).

Both public transport and car users consider aRP to be more flexible as conventional public transport. More flexibility with regards to routing and the possibility of door-to-door transport is mainly valued as an advantage among regular public transport users. However, flexibility is perceived to come at the cost of time loss due to detours. This is in line with the findings of König and Grippenkoven (2020): longer detours and longer travel time reduce willingness to use aRP. Hence, some studies described a certain paradox as passengers want to plan ahead and have a sense of reliability, yet this comes at the cost of reduced flexibility for spontaneous adjustments (Etminani-Ghasrodashti et al., 2021; Schuß et al., 2021). In the study at hand, car users see flexibility as an advantage of aRP compared to conventional public transport, yet they still consider their own private car to be more flexible.

For the practical implementation of aRP, the paradox between flexibility and unpredictability should be considered. Since high flexibility can be linked to a certain unpredictability, this might undermine a feeling of control in the given situation. When designing an aRP service, detailed and reliable travel information should be provided as this can restore feelings of control and thus improve customer satisfaction (Dziekan & Kottenhoff, 2007).

The factor time is seen as ambivalent: on the one hand trips might be shorter due to direct routes, yet on the other hand might be longer due to detours. Several studies have shown the relevance of a short waiting and travel for the willingness to use aRP (König & Grippenkoven, 2020; Krueger et al., 2016; Schuß et al., 2021; Stoiber et al., 2019). Another study, however, found that a short walking time is even more important than waiting and travel time (Susilawati & Lim, 2021). Thus, direct routing might to some extent make up for a longer travel time.

Participants of the present study generally see aRP as an environmentally friendly mode of transport. However, people also expressed differentiated views and considered potential backlashes. Better use of vehicle capacity is considered an important element of the sustainability of aRP. While previous studies have also found that aRP is seen as environmentally friendly, environmental advantages were mostly associated with electric driving (Nordhoff et al., 2018; Paddeu et al., 2020). Hence, the present study shows that sustainability is not perceived as one-dimensional but rather as a complex and multi-faceted concept. For the implementation in practice a trade-off might ensue between use of capacity, flexibility, and availability which are also essential for customer satisfaction. To maintain the perceived environmental advantages, the use cases of aRP should be designed accordingly.

Public transport users and car users perceive better availability as an unequivocal advantage of aRP compared to conventional public transport. This is in line with findings from other studies that showed that potential users expect broad availability of aRP services – both in terms of location and time (Etminani-Ghasrodashti et al., 2021; Schuß et al., 2021). Nonetheless, in the present study, car users show some reluctance in using aRP, as the availability of a private car is considered preferable. Similarly, a qualitative study found that some people doubted that the availability of aRP would ever be sufficient to do without a car (Dolins et al., 2021). This implies that sufficient availability and network coverage is a prerequisite for the success of an aRP service.

The most frequently discussed factor of the construct effort expectancy was trip planning, which is perceived a basic requirement for travelling in an aRP as it increases predictability. Accordingly, a qualitative study found that participants wished for an app that combines multiple services to facilitate planning (Etminani-Ghasrodashti et al., 2021). Furthermore, comprehensive information and real-time information was found to be important for potential passengers (Schuß et al., 2021). In the present study, public transport users consider aspects of planning more than car users do. To our knowledge, no previous study in the context of aRP has found such a link. A possible explanation is the context of perceived control: since car driving is linked to feelings of autonomy and control (Beirão & Sarsfield Cabral, 2007; Gardner & Abraham, 2007), external circumstances and dependencies such as traffic jams might not be adequately considered. In contrast, public transport is associated with a lack of control (Beirão & Sarsfield Cabral, 2007) and planning is required to regain control. Perception of control is thus an important psychological aspect that needs to be considered for the design of aRP services, especially for car users. One possibility is to provide sufficient information for planning to re-establish a sense of control (Gardner & Abraham, 2007). Furthermore, communication strategies could target control-relevant aspects of aRP such as foregoing the uncertainty of finding a parking space.

Within the construct of social aspects, socializing is a relevant factor in the present study. Willingness to socialize not only depends on the type of person, but also on the context, mood, or time of day. No differences between public transport users and car users seem to exist in this regard. Both groups anticipate a new social situation in an aRP due to the smaller vehicle that encourages socializing. This goes in line with findings of a field study of an AV shuttle, where passengers stated that the vehicle feels "more intimate" and thus sometimes felt uncomfortable (Nordhoff et al., 2020). Ambivalent attitudes towards socializing were also found in a qualitative study by Nielsen and colleagues (2015): sharing a vehicle can lead to social awkwardness, yet it also presents an opportunity to make new acquaintances. Sanguinetti and colleagues (2019) discuss the influence of the vehicle design when travelling in close proximity to strangers. Interpersonal distance is relevant in this situation and seating design can support either reducing or promoting social interactions. Furthermore, the researchers address potential social benefits of aRP as social interactions might strengthen social networks. Research has shown that even short social interactions with strangers enhance subjective well-being (Sandstrom & Dunn, 2014), yet people underestimate their positive effect (Epley & Schroeder, 2014). Consequently, particular attention should be paid to the interior design. A vehicle design that facilitates socializing might promote higher well-being, however, it should also provide the option to withdraw from social interaction when desired.

With regard to the construct of price value, cost-effectiveness is seen as a motivator for using aRP for both public transport users and car users. Estimated travel costs are often based on current and past experience and are compared to the cost of existing modes. This corresponds to findings from other studies that cost savings are an important motivation to use aRP (Etminani-Ghasrodashti et al., 2021; König & Grippenkoven, 2020; Nielsen et al., 2015), whereby the term 'saving' suggests that an implicit comparison is made. Dolins and colleagues (2021) conducted an in-depth analysis of cost perceptions and found that people were willing to spend more money for more comfort, yet always within the boundaries of a favorable price comparison – be it a taxi or other transport services. In our study, car users often compare travel costs with costs for public transport and seldom consider the total costs of car ownership. Since depreciation and running costs are often not sufficiently factored in, costs for a privately owned car are often underestimated (Andor et al., 2020). Consequently, price psychology should be considered when creating pricing models for aRP services. For example, flat-rate subscriptions are often preferred to pay-per-use models (Lambrecht & Skiera, 2006) and service bundles that combine different transport modes are valued higher than paying for each service individually (Guidon et al., 2020).

To sum up, answering to Research Question 1 the study revealed that potential users associate controversial and ambivalent meanings with using aRP. Ambivalent attitudes also resonate with the response to Research Question 2: The study fell short to identify distinct factors as motivators and barriers. More specifically, and in response to Research Question 3, whether a factor is perceived as a motivator or a barrier to using aRP often depends on a persons' mobility habits, i.e. whether they mainly use cars or public transport in their normal mode choices (Verplanken et al., 1997). Hence, both public transport users and car users evaluate the novel mode of aRP in comparison with their current mode of transportation. As a result, information processing is biased towards the habitual behavior (Verplanken et al., 1997). These established attitudes towards a transport mode might also be projected onto novel transport modes such as aRP.

### 5.2. Further contributions to understanding perceptions of aRP: Paradoxes and the role of habits

As a unique contribution the study at hand uncovered several ambivalent and controversial meanings related to this novel mobility service. These paradoxical perceptions of aRP call for a detailed discussion.

Paradoxes are found, in particular, with respect to performance expectancies that are central to aRP's success. Remarkably, the paradox in all these issues is rooted in the shared nature of the investigated transportation service. Participants reported ambivalent feelings about safety, opposing high trust in autonomous vehicles to initial perceptions of insecurity and higher risks, particularly among car users. Flexibility, a key advantage for public transport users, comes with concerns about time loss due to detours. This leads to a "flexibility paradox": flexible and spontaneous use of the service is considered favorable, yet this advantage is inherently linked to reduced reliability. Furthermore, flexibility is closely linked to aspects of planning and time: to handle a flexible aRP service, one needs to be able to plan their journey and thus requires reliable and detailed information about travel time. Likewise, availability is a critical aspect for the success of aRP and is controversially discussed: while participants recognize better availability as an advantage, car users prefer the availability of their private vehicles. In addition, with no driver or official steward, aRP presents a new social situation, and controversial attitudes exist towards socializing, both between different individuals and within the same person.

The in-depth analysis further reveals that the acceptance of aRP depends on the user's mobility routines and practices. Therefore, another unique contribution of the present study is the detailed exploration of the influence of users' current mobility habits on the perception of aRP. Whether users mainly use public transport, or a private car shapes their expectations with respect to some relevant factors such as sustainability, comfort, and availability. In accordance with their mobility routines, public transport users seem to accept or anticipate characteristics of aRP that are in line with their mobility practices, i.e. fixed lines, predictable schedules, sharing space with other travelers. Similarly, car users react more pronounced to a perceived loss of control, e.g., handing over control to automated driving or having limited flexibility and availability. In addition, motivated to confirm their expectations both car and public transport users seek stereotypical characteristics in characteristics of aRP they are not familiar with. Confirmation bias is likely to play a role, as individuals selectively gather and interpret information in a way that confirms their preexisting views of their own mobility practice and other mobility practices, which they are less familiar with (Innocenti et al., 2013). In line with previous research on travel mode choice (Lanzini & Khan, 2017), also new mobility technologies, such as aRP, are interpreted through existing habits and preferences and reinforcing preconceived beliefs. Eventually, this could result in a preference for the status quo: individuals might not be willing to adopt their mobility practices.

### 5.3. Limitations & future research

Notwithstanding its contributions, the present study also has several limitations. First, the study's results draw on a qualitative approach. While qualitative research has undisputable advantages of discovering and exploring meanings, neither the importance of the discussed determinants nor their causal influence on the acceptance of aRP can be derived from the study at hand. Hence, testing the propositions that can be derived from these exploratory results in a quantitative approach is recommended.

To investigate motivators and barriers of different potential users, the present study categorizes users based on their mobility habits and differentiates between public transport users and car users. However, other aspects of individual travel behavior might also influence the perception of aRP and were not systematically analyzed. Additionally, individual differences in the participants' residential location and the corresponding public transport infrastructure were not investigated since the focus of the present study was the general perception of different aspects of aRP. The study was conducted in Switzerland and the distinct context of its public transport system needs to be considered. Overall, Switzerland has a very good public transport system that is characterized by a dense network, mostly well-coordinated timetables, and high punctuality.

Another limitation is related to the fact that the findings are based on a prospective investigation of participants' perceptions of aRP. Their perceptions are based on an imagined journey in the future instead of real-life experiences. While the applied interview techniques might mitigate certain issues, the use of aRP remains a hypothetical scenario. Hence, the external validity of the results is limited, and it is necessary to continue this research avenue with pilot studies in the field.

## 6. Conclusions

This study offers insights into the factors influencing the acceptance of automated ridepooling (aRP), contributing to the broader understanding of future transportation modes. First, by adapting the UTAUT2 framework to the context of aRP, this study refines the factors influencing acceptance. Second, the study identifies several paradoxes in the acceptance process, such as conflicting views on safety, flexibility, and availability, which must be balanced to ensure a positive user experience. These challenges can be addressed by advances in digitalization and artificial intelligence, which offer the potential to tailor aRP services to user preferences while maintaining predictability in waiting and travel time. Third, systematic differences in the perceptions of aRP are identified, based on individuals' current mobility habits. The study

highlights how mobility routines, as those of individuals currently using a private car or public transport, shape users' expectations, making it clear that overcoming status quo bias is a significant challenge. Furthermore, effective behavior change may be better achieved by altering the decision context instead of solely focusing on changing attitudes. For example, pricing strategies that make private car usage less attractive, or regulations like dedicated carpool lanes, can enhance the appeal of aRP.

In conclusion, this research underscores the value of adopting a user-centered approach and integrating psychological factors into the design of future aRP services. Ensuring that aRP services align with the expectations of different user groups, while also accounting for their mobility habits and preferences, will be essential for acceptance and adoption of autonomous ridepooling.

## Credit authorship contribution statement

**Nora Studer:** Writing – review & editing, Writing – original draft, Investigation. **Dorothea Schaffner:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Nicole Haiderer:** Writing – original draft, Investigation, Formal analysis. **Annalisa Stefanelli:** Investigation, Formal analysis. **Michael A.B. van Eggermond:** Writing – review & editing, Supervision, Conceptualization. **Alexander Erath:** Writing – review & editing, Funding acquisition.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A

Interview guide.
A) Introduction
*Interviewee shortly describes themselves.*

- What is your name and profession?
- How do you usually travel? Which modes of transport do you commonly use?

*Interviewer gives more information about research project.*

- Research project is a collaboration between different universities.
- Topic of interview: autonomous vehicles and ridepooling, focus is on user needs.

*Description of the relevant concepts along the following keywords. The pictures were shown on a PowerPoint slide.*
Ridepooling.

- Ridepooling is a form of public transport without a timetable.
- Passengers are transported in minibuses according to demand.
- Departure point, departure time, and routes are flexible and planned in real-time depending on customer demand.
- Different than conventional on-demand buses, the whole journey is planned via app.

Have you ever used ridepooling?
Autonomous vehicles.

- An autonomous vehicle drives without a driver or any external controls.
- Sensors such as laser scanners, radars and cameras combine and process all the data in such a way that the vehicle can move safely in traffic.
- Autonomous vehicles are currently mainly intended for taxi or ridepooling services.

Have you had any experience with autonomous vehicles?
B) Narrative storytelling: ridepooling in autonomous vehicles.
Imagine that you are travelling via ridepooling in an autonomous vehicle. I am interested in how that fictitious journey looks like. Please describe it from the beginning of planning until the end of the journey.
Please also think about what kind of journey you would undertake with autonomous ridepooling, e.g. leisure time, work, shopping, long-distance travel.
*General questions*.
Why would you use ridepooling in autonomous vehicles? Under what conditions?
Why would you not use it?
*Follow-up questions (only ask if person does not mention the subject themselves)*.

- Autonomous ridepooling heavily relies on technology – how is that for you?
- One aspect of autonomous ridepooling is that you don't know the other passengers – how do you feel about this?

- Autonomous ridepooling offers the opportunity to get to know other people and socialize – how do you feel about this?
- How do you imagine it in terms of price? What are you willing to pay?
- How would your friends and family react if you used autonomous ridepooling?
- How flexible do you imagine the service to be?
- How does autonomous ridepooling affect the planning / organization of your journey?
- How does autonomous ridepooling affect your travel time?
- How can autonomous ridepooling contribute to sustainability? How is this relevant for you?
- Would you enjoy autonomous ridepooling?

C) Reaction to videos (third-person technique).
*This part of the interview was not used for the analysis in this paper.*
D) Closing the interview.

- Thanks for your participation
- Incentive

## Appendix B

Systematic Coding Scheme

| Construct | Psychological factors | Motivators and barriers | |
|---|---|---|---|
| Performance expectancy | Safety | Motivators | Less susceptible to human errorsTrust in technical functionalitiesTrust in safety standardsTrust with increasing familiarityInformation about safety standardsPresence of other passengersPresence of steward during initial drives |
| | | Neutral | New and unfamiliar at the beginningOpen questions about how the vehicle works |
| | | Barriers | Feelings of insecurity and uneasinessSkeptical about technical functionalitiesFear of accidentsNot possible to intervene when automated driving failsFear of technical issuesGeneral fear of AV'sin case of an accident |
| | Comfort of the vehicle | Motivators | Spatial design of vehicle, e.g., standing places or luggage spaceInterior design of vehicle, e.g., comfort of seatsAccess for elderly or disabled peopleServices in vehicle, e.g., phone charging or snack machineCleanliness |
| | | Neutral | Standing places and seatsIdentification of vehicleComfort depends on length of journey |
| | | Barriers | Spatial design, e.g., small vehicle or standing placesBad air qualityPoor vehicle performance |
| | Time | Motivators | Shorter travel time due to direct journeyShorter waiting timesTime savings as current public transport connections are not goodFlexibility in travel time is rewarded with cost savingsIndication of maximum travel timeSimilarly fast as public transport |
| | | Neutral | Slightly longer travel time is ok |
| | | Barriers | Longer journey due to detoursTravel / waiting time difficult to estimateOccasional delays due to technical issuesNo time savings compared with current public transportSlow speed of aRP vehicleFixed departure times are stressful |
| | Environmental considerations | Motivators | Higher use of vehicle capacityAlternative propulsion technologiesReduction of car ownershipReduction of traffic volumeSmart routingSustainable (general) |
| | | Neutral | Sustainability is not an important argument |
| | | Barriers | Conventional public transport is more sustainableIncrease in traffic volumeUse of vehicles with combustion enginesNegative effects of electric vehicles, e.g., batteryInsufficient use of capacity |
| | Reliability | Motivators | That the vehicle reliably adheres to the schedule.Transparent information about the timeframe for when the vehicle will arrive or when one will be picked up is desired. |
| | | Neutral | |
| | | Barriers | RP is perceived as unreliable when punctuality is crucial at the destination, for example, for appointments, work, connections (public transport), or when it's important to adhere to a strict schedule.One needs to gather experiences with RP first to see if it's truly punctual.Punctuality depends on the availability of vehicles. This availability is difficult to plan in advance.Punctuality is better with a car than with aRP. |
| | Flexibility | Motivators | Door-to-door travelDirect trips without any transfersWell-defined, easily accessible stopsSpontaneous useFewer stops / detoursBooking in advanceRegular scheduleCombination with public transportExclusive booking for a group for direct trips |
| | | Neutral | Short walk to vehicle / destination is acceptable |
| | | Barriers | Detours due to pick-up / drop-off of passengersMore flexibility with private carNo short-term booking or changing of journeyLong distance to destination |
| | Availability | Motivators | Service for off-peak hoursService for areas with insufficient public transport networkService for urban areasSufficient vehiclesAddition to public transportExtensive network to enable direct tripsAppropriate vehicles, e.g., for transport of luggageWeather-dependent service, e.g., snowReplacement for public transport |
| | | Neutral | |
| | | Barriers | Insufficient number of vehiclesService not suitable for urban areasPrivate car is always availableService is not immediately available |
| | Privacy | Motivators | Good data protection (e.g., no sharing with third parties). |
| | | Neutral | |
| | | Barriers | Negative feelings regarding data privacy (in general).Unwillingness to disclose personal data. |
| | Trip purpose | Motivators | Leisure trips (going out, excursions).Work.Locations poorly accessible by public transport.Shopping.Trips within the city. |
| | | Neutral | |
| | | Barriers | No spontaneous usage. |
| | Parking Space | Motivators | No parking necessary (no need for parking space search and costs). |
| | | Neutral | |
| | | Barriers | The aRP vehicle has difficulty finding a parking space (due to its large size). |
| | Activity during journey | Motivators | |

(*continued on next page*)

(*continued*)

| Construct | Psychological factors | Motivators and barriers | |
|---|---|---|---|
| Performance expectancy | Safety | Motivators | Less susceptible to human errorsTrust in technical functionalitiesTrust in safety standardsTrust with increasing familiarityInformation about safety standardsPresence of other passengersPresence of steward during initial drives |
| | | Neutral | |
| | | Barriers | |
| Effort expectancy | Interaction with vehicle | Motivators | Automatic recognition by the vehicle.Direct communication with the vehicle (spontaneous exit, signal upon arrival, etc.).Communication with the vehicle via app (boarding, payment, trip changes, etc.).Vehicle greeting. |
| | | Neutral | |
| | | Barriers | |
| | Information on the app | Motivators | Information on vehicle availability.Pick-up and arrival time information.Travel duration and route details.Information on other passengers (e.g., number of co-travelers).Details about the vehicle (e.g., amenities); selection of a specific vehicle.Environmentally relevant information (saved CO2, energy consumption).Connections with public transport. |
| | | Neutral | |
| | | Barriers | |
| | Perceived control | Motivators | |
| | | Neutral | |
| | | Barriers | Difficulty in relinquishing control. |
| | Planning | Motivators | Planning via app / onlinePossibility of short-term planningPossibility of planning aheadEasy planningGroup travelReal-time data of vehiclesMultimodal journeysBooking of extras, e.g., luggage |
| | | Neutral | |
| | | Barriers | Uncertainty in planningPrivate care requires less planning |
| | Payment | Motivators | Monthly/yearly pass/subscription.Payment via credit card/app.Usage possible without membership, subscription, etc. |
| | | Neutral | |
| | | Barriers | |
| | Liability | Motivators | The offer should include insurance coverage for breakdowns/accidents. |
| | | Neutral | |
| | | Barriers | Uncertainty about who will handle the vehicle in the event of a breakdown (oneself or roadside assistance) / unclear responsibility.In the event of a breakdown, one must wait (at the roadside) for roadside assistance.One cannot intervene personally in case of breakdowns. |
| Social influence | Norm | Motivators | Openness / positive feedback from the private environment.Social circle would be surprised. |
| | | Neutral | |
| | | Barriers | Distrust towards technology in the private environment.Negative feedback from colleagues; preferring to drive to work with a private car (status).Distrust towards aRP in the family environment (especially among those who primarily drive their own cars). |
| Social aspects | Security | Motivators | Presence of other individuals poses no security concerns.Trips exclusively for female passengers. |
| | | Neutral | |
| | | Barriers | Absence of driver or security personnelFear in case of no camera surveillanceFeelings of insecurity at night |
| | Comfort / discomfort social situation | Motivators | The presence of other passengers is not a problem.There's hardly any difference from public transport, so it's not an issue since one is familiar with it.The interior design affects comfort; sufficient private space.The presence of other people is an advantage. |
| | | Neutral | |
| | | Barriers | Discomfort when in close quarters with other (strange) people.Being alone while traveling is an advantage.Unpleasant when there are too many people, and one has to stand.Seating arrangements can make the journey uncomfortable. |
| | Socializing | Motivators | Open to socializingPossibility to make new acquaintancesUsing aRP as a common featureSmall vehicle is better for socializingGrowing familiarity when regularly meeting same passengersDifferently themed vehicles |
| | | Neutral | Social interaction similar to public transportDepending on personality type(Non-verbal) communication about willingness to socializeDifferent social space |
| | | Barriers | No need for socializingNo need for socializing depending on contextAwkward social situation in small vehicle |
| Price value | Travel cost | Motivators | Generally cheapSimilarly priced to public transportCheaper than a private carSlightly more expensive than public transportCheaper than a taxiEqual pricing for everyoneNo extra costs for luggageTest offers without subscription |
| | | Neutral | Flexible pricingPrice is not the main factor |
| | | Barriers | High costsMore expensive than public transport |
| Facilitating conditions | Skills | Motivators | |
| | | Neutral | |
| | | Barriers | Technical competencies. |
| | Convenience | Motivators | |
| | | Neutral | |
| | | Barriers | Technical competencies. |
| Hedonic motivation | Hedonic motivation | Motivators | aRP is enjoyable.aRP is relaxing.Entertainment during the trip (e.g., information about the area). |
| | | Neutral | |
| | | Barriers | Initially unfamiliar.Driving is enjoyable.aRP always drives correctly, no strong acceleration, no racing mode. |
| Mediating factors | Age | Motivators | aRP is beneficial for older people: the distance to the vehicle is shorter; especially if they can no longer drive.Younger individuals are more open to new technology and would be more likely to use it.Younger people are more price-sensitive and would therefore be more inclined to use aRP. |
| | | Neutral | |
| | | Barriers | Technology is a challenge for older individuals.Elderly people are more traditional and would prefer to use private cars. |
| Remaining factors | Vandalism | Motivators | |
| | | Neutral | |
| | | Barriers | Risk of vandalism. |

(*continued on next page*)

(*continued*)

| | | | |
|---|---|---|---|
| Construct<br>Performance expectancy | Psychological factors<br>Safety | Motivators and barriers<br>Motivators | Less susceptible to human errorsTrust in technical functionalitiesTrust in safety standardsTrust with increasing familiarityInformation about safety standardsPresence of other passengersPresence of steward during initial drives |
| | Jobs | Motivators<br>Neutral<br>Barriers | Concern about the loss of jobs. |

## Data availability

The data that has been used is confidential.

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