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Sharing vehicles or sharing rides - Psychological factors influencing the acceptance of carsharing and ridepooling in Germany

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ABSTRACT

Shared mobility has the potential to reduce private car use and can thereby contribute to a mobility transition which reduces energy demand and greenhouse gas emissions. At the same time, shared mobility services still have a niche existence - even in major cities. If the goal is to establish shared mobility as a significant part of the mobility system, a key question is which factors determine the acceptance of individual services. Can perceived innovation-specific factors that can be more directly influenced by policies explain differences in attitudes and acceptance or does the explanatory power lie with psychological dispositions that are more difficult to change by policies? Do these factors apply in general or differ between different sharing services? We investigate these questions based on a survey study in major German cities to analyse the acceptance of two car-based shared mobility services, carsharing and ridepooling, in society (N = 1,531). The data analysis based on two path models shows that perceived compatibility with daily life is the most important factor related to the acceptance of carsharing and ridepooling. Perceived ease of use positively affects the general attitude towards both services. We conclude that our findings offer potential intervention routes for policies that increase the acceptance of shared mobility. The prerequisites for the services to contribute to a reduction in energy consumption in the transport sector are also discussed.

1. Introduction

Switching to low- or zero-emission vehicles, such as electric vehicles, is not enough to reduce energy demand in transport and to achieve a mobility transition. Especially in cities, cars use up a lot of space and cause problems regarding air quality, safety, and noise. The number of cars and the use of cars therefore needs to be reduced and a modal shift to more efficient modes of transport is necessary to achieve a sustainable mobility transition (SRU, 2017).

Shared mobility can help to reduce the number of private cars in cities and thus contribute to energy savings in the transport sector and therefore to the success of the energy transition. In addition, in (carsharing) fleets the transition to electric mobility can be achieved more quickly than in the private sector (Yi and Yan, 2020).

The term 'shared mobility' refers to transportation modes that can be shared on an as-needed basis, such as carsharing, sharing rides (drivers giving other people a lift), bikesharing or e-scooter-sharing (Shaheen, Cohen, Chan and Bansal, 2020).

The shift from owning to sharing a mode of transport requires the user to change habits that play a major role in mobility behaviour. For this reason, it is important to analyse the factors that influence acceptance of shared mobility, i.e. the intention to use these services as well as the actual use. In this paper, we focus on two car-based sharing concepts, carsharing as a more established service and ridepooling as a fairly new service, and analyse (socio-)psychological factors influencing the acceptance of both services in Germany.

Carsharing and ridepooling show similarities as well as differences. Carsharing means the temporary use of a car on a demand basis. Ridepooling is the collective transport of several, unrelated persons according to their respective travel wishes. Both carsharing and ridepooling are car-based mobility services and both services can take the place of a car, i.e. both services can lead to decreased car ownership. Carsharing, however, is the individual use of a means of transport, while ridepooling is the collective use. That is, ridepooling is more similar to taxi drives or the use of public transport (Rube et al., 2020). This also means that the environmental effect of ridepooling depends, among other things, on the pooling rate (Knie et al., 2020), while the environmental impacts of carsharing - especially station-based carsharing - are predominantly

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positive (Münzel et al., 2018). Whereas carsharing has been available in many German cities for several years and is a widely known service, ridepooling in its 'new', digitalized form[1] is a fairly new service and so far only available in major cities in Germany. Ridepooling can serve as a supplement to public transport and can promote multimodal travel behaviour (Kostorz et al., 2021). Nevertheless, both carsharing and ridepooling still occupy niches in the transport system as a whole and policies are needed to integrate these systems into the transport system and to make their use attractive. This means that in order for these services to contribute to a reduction in energy consumption in the transport sector, their widespread use must be promoted and it must be ensured that the services do not replace the use of environmentally friendly means of transport, such as public transport, cycling or walking, but complement them in a meaningful way.

As some features of the services are the same and some features are different, a comparison can show whether factors for the acceptance of both services and policy recommendations can be approached jointly or should be considered separately in the future.

For the further diffusion of shared mobility services, user acceptance is crucial. We therefore investigate the following research questions: Which (socio-)psychological factors influence the acceptance, i.e. the intention to use and the actual use, of carsharing and ridepooling? How do these (socio-)psychological factors differ between the two services? Under (socio-)psychological factors we include innovation-specific factors and psychological dispositions. The research questions are examined on the basis of a representative survey carried out in major German cities. Perceived attributes and acceptance of carsharing and ridepooling are surveyed separately in two service-specific subsamples. Two path models are hypothesized and tested, one for each service. In the models, general attitudes towards the environment and towards routines as well as individually perceived attributes of the innovations according to Rogers' model of the Diffusion of Innovations (DoI) (Rogers, 1983) represent the independent variables. The acceptance of carsharing and ridepooling - operationalized as intention to use and actual use - are determined as the dependent variable. For the theoretical framework, we combine the DoI model with acceptance theories and thus contribute to the theory in this field. By including the perceived attributes of innovations it is possible to derive policy recommendations, because these attributes are assumed to be more easily influenced by policies (e.g. providing infrastructures or regulatory approaches) than general attitudes towards the environment and towards routines. This makes it possible to extend the more psychological approach of our paper (i.e. a focus on agency) with aspects that concern the structure (e.g. infrastructure, mobility culture, built environment, institutions).

This paper starts with a background section on the acceptance of carsharing and ridepooling, in which, after some general information on both services, the theoretical framework and the state of research are presented. Based on this, we develop hypotheses and the study model for the analysis. Section 3 presents the data and the methods of this paper. The results section contains the descriptive statistics as well as the path models and hypothesis testing. At the end of this paper, we discuss the results, draw conclusions and identify policy implications.

2. Background: acceptance of shared mobility

This section establishes the background of our study in four steps. Firstly, we introduce the two shared mobility services of carsharing and ridepooling. Secondly, we present established theories of technology acceptance and adoption and explain our focus on (socio-)psychological variables. Thirdly, we synthesize the empirical literature that has begun to examine how psychological factors influence the acceptance of shared mobility to narrow down possible variables from the theories. Fourthly, we develop the hypotheses and the study model for our analysis.

2.1. Carsharing and ridepooling in Germany

Carsharing means the temporary use of a car on a demand basis as an alternative to private car ownership (Münzel et al., 2018). A basic distinction can be made between business-to-consumer (B2C), peer-to-peer (P2P), also known as consumer-to-consumer (C2C), and cooperative carsharing. In B2C a company lends cars to customers - this paper refers exclusively to this form of carsharing. Here, a distinction can be made between station-based and free-floating carsharing. In station-based carsharing, the car can be borrowed and returned at various carsharing stations operated by the provider. With free-floating carsharing, the car can be picked up within a defined area - usually the extended city limits - at a location that can be found using an app, and can be parked again at any desired location (Münzel et al., 2018). In this paper, we understand carsharing as both station-based and free-floating.

Carsharing has the potential to meet individual transport needs in a sustainable and socially beneficial way through the following effects: reduction in car ownership due to members relinquishing their cars or avoiding purchasing one in the first place (Rabbitt and Ghosh, 2016), reduction of vehicle-kilometres travelled after joining a carsharing organisation (Nijland and van Meerkerk, 2017), decreasing emissions due to smaller and cleaner cars in carsharing fleets, reduction in traffic and parking congestion, and increasing social cohesion between carsharing customers (Münzel et al., 2018). The risk that carsharing is used as often as a private car, thus diminishing the positive environmental effects, often does not exist for cost reasons (Schuster et al., 2005). The potential for a reduction in car ownership and car use is smaller for free-floating systems (Firnkorn and Müller, 2011). In terms of car ownership, however, the literature also shows that not all car owners can forego car ownership and that carsharing can take the place of a second or third car (Ferrero et al., 2018). In addition, carsharing services might increase car demand in the future as these services can introduce users to new vehicle technology (Shaheen, Martin and Totte, 2020; Zoepf and Keith, 2016). This shows the importance of policies to integrate shared mobility systems into existing transport systems and to exploit the potential to reduce energy demand in these systems. In addition, restrictive measures designed to reduce the use of private cars can also help to make sharing services more attractive.

From a user perspective, in contrast to a private car, the use of carsharing requires advance route planning. At the same time, users can choose from a variety of models and select the one that best suits the purpose of their journey. In addition, users do not have to deal with maintenance and servicing.

As at January 2021, there are 2,874,400 registered drivers in carsharing organisations in Germany (station-based 724,000; free-floating 2,150,300) who have access to 26,220 carsharing vehicles. Between 2020 and 2021, there was a 25.5% growth in the number of users. 855 German cities and municipalities offer carsharing services (Bundesverband CarSharing e.V., 2021). In terms of the proportion of the total population, 5% of all German households have at least one person who is a customer of a carsharing organisation; in metropolitan areas, this rate is 14% (Nobis and Kuhnimhof, 2018). The measures introduced to contain the Covid-19 pandemic have led to sometimes considerable declines in bookings and turnover for carsharing providers. However, in 2020, providers managed to largely maintain their services - partially supported by public funding. In major cities, free-floating carsharing became more attractive in 2020: some public transport customers might have switched to carsharing services due to the Covid-19 pandemic (Bundesverband CarSharing e.V., 2021).

Ridepooling is a commercial transport service for the purpose of collective transport of several unrelated persons according to their respective travel wishes. Customers can influence the pick-up location, destination and time frame of the trip, but not the route (Rube et al., 2020). Ridepooling services are typically booked through a mobile

[1] Especially in rural areas and in countries of the global South, early forms of ridepooling have existed for decades (Kostorz et al., 2021).

application, which enables coordination between the driver and the multiple customers and routes. The legal framework for these services varies between countries and, within Germany, also to some extent between municipalities. We therefore refer to German sources for the definition of this service. Ridepooling as collective transport is offered in Germany with consideration for public transport interests and within the framework of the Passenger Transport Act (PBefG) both as an independent service and as part of public transport (Rube et al., 2020). Despite this legal integration into public transport and a number of similarities resulting from the shared occupation of a vehicle, the greater flexibilities on the customer side make ridepooling a distinct service. On-demand ridepooling can be suitable for supplementing the often more centrally organised or starlike public transport with tangential and night services (Kostorz et al., 2021). As these are always on-demand services, public transport infrastructure does not have to be provided everywhere and all the time.

In international literature, ridepooling is considered a type of 'microtransit' (Shaheen, Cohen, et al., 2020) and a variety of terms exist as synonyms or descriptions of related and overlapping concepts. Non-commercial systems are called ridesharing and are not in the focus of this paper. Rideselling (also known as ridehailing) is the private (commercial) provision of taxi-like rides in a motor vehicle.[2] In this paper, we focus on the commercial pooled service introduced above, i.e. ridepooling.

The socio-political discussion about the benefits of ridepooling, in contrast to carsharing, is much more heterogeneous and critical. Firstly, it is often difficult to distinguish ridepooling from non-pooled rideselling in the discussion. Secondly, ridepooling is by definition compared to and thus competes with taxis and public transport. Moreover, these services are still new and the market and the services themselves are developing dynamically. Public familiarity with this service is also still low (Lavieri and Bhat, 2019).

In terms of the environmental impact of ridepooling, the pooling rate is key. Pooled services increase vehicle occupancy in regions with a predominance of drive-alone trips, which results in a reduction in vehicle miles travelled (Lavieri and Bhat, 2019). In their survey of CleverShuttle customers, Knie et al. (2020) investigated the pooling rate for ridepooling in four German cities and found that around 50%–40% of trips involve additional passengers. At night, the pooling share rises to up to 65%. To determine the environmental impacts it is also important to analyse which means of transport ridepooling replaces. CleverShuttle is mainly used at times of the day (evenings and nights) when bus or train journeys involve long waiting times or many transfers. This was also found in a large survey of MOIA users in Hamburg (Kostorz et al., 2021). This means that public transport or taxi journeys are replaced, with different environmental effects depending on the pooling rate.

The MOIA users indicated reasons for using ridepooling instead of a private car; the most often stated reason was convenience, e.g. driving is not possible, the car is not available, parking space is scarce, bad weather conditions or public transit is not available (Kostorz et al., 2021). In the future, around 45% of respondents with a car in their household could imagine CleverShuttle replacing it (Knie et al., 2020). However, according to Coulombel et al. (2019) ridesharing can increase the perceived attractiveness of the car from the users' perspective and thus diminish the positive environmental impacts of ridesharing, which is defined as the rebound effect. Ridesharing is broadly defined here and includes all forms of sharing rides.

However, despite these somewhat mixed and not yet fully researched effects, ridepooling services that have a high pooling rate do essentially have the potential to reduce energy consumption in the transport sector. This makes ridepooling an interesting topic for energy policies.

Ridepooling or microtransit has existed in Germany for about six years: CleverShuttle launched its 'RidePooling' service in Munich in February 2016 (CleverShuttle, 2021). Other examples of ridepooling or microtransit services in Germany are BerlKönig (cooperation between ViaVan and Berliner Verkehrsbetriebe) and MOIA (subsidiary of VW). As in the case of BerlKönig, some services are a cooperation between sharing providers and public transport companies. No current user figures or Germany-wide vehicle numbers are available for ridepooling (Göddeke, 2020).

2.2. Theories of technology acceptance and adoption

Theories of technology acceptance have been widely applied to study consumers' willingness to adopt (technological) innovations. Acceptance of a new technology has been defined as "behavior that enables or promotes (support) the use of a technology, rather than inhibits or demotes (resistance) the use of it" (Huijts et al., 2012). We supplement this definition with that of Upham et al. (2015) to also take into account the usage intention; i.e. we do not differentiate between usage intention and actual usage and summarize both concepts under the term acceptance.

Applied to the areas of interest in this paper, this includes intending to subscribe or subscribing to carsharing and ridepooling and using it. Widespread theoretical models of acceptance are based on social psychology and include the theory of reasoned action (TRA) by Ajzen and Fishbein (1980), the (decomposed) theory of planned behaviour (TPB) (Ajzen, 1991; Taylor and Todd, 1995), and the Technology Acceptance Model (TAM) by Davis (1993). TPB is an extension of TRA and assumes that attitude, subjective norms and perceived behavioural control influence behavioural intention, which in turn influences actual behaviour. The TAM includes perceived usefulness and perceived ease of use as influencing factors on the attitude and behavioural intention.

We base our theoretical framework on the central hierarchical structure and the dependent variables proposed by these models: the perceived characteristics of an innovation influence the general attitude towards the innovation and this in turn influences the intended and actual use of the technology.

This study integrates Rogers' model of the Diffusion of Innovations (DoI) into this theoretical basis of acceptance studies (Rogers, 1983). The DoI model represents a well-established framework in the field of technology acceptance. It outlines the process and determinants of individual adoption decisions related to a specific innovation. The decision to adopt or reject an innovation is influenced by the individually perceived attributes of the innovation: (1) the relative advantages (RA) (and disadvantages) of an innovation compared to conventional alternatives on the market, (2) the compatibility with the adopter's values, experiences and needs, (3) the complexity, i.e. difficulty of understanding and using the innovation (this is similar to the concept of perceived ease of use put forward by TAM), (4) the trialability, i.e. the possibility of testing the innovation before the decision to adopt and (5) the observability or visibility of an innovation and its consequences. Rogers also differentiates between five groups of individuals, who adopt innovations at different points in time - so-called adopter groups (Rogers, 1983). After the smallest group of the innovators, early adopters follow, jointly making up around 16% of the potential adopters. They are followed by the early majority and late majority, at around a third of all potential adopters each. The remaining adopters are then conceptualized as laggards. Considering the low distribution of both studied sharing services in Germany, current users of carsharing and ridesharing are expected to fall within the groups of innovators and

[2] In ridesharing services, free spaces in private cars are made available to third parties via a generally internet-based platform. Passengers are transported in private vehicles for a small fee Rube et al. (2020). Rideselling is digitally mediated, paid and demand-oriented transportation. Trips are only carried out when there is demand based on a trip request. This is usually done via internet-based platforms, i.e. apps. The passenger determines whether a one-way trip is undertaken and what the destination is. In Germany, these direct ride services are currently not legally permissible, due to competition with taxis and to a return obligation based on rental car services in accordance with the PBefG (Rube et al., 2020).

early adopters, with a potential development in the direction of an early majority.

2.3. (Socio-)Psychological and innovation-specific factors related to the acceptance of carsharing and ridepooling

In this section, we provide an overview of the theories used in empirical literature on factors influencing the acceptance of shared mobility to date, starting with carsharing and then looking at the literature on ridepooling. This overview yields a list of potentially influential variables to be included in the study model. A more detailed review of the results for each variable in the following section 2.4 then narrows down the list of variables, from which we derive a list of hypotheses and our study model.

The relationship between socio-demographic variables, mobility-related characteristics (such as transport-related behaviour or availability of means of transport) and the acceptance of carsharing has been studied frequently (see e.g. Becker et al., 2017; Bulteau et al., 2019; Ko et al., 2017; Münzel et al., 2019; Wittwer and Hubrich, 2018). Since these factors are not central to our research interest, this literature review focuses on (socio-)psychological factors, i.e. perceived usage-related attributes and underlying (socio-)psychological variables in connection with the attitudes towards and acceptance of carsharing.

Only a few studies use psychological factors to explain individual interest in carsharing. A previous study by one of the authors uses constructs from Roger's DoI to explain the acceptance of carsharing but does not include further psychological variables that have been shown to influence acceptance of sustainable mobility innovations, such as environmental identity (Burghard and Dütschke, 2019).

Other studies have examined the relevance of environmental awareness to the acceptance of (electric) carsharing without addressing innovation-specific attributes. Dependent variables range from attitudes (Clewlow, 2016; Rotaris and Danielis, 2018) to interest and adoption (Becker et al., 2017; Efthymiou and Antoniou, 2016; Jin et al., 2020) and the decision to use carsharing (Hartl et al., 2018).

Interest in new things and psychological ownership have been studied as further potentially relevant factors for the acceptance of carsharing, concepts not addressed in theories of technology acceptance and adoption or in the DoI. Interest in new things shows a positive influence (Becker et al., 2017); psychological ownership, i.e. the extent to which it is important to individuals to be the owner of a car, a negative influence (Paundra et al., 2017).

Jo et al. (2018) analysed the influence of perceived functional and economic benefits as well as trust on the intention to use carsharing. Perceived benefits are similar to the concept of relative advantages in the DoI and the perceived social benefit, i.e. expected perceptions by others, resembles the concept of subjective norm in the Theory of Reasoned Action (TRA) and Theory of Planned Behaviour (TPB). However, no reference is made to the corresponding acceptance and adoption theories.

As is the case with carsharing, only few studies on ridepooling use psychological factors as explanations for individuals' interest in the service. More often the focus is on socio-demographic or mobility-related variables, on specific positive or negative objective characteristics of the ridepooling in question, or on the use experience, including factors such as privacy, trust, and security (Alonso-González et al., 2020; Aw et al., 2019; Du et al., 2020; Gilibert, 2019; Goodspeed et al., 2019; Lee et al., 2018; Nielsen et al., 2015; Vaclavik, Macke, & Faturi e Silva, 2020; Zhang and Zhang, 2018). Within the dimensions of trust and security, prejudice towards other individuals has also been a topic of study, building a bridge towards more psychological approaches (Moody et al., 2019; Sarriera et al., 2017).

Amongst the studies looking at psychological variables, two fall within the realm of acceptance and the Diffusion of Innovations. Cheah, Shimul, Liang, and Phau (2020) base their study on the TPB by Ajzen (1991) and on the Technology Acceptance Model (TAM) by Davis (1993) and examine the attitudes towards UberX in Australia and New Zealand. The authors find that the perceived usefulness of UberX in the surveyed population is positively related to the attitudes towards this service innovation. For the perceived ease of use they do not find a significant positive relationship. Min, So, and Jeong (2019) survey Uber users in the US and combine the Diffusion of Innovations Theory (DoI) with the TAM. They find that all measured DoI factors of the study, namely relative advantage, compatibility, complexity, observability, and social influence, are significantly and positively related to the variables of perceived usefulness and perceived ease of use (Min et al., 2019). Neither study bridges the gap between perceived usefulness, ease of use or attitudes and the actual acceptance of the service by individuals.

Two studies on ridepooling include variables related to the environment and come to different conclusions. Alemi, Circella, Handy, and Mokhtarian (2018) find a positive effect between agreement with pro-environmental policies and the rate of adoption for Uber usage among millennials (adults born between 1981 and 1997) and Generation X (adults born between 1965 and 1980) in California. Amirkiaee and Evengelopoulus (2018), on the other hand, measure sustainability concerns and find no direct effect on attitudes in their study population of undergraduate students in Texas, USA. The former study does not address attitudes and the latter does not address adoption, and no connection is made with variables of the DoI.

As is the case with carsharing, interest in new things has been found to positively correlate with adoption of the service. The study by Alemi et al. (2018) confirms this finding for the variable of technology embracing, that is the degree of familiarity with modern technologies, leading to a higher likelihood of adopting ridepooling but not relating this result to the DoI.

In sum, similar psychological concepts have been analysed that seem to be relevant to both the acceptance of carsharing and ridepooling. Studies, both on the acceptance of carsharing and ridepooling, apply the DoI Theory, the TPB or the TAM to explain acceptance, i.e. focus on the perception of innovation-specific aspects. Other studies have examined the relevance of psychological factors such as environmental identity or psychological ownership. However, to the best of our knowledge, there is no study available that integrates innovation-specific factors with psychological dispositions. In addition, few studies look at both attitudes and behavioural intentions, as well as actual behaviour toward a particular innovation.

2.4. Hypotheses and study model

The previous section reviewed literature on carsharing and ridepooling to determine which (psychological) variables have been studied in relation to one another so far. It shows that each of the studies addresses a part of our theoretical approach but that no integrated analysis has yet been conducted. This section looks at the empirical findings of the studies introduced in section 2.3 in more detail to arrive at a narrowed-down and supplemented list of potential influences on the acceptance of carsharing and ridepooling. This means that only variables from the TPB, TAM, or DoI that have been shown to be relevant to the acceptance of sharing services remained in the analysis. We consider this adjustment from a full list of variables necessary due to the multitude of integrated concepts, which would otherwise lead to an overcrowded model which is already quite extensive. For each variable, the section arrives at hypotheses which make up the final study model.

A number of pre-researched concepts can be derived from the literature reviews on carsharing and ridepooling, despite the overall limited attention to psychological factors in the literature on both services. Even though carsharing and ridepooling exhibit many differences, similar concepts proved to be relevant for either attitudes towards or usage of both services in previous studies. Overall, we therefore consider the same basic study model for carsharing and ridepooling (Fig. 1). This also allows a comparison of the variable effects between the two services and

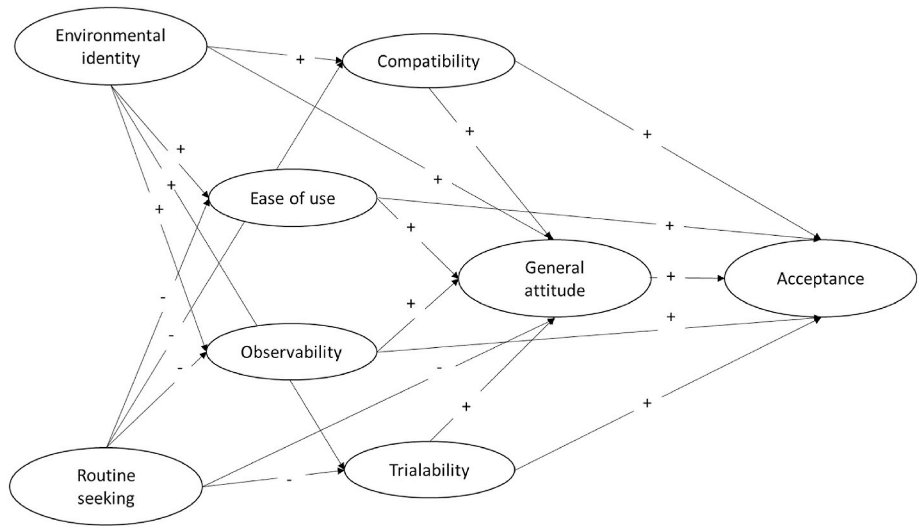

Fig. 1. Conceptual model (i.e. initial model) including hypotheses.

can thereby make it easier to identify differences.

Below, the section outlines 19 hypotheses, which make up the final study model based on a more detailed review of the literature and sorted list of variables.

The literature reviews show that variables related to the environment have been researched in many different configurations both between and within the two services. Positive as well as no effects have been found for operationalizations along the lines of environmental attitudes, environmental consciousness, and environmental and sustainability concerns, or for the extent to which environmental policies are supported (Alemi et al., 2018; Amirkiaee and Evengelopoulus, 2018; Becker et al., 2017; Clewlow, 2016; Efthymiou and Antoniou, 2016; Hartl et al., 2018; Jin et al., 2020). To clarify the importance of environmental consciousness for our representative sample of German urban dwellers, we include a measure of environmental identity in the models of both services based on the construct of Whitmarsh and O'Neill (2010). We expect a greater identification with environmental concerns to positively affect the compatibility of the service with a person's everyday life. We also expect the perceived ease of use of a service to be greater for respondents with higher environmental identity scores based on their personal motivation to find an alternative to less environmentally friendly individual car usage. Finally, we expect such respondents to perceive a greater observability and trialability of the services as a higher environmental identity can be related to an increased perception of environmentally friendly transport options in the respondent's vicinity as well as a like-minded peer group with access to and/or experience of such services. Overall, as in many of the studies presented (Alemi et al., 2018; Clewlow, 2016; Rotaris and Danielis, 2018), we finally expect environmental identity to positively correlate with the attitude towards the services.

H1. Environmental identity positively affects perceived compatibility (of carsharing / ridepooling)

H2. Environmental identity positively affects perceived ease of use (of carsharing / ridepooling)

H3. Environmental identity positively affects perceived observability (of carsharing / ridepooling)

H4. Environmental identity positively affects perceived trialability (of carsharing / ridepooling)

H5. Environmental identity positively affects the general attitude (towards carsharing / ridepooling)

An interest in new things or new technologies has been shown to positively affect the affinity for both sharing services in the previous literature (Alemi et al., 2018; Becker et al., 2017). We intend to test this relationship again in our study models and operationalize the variable through the inverted concept of *routine seeking* (Oreg, 2003). We differ slightly from the variables in the literature since we believe that the usage of sharing services includes a new set of behaviours and routines that goes beyond the degree of comfort that individuals have with technologies. We expect respondents with a generally greater need for stability and routines in their lives to initially consider it more difficult to perceive or seek out opportunities to try the services and to integrate them into their everyday lives. We therefore expect higher scores on the variable of routine seeking to negatively affect perceived compatibility, ease of use, observability and trialability. Finally, we also expect that individuals with higher routine seeking scores will have a more negative attitude towards carsharing and ridepooling. This hesitance is not expected to persist as individuals integrate the usage of the services into their everyday lives but to be an important factor for the initial acceptance of carsharing and ridepooling, which needs to be overcome. This leads us to the following hypotheses for our two study models:

H6. Routine seeking negatively affects perceived compatibility (of carsharing / ridepooling)

H7. Routine seeking negatively affects perceived ease of use (of carsharing / ridepooling)

H8. Routine seeking negatively affects perceived observability (of carsharing / ridepooling)

H9. Routine seeking negatively affects perceived trialability (of carsharing / ridepooling)

H10. Routine seeking negatively affects the general attitude (towards carsharing / ridepooling)

For all variables based on Roger's Diffusion of Innovations Theory, a positive effect on the general attitude towards and acceptance of the services is expected. In the study by Burghard and Dütschke (2019), compatibility with daily life is the most important predictor for the attitude towards using carsharing. This holds true for the overall sample as well as for all other adoption groups (users, intending to use, interested, not interested) - showing a greater frequency in the 'intending to use' group. For ridepooling, perceived compatibility is found to have a positive effect on perceived usefulness and perceived ease of use (Min et al., 2019). We therefore arrive at the following hypotheses:

H11. Perceived compatibility positively affects the general attitude (towards carsharing / ridepooling)

H12. Perceived compatibility positively affects acceptance (of carsharing / ridepooling)

In a previous study on carsharing (Burghard and Dütschke, 2019) and another on ridesharing (Cheah et al., 2020), ease of use is significantly predictive for the attitude towards the respective service. We therefore hypothesize:

H13. Perceived ease of use positively affects the general attitude (towards carsharing / ridepooling)

H14. Perceived ease of use positively affects acceptance (of carsharing / ridepooling)

According to Rogers, observability, that is, the visibility of an innovation, as well as trialability, i.e. the possibility of testing a certain innovation before the decision to adopt, are positively related to its adoption (1983). However, a previous study on carsharing found a negative effect of trialability on the general attitude towards this service (Burghard and Dütschke, 2019). For ridepooling, no previous results are available on these variables. Since experience of a new service and perceiving it to be available to be tested can still be expected to positively affect the attitude towards sharing services and their acceptance, we assume a positive relationship based on the following hypotheses:

H15. Perceived observability positively affects the general attitude (towards carsharing / ridepooling)

H16. Perceived observability positively affects acceptance (towards carsharing / ridepooling)

H17. Perceived trialability positively affects the general attitude (towards carsharing / ridepooling)

H18. Perceived trialability positively affects acceptance (towards carsharing / ridepooling)

Finally, our model addresses the relationship between attitude and behaviour. Despite the much-discussed attitude-behaviour gap in social psychology, previous studies on carsharing found that more positive attitudes towards carsharing are related to a higher likeliness of adoption of this innovation (Burghard and Dütschke, 2019). Studies on ridepooling find the same positive connection (Amirkiaee and Evangelopoulus, 2018; Cheah et al., 2020). Behaviour towards the sharing services can be measured as self-reported usage intentions (= adoption intentions) or self-reported actual usage. Since we are interested in the determinants of individuals deciding to use the services in general, we do not differentiate between usage intention and actual usage and summarize both measures under the overarching variable of acceptance, following the definitions of acceptance and behavioural acceptance by Huijts et al. (2012) and Upham et al. (2015) respectively. Since, despite the empirical evidence, we cannot be certain that no attitude-behaviour gap exists, we keep both concepts as separate variables, with behaviour including intention. Based on the evidence for both sharing services, we therefore arrive at the following final hypothesis for the study model:

H19. The general attitude (towards carsharing / ridepooling) positively affects acceptance (of carsharing / ridepooling).

These hypotheses are part of the study model (Fig. 1). The model (i.e. from left to right) reflects the sequential relationships between more basic attitudes towards environmental protection, the disposition for routine seeking, and the individually perceived attributes of the innovation (H1-H4, H6-H9) as well as the general attitude towards the innovation (H5, H10). In the intermediate part of the model (i.e. the association between the DoI constructs and general attitude as well as acceptance, H11-H18) and for the final relationships in the model (between general attitude and acceptance, i.e. the intended or actual use, H19) Rogers' DoI and available empirical literature were used to formulate hypotheses.

The objective of this study is to test this sequential model, i.e. in this case, the theoretical location of underlying attitudes and the DoI constructs as predictors in the sequential pathway. One important reason for building the model is the assumption that underlying attitudes towards environmental protection (Whitmarsh and O'Neill, 2010) and routine seeking (as the behavioural component of resistance to change) (Oreg, 2003) are more basic dispositions whereas the DoI constructs are assumed to be more mutable.

3. Data and methods

To test the hypotheses, an online survey was conducted among the German urban population. The aim of the survey was to study the attitude towards and the acceptance of different shared mobility services. The following sections describe the data collection and survey design, the sample population, and the operationalization of the measures of the conceptual model.

3.1. Data collection and survey design

The data for this study was collected via an online survey (N = 3,061) in German major cities, i.e. in cities with more than 100,000 inhabitants (categories 71 and 72 of the Regional Statistical Space Typology RegioStaR (BMVI, 2020). Participants for the survey were recruited from an online panel by a market research company specialising in such surveys. The data collection took place between September and October 2019.

The questionnaire asked about mobility resources (e.g. driver's licence, public transport season ticket), mobility behaviour and experiences with four different shared mobility services. Attitudes towards different means of transport, environmental identity (Whitmarsh and O'Neill, 2010) and the tendency to routines (Oreg, 2003; Rieser-Schüssler and Axhausen, 2012) were also surveyed. For the second part of the questionnaire, the sample was divided into four subsamples: carsharing (n = 767), bike sharing (n = 764), e-scooter-sharing (n = 766) and ridepooling (n = 764). Individual respondents were randomly assigned to one of these groups. Each subsample was quoted according to region (North, East, South), level of education (low, medium, high) and a gender age-category (men and women aged 18–29, 30–39, 40–49, 50–59, 60–69, 70+), in order to be representative of the urban population in the selected city categories according to these criteria. In each group, the individual mobility service was explained and afterwards questions were asked on the evaluation and acceptance of each service.

Below, we provide more information on the descriptions of the two sharing services that are the focus of our paper. The survey described carsharing as "the use of vehicles that are shared between users". Carsharing was then delineated from a similar service: "In contrast to rental cars, use for registered customers can also be spontaneous and for shorter periods of time." Station-based and free-floating carsharing were described as "two different variants". However, general questions on the evaluation of carsharing, which were put to all respondents of the subsample, did not distinguish between station-based and free-floating carsharing. Finally, examples were given to illustrate the costs of using carsharing. The introductory text in the survey described ridepooling as: "a transport service similar to a shared taxi […]". Ridepooling was further defined as distinct from taxis (and public transport): "In contrast to a taxi, the journey may not be made exclusively as a single passenger, but shared with up to six other (unknown) passengers. […] The fares are significantly lower than those of taxis, but still well above the usual prices of public transport." Similar to the carsharing text, examples of the fares of different trips were given.

3.2. Sample description

For the subsamples of carsharing and ridepooling, the mean age is 47 years and the share of male and female respondents is equally distributed. The subsamples differ in that the carsharing subsample exclusively includes people who have a car driver's licence (since this is a prerequisite for using carsharing), while in the ridesharing subsample only 79% of the people have a driver's licence. When it comes to mobility behaviour, 31% of the respondents in the samples use a car (almost) every day and 29% local public transport. 13% use a bicycle (almost) daily and 61% of the respondents walk on foot every day or almost every day. This high proportion is partly due to the fact that access and exit routes to public transport and other short distances are also included. The results are in line with the results of the Mobility in Germany survey (Nobis and Kuhnimhof, 2018), which shows similar modal shares for the urban population (45% cars, 15% bicycles). Only the use of local public transport (29%) differs significantly from the MiD (13% public transport). This is probably due to the fact that the MiD survey was carried out on a key date, whereas this study surveyed general mobility patterns that do not take into account the distance travelled.

3.3. Measures

The literature on the Diffusion of Innovations (DoI), as outlined above, presents the basis for our choice of variables and analysis (Rogers, 1983). The measures used include i) acceptance, ii) the general attitude towards the sharing systems, iii) environmental identity (scale translated and slightly modified based on Whitmarsh and O'Neill, 2010), iv) routine seeking (Oreg, 2003), and the DoI constructs of v) compatibility, vi) trialability, vii) ease of use and viii) observability. The variable of *acceptance* includes information on the intended use of carsharing or ridepooling ('In principle, could you imagine using [carsharing / ridepooling] (again) in the future?') and actual use ('Have you ever used [carsharing / ridepooling] yourself?') and is rated on a six-point Likert scale (1 'Definitely not' to 5 'Definitely' plus 6 for actual users who also plan to use the service in the future).[3] With this operationalization, we follow the definition of acceptance by Upham et al. (2015) rather than the definition of acceptance in the DoI, which describes acceptance as a separate intention prior to behaviour (see section 2.2). This prior step we consider to be covered by attitudes (what Huijts et al., 2012 call 'acceptability'). The *general attitude* is rated on a seven-point Likert scale ranging from 1 'very negative' to 7 'very positive'. All DoI items are rated on a six-point Likert scale ranging from 1 'do not agree at all' to 6 'fully agree'. *Environmental identity*, the *routine seeking* construct (Oreg, 2003) and the DoI *constructs* (except for item vi) *trialability*) were measured with several items; most of them were developed in earlier studies by members of the authors' research team which focused on EVs (Peters and Dütschke, 2014, see also Burghard and Dütschke, 2019). Items on the *relative advantages* were not included in the questionnaire as they caused problems in an earlier study (Peters and Dütschke, 2014).[4]

3.4. Data analysis

The data in the study was analysed by means of path analysis (PA). First, the model was specified based on existing literature and empirical evidence. The second step is model identification, i.e. the model should be over-identified or just identified. In this study, the model has been identified properly and is over-identified. In a third step, maximum likelihood (ML) was selected with robust standard errors and a Satorra-Bentler scaled test statistic as the estimation method. The R package lavaan was used to test the model and to calculate the direct and indirect effects as well as the fit indices. For model testing, the goodness of fit indices were examined in order to evaluate the fit of the model to the data. These include Chi-Square (χ^2), Root-Mean-Square-Error of Approximation (RMSEA), Standardized Root-Mean-Residual (SRMR), Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI). The last step is modification, i.e. models with poor model fit indices are revised.

4. Results and discussion

4.1. Descriptive statistics

For the variables in the path model, descriptive statistics were examined (Table 1).

9.3% use carsharing, 4.2% use ridepooling. 4.7% of respondents stated a strong intention to use carsharing and 5.2% a strong intention to use ridepooling. For carsharing, the results can therefore be considered to have most explanatory power for the group of early adopters, leaning towards an early majority. For ridepooling, adoption is less advanced and so far remains between innovators and early adopters.

4.2. Reliability and validity assessment

Before aggregating items into scales by averaging across them, we analysed whether the measurement is consistent by applying factor analysis and estimating Cronbach's α. In a first step, for each of the constructs iii) (environmental identity), iv) routine seeking, and the DoI constructs of v) compatibility, vii) ease of use and viii) observability a separate explorative factor analysis was conducted with varimax rotation. This led to the expected one-factor solution for constructs iii-vii. Vi trialability consists of only one item. The items for v and vii formed two factors, so two items were excluded from further analyses.[5] Next, the items for the DoI constructs v-vii were added to a factor analysis simultaneously, which led nearly to the expected structure (varimax rotation, pre-defined number of factors extracted; items were expected to have factor loadings of >0.6 on the relevant factor and no factor loading >.4 on other factors). As Cronbach's α was not sufficient for the scale on observability this factor was excluded.[6]

All items and descriptive statistics as well as Cronbach's α values are provided in Table 7 in the annex. In Tables 8 and 9 in the annex the rotated factor loadings are shown for the DoI constructs v-vii for carsharing and ridepooling.

Table 1
Descriptive statistics for the path analysis (PA) model variables.

Variables	Mean		SD		Min	Max
	CS	RP	CS	RP		
Acceptance	2.94	2.85	1.53	1.36	1	6
General attitude	4.08	3.97	1.72	1.62	1	7
Compatibility	2.67	2.64	1.55	1.50	1	6
Ease of use	4.48	4.42	1.35	1.36	1	6
Trialability	3.62	2.96	1.83	1.88	1	6
Routine seeking	3.45	3.47	1.10	1.08	1	7
Environmental identity	5.46	5.48	1.41	1.45	1	7

Notes: N carsharing = 767, N ridepooling = 764; CS = carsharing, RP = ridepooling.

[3] To calculate the variable 'acceptance', the values of the two variables 'intended use' and 'actual use' were combined for each respondent. Individuals who already use carsharing or ridepooling were not asked about their intention to continue using them. This makes it possible to combine the variables and prevents the exclusion of respondents.

[4] The items did not show a factor structure in line with expectations.

[5] These were the following items: Compatibility: "It is difficult for me to use [carsharing/ridepooling] according to my plans." Ease of use: "In order to use [carsharing/ridepooling], I need to know about some technical things."

[6] This only applies to carsharing (.68); Cronbach's α for ridepooling was sufficient (0.74). However, since the same path models were to be calculated for both services for better comparability, this factor was also excluded for ridepooling.

Reflecting the different factors, four new variables - environmental identity, routine seeking, and the DoI constructs of compatibility and ease of use - were constructed by computing the mean scores of items that correlated higher than .60 with each of the five factors.

4.3. Path models/hypothesis testing

The initial model was modified by removing insignificant paths (e.g. between environmental identity and/or routine seeking and trialability and/or ease of use) and by adding regression paths between environmental identity and routine seeking and acceptance in the carsharing model as suggested by the modification indices. Regression paths were also added in the ridepooling model: between environmental identity and routine seeking and general attitude as well as between routine seeking and acceptance.

The final PA models for carsharing and ridepooling demonstrated a good fit and no difference between the observed and expected matrices ($\chi^2 = 7.79$ and 1.95 respectively, $p = .17$ and $p = .72$ respectively). RMSEA and SRMR are less than .05 and CFI and TLI range from 0.99 to 1.01. That is, all indices show good model fit (Table 2).

The paths are significant ($p < .05$) and in the expected directions.

In both models, the path between compatibility with daily life and the general attitude shows the largest positive standardized path coefficient ($\beta = .62$ and .65 respectively), followed by the path between compatibility and acceptance ($\beta = .47$ and .44 respectively). As expected, the general attitude has a positive effect on acceptance in both models. The remaining DoI variables of trialability and ease of use have a positive impact on the general attitude in the ridepooling model; in the carsharing model, only ease of use has an influence. In contrast to the hypothesis, no effect of ease of use on acceptance was found in either model. As hypothesized, environmental identity has a positive effect on compatibility and on the general attitude in the carsharing model, but a negative impact on acceptance. In the ridepooling model, environmental identity positively influences all DoI variables and the general attitude but not acceptance. As expected, routine seeking negatively influences ease of use in both models; however, no effect was found on the variable of trialability. In the carsharing model, surprisingly, there is a positive effect of routine seeking on compatibility. In the carsharing model, this variable has a negative effect on acceptance and in the ridepooling model there is - as expected - a negative influence on general attitude (Fig. 2, Fig. 3).

Overall, we therefore find support for hypotheses H1, H5, H7, H11, H12, H13 and H19 for the model on carsharing and support for hypotheses H1, H2, H4, H5, H7, H10, H11, H12, H13, H17 and H19 for the ridepooling model. Hypotheses H6, H9 and H14 were rejected for both models. In addition, an influence of environmental identity and routine seeking on acceptance was found in the carsharing model, which was not previously represented in the hypotheses. Hypotheses H3, H8, H15 and H16 could not be tested because observability was excluded from the analysis (Table 3).

For the DoI variables, the direct and indirect effects on the dependent variable are also considered. The total effects of compatibility and ease of use on acceptance through general attitude ($\beta = .68$, $\beta = .07$ and $\beta = .01$, respectively) were significant in the carsharing model. For ease of use there is a complete mediation, however, with a weak effect (Table 4).

The total effects of compatibility and trialability on acceptance through general attitude ($\beta = .66$ and $\beta = .1$, respectively) were significant in the ridepooling model (Table 5).

Table 2
Fit indices of the carsharing and ridepooling model.

Selected Fit Indices	CS (N = 614)	RP (N = 539)
χ^2	7.79	1.95
RMSEA	0.03	0.00
SRMR	0.02	0.01
CFI	0.99	1.00
TLI	0.99	1.01

Note. CS = carsharing, RP = ridepooling.

4.4. Discussion

Overall, acceptance of carsharing and ridepooling is still limited even in large cities, i.e. few use or intend to use these services (see also Nobis and Kuhnimhof, 2018). Thus, these services represent a niche, with carsharing being more widespread. The goal of this study was to test whether the perception of innovation-specific attributes, based on Roger's DoI, is related to the general attitudes towards and the acceptance of these innovative mobility services. It was further hypothesized that the basic dispositions of environmental identity and routine seeking have an impact on the perceived attributes of these innovations and potentially on attitudes and acceptance directly.

The path analysis reveals many significant correlations in the predicted directions; thus, the (socio-)psychological variables in the model can predict whether or not individuals use and intend to use carsharing or ridepooling. First, the influence of the innovation-specific factors on the acceptance of sharing services is discussed. *Compatibility* turned out to be the strongest predictor for attitude and acceptance; this is in line with the literature (Burghard and Dütschke, 2019). Individuals therefore tend to favour new services that are compatible with their established daily routines and mobility behaviour. Compatibility was measured with items referring to a congruence of the mode of transport with (daily) habits and individual personality. In other words, the concept captures a mixture of self-identity and mobility patterns and requirements. Consequently, perceived compatibility can be influenced by situational and contextual factors, e.g. which modes of transport are (likely to become) available at an individual's home. In addition, it refers to personal factors and might be related for example to personal values. *Ease of use* exhibits a positive influence on attitude, but not on acceptance directly. This can be explained by the fact that other variables besides ease of use are more important for explaining acceptance but that the indirect effect through attitudes should not be neglected. *Trialability* has a positive influence on acceptance in both models and a positive influence on attitude in the ridepooling model. It is therefore important for new mobility services to be visible in the individuals' mobility reality and that the first usage of a new mobility service is incentivized and made as easy as possible.

The analysis shows that the basic psychological dispositions of *routine seeking* and *environmental identity* shape individuals' perception of attributes of the innovation, i.e. *compatibility* with daily life, *ease of use* and *trialability*. As hypothesized, *routine seeking* negatively influences the perceived *ease of use* of both sharing services (Alemi et al., 2018; Becker et al., 2017). However, *routine seeking* positively influences the perceived *compatibility* that respondents see between carsharing and their daily life. Contrary to our hypothesis, routine behaviour might therefore not be detrimental to carsharing usage overall and individuals with routine-oriented lives could still be reached by such a service. One possible reason could be that carsharing cars can be used similarly to private cars in cities with a high carsharing density and would therefore not require large adjustments in respondents' routines. In contrast, no effect of *routine seeking* on *compatibility* was found for ridepooling. This could be explained by the novelty of the service, which means that it is not yet clear to respondents how far the service would alter their mobility routines.

As expected, the significant relationships between *environmental identity* and the *DoI variables* were all positive. For carsharing such a significant relationship was found between *environmental identity* and *compatibility* and for ridepooling between *environmental identity* and all three *DoI variables*. The lower path coefficients for the carsharing model as well as the lower significant paths indicate that environmental identity plays a more important role in the acceptance of ridepooling

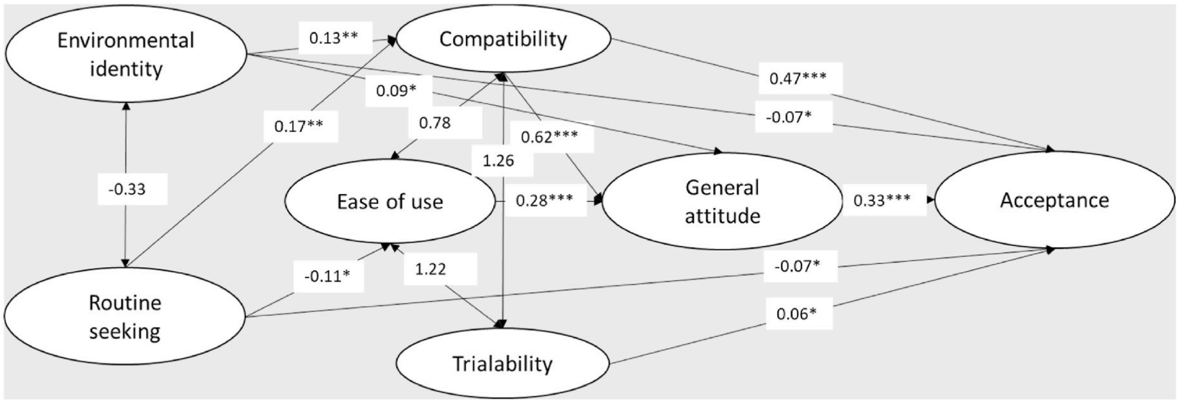

Fig. 2. Final model for carsharing with standardized path coefficients and covariances.

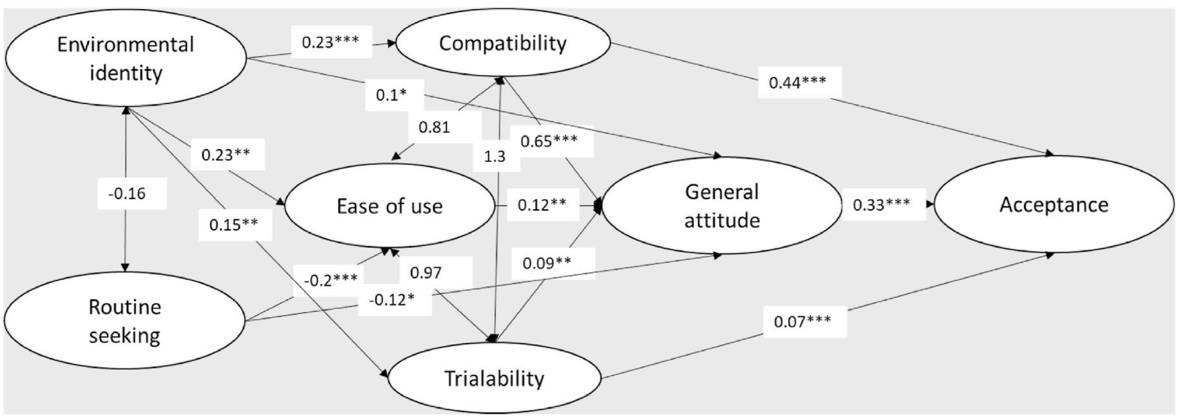

Fig. 3. Final model for ridepooling with standardized path coefficients and covariances.

than in the acceptance of carsharing.

In the final carsharing model, additional paths between basic dispositions and acceptance were included, i.e. *environmental identity* and *routine seeking* also directly influence *acceptance*. Surprisingly, we found a negative influence of environmental identity on acceptance in the carsharing model. This shows that the effect of environmental orientation on the acceptance of carsharing is not clear (Hartl et al., 2018). One possible reason might be the rejection of motorised individual transport in general among respondents with higher environmental protection attitudes. For ridepooling the effect is more clear, i.e. *environmental identity* is positively related to the *attitude* towards ridepooling (and carsharing), but not negatively related to *acceptance*. This could be explained by the perceived similarities of ridepooling with public transport and the related expectations towards this shared mobility service as reducing individual rides.

Finally, as expected, the *general attitude* shows a positive influence on *acceptance*, i.e. the intention to use or actual usage, which is in line with findings from the literature (Amirkiaee and Evengelopoulus, 2018; Burghard and Dütschke, 2019; Cheah et al., 2020).

With regard to the differences in the models for carsharing and ridepooling, it can be stated that the effects of the basic psychological factors of environmental identity and routine seeking correspond more closely to expectations in the case of ridepooling (i.e. positive influence of environmental identity and negative influence of routine seeking). In the case of carsharing, these effects are less clear. In diffusing to more adopter groups, as far as using carsharing is concerned, pragmatic motives may play an increasingly important role while environmentalism and innovativeness become less important. The influence of the Rogers variables is the same in both models with the exception of trialability, which has a positive influence on the attitude in the still new service of ridepooling, but not in carsharing.

The study faces a number of limitations, some of which could be accounted for in future studies. Firstly, not all business models of carsharing and ridepooling could be considered in the path model, i.e. no distinction was made between station-based and free-floating carsharing or between different variants of ridepooling, i.e. ridselling or ridesharing. Infrastructural conditions, such as the provision of local public transport or the local distribution of services, could not be taken into account. Furthermore, the effect of electric vehicles in sharing fleets on acceptance was not considered in the analysis. However, it can be assumed that these features do not yet play a significant role in acceptance for the large majority of respondents (who do not yet use these services and in some cases are not even aware of them). In future studies, the relevance of infrastructural and service-specific characteristics to the acceptance of the services could be investigated. Secondly, ridepooling was evaluated by most respondents based on the descriptions of the service only, as many respondents were not yet familiar with this service. As ridepooling becomes available in more cities, more valid assessments can be collected in future studies. Additionally, two separate samples, one for each service, were analysed, i.e. no absolute comparison of the acceptance of both sharing systems is possible. The measure of acceptance itself included both the intention to use the services and their actual usage. Once more actual users can be captured in representative samples, a separate analysis of these measures would be interesting for future studies. In addition, the samples differ in the availability of a driver's licence (i.e. the carsharing subsample only includes people with a car driver's licence, while the ridepooling sample also includes people without a driving licence). This means that for the people in the carsharing sample, driving is more of an option in their everyday mobility behaviour than it is in the ridepooling sample. This should be considered

Table 3
Summary of results for each hypothesis.

Hypothesis	Results CS	Results RP
H1: Environmental identity positively affects perceived compatibility*	✓	✓
H2: Environmental identity positively affects perceived ease of use*	–	✓
H3: Environmental identity positively affects perceived observability*	*excluded*	
H4: Environmental identity positively affects perceived trialability*	–	✓
H5: Environmental identity positively affects the general attitude*	✓	✓
H6: Routine-seeking negatively affects perceived compatibility*	–	–
H7: Routine-seeking negatively affects perceived ease of use*	✓	✓
H8: Routine-seeking negatively affects perceived observability*	*excluded*	
H9: Routine-seeking negatively affects perceived trialability*	–	–
H10: Routine-seeking negatively affects the general attitude*	–	✓
H11: Perceived compatibility positively affects the general attitude*	✓	✓
H12: Perceived compatibility positively affects acceptance*	✓	✓
H13: Perceived ease of use positively affects the general attitude*	✓	✓
H14: Perceived ease of use positively affects acceptance*	–	–
H15: Perceived observability positively affects the general attitude*	*excluded*	
H16: Perceived observability positively affects acceptance*	*excluded*	
H17: Perceived trialability positively affects the general attitude*	–	✓
H18: Perceived trialability positively affects acceptance*	–	–
H19: The general attitude* positively affects acceptance*	✓	✓

Note. * of/towards carsharing or ridepooling. CS = carsharing, RP = ridepooling.

Table 4
Mediation model for carsharing: total, direct and indirect effects.

Variables	Direct effect	Indirect effect (Att.)	Total effect
Comp– > Acc.	.47***	.21***	.68***
Ease– > Acc.	0	.09***	.01***

Note. Comp = compatibility; Trial = trialability; Ease = ease of use; Acc. = acceptance; Att. = attitude; *$p < .05$, **$p < .01$, ***$p < .001$.

Table 5
Mediation model for ridepooling: total, direct and indirect effects.

Variables	Direct effect	Indirect effect (Att.)	Total effect
Comp– > Acc.	.39***	.22***	.66***
Trial– > Acc.	.05*	.03**	.1***
Ease– > Acc.	0	.04**	.01

Note. Comp = compatibility; Trial = trialability; Ease = ease of use; Acc. = acceptance; Att. = attitude; *$p < .05$, **$p < .01$, ***$p < .001$.

in future studies. Finally, no longitudinal data were collected, i.e. no causality can be assumed. However, since the models are theoretically sound, a certain validity can be assumed.

Notwithstanding the aforementioned limitations, our study offers a number of key research contributions. The path models of our study make it possible to distinguish between more fundamental psychological dispositions and perceived attributes that relate directly to the innovation. Our findings supplement existing literature by showing that these psychological dispositions and perceived innovation attributes are related to attitudes and acceptance in a sequential manner. This means that changes in innovation-specific attribute perceptions can be considered a relevant entry point for policies but that changes in psychological dispositions can further improve or, if mismanaged, counteract these perceptions. With this approach, the paper enriches the structure-agency debate by deriving recommendations from a psychological analysis (agency-related) which concern, for example, the topics of infrastructure or mobility culture (structure-related). The fact that two models, one for each sharing service, have been developed and tested allows specific policy recommendations to be derived here. Our findings present the first results on the connections between these factors for sharing services and can build the foundation for further studies on new sustainable mobility services, which have not yet diffused widely. A further valuable feature of our study is that we included both users and non-users of sharing systems in the analysis. This means that we were able to differentiate between attitudinal and behavioural levels of both, extending the studied respondent group beyond just innovators and early adopters and achieving knowledge spanning further potential adopter groups towards the majority of the population.

5. Policy implications

The widespread use of shared mobility services helps to realise their potential for reducing energy demand in the transport sector. Based on the results presented here, recommendations were therefore developed for policy-makers and also for service providers on ways of increasing acceptance of these services. However, we also consider how these services can be intelligently integrated into the transport system so that they do not have the opposite effect, namely an increased demand for motorised (individual) transport or a decreasing demand for public transport and active mobility, i.e. cycling or walking.

Whether or not individuals use or intend to use carsharing or ridepooling systems can be predicted by innovation-specific factors as well as more fundamental psychological dispositions. The results show many highly significant correlations in the predicted directions, perceived compatibility with daily life being the most important factor. For ridepooling, in sum, more significant effects were found; however, the acceptance (i.e. the use and intended use) of carsharing is more strongly influenced by basic attitudes towards the environment and routines.

Findings on these questions can provide evidence for the types of variables that policy-making needs to tackle if the goal is to increase the acceptance of potential energy-saving transport innovations. The key difference lies in knowing whether only basic (socio-)psychological dispositions have an effect, a domain that is difficult to influence through policy, or whether perceptions of innovation-specific attributes are significantly related to attitudes and acceptance - a domain that can be more readily influenced by innovation- or sector-specific policies.

Table 6 gives an overview of the central recommendations for policy-makers (government and municipalities) and service providers based on the results of our analysis. The recommendations are then further discussed below.

The innovation-specific items from Rogers' DoI show many significant influences on attitudes and/or acceptance. That is, the acceptance of shared mobility depends (strongly) on these innovation-related factors and is thus potentially open to many user groups (i.e. the early majority).

Trialability, i.e. the perceived possibility of testing an innovation, can be influenced by service availability, for example. This means governments can establish (more) transport pilot regions in which ridepooling is particularly promoted. Municipalities can increase the visibility of the services in public spaces, for instance by creating (more) ridepooling stations in densely populated residential areas. Service providers can also improve visibility of the services and could offer incentives for people to try out their service with a social connection who is already a user or through a trial event or offer.

Perceived compatibility could be improved by highlighting the usage similarities of the new services with existing mobility options while also

Table 6
Policy implications and recommendations to improve attitudes and acceptance of shared mobility.

Factors influencing attitudes and acceptance	Shared mobility service		Recommendations for …		
	CS	RP	Government	Municipalities	Service providers
Perceived trialability		+	Establishment of transport pilot regions in which ridepooling is particularly promoted	Improving visibility of the services by creating (more) ridepooling stations in densely populated residential areas	Offering incentives to try out the services
Perceived compatibility and perceived ease of use	+	+		Integration of sharing services into public transport	Highlighting usage similarities of shared mobility with existing mobility options and highlighting potential benefits to users
Routine seeking	–	–			Demonstrating similarities between individuals' existing mobility routines and usage of shared mobility
Environmental identity	+/−	+	Setting up information programmes to highlight environmental benefits of shared mobility	Introducing restrictive measures regarding the use of private cars in cities	Ensuring good pooling rate and integrating electric vehicles in the fleets, purchasing green electricity

Note. CS = carsharing, RP = ridepooling; + = positive correlation of the factor with attitudes and acceptance shown in study; - = negative correlation of the factor with attitudes and acceptance shown in study.

highlighting potential benefits to users. This could also make the services attractive, especially for former car users, which is important for the services to have a positive environmental impact. An example would be a large number of carsharing stations in residential areas where many vehicles are available so that flexible booking is possible. Thus, from the point of view of (potential) users, carsharing use can come close to the use of a private car. Incentives from municipalities, for example to encourage new citizens to give up their cars and switch to carsharing, can also help. The integration of sharing services into public transport (Kramer et al., 2014) (e.g. in terms of tariffs and informational and spatial integration) is very important in this context - not only to increase user-friendliness and perceived ease of use but also to ensure that sharing systems do not cause more traffic. Examples of spatial integration include mobility stations or so-called 'mobility points' at transfer points from public transport or cycling to ridepooling and carsharing and vice versa. This could be aimed primarily at public transport users and could cover parts of the route where public transport is not available. This again points to the central role of municipalities in this process, as they have to plan and finance the integration of transport systems strategically and conceptually.

The results on basic psychological dispositions provide hints as to which societal groups or milieus could be addressed as initial potential users for shared mobility services. Our results show that highly routine-oriented behaviour of individuals does not necessarily rule out the usage of carsharing or ridepooling. That is, a differentiated approach could potentially also activate individuals with a high affinity for routines. This could again be a matter of demonstrating the similarities between individuals' existing mobility routines and the usage of one of the new services. The risk that carsharing in particular is used in the same way as a private car, thus negating the positive environmental effects, often does not exist for cost reasons (for high mileage, a private car is cheaper than carsharing) (Schuster et al., 2005).

The relationship between environmental identity, i.e. the personal identification of individuals with environmental protection, and the perception and acceptance of sharing services remains complex. While higher environmental identity scores were related to more positive innovation-specific factors and attitudes towards ridepooling, less positive effects were observed with carsharing. This indicates that, to ensure positive environmental effects of ridepooling, providers should be incentivized to ensure a good pooling rate and integrate electric vehicles in their fleets as well as purchasing green electricity. In addition, as mentioned in section 2.1, restrictive measures regarding the use of private cars in cities, e.g. parking restrictions or congestion charging, are important to strengthen more environmentally friendly means of transport. Urban upgrading, such as the creation of more green spaces and meeting areas, can then in turn help to increase the acceptance of these restrictive measures (Schippl et al., 2021). Whether or not a framing involving environmental consciousness helps with the adoption of carsharing remains service- and context-specific. This presents an avenue for further research. However, in general, information programmes are important means of highlighting the environmental benefits of using carsharing and ridepooling, as well as the associated multimodal mobility behaviour.

6. Conclusion

In this paper, we investigated factors influencing the acceptance, i.e. usage intention and actual use, of carsharing and ridepooling systems in a survey study carried out in German major cities. The data analysis based on two path models reveals that so-called innovation-specific factors show many significant influences, perceived compatibility with daily life being the most important factor. Fundamental psychological dispositions also show an influence on acceptance, but the effects differ for the two services: environmental identity is positively related to the acceptance of ridepooling, while for carsharing the effects are less clear.

In order to reduce energy consumption in the transport system, policies must ensure that car-based shared mobility does not increase car passenger kilometres. The intelligent integration of shared mobility services into the municipal transport system can contribute to this. Particularly against the background of the decreased attractiveness of public transport in connection with the Covid-19 pandemic, municipal policies need to strengthen public transport but also intelligently supplement it with sharing systems. This can bring benefits from the point of view of (potential) users, for example by facilitating changing between a sharing service and other means of transport. Ridepooling as a new form of public transport can improve the image of public transport and make it more attractive for previous non-users. But this can also be an advantage for municipalities: if, for example, public transport is supplemented by ridepooling at off-peak times or in peripheral areas, more expensive public transport options can be replaced. Finally, the services should be made better known and more visible and barriers to use for potential users should be removed.

On the other hand, so-called push policies must also make the use of motorised individual transport less attractive, especially in cities. This means that policies must help sharing services to overcome their niche existence given that, at present, institutions (laws, regulations), the mobility culture and car ownership as a standard, as well as the built environment, contribute to maintaining the existing regime structures. Policies are therefore an important component of a mobility transition. At the same time, a change in values, i.e. a greater emphasis on sustainability, as well as cultural change, such as an increase in remote working, can further contribute to a change in the mobility culture towards more sustainability.

CRediT authorship contribution statement

Uta Burghard: Conceptualization, Methodology, Software, Formal analysis, Investigation, Project administration, Writing – original draft, Writing – review & editing. **Aline Scherrer:** Conceptualization, Methodology, Investigation, Resources, Visualization, Writing – original draft, Writing – review & editing.

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

Table 7
Items with descriptive statistics (M = mean, SD = standard deviation) and Cronbach's α for the scales

	Carsharing			Ridepooling		
	α	M	SD	α	M	SD
Acceptance of carsharing/ridepooling	–	2.94	1.53	–	2.85	1.36
Attitude towards carsharing/ridepooling use	–	4.08	1.72	–	3.97	1.62
Compatibility: [Using carsharing/ridepooling]	.92	2.7	1.6	.92	2.6	1.5
… is in line with my habits.		2.8	1.7		2.8	1.6
… fits with my personality.		2.7	1.7		2.7	1.7
… is very suitable for my daily tasks.		2.6	1.6		2.5	1.6
Ease of use	.77	4.5	1.4	.79	4.4	1.4
[Carsharing/ridepooling] is easy to understand.		4.6	1.5		4.5	1.4
I am confident in using [carsharing/ridepooling].		4.4	1.7		4.3	1.7
Observability	.68	–	–	.74	–	–
[Carsharing/ridepooling] has noticeably changed today's transport landscape.		3.3	1.6		3.0	1.6
When I use [carsharing/ridepooling], it is noticed by most people in my personal environment.		2.9	1.7		2.7	1.7
I have often noticed [car-sharing/ridepooling] cars on the road.		3.6	1.9		2.4	1.8
Trialability	–			–		
I have the option of trying out [carsharing/ridepooling] before coming to a final evaluation.		3.6	1.8		2.9	1.9
Routine seeking	.73	3.5	1.1	.73	3.5	1.1
I'd rather be bored than surprised.		3.1	1.7		3.1	1.7
I'll take a routine day over a day full of unexpected events any time.		4.1	1.7		4.1	1.7
Whenever my life forms a stable routine, I look for ways to change it.		4.1	1.5		4.1	1.5
I generally consider changes to be a negative thing.		2.9	1.6		2.9	1.6
I like to do the same old things rather than try new and different ones.		3.5	1.6		3.5	1.6
Environmental identity	.93	5.5	1.4	.94	5.5	1.5
I think environmental protection is a very important issue.		5.7	1.5		5.7	1.5
Environmental protection is an important concern for me personally.		5.4	1.5		5.4	1.5
It is important to me to behave in an environmentally conscious way.		5.4	1.5		5.4	1.5

Note. Ratings for attitudes range from 1 to 7, for all other constructs from 1 to 6. Higher numbers indicate a more positive evaluation.

Table 8
Rotated factor loadings of items measuring Rogers' constructs for carsharing

	Factor 1 Compatibility	Factor 2 Ease of use	Factor 3 Trialability
[Using carsharing] is in line with my habits.	.898	.155	.219
[Using carsharing] fits with my personality.	.896	.172	.190
[Using carsharing] is very suitable for my daily tasks.	.908	.096	.108
[Carsharing] is easy to understand.	.112	.928	.067
I am confident in using [carsharing].	.202	.722	.414
I have the option of trying out [carsharing] before coming to a final evaluation.	.256	.234	.914
Cronbach's alpha	.92	.77	–

Table 9
Rotated factor loadings of items measuring Rogers' constructs for ridepooling

	Factor 1 Compatibility	Factor 2 Ease of use	Factor 3 Trialability
[Using ridepooling] is in line with my habits.	.901	.179	.197
[Using ridepooling] fits with my personality.	.887	.204	.209
[Using ridepooling] is very suitable for my daily tasks.	.898	.162	.139
[Ridepooling] is easy to understand.	.133	.911	.042
I am confident in using [ridepooling].	.249	.805	.256
I have the option of trying out [ridepooling] before coming to a final evaluation.	.275	.193	.936
Cronbach's alpha	.92	.79	–

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