Transportation Research Part F: Psychology and Behaviour 101 (2024) 218–235

Contents lists available at ScienceDirect

Transportation Research Part F: Psychology and Behaviour

journal homepage: www.elsevier.com/locate/trf

Can cargo bikes compete with cars? Cargo bike sharing users rate cargo bikes superior on most motives – Especially if they reduced car ownership

Michael Bissel [a,*], Sophia Becker [a,b]

[a] Chair of Sustainable Mobility and Transdisciplinary Research Methods, Technische Universität Berlin, Berlin, Germany (Marchstraße 23, 10587 Berlin, Germany)

[b] Research Institute for Sustainability Potsdam, Potsdam, Germany (Berliner Straße 130, 14467 Potsdam, Germany)

ARTICLE INFO

Keywords:
Motives
User behavior
Cargo bikes
Car ownership
Shared mobility
Sustainability

ABSTRACT

The transport sector and especially private cars pose environmental, economic, and social challenges. For this reason, cargo bikes and shared mobility are considered viable alternatives for road transport. In order to understand the potential and barriers of alternative transport modes, it is essential to analyze underlying motives. Moreover, comparing sustainable alternatives (such as public transport) to cars in terms of motives has been established as a research approach (Steg, 2003). Despite increasing interest in cargo bikes and cargo bike sharing, research on this topic is relatively rare. Particularly, there exists a lack of research addressing the impact of cargo bike sharing on car ownership. Against this background, this study quantifies the car ownership reduction effect of cargo bike sharing. In addition, it is investigated how cargo bikes differ from cars with regard to the underlying motives of users which also helps understanding potential barriers. To answer these research questions, this study is based on a large-scale survey with n = 2,590 cargo bike sharing users. The results imply that cargo bike sharing has a notable impact on car ownership. In general, cargo bikes are rated superior in regard to affective, symbolic, and environmental motives as well as on flexibility and price. However, discrepancies to cars do exist in terms of other instrumental aspects (traffic safety, travel speed, comfort, weather-independence). Notably, users who reduced car ownership tend to rate cargo bikes superior compared to car-dependent users. The results imply that cargo bikes can play a marked role in reducing car dependency. Improving infrastructure and cargo bike technology as well as stimulating favorable social norms for cargo bikes have been identified as beneficial conditions that could help to leverage this potential.

1. Introduction

Transport is a main driver of climate change, responsible for nearly a quarter of global energy-related CO_2 emissions (IEA, 2020). These are largely attributable to road transport and cars (EEA, 2022). Recent years have brought a wide range of innovations with regard to propulsion (e.g., electric mobility; Noppers et al., 2019) and new mobility solutions (e.g., car sharing; Gössling, 2018). Looking to the future, much hope is being placed in new technologies such as autonomous driving (Benleulmi & Ramdani, 2022;

* Corresponding author.
E-mail addresses: Michael.bissel@campus.tu-berlin.de (M. Bissel), Sophia.becker@tu-berlin.de (S. Becker).

https://doi.org/10.1016/j.trf.2023.12.018
Received 31 May 2023; Received in revised form 20 December 2023; Accepted 25 December 2023
Available online 18 January 2024

Yigitcanlar et al., 2022). However, scholars stress that it is not self-evident that these technological approaches will radically decarbonize the mobility sector (Lange & Santarius, 2020; Vergragt & Brown, 2007). For instance, car sharing could function as a "gateway drug" to car ownership (Giesel & Nobis, 2016) and production of cars alone is resource intensive (Bieker, 2021). Furthermore, cars are associated with additional environmental, social, and economic drawbacks such as land use, accidents as well as noise and air pollution (Shaheen et al., 2004; Urry, 2004). Thus, it seems useful to not only reduce the trips and distances traveled by car but also the number of private cars (Rammler, 2018). However, current data show the trend moving in the opposite direction, as passenger cars in the EU recently increased by almost 9 % in five years (Eurostat, 2022). Promoting sustainable alternatives outside of the "automobility system" (Urry, 2004) therefore appears reasonable.

1.1. Cargo bikes as a potential substitute for private car ownership

One approach to reach this objective is to promote the diffusion of cargo bikes (CBs). CBs are special bicycles for transporting goods or children (S. Becker & Rudolf, 2018a). These use cases are typical reasons for choosing cars (Carracedo & Mostofi, 2022). Studies indicate that (electric) CBs lie between bikes and cars in terms of important attributes such as cost, payload, and range (Gruber et al., 2014). For these reasons, CBs are considered a promising alternative to car use and ownership (Börjesson Rivera & Henriksson, 2014; Pearce, 2016). As an illustrative example, a research project on CBs in logistics was named "I replace a car" (Gruber et al., 2014). In recent years, popularity of CBs increased and a number of cargo bike sharing (CBS) operators emerged that facilitate the use of CBs (S. Becker & Rudolf, 2018b).

1.2. Understanding motives of transport choices can inform behavior change interventions

From a psychological perspective, investigating underlying motives for mobility decisions is helpful to understand drivers of behavior and barriers to behavior change (Steg, 2005). In previous research, instrumental, affective, symbolic and environmental motives for transport mode choice were differentiated (Noppers et al., 2014; Steg, 2005). Understanding motives is particularly relevant for the adoption of sustainable innovations (Noppers et al., 2015). Apparently, CBs and CBS fall into this category (Hess & Schubert, 2019). An established research approach consists of directly comparing alternative transport modes with cars on underlying motives (Anable & Gatersleben, 2005; Steg, 2003).

1.3. Research gaps and objectives

This paper contributes to closing two major research gaps. Firstly, to the best of our knowledge, there is so far no empirical research that investigates the impact of CBs and particularly CBS on actual car ownership. This is especially noteworthy in view of numerous studies focusing on the impact of car sharing on car ownership which forms the most widespread form of shared mobility (cf. Section 2.1). Respective research in the CB context is confined to the potential of CBS for car trip substitution (S. Becker & Rudolf, 2018a) as well as stated considerations of CB owners to reduce car ownership (Riggs, 2016). Investigating the impact of CBS rather than privately owned CBs on car ownership seems especially worthwhile in view of the existing research strand on car sharing and shared mobility as well as its potential indirect effect via the promotion of CBs (cf. Section 2.2).

Secondly, there are no studies to date that analyze underlying motives for using CBs in dedicated comparison to private cars. This comparison, however, is relevant because the latter is the predominant form of personal mobility in many industrialized countries (P. Jones, 2011). Also, this "gap analysis" is regarded useful for developing people-centric policies (Anable & Gatersleben, 2005; Steg, 2003).

The objective of this paper is to help fill these research gaps by analyzing the results of a large-scale survey conducted with CBS users. On this empirical basis, we firstly analyze the impact of CBS on car ownership by transferring an approach from the car sharing context to the novel area of CBS (Firnkorn & Müller, 2012). Afterwards, we analyze motives for using CBs in comparison to private cars building on the described approach from traffic psychology (Steg, 2003). In doing so, we investigate discrepancies between the perception of CBs and cars in general as well as between different subgroups of our sample (Anable & Gatersleben, 2005). Precisely, we contrast the ratings of car-dependent individuals and participants that reduced car ownership in the context of CBS. Thus, the following research questions are elaborated:

1) To what extent does cargo bike sharing influence car ownership of users?
2) How do individual motives for using cargo bikes differ from motives for using cars?
3) How do motives differ between car-dependent individuals and those who reduced car ownership?

2. Literature review

The present paper draws on and integrates three strands of research. These are research on car dependency and shared mobility, CBs and CBS as well as motives for mobility decisions.

2.1. Car dependency and shared mobility

Intense car use in industrialized countries traces back to mass motorization in the second half of the 20th century (D. W. Jones,

2008). Car use is related to benefits and drawbacks for individuals and the society (P. Jones, 2011). Regarding greenhouse gas (GHG) emissions, for instance, living car-free represents the largest household-level mitigation lever (Ivanova et al., 2020). Yet, several factors "lock-in" patterns of car use and ownership (Geels, 2012; Gössling, 2017). In this context, the term "car dependency" was coined. Building on Jones (2011), Gössling (2017) distinguishes "real" car dependency, driven by instrumental barriers, from "perceived" car dependency caused by affective and symbolic aspects.

Against this background, the provision of more environmentally friendly but also safe and comfortable alternatives to private cars is deemed necessary which also includes first and last mile connectivity with other existing transport modes (Kumar & Sinha, 2022). High expectations are placed on shared forms of mobility (Giesel & Nobis, 2016; Gössling, 2017) which could support less car-dependent lifestyles (Martin et al., 2010). Several studies examined the car ownership impact of car sharing (Tarnovetckaia & Mostofi, 2022). In one of the first studies, Firnkorn and Müller (2012) identified a car ownership reduction of 4.7 % to 11.4 %. Subsequent research yielded similar results with reductions of 5.2 % to 15 % (H. Becker et al., 2018; Giesel & Nobis, 2016; Stocker et al., 2016) or 9 to 20 private cars per shared vehicle (Jochem et al., 2020; Martin et al., 2010). Among the highest estimates is the finding that 37 % of car sharing users were impacted regarding car ownership, which, however, was largely due to decisions against buying a car (Le Vine & Polak, 2019). Besides that, negative side-effects of car sharing such as the threat of substituting more sustainable transport modes must be considered (Tarnovetckaia & Mostofi, 2022).

2.2. Cargo bikes and cargo bike sharing

The history of CBs is intertwined with the invention of bicycles. CBs were particularly popular in the first half of the 20th century. With the onset of mass motorization, their spread declined. After a second wave in the 1970s and 80s, the recent third wave was fueled by factors such as the climate crisis and technological improvements (S. Becker & Rudolf, 2018a; Ghebrezgiabiher & Poscher-Mika, 2018). In view of the environmental challenges of the car-centric transport system, a growing role of CBs is seen as promising. For instance, in a "radical transport vision" outlined in the context of car dependency, Gössling envisions that "most transports are covered by electric cargo bikes" (2017, p. 228).

With regard to shared mobility, collective use through CBS is attractive for users due to high purchase prices of own CBs, lack of parking space, or irregular demand (Dorner & Berger, 2020; Ghebrezgiabiher & Poscher-Mika, 2018). A widespread concept is "commons cargo bikes" which describes free (or donation-based) CBS offered by more than 165, mostly German, initiatives listed in the "commons cargo bikes forum" in cooperation with local hosts (S. Becker & Rudolf, 2018a; Forum Freie Lastenräder, 2023). For a more detailed description of the concept of commons cargo bikes (also referred to as Free Cargo-Bikesharing) see Becker & Rudolf (2018a). A broader overview of the different types of CBS is provided by Becker & Rudolf (2018b).

Despite the great potential, research on CBs has so far been limited (Hess & Schubert, 2019; Riggs, 2016). Existing studies have examined user structure and behavior of (shared) CBs as well as their impact on mobility behavior. Research found that CBS tend to be rather used by men, higher educated individuals and cyclists (S. Becker & Rudolf, 2018a; Hess & Schubert, 2019). Moreover, the role of CBS for first contacts and testing is emphasized (S. Becker & Rudolf, 2018a; Dorner & Berger, 2020). Studies consistently show a high potential for CBs to substitute car trips (S. Becker & Rudolf, 2018a; Riggs, 2016). Finally, Riggs (2016) reported in an earlier issue of this journal that 62 % of CB owners considered shedding a car as a result of CB ownership – although data on actual car ownership reductions were not collected. A comprehensive literature review was recently provided by Carracedo and Mostofi (2022).

2.3. Motives for mobility decisions

The central assumption of motives is that a means of transport fulfills more than only instrumental functions for the users (Steg, 2005; Steg et al., 2001). It is expected that consumers whose decisions are shaped by a particular motivational dimension would focus primarily on the respective attributes (Schuitema et al., 2013). While mobility research has long focused on instrumental attributes, the importance of non-instrumental factors is emphasized in psychological research (Anable & Gatersleben, 2005; Noppers et al., 2014; Steg, 2005). Building on Dittmar's (1992) model of material possessions, Steg (2005) differentiates symbolic and affective motives in addition to instrumental motives. Notably, these dimensions correspond to the influencing factors of car dependency (Gössling, 2017). In later work, environmental motives were highlighted for sustainable mobility (Noppers et al., 2014).

2.3.1. Instrumental motives

Instrumental attributes describe functional outcomes derived from ownership or use of a vehicle. These outcomes can be positive or negative and thus result in convenience or inconvenience. Examples include speed, flexibility or safety (Noppers et al., 2014, 2015; Steg, 2005; Steg et al., 2001).

2.3.2. Affective motives

Affective motives are related to the emotions evoked by using a vehicle and thus to the effect on individual's mood (Steg, 2005). As Anable and Gatersleben (2005) argue, affective motives comprise negative (e.g., stress) and positive (e.g., pleasure) emotions.

2.3.3. Symbolic motives

Symbolic motives can be defined as outcomes on individual's (self-) identity and social status (Noppers et al., 2014). They also refer to people's expression of themselves and their values. Moreover, symbolic motives are related to the impact of social norms on individual decisions (Steg, 2005).

2.3.4. Environmental motives

Environmental motives are, among others, investigated in the context of sustainable innovations (i.e., electric cars) and directly refer to the environmental impact of vehicles. Thus, they are related to people's motivation to protect the environment with their consumption choices (Noppers et al., 2014).

2.3.5. Previous research

Motives were investigated with regard to cars in general (Steg, 2005), electric (Noppers et al., 2014; Schuitema et al., 2013) and autonomous vehicles (Benleulmi & Ramdani, 2022) as well as conventional bikes (Cepeda Zorrilla et al., 2019) and e-bikes (Simsekoglu & Klöckner, 2019a). Steg (2005) found that symbolic and affective motives are relevant predictors for commuter car use whereas instrumental motives were not significantly related. Non-instrumental motives were particularly valued by frequent drivers and persons with positive car attitudes. Similarly, intention to adopt electric vehicles was found to be related to symbolic and environmental attributes, but not to instrumental attributes (Noppers et al., 2014). However, an indirect effect of the latter mediated by symbolic and affective factors was found. This finding demonstrates the interrelatedness of instrumental and non-instrumental aspects (Schuitema et al., 2013).

Comparing private cars to public transport, Steg (2003) showed that cars are evaluated more favorably than public transport on nearly all attributes (esp. convenience, independence, and flexibility) except traffic safety. Anable and Gatersleben (2005) found that car users rate cars more favorably than other modes on the instrumental attributes most important to them (i.e., convenience and flexibility) but less favorably on less important attributes. Users of non-motorized modes, however, were found to be similarly or more satisfied with their mode of transport for work journeys (Anable & Gatersleben, 2005).

Finally, one study applied the approach of examining underlying motives to CBS. Dorner and Berger (2020) showed that affective motives are correlated with the intended usage frequency for users as well as non-users. In contrast, differences were found between both groups regarding instrumental and symbolic motives. In view of aspects that were categorized as instrumental, health and easy parking were relevant predictors for users, whereas saving time and money was relevant for non-users. Also, with regard to motives defined as symbolic, different aspects are relevant for users (showing their own environmentally friendly behavior) as well as non-users (being recognized by others; Dorner & Berger, 2020).

3. Hypotheses

Based on the reviewed research, hypotheses were formulated for each of the three research questions. Firstly, research question 1 addresses the car ownership impact of CBS. Due to the novelty of this issue and the exploratory nature, we cannot derive substantiated hypotheses on the magnitude of this effect. It can only be assumed that the numbers reported by Riggs (2016) are significantly higher than the effect to be found here due to intention-behavior gaps (Sheeran & Webb, 2016) and because CBS users rather than CB owners are investigated in the present study. However, a hypothesis can be formulated about how car ownership reduction occurs. Based on previous research (Firnkorn & Müller, 2012; Le Vine & Polak, 2019; Stocker et al., 2016) in combination with general behavioral tendencies of keeping the status quo of possessions (Kahneman et al., 1991) it is expected that most reductions result from "passive" actions such as decisions of not buying a car. This hypothesis refers to different "routes" of car ownership reduction which are described in more detail in Section 4. Thus, the first hypothesis is:

H1: The largest share of car ownership reduction induced by CBS can be attributed to individuals without an own car deciding against purchasing a car.

Secondly, in terms of research question 2 addressing overall ratings of CBs and cars, research indicates that instrumental, affective and symbolic motives are in principle relevant for CB use (Dorner & Berger, 2020). Moreover, affective aspects are important for cycling (Anable & Gatersleben, 2005) and symbolic motives for sustainable innovations (Noppers et al., 2014). The latter particularly applies to early adopters (Noppers et al., 2015) which CBS users represent for CBs (S. Becker & Rudolf, 2018a). CBs are also rated positively in terms of price and environmental friendliness (Dorner & Berger, 2020) which corresponds to findings on bicycles compared to cars (Anable & Gatersleben, 2005). However, in direct comparisons, cars are typically rated superior to other modes on instrumental aspects such as comfort, flexibility and speed (Anable & Gatersleben, 2005; Steg, 2003). Moreover, safety and weather protection were identified as potential weaknesses of CBs (Dorner & Berger, 2020; Hess & Schubert, 2019). Against this background, one main hypothesis and three directed sub-hypotheses were formulated:

H2: CBS users rate CBs superior to cars on some aspects but inferior on others.

H2a: CBS users rate CBs superior to cars with regard to price.

H2b: CBS users rate CBs inferior to cars on all instrumental attributes other than price.

H2c: CBS users rate CBs superior to cars on affective, symbolic and environmental attributes.

Finally, with regard to research question 3, hypotheses on group differences can be derived. Specifically, we expect differences between car-dependent individuals on the one hand and participants that reduced car ownership, at least partly due to CBS, on the other. This is based on the assumption that car-dependent individuals perceive stronger or additional benefits from car use (Anable & Gatersleben, 2005; Steg, 2003, 2005). At the same time, individuals that reduced car ownership rely more strongly on CBs (and other transport modes) and are therefore expected to perceive no or smaller "gaps" to cars. Regarding the rating of CBs, this particularly refers to instrumental barriers such as safety which were found to be less pronounced for active users (Hess & Schubert, 2019). With regard to the rating of cars, car dependency is related to either instrumental or affective and symbolic aspects of cars (Gössling, 2017) which informs hypothesis H3b. Lastly, regarding environmental aspects, CBS users were found to be characterized by strong pro-environmental values (S. Becker & Rudolf, 2018a). As we expect this to be more pronounced for individuals that reduced car

ownership, it is assumed that this results in more polarized ratings for this group. Thus, the following hypotheses on group differences are tested:

H3: Ratings of car-dependent participants differ significantly from ratings of participants that reduced car ownership in the context of CBS usage.

H3a: Individuals that reduced car ownership rate CBs better on instrumental attributes compared to car-dependent participants.

H3b: Car-dependent participants rate cars better than individuals that reduced car ownership with regard to instrumental, affective and symbolic aspects.

H3c: Individuals that reduced car ownership rate CBs more and cars less positive on environmental aspects compared to car-dependent individuals.

4. Material and methods

To test these hypotheses, a survey with CBS users was conducted. To reach as many CBS users as possible, we collaborated with the commons cargo bikes network which comprises local initiatives in different geographical contexts (cf. Section 2.2). Our sample therefore consists of individuals who are experienced with using CBs. It is neither intended to be representative for the German population nor for CB owners. However, in view of the relatively low market penetration of CBs (Dorner & Berger, 2020), this approach enabled us to examine the motives of a large number of individuals who are well qualified to evaluate CBs. The user survey was part of a larger research project focusing on commons cargo bikes as a social innovation which is described in more detail by Bissel & Becker, (2023).

4.1. Procedure

The study was carried out following three overarching steps. These stages are summarized in the flow chart in Fig. 1. In a first step, the research questions were defined and the questionnaire was developed. The survey was co-created with the commons cargo bikes network's national spokespersons to refine the research objectives, agree on the procedure and timeline, and to ensure that the questionnaire is clearly understandable for participants (Spekkink et al., 2022). To do so, meetings with the network's spokespersons were conducted between March and May 2022. This process was guided by principles of transdisciplinary research (Lang et al., 2012) and was essential to reach local initiatives and their users as effectively as possible.

Secondly, the authors hosted or participated in a number of events to inform the local CBS initiatives about the survey and to ask them to join the study by spreading the questionnaire among their registered users. This step was necessary due to the decentralized structure of the commons cargo bike network (S. Becker & Rudolf, 2018a). Different formats were used to maximize the number of participating initiatives. This included two online information sessions, a presentation at the network's annual meeting in June 2022 in Münster (Germany), an e-mail to all initiatives as well as a blog post in the network's online forum.

In a third step, all initiatives that agreed to participate in the research project received the link to the online survey together with a mail template and were asked to forward it to all registered users. The participating local initiatives distributed the survey link via e-mail, websites as well as on social media. The online platform SoSci Survey was used for data collection. The individual survey participants were able to contact the study authors directly in case of questions regarding the questionnaire. The participants had the chance to win one of ten gift cards worth €50 each for an online store selling sustainable products. Data collection took place from June 11 to August 21, 2022. Reminders were sent to the initiatives which included the request to remind their registered users to take part.

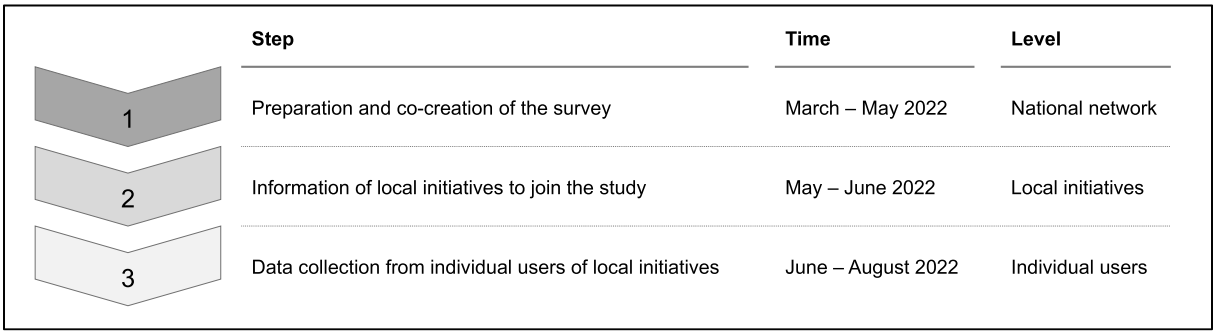

Fig. 1. Flow chart of the study procedure.

Table 1
Overview of questionnaire items.

Category	Description	No. of items	Primary source
CBS experience	Past experience with CBS (e.g., number of trips, trip length, city and initiative)	7	Becker & Rudolf, 2018a
Mobility behavior	Means of transport in household, main transport mode	6	Becker & Rudolf, 2018a
Motives	Importance of motives and ratings of cars and CBs on each attribute	48	Anable & Gatersleben, 2005
Car ownership reduction	Past car ownership reduction and impact of CBs and (if applicable) own CBs	2–6	Firnkorn & Müller, 2012
Car ownership reduction reasons	General reasons to live car free (e.g., financial reasons)	5	Anable, 2002
Intentions	Intentions to use CBs as well as to reduce car ownership[1]	6	Becker & Rudolf, 2018a
Socio-demographic information	Socio-demographic variables (e.g., age and gender)	4	Becker & Rudolf, 2018a

Note: Order of categories based on structure of the questionnaire. [1] Intentions measured with five-point Likert scales from *disagree* to *agree*, building on recommendations by Fishbein and Ajzen (2009).

4.2. Study design and measures

The online questionnaire consisted of 11 pages. Routing rules were implemented so that participants saw only questions relevant to them. The items analyzed in this study fall into seven categories. An overview is included in Table 1 while details on the main concepts are provided below the table. Wherever possible, relevant items were adapted from previous research in order to allow for comparisons.

4.3. Motives

A two-part measurement instrument was used which comprises ratings of importance as well as experience / performance (Anable, 2002; Anable & Gatersleben, 2005). Users were asked to rate importance first by asking "How important are the following attributes to you in a transport mode?". Afterwards they were asked to rate "an own cargo bike" as well as "an own car" on these attributes on a separate page. The overarching question was "To what extent do you agree with the statements below regarding the following two transport modes?". The attributes were preceded by the phrase "The transport mode is …". All items were measured with five-point Likert scales ranging from *very unimportant* to *very important* (importance rating) or *disagree* to *agree* (experience / performance rating). The item order was randomized separately for each section. Relevant attributes were selected based on a literature review of 18 publications on motives and related constructs. These publications focused on:

- Cars (Anable, 2005; Noppers et al., 2014, 2015, 2019; Steg, 2005; Steg et al., 2001)
- CBs (S. Becker & Rudolf, 2018a; Börjesson Rivera & Henriksson, 2014; Dorner & Berger, 2020; Gruber et al., 2014; Gruber & Rudolph, 2021; Hess & Schubert, 2019; Riggs, 2016; Riggs & Schwartz, 2018; Rüdiger et al., 2016)
- E-bikes (Simsekoglu and Klöckner, 2019b)
- Multiple modes of transport (Anable & Gatersleben, 2005; Steg, 2003).

Building on this review, 16 attributes were included (see Section 5.2). Inclusion decisions were made based on frequency of use of the attributes in the reviewed studies as well as fit to our study context.

4.3.1. Car ownership reduction

With respect to car ownership actions, we built on Firnkorn and Müller's (2012) work on car sharing that differentiated four routes of car ownership reduction. Namely, car owners may reduce the number of cars in their household or forgo the replacement of a car while individuals without a private car might have abolished a previously possessed vehicle or decided against purchasing a car. Thus, we included four questions to analyze car ownership actions of which two were included in the questionnaire based on respondents' information on car ownership. The precise questions are included in Fig. 3. Moreover, to assess causal relationships, we added questions asking participants to rate the impact of CBS on each of these decisions if one or both of them were marked with yes. Depending on participants' information on CB ownership, the equivalent questions were included for own CBs. The impact was measured on five-point scales from *not at all* to *very strong*.

4.4. Data analyses and sample description

4.4.1. Data analyses

Analyses of the survey data were performed using the R statistics program. In a first step, two new variables for research question 1 and 3 were computed. With regard to research question 1, we built on the approach to distinguish narrow and broad causality of car ownership reduction which has been established in research on car sharing (Firnkorn & Müller, 2012). Thus, a new variable distinguishing narrow and broad causality was calculated for all participants that reduced car ownership. For the present study, narrow causality is defined as participants stating that CBS had a strong or very strong impact on their respective car ownership decision. Broad causality is also fulfilled if participants indicate only a weak or medium impact. Moreover, since one purpose of CBS is to enable testing (S. Becker & Rudolf, 2018a), we also assume broad causality if CBS is (at least weakly) associated with the purchase of an own CB that in turn results in car ownership reduction.

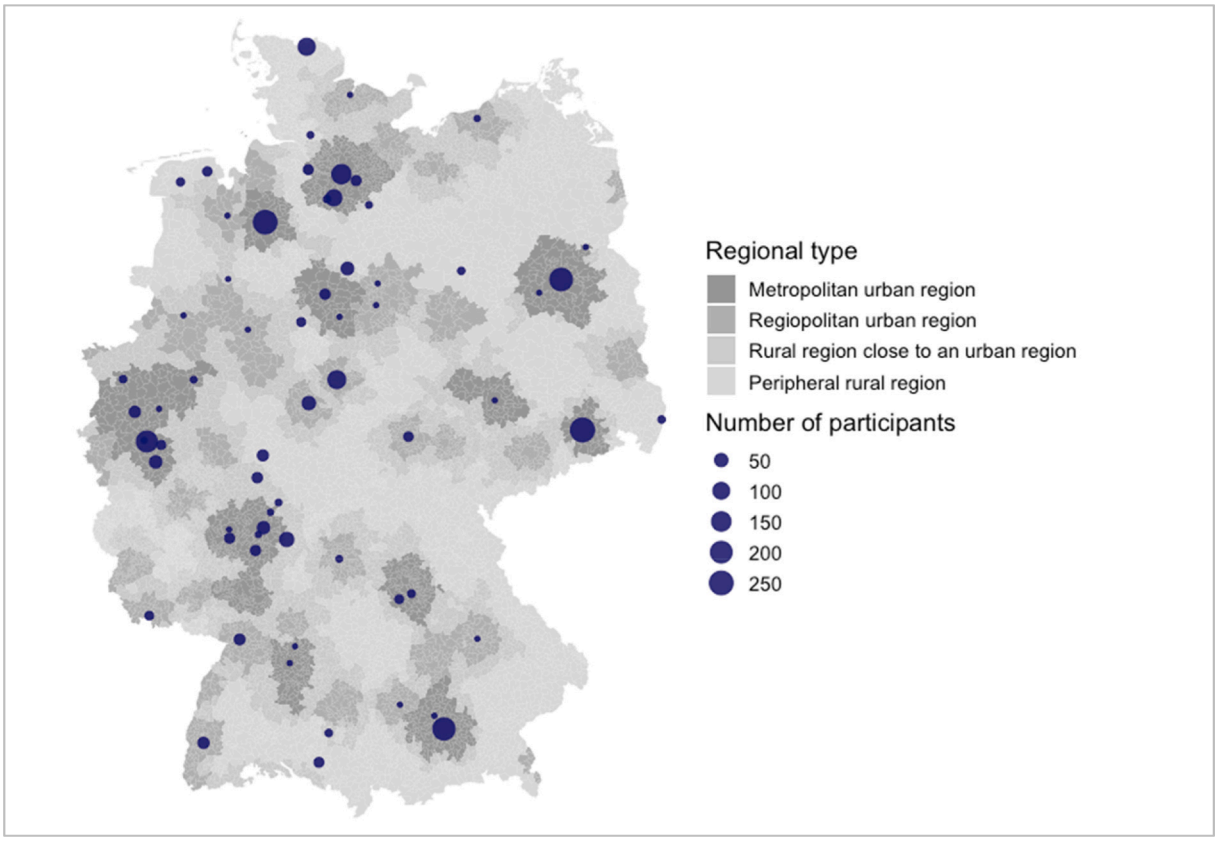

Fig. 2. Geographic overview of the sample.

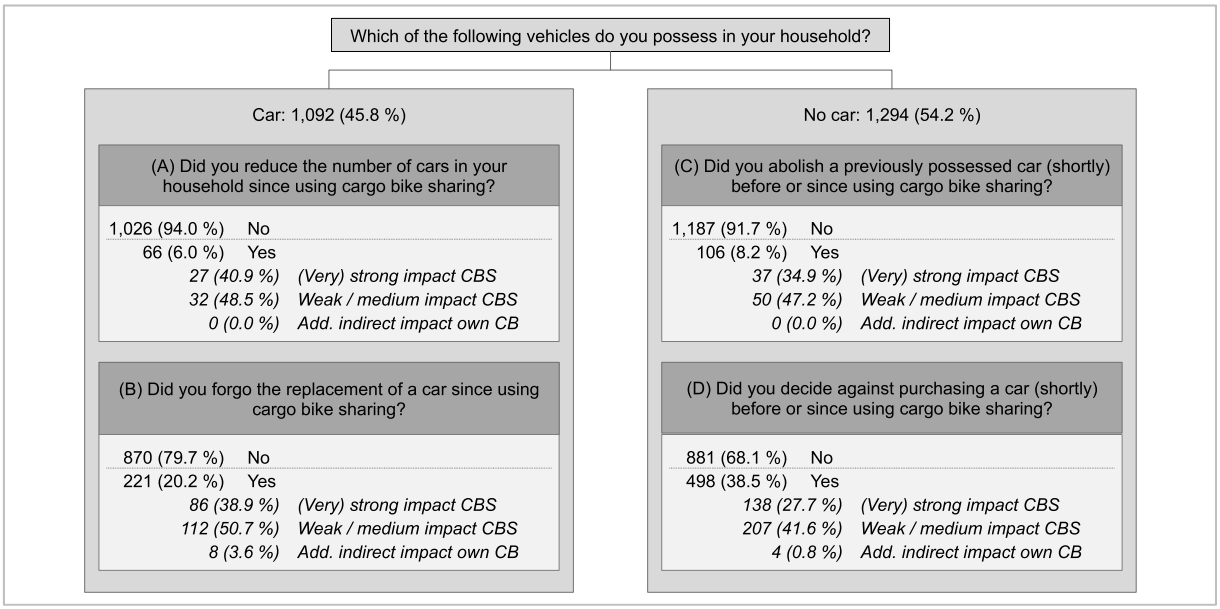

Fig. 3. Impact of CBS on vehicle possessions in the active sample.

Regarding research question 3, criteria for two subgroups were defined. As stated earlier, "car-dependent" users are of particular interest for this research question. For the purpose of this study, car dependency is operationalized as individuals indicating a car as their main transport mode. This operationalization does comprise different types of car dependency (Gössling, 2017). In parallel, the subgroup of individuals that reduced car ownership, at least partly due to CBS, was defined based on the "narrow causality" definition. This group was chosen as a comparator to investigate the "competitiveness" of CBs in the best case, that is, if individuals considered them as relevant to shed their cars. Both subgroups therefore make use of the within sample variance of our survey.

4.4.2. Sample description

Overall, 2,590 users from 58 initiatives completed the survey. These 58 initiatives provide 751 CBs and collectively have 87,766 registered users. A small group of 41 cases (1.6 %) were excluded based on three pre-defined quality criteria indicating low attention or effort. Namely, responses were assessed with regard to missing values (less than 90 % of relevant items answered), intra-individual response variability (identical responses on all 16 attributes in terms of importance and ratings of CBs and cars) as well as short time to complete the survey (less than 5 min). The latter was determined a priori based on feedback from a pre-test of the questionnaire. Thus, 2,549 responses remained in the cleaned sample. Of this cleaned sample, 163 individuals (6.4 %) had never used a CB. Although being registered for shared mobility services might in rare cases suffice to influence car ownership, causal relationships become more likely with active use (Firnkorn & Müller, 2012). For this reason, the 2,386 participants that used CBs at least once are defined as our active sample for further analysis.

With regard to demographics of the active sample, the average age is 41.6 years. Moreover, 42.8 % of participants indicated they were female whereas 53.9 % identified as male and 1.3 % stated they were diverse. 1.9 % of participants preferred not to answer. Regarding geographic spread, participants stem from different regions in Germany and various regional types (see Fig. 2). From 2,195 active users that selected a location, 73.2 % were located in metropolitan urban regions, 11.8 % in regiopolitan urban regions, 6.7 % in rural regions close to an urban region and 8.3 % in peripheral rural regions as categorized by the RegioStaR typology (BMVI, 2018). With respect to current car ownership, 45.8 % indicated having at least one car in their household while 54.2 % lived car-free (see Fig. 3).

5. Results

This section summarizes the results of the study in accordance with the order of the research questions.

5.1. Impact of cargo bike sharing on car ownership

To assess the influence of CBS on car ownership in line with research question 1, we analyzed the retrospective impact. This analysis builds on the different routes to car ownership reduction (Firnkorn & Müller, 2012) described before. As Fig. 3 shows, 66 users with at least one car in their household indicate having reduced the number of cars (A) and 221 users report having forgone replacement (B) since using CBS. In addition, 106 users without a car state that they abolished a previously possessed car (C) and 498 users report having decided against purchasing a car (shortly) before or since using CBS (D).

Building on these results, we calculated the number of cars that would be expected without CBS. Following Firnkorn and Müller (2012), forgoing replacements (B) is not counted as the purchase might only be postponed. Decisions against purchasing a car (D) are included which assumes that respondents were actively thinking about purchasing a car and would have done so otherwise. Thus, car ownership is reduced compared to a hypothetical alternative scenario. Also, of all the cases in Fig. 3, 75 users indicated both having abolished a car (C) as well as decided against purchasing a car (D). Thus, a correction is necessary to avoid double counting. This affects 64 (broad causality) and 26 cases (narrow causality) respectively.

As can be seen in Table 2, there would be between 1,772 (broad causality) and 1,517 (narrow causality) cars within the active sample without CBS. For broad causality, the net reduction is thus estimated to be 431 cars, which corresponds to a share of 18.1 % compared to the active sample ($n = 2{,}386$). In analogy, for narrow causality, the net reduction of 176 cars corresponds to a quota of 7.4 %. In line with hypothesis H1, most car ownership reduction is due to individuals deciding against buying a car.

Table 2
Impact of CBS on car ownership in the active sample.

	Broad causality	Narrow causality
Current number of cars (with CBS)	1,341	1,341
Car - reduction	+ 59	+ 27
No car - reduction	+ 87	+ 37
No car - not purchased	+ 349	+ 138
Correction for double counts	− 64	− 26
Current possession of private cars if CBS was not offered	1,772	1,517
Car net reduction (incl. not purchased)	**− 431**	**− 176**
Projected percentage of active sample reducing car ownership by one car	**18.1 %**	**7.4 %**

Note: Number of cars also reflects multiple cars per household. Postponed replacements not included.

5.2. Understanding reasons and motives for using cars and cargo bikes

As multiple factors affect car ownership reduction, the analysis of underlying causes starts with five general reasons to live car-free (Anable, 2002). Of the 172 users who reduced the number of cars (A) or abolished a car (C), 80.0 % note that environmental protection (strongly) influenced their decision. 48.8 % report financial reasons and 42.4 % state no interest in driving a car as (strongly) influencing factors. Finally, 23.3 % name health reasons and 9.9 % risks of driving a car as (strong) influences.

5.2.1. Factor structure and importance of attributes

To better understand potential reasons (and barriers) that lead users to (not) reduce car ownership, we further analyzed the importance and rating of CBs and cars regarding motives. Firstly, a confirmatory factor analysis (CFA) was conducted to validate the four-factor structure consisting of instrumental, affective, symbolic and environmental motives. 15 items on attribute importance were categorized based on motive literature. To maximize theoretical grounding and statistical fit of the factor structure, one instrumental aspect (health) not included in the original studies (Steg, 2003, 2005) was dropped. Evaluation of fit indices reveals good overall model fit with a CFI of 0.923, RMSEA of 0.057 and SRMR of 0.051. Chi-square is significant, which can be expected in view of the large sample size (Hair, 2014). Thus, the factor structure was accepted based on established cut-off criteria (Hair, 2014; Hu & Bentler, 1999).

With regard to internal consistency of factors, Cronbach's alpha indicates high consistency for environmental attributes (cf. Table 3). While the score for symbolic attributes is also satisfactory, values for instrumental and affective attributes are rather moderate. This may be caused by a small number of items or heterogeneity within the constructs (Tavakol & Dennick, 2011), which will be discussed later in this article. Nevertheless, these values are also often considered sufficient in research (Taber, 2018).

Interrelatedness between factors was tested with correlation analyses (cf. Table A1 in the Appendix). All factor means are positively correlated with weak to moderate correlation coefficients. This implies a low risk of multicollinearity. The strongest correlation was found between instrumental and affective attributes, $r(2,384) = 0.40$, $p < .001$, which is in line with the CFA (cf. Fig. A1 in the Appendix).

The analysis of overall importance ratings (cf. Table 3) shows that environmental aspects are considered most relevant by respondents when it comes to transport modes. On average, affective attributes are ranked second most important with little variance between the three assessed attributes. For instrumental attributes, the results indicate varying importance with flexibility ranked most important and weather-independence less important. Finally, users consider symbolic attributes to be least important.

To verify the importance of motives, correlation analyses were conducted based on factor means of CB and car ratings. In the case of CBs, positive relations between instrumental ($r(2,382) = 0.20$, $p < .001$), affective ($r(2,382) = 0.30$, $p < .001$), symbolic ($r(2,382) = 0.14$, $p < .001$) as well as environmental ($r(2,382) = 0.08$, $p < .001$) ratings of CBs and intention to use CBs are found. For cars and car owners, analyses reveal negative relations for instrumental ($r(1,087) = -0.25$, $p < .001$), affective ($r(1,087) = -0.23$, $p < .001$), and environmental ($r(1,087) = -0.11$, $p < .001$) attributes of cars and the intention to shed cars. Thus, better ratings of cars are related to less intention to reduce car ownership. However, there is no significant correlation with this intention for symbolic motives ($r(1,087) = -0.03$, $p = .371$). To assess the relationship of each factor after controlling for the others, regression analyses were conducted (cf. Table A2 in the Appendix). These analyses highlight the role of affective attributes for CB use as well as the importance of instrumental and, to a lesser extent, affective motives for decisions against car ownership reduction.

Table 3
Descriptive statistics of importance ratings.

Dimension	Attribute	*M*	*SD*	Cronbach's α
Instrumental		**3.86**	**0.49**	**.56**
	Flexibility	4.52	0.64	
	Low price	4.06	0.88	
	Traffic safety	4.05	0.87	
	Travel speed	3.73	0.94	
	Comfort	3.62	0.87	
	Weather-independence	3.18	0.98	
Affective		**4.08**	**0.63**	**.55**
	No stress	4.20	0.75	
	Freedom	4.02	1.00	
	Pleasure	4.01	0.86	
Symbolic		**2.34**	**0.90**	**.69**
	Part of movement	2.61	1.19	
	Social recognition	2.35	1.14	
	Self-expression	2.04	1.11	
Environmental		**4.45**	**0.71**	**.89**
	Environment friendly	4.53	0.72	
	Resource conservation	4.44	0.79	
	Low GHG-emissions	4.39	0.83	

Note: Based on the question "How important are the following attributes to you in a transport mode?". Scale ranging from 1 (very unimportant) to 5 (very important).

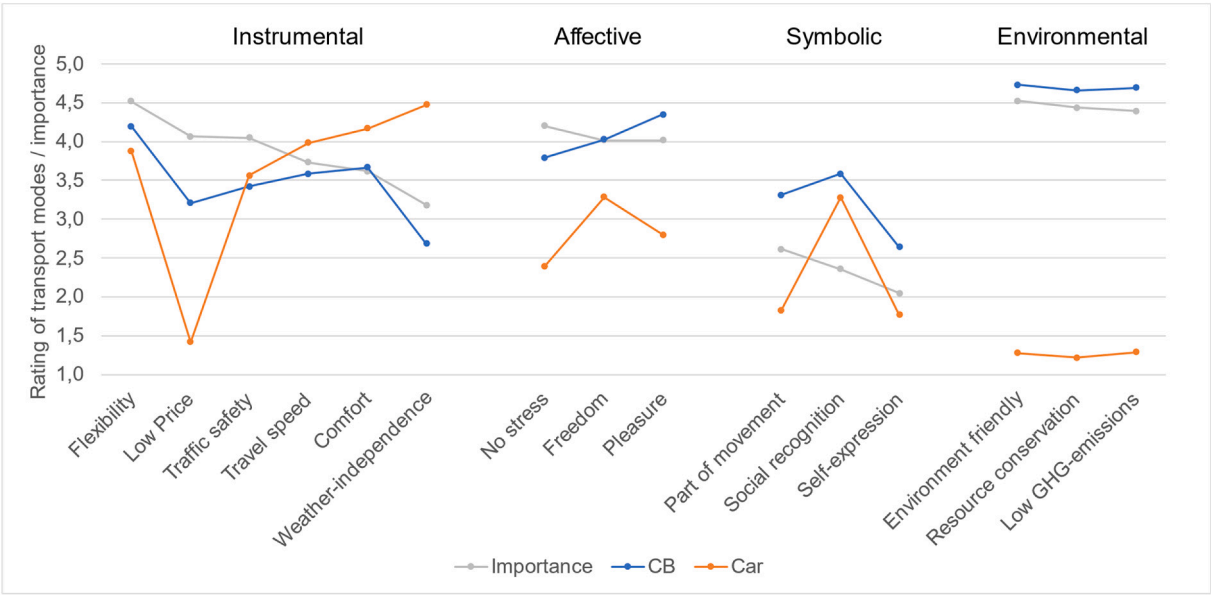

Fig. 4. Ratings of CBs and cars with regard to different motives.

5.2.2. Overall evaluation of cars and cargo bikes

With regard to research question 2, comparing the ratings of CBs and cars among all participants reveals a nuanced pattern that is summarized in Fig. 4. Due to the ordinal scales, Wilcoxon signed-rank tests were used to test for statistical significance. Effect sizes were calculated following Field et al. (2014) and were interpreted based on cut-off values proposed by Cohen (1992). As significance tests were conducted individually and analyses were independent from each other, alpha levels were not adjusted (Rubin, 2021).

Firstly, referring to hypothesis H2a, CBs are rated superior in direct comparison with cars in terms of price, $z = 36.82$, $p < .001$, with a large effect size, $r = 0.53$. With regard to hypotheses H2b, cars are rated more positively than CBs on four instrumental attributes: traffic safety (z = -4.81, $p < .001$, $r = 0.07$.), travel speed (z = -13.05, $p < .001$, $r = 0.19$), comfort (z = -17.47, $p < .001$, $r = 0.25$) as well as weather-independence (z = -36.11, $p < .001$, $r = 0.52$). The effect sizes indicate at most small effects, with the exception of a large effect for weather-independence. In contrast, and in contradiction with hypothesis H2b, CBs are considered more flexible than cars, $z = 10.89$, $p < .001$, with a small effect size, $r = 0.16$.

Regarding hypothesis H2c, CBs get better ratings than cars on all affective, symbolic and environmental attributes. With regard to affective aspects, CBs are rated superior on no stress ($z = 32.77$, $p < .001$, $r = 0.47$), freedom ($z = 21.22$, $p < .001$, $r = 0.31$) as well as pleasure ($z = 34.63$, $p < .001$, $r = 0.50$). Notably, the rating for cars on freedom is relatively high compared to the other two attributes which results in a smaller gap, even though the effect size still represents a medium effect. Similarly, for symbolic aspects, CBs are perceived superior on all aspects: whether it is about being part of a movement ($z = 32.92$, $p < .001$, $r = 0.48$), getting social recognition ($z = 8.94$, $p < .001$, $r = 0.13$) or self-expression ($z = 25.24$, $p < .001$, $r = 0.37$). Strikingly, due to relatively positive ratings of cars compared to the other two symbolic attributes, the gap for social recognition is rather narrow with a small effect size, while a medium effect is found for the other attributes. Finally, CBs are rated very positively on all three environmental aspects and more positively than the ascribed importance. In contrast, cars get the most negative evaluations among all aspects which results in large effect sizes. This applies to all attributes, namely environmental friendliness ($z = 43.52$, $p < .001$, $r = 0.63$), resource conservation ($z = 43.48$, $p < .001$, $r = 0.63$) and low GHG-emissions ($z = 43.42$, $p < .001$, $r = 0.63$).

5.3. Group differences with regard to motives for using cargo bikes and cars

In line with the third research question, group differences regarding motives for using CBs and cars were analyzed to investigate why specific groups do (not) reduce car ownership in view of CBs. Specifically, the first group ("car reduced") consists of individuals who were impacted by CBS regarding car ownership with narrow causality (see Table 2). The second group ("car-dependent") comprises those users who indicated cars as their main transport mode (cf. Section 4.2). As two users fulfilled both criteria, their answers were excluded. This resulted in $n = 174$ "car reduced" and $n = 186$ "car-dependent" participants.

Table 4 summarizes characteristics of both groups. The groups do not differ significantly with regard to gender and regional types. Regarding age, car-dependent participants were found to be significantly older. The effect size indicates a small effect, $d = 0.22$. Moreover, participants that reduced car ownership possess significantly more privately owned CBs. Unsurprisingly, the overall car ownership rate for individuals that reduced car ownership is significantly lower. The cars in this group are due to the reduction of cars in households with previously more than one car (group A in Fig. 3). In addition to the data in the table, group differences for CB use reveal more experience among respondents who reduced car ownership, X^2 (3, N = 360) = 26.42, $p < .001$. The effect size of $w = 0.27$

Table 4
Overview of group differences between "car reduced" and "car-dependent" participants.

Sample characteristic	Car reduced (n = 174)	Car-dependent (n = 186)	Significance
***Age** (Mean)*	41.5	43.8	$t(358) = -2.06, p = .040$
***Gender** (%)*[1]			X^2 (1, N = 350) = 1.21, $p = .272$
Female	38.5 %	45.7 %	
Male	56.9 %	53.2 %	
Diverse	1.7 %	0.0 %	
***CB ownership** (%)*	28.2 %	10.8 %	X^2 (1, N = 360) = 17.59, $p < .001$
***Car ownership** (%)*[2]	14.4 %	100.0 %	X^2 (1, N = 360) = 271.75, $p < .001$
***Regional type** (%)* [3]			X^2 (3, N = 332) = 6.37, $p = .100$
Metropolitan urban region	69.1 %	64.7 %	
Regiopolitan urban region	12.1 %	8.4 %	
Rural region close to an urban region	7.3 %	15.6 %	
Peripheral rural region	11.5 %	11.4 %	

Note: 1. Chi-Square test based on female and male participants only, due to low frequencies in other cells; N/A not listed in table. 2. Households with at least one car. 3. Participants without specified location excluded (9 for "car reduced", 19 for "car-dependent").

indicates a small, near-medium effect.

The results on motive differences between the two groups are plotted in Fig. 5. Group differences for one of the modes were tested on significance with Wilcoxon rank-sum tests. Regarding hypothesis H3a (rating of CBs on instrumental attributes), the blue lines in Fig. 5 reveal better ratings for CBs by users that reduced car ownership compared to car-dependent participants. Differences are statistically significant for flexibility (z = -5.97, $p < .001$, $r = 0.31$), price (z = -6.63, $p < .001$, $r = 0.35$), travel speed (z = -5.57, $p < .001$, $r = 0.29$), comfort (z = -3.86, $p < .001$, $r = 0.20$), and weather-independence (z = -5.63, $p < .001$, $r = 0.30$). Effect sizes indicate small to medium effects. The effect for traffic safety is not statistically significant, z = -1.82, $p = .069$., $r = 0.10$. In addition, with regard to the four instrumental attributes on which cars were rated superior overall (cf. Fig. 4), results show a different pattern for users that reduced car ownership (dashed lines). For this group, differences between modes are less pronounced for weather-independence (z = -8.66, $p < .001$, $r = 0.46$), not significant for speed ($z = 0.20$, $p = .843$, $r = 0.01$) as well as comfort (z = -0.86, $p = .390$, $r = 0.05$), and reversed for traffic safety ($z = 2.48$, $p = .013$, $r = 0.13$).

In terms of hypothesis H3b, which assumes superior ratings for cars on instrumental, affective and symbolic aspects by car-dependent participants, the orange lines in Fig. 5 reveal better ratings by this group for instrumental attributes. The effects are significant with small to medium effect sizes: flexibility ($z = 8.66$, $p < .001$, $r = 0.46$), price ($z = 4.82$, $p < .001$, $r = 0.25$), traffic safety ($z = 6.88$, $p < .001$, $r = 0.36$), travel speed ($z = 6.11$, $p < .001$, $r = 0.32$), comfort ($z = 6.17$, $p < .001$, $r = 0.33$), and weather-independence ($z = 5.40$, $p < .001$, $r = 0.28$). Secondly, car-dependent participants rate cars better on all affective attributes, with medium effect sizes: no stress ($z = 8.89$, $p < .001$, $r = 0.47$), freedom ($z = 6.56$, $p < .001$, $r = 0.35$), and pleasure ($z = 6.24$, $p < .001$, $r = 0.33$). For symbolic aspects, however, ratings do not differ between groups for "being part of a movement" ($z = 1.72$, $p = .086$, $r =$

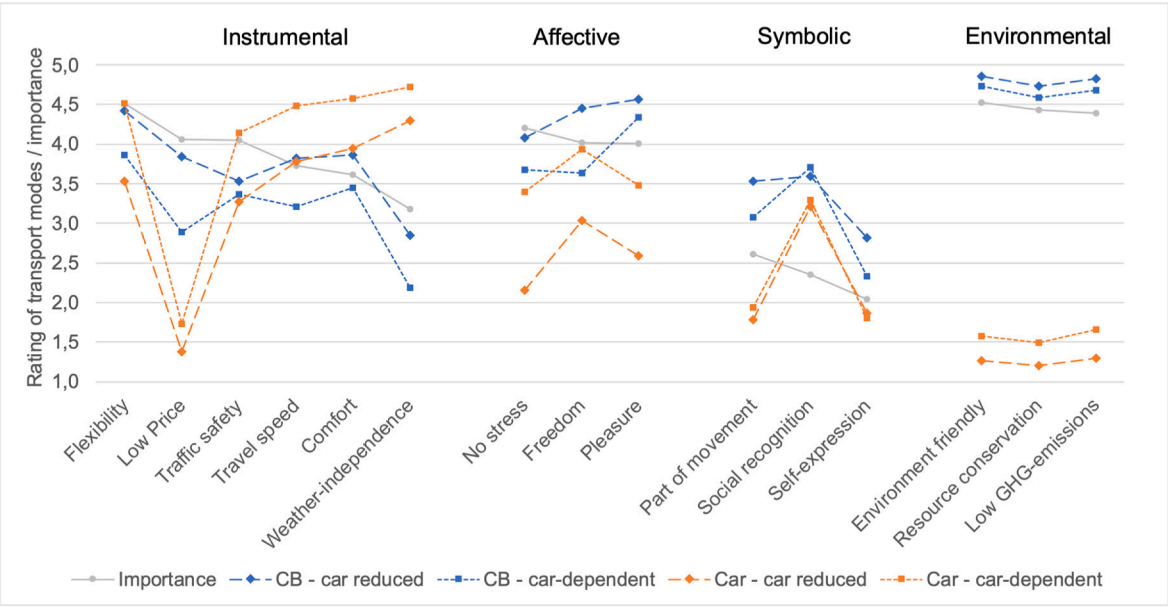

Fig. 5. Group differences with regard to transport mode ratings.

0.09), social recognition ($z = 0.63$, $p = .526$, $r = 0.03$), and self-expression ($z = 0.51$, $p = .612$, $r = 0.03$).

Regarding hypothesis H3c (polarized environmental ratings by users that reduced car ownership), CBs are indeed rated better by this group compared to car-dependent individuals. Significant differences and small effect sizes were found for environment friendliness ($z = -2.17$, $p = .030$, $r = 0.11$), resource conservation ($z = -2.55$, $p = .011$, $r = 0.13$), and GHG-emissions ($z = -2.64$, $p = .008$, $r = 0.14$). Conversely, the group rates cars as inferior compared to car-dependent individuals: environmental friendliness ($z = 5.11$, $p < .001$, $r = 0.27$), resource conservation ($z = 3.64$, $p < .001$, $r = 0.19$), and GHG-emissions ($z = 4.49$, $p < .001$, $r = 0.24$). Again, effect sizes can be classified as small effects.

Finally, an additional analysis reveals that car-dependent users prefer CBs over cars on many attributes. In fact, in addition to the four instrumental attributes on which cars are rated superior by the overall sample, they only prefer cars on flexibility ($z = -6.13$, $p < .001$, $r = 0.32$) and freedom ($z = -2.92$, $p = .004$, $r = 0.15$).

6. Discussion

In summary, regarding the first research question, the results of our study imply a substantial potential of CBs to contribute to car ownership reduction. We find evidence that car ownership is reduced by a rate corresponding to 7.4 to 18.1 % of the active sample due to CBS, depending on the causality definition. As expected in hypothesis H1, the largest share relates to users deciding against purchasing a car. However, a substantial number of participants also actively reduced car ownership.

Regarding reasons for car ownership reduction, environmental concerns, financial aspects as well as lack of interest in driving were identified as most relevant reasons. Referring to research question 2, these reasons are reflected in drawbacks of cars compared to CBs on underlying motives. In short, CBs are rated superior by our overall sample on all but four (instrumental) attributes. The latter, however, represent the least important instrumental attributes. More precisely, CBs were rated more favorably on price as assumed in H2a. Unlike hypothesized in H2b, CBs were also rated superior on flexibility. The ratings on other instrumental attributes correspond to hypothesis H2b. Thus, results are only partially in line with the hypothesis. The superior rating on environmental, affective and symbolic attributes corresponds to H2c.

With regard to the third research question, group comparisons between car-dependent individuals and users that reduced car ownership reveal diverging patterns as was hypothesized in H3. As expected in H3a, CBs are rated more favorable by users that reduced car ownership compared to car-dependent participants on instrumental attributes. This effect does not reach statistical significance for traffic safety. With regard to this attribute, it is however notable that those who reduced car ownership rated CBs superior to cars which does not apply to car-dependent respondents. This is in line with the general finding that the first group perceives CBs as more competitive regarding instrumental aspects on which discrepancies for the overall sample were found. In contrast, and in line with hypothesis H3b, car-dependent individuals rate cars better on instrumental and affective attributes. Inconsistent with this hypothesis, there are no significant differences for symbolic attributes. Thus, also hypothesis H3b is only partially supported. Notably, car-dependent individuals rate the flexibility of cars as superior to CBs and see the car, rather than the CB, as a symbol of freedom. Both does neither apply to respondents that reduced car ownership nor to the overall sample. Finally, and as hypothesized in H3c, individuals that reduced car ownership rate CBs more favorably and cars less favorably on environmental aspects compared to car-dependent users.

6.1. Theoretical implications

The results of this study complement and extend previous research on the impact of CBS as well as existing literature on motives for transport mode choices.

6.1.1. Impact of cargo bikes and cargo bike sharing

By providing insights on the car ownership impact of CBS, this study complements findings on car use substitution of CBS (S. Becker & Rudolf, 2018a). As expected, the reduction is substantially lower compared to findings on considerations of car ownership reduction by CB owners (Riggs, 2016). At the same time do results on users stating to have forgone the replacement of a car indicate further potential. It is notable that the car ownership reduction impact of CBS is higher than the impact of car sharing found, for instance, in the methodologically and geographically most similar study by Firnkorn and Müller (2012). It must be stressed, however, that this comparison is indicative and limited by differences in sample, methodology and time. Studies on car ownership reduction potential of car sharing were also found to be heterogenous with some reporting larger effects.

6.1.2. Motives for mobility decisions

Overall, as in previous studies (Dorner & Berger, 2020), motives were found to be a relevant predictor for the intention to use CBs. Also, instrumental, affective and environmental motives were related to intended car ownership reduction. As summarized, when directly compared to CBs in our sample, cars are not rated superior on (nearly) all aspects. This stands in contrast to previous studies on cars and public transport (Steg, 2003). Instead, user preferences of CBs over cars in terms of, inter alia, affective and environmental aspects share similarities with findings on active travel modes (Anable & Gatersleben, 2005). Among other explanations, the unexpected finding that CBs are rated superior on flexibility could support the notion that CBs enable users to reach places inaccessible by car (Hess & Schubert, 2019). It is noteworthy that flexibility has been identified as an essential attribute in prior studies, and cars typically score high on this dimension (Anable & Gatersleben, 2005; Steg, 2003). The deficits of CBs on some instrumental attributes correspond to previous findings for CBs and e-bikes (Carracedo & Mostofi, 2022; Hess & Schubert, 2019; Simsekoglu & Klöckner,

2019a) and also underscore prior results on the positive assessment of cars with regard to aspects such as comfort and speed (Steg, 2003). It should be noted that, even though CBs were rated superior in the overall sample, cars were relatively strongly associated with freedom and social recognition compared to other attributes in the respective domains (Geels, 2012; Steg, 2005). With regard to freedom, car-dependent participants even rate cars superior.

The group differences support findings that frequent car drivers rate cars more favorably and that alternative modes (such as public transport) are more competitive for individuals not primarily travelling by car (Anable & Gatersleben, 2005; Steg, 2003). This is also in line with findings that highlight the strong performance of cars on flexibility and convenience for car drivers (Anable & Gatersleben, 2005). However, car-dependent users also consider CBs superior to cars on certain attributes: namely price, no stress, pleasure as well as all symbolic and environmental attributes. This finding is comparable to research indicating that car users rate conventional bicycles equally well or superior to cars on costs, excitement, no stress, and environmental impact (Anable & Gatersleben, 2005).

Taken together, our study reveals numerous strengths but also some shortcomings of CBs in direct comparison with cars in our sample. This supports the view that no transport mode dominates on all attributes. For instance, whereas public transport has been found to be superior to cars on traffic safety only (Steg, 2003), cars were rated better than CBs in this regard by the overall sample in our study.

6.2. Practical and policy implications

Regarding practical implications, the results of this study first of all indicate that CBs and CBS can represent a viable pathway to reduce car dependency. For this reason, actively promoting a wider spread of this transport mode could be promising in view of the environmental challenges in the transport sector. Development of sustainable transport policies could therefore focus on understanding motives and closing relevant gaps to cars in order to increase the competitiveness of alternative transport modes (Anable & Gatersleben, 2005). Gaps in terms of traffic safety, travel speed and comfort could likely be reduced by making cities less car-centered, more bike-friendly, and by prioritizing the safety of cyclists and CB users (Bixhaku et al., 2023; Hess & Schubert, 2019). Improving infrastructure for CBs such as implementing dedicated bicycle lanes and providing parking spaces for CBs might help make them more attractive (Bixhaku et al., 2023; Carracedo & Mostofi, 2022; Wang & Akar, 2018). In addition, offering safety trainings could improve competencies (Hess & Schubert, 2019). Notably, these discrepancies were particularly pronounced for car-dependent users, so reducing them could play a large role for this group.

Moreover, development of more advanced (e.g., weather-protected) CBs could be supported to increase comfort and weather-independence. Results on the importance of prices indicate that subsidies on CBs might be a viable instrument to promote CB purchases. However, as CBs are already perceived as considerably less expensive than cars, our results also suggest that a communicative focus on savings compared to cars (in contrast to the absolute price for CBs or the additional costs compared to conventional bicycles) could be an effective strategy (Carracedo & Mostofi, 2022). Regarding communication, there is also a need for a shift in societal thinking and social norms for cars and CBs, which could be actively promoted. For instance, it could be emphasized that CBs can also represent freedom and fulfill affective and symbolic aspects (S. Becker & Rudolf, 2018b). In this context, our findings indicate that even car-dependent users in our sample rate CBs superior on symbolic aspects and do not express more favorable ratings for cars than other participants.

6.3. Strengths and limitations

Due to the collaboration with a widespread CBS network, this study builds on a large sample which is valuable in view of the limited spread of CBs. The transdisciplinary approach allowed to identify research gaps that are relevant for academia as well as practitioners. Regarding motives, our study covers all four dimensions defined in literature, whereas previous studies were limited to three dimensions (Noppers et al., 2014; Steg, 2005). The general structure was successfully validated by the CFA. At the same time, internal consistency for instrumental and affective attributes was rather moderate. However, especially instrumental attributes form a broad category and the rating of some attributes (e.g., price) might be more strongly connected with aspects such as income than others. The interrelatedness of factors is also in line with previous research and stresses causal interdependencies between instrumental aspects (e.g., weather-independence) and, for instance, affective attributes such as pleasure (Schuitema et al., 2013).

With regard to limitations, differences regarding motives between groups cannot be causally attributed to car ownership reduction. They could, for example, have contributed to actions, occurred from them or be unrelated. The analyzed attributes are not exhaustive as the total number is in principle infinite (Anable & Gatersleben, 2005). Car ownership in households is also difficult to assess and some persons may not be able to decide about car reduction on their own. In addition, in line with Firnkorn and Müller (2012), decisions against purchasing a car were included in the calculation of car ownership reduction. This is based on the assumption that cars would actually have been purchased in a hypothetical alternative scenario. If this assumption does not hold true for some participants, the rate of car ownership reduction would decrease. Operationalizing car dependency by use of cars as main transport mode does not allow for distinguishing different types of car dependency (Gössling, 2017). The fact that users that were defined as car-dependent do not rate cars better than the other group on symbolic aspects could indicate that rather structural aspects influence their mode choices. It should be noted, however, that other operationalizations of car dependency could lead to different results. This study focused on evaluations of CBs and cars in general, irrespective of specific types or contexts (e.g., trip purposes), which can affect evaluations (Anable & Gatersleben, 2005). Regarding our sample, selection biases are possible as, for instance, frequent users might be over-represented (Firnkorn & Müller, 2012). In addition, while the sample guarantees that participants have experience with CBs, we assumed that participants are sufficiently experienced to rate cars in view of the ubiquity of cars in society (cf. Section 2.1). Finally, the

focus of this study on individuals and their subjective motives is only one piece of a larger, complex puzzle. In this regard, structural barriers to individual mobility behavior change are stressed (Ruhrort & Allert, 2021). This, however, is indirectly reflected in participants' perceptions of transport modes and addressed in structural implications of our study such as infrastructure improvements.

6.4. Future research

This study provides direct implications for future research. Firstly, with regard to car ownership effects of CBs, other groups such as CB owners could be investigated. This would provide insights into the car ownership reduction potential of different forms of CB provision. In addition, for precise quantifications of environmental impacts, future research could build on studies on car sharing (Martin et al., 2010) and ask for information on the type of car and its usage. In addition, while our group comparison did not reveal substantial differences with regard to socio-demographic and geographic factors, researchers could aim at diving deeper into the differences between individuals who shed their cars and those who do not to better understand what drives and what inhibits this decision. For instance, cluster analyses could provide valuable insights (Anable, 2005; Hunecke & Haustein, 2007). In addition, investigating general differences in motives based on aspects such as age, gender, income, or CB experience seems promising (Bixhaku et al., 2023; Kumar & Sinha, 2022).

Secondly, regarding motives, the present study analyzed the perspective of existing CB users. While this is important, this group still represents early adopters and is characterized by, for instance, strong environmental values (S. Becker & Rudolf, 2018a; Hess & Schubert, 2019). As current non-users perceive divergent and additional barriers regarding CBs (Hess & Schubert, 2019), it is also important to better understand their motives to (not) use CBs compared to cars. This could be assessed with representative samples covering the overall population. With regard to the results in general, studies could investigate causal relationships, for instance, by deploying randomized controlled trials (Bjørnarå et al., 2019).

7. Conclusion

The objective of this study was to help fill two research gaps by analyzing the potential of CBS with regard to car ownership and by investigating discrepancies between cars and CBs in terms of underlying motives. To do so, we applied an established approach from traffic psychology to CBs as a rather less researched means of transport. Overall, our results indicate a considerable potential of CBs and CBS to reduce car ownership. Participants consistently state environmental motives and concerns as the most important reason to shed their cars as well as the most important for choosing a transport mode in general. At the same time, cars are rated better on several instrumental attributes which does, however, not or only to a limited extent apply to users that reduced car ownership. Our results therefore indicate that CBs and CBS are promising and sustainable alternatives to private car ownership. Thus, they could contribute not only to reduced car use but also to reduced car ownership, resulting in additional environmental, social, and economic advantages. Referring to the initial question stated in the title, CBs can indeed to some extent compete with the private car. Nevertheless, competitiveness could be further improved with infrastructural measures which particularly aim at closing gaps on instrumental attributes.

CRediT authorship contribution statement

Michael Bissel: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft. **Sophia Becker:** Conceptualization, Funding acquisition, Methodology, Resources, Supervision, 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.

Data availability

The data that support the findings of this study can be provided by the corresponding author, MB, upon reasonable request.

Acknowledgements

This work was supported by the German Federal Ministry for Education and Research, FONA-program (EXPERI Project, grant number 01UU1902A), as well as by a PhD scholarship granted to the first author by the Foundation of German Business. Moreover, we would like to thank all participating commons cargo bikes initiatives as well as the spokespersons of the commons cargo bikes forum, especially Wiebke Höfker, for their support in gathering data for this paper. The authors would also like to thank all users of commons cargo bikes that participated in the survey. Leon Handke provided valuable comments on an earlier version of this manuscript and Rozaliia Tarnovetckaia shared helpful advice on car sharing research. Statistical advice was provided by Josh Cetron at the Institute for Quantitative Social Science (IQSS). The content and conclusions of this paper are solely the responsibility of the authors. Finally, the authors would like to express their gratitude to three anonymous reviewers for providing constructive and detailed feedback.

Appendix

(See Fig. A1).
(See Table A1-A2).

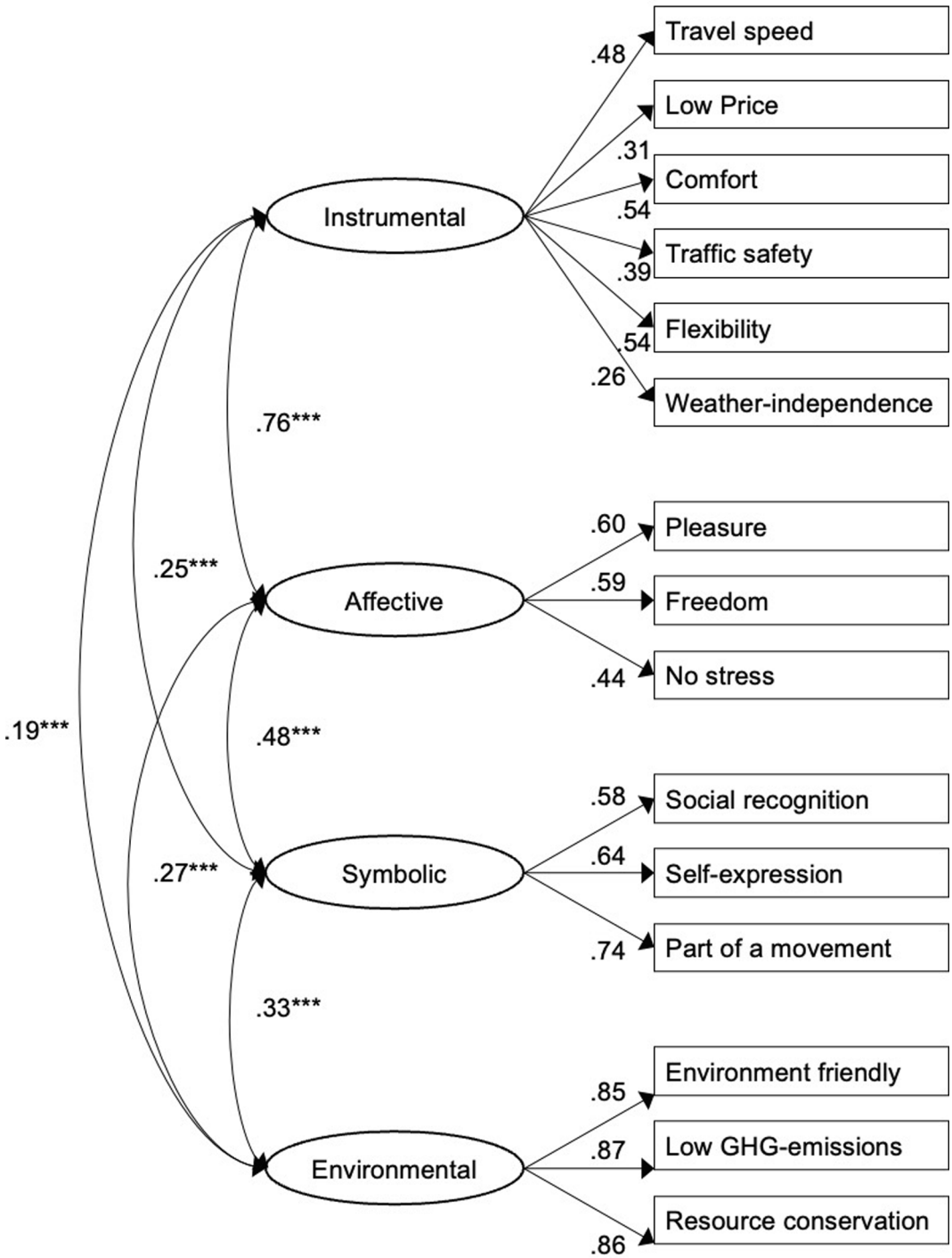

Fig. A1. Results of the Confirmatory Factor Analysis (CFA) regarding the importance of motives.

Table A1
Pearson correlations of factor means.

	Instrumental	Affective	Symbolic	Environmental
Instrumental	1.00			
Affective	.40***	1.00		
Symbolic	.17***	.29***	1.00	
Environmental	.13***	.19***	.25***	1.00

Note: *** $p < .001$ (two-tailed test).

Table A2
Regression of relevant dependent variables on ratings of CBs and cars.

	R 2	*F*	*df*	*β*	*t*	*p*
DV: Intention to use CBs	0.09	61.18	2,379			< .001
Instrumental				0.03	0.86	.389
Affective				0.28	10.88	< .001
Symbolic				0.02	1.38	.169
Environmental				−0.00	−0.10	.917
DV: Intention to sell car	0.07	22.91	1,084			< .001
Instrumental				−0.45	−5.22	< .001
Affective				−0.15	−3.17	.002
Symbolic				0.09	1.92	.055
Environmental				−0.08	−1.39	.165

Note: Ratings of CBs were used to predict intention to use CBs while ratings of cars were used to predict intention to sell cars. Regression for intention to sell car is based on car owners only.

References

Anable, J. (2002). Mobility management in the leisure sector: The application, psychological theory and behavioural segmentation [Doctoral dissertation, Imperial College London (University of London)]. *Spiral.* http://hdl.handle.net/10044/1/7811.

Anable, J. (2005). 'Complacent Car Addicts' or 'Aspiring Environmentalists'? Identifying travel behaviour segments using attitude theory. *Transport Policy, 12*(1), 65–78. https://doi.org/10.1016/j.tranpol.2004.11.004

Anable, J., & Gatersleben, B. (2005). All work and no play? The role of instrumental and affective factors in work and leisure journeys by different travel modes. *Transportation Research Part A: Policy and Practice, 39*(2–3), 163–181. https://doi.org/10.1016/j.tra.2004.09.008

Becker, H., Ciari, F., & Axhausen, K. W. (2018). Measuring the car ownership impact of free-floating car-sharing – A case study in Basel, Switzerland. *Transportation Research Part D: Transport and Environment, 65*, 51–62. https://doi.org/10.1016/j.trd.2018.08.003

Becker, S., & Rudolf, C. (2018a). Exploring the Potential of Free Cargo-Bikesharing for Sustainable Mobility. *GAIA - Ecological Perspectives for Science and Society, 27*(1), 156–164. https://doi.org/10.14512/gaia.27.1.11

Becker, S., & Rudolf, C. (2018b). The Status Quo of cargo-bikesharing in Germany, Austria and Switzerland. In *Framing the Third Cycling Century. Bridging the Gap between Research and Practice* (pp. 168–180). German Environment Agency.

Benleulmi, A. Z., & Ramdani, B. (2022). Behavioural intention to use fully autonomous vehicles: Instrumental, symbolic, and affective motives. *Transportation Research Part F: Traffic Psychology and Behaviour, 86*, 226–237. https://doi.org/10.1016/j.trf.2022.02.013

Bieker, G. (2021). *A Global Comparison of the Life-Cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars* (ICCT White Paper). International Council on Clean Transportation Europe (ICCT). https://theicct.org/wp-content/uploads/2021/12/Global-LCA-passenger-cars-jul2021_0.pdf.

Bixhaku, M., Hoxha, G., & Duraku, R. (2023). Analysis of Perceptions of Cycling Safety on Roads with Mixed Traffic Depending on Age, Gender, and Riding Experience. *Civil Engineering Journal, 9*, 141–151. https://doi.org/10.28991/CEJ-SP2023-09-011

Bjørnarå, H. B., Berntsen, S., te Velde, J., & S., Fyhri, A., Deforche, B., Andersen, L. B., & Bere, E.. (2019). From cars to bikes – The effect of an intervention providing access to different bike types: A randomized controlled trial. *PLOS ONE, 14*(7), e0219304.

Bissel, M., & Becker, S. (2023). One decade of Commons Cargo Bikes: Lessons for social innovation in the context of sustainable mobility and beyond *[Manuscript Submitted for Publication]*.

BMVI. (2018). *Regionalstatistische Raumtypologie (RegioStaR) des BMVI für die Mobilitäts- und Verkehrsforschung* [Working Paper]. Bundesministerium für Verkehr und digitale Infrastruktur. https://bmdv.bund.de/SharedDocs/DE/Anlage/G/regiostar-arbeitspapier.pdf?_blob=publicationFile.

Börjesson Rivera, M., & Henriksson, G. (2014). Cargo Bike Pool: A way to facilitate a car-free life? *Resilience – the New Research Frontier. Proceedings of the 20th Annual International Sustainable Development Research Conference (ISDRC 2014) Trondheim 18-20 June 2014*, 273–280.

Carracedo, D., & Mostofi, H. (2022). Electric cargo bikes in urban areas: A new mobility option for private transportation. *Transportation Research Interdisciplinary Perspectives, 16*, 100705. https://doi.org/10.1016/j.trip.2022.100705

Cepeda Zorrilla, M., Hodgson, F., & Jopson, A. (2019). Exploring the influence of attitudes, social comparison and image and prestige among non-cyclists to predict intention to cycle in Mexico City. *Transportation Research Part F: Traffic Psychology and Behaviour, 60*, 327–342. https://doi.org/10.1016/j.trf.2018.10.009

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155

Dittmar, H. (1992). *The social psychology of material possessions: To have is to be.* Harvester Wheatsheaf: St. Martin's Press.

Dorner, F., & Berger, M. (2020). Peer-to-peer Cargo Bike Sharing: Findings from LARA Share project. *Proceedings of 8th Transport Research Arena TRA 2020*, 1–11. Doi: 10.26226/morressier.5e4fe9c16bc493207536f8ed.

EEA. (2022). *Decarbonising road transport: The role of vehicles, fuels and transport demand.* EEA Report). Publications Office of the European Union. No 02/2022;.

Eurostat.. (2022). Passenger cars in the EU (Statistics Explained). European Statistical. *Office.* https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Passenger_cars_in_the_EU.

Field, A., Miles, J., & Field, Z. (2014). *Discovering statistics using R (Repr).* Sage.

Firnkorn, J., & Müller, M. (2012). Selling Mobility instead of Cars: New Business Strategies of Automakers and the Impact on Private Vehicle Holding. *Business Strategy and the Environment, 21*(4), 264–280. https://doi.org/10.1002/bse.738

Forum Freie Lastenräder. (2023). *Freie Lastenräder*. https://dein-lastenrad.de/wiki/Freie_Lastenräder.

Fishbein, M., & Ajzen, I. (2009). *Predicting and Changing Behavior*. Psychology Press. https://doi.org/10.4324/9780203838020

Geels, F. W. (2012). A socio-technical analysis of low-carbon transitions: Introducing the multi-level perspective into transport studies. *Journal of Transport Geography, 24*, 471–482. https://doi.org/10.1016/j.jtrangeo.2012.01.021
Ghebrezgiabiher, J., & Poscher-Mika, E. (2018). *Cargobike Boom: Wie Transporträder unsere Mobilität revolutionieren*. Maxime Verlage.
Giesel, F., & Nobis, C. (2016). The Impact of Carsharing on Car Ownership in German Cities. *Transportation Research Procedia, 19*, 215–224. https://doi.org/10.1016/j.trpro.2016.12.082
Gössling, S. (2017). *The Psychology of the Car: Automobile Admiration, Attachment, and Addiction*. Elsevier.
Gössling, S. (2018). ICT and transport behavior: A conceptual review. *International Journal of Sustainable Transportation, 12*(3), 153–164. https://doi.org/10.1080/15568318.2017.1338318
Gruber, J., Kihm, A., & Lenz, B. (2014). A new vehicle for urban freight? An ex-ante evaluation of electric cargo bikes in courier services. *Research in Transportation Business & Management, 11*, 53–62. https://doi.org/10.1016/j.rtbm.2014.03.004
Gruber, J., & Rudolph, C. (2021). *Ich entlaste Städte: Das Lastenrad-Testangebot für gewerbliche und öffentliche Nutzer*. Deutsches Zentrum für. *Luft- und Raumfahrt*. https://elib.dlr.de/144453/1/Schlussbericht_Ich-entlaste-Staedte.pdf.
Hair, J. F. (Ed.). (2014). *Multivariate data analysis* (7. ed., Pearson new internat. ed). Pearson.
Hess, A., & Schubert, I. (2019). Functional perceptions, barriers, and demographics concerning e-cargo bike sharing in Switzerland. *Transportation Research Part D: Transport and Environment, 71*, 153–168. https://doi.org/10.1016/j.trd.2018.12.013
Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118
Hunecke, M., & Haustein, S. (2007). Einstellungsbasierte Mobilitätstypen: Eine integrierte Anwendung von multivariaten und inhaltsanalytischen Methoden der empirischen Sozialforschung zur Identifikation von Zielgruppen für eine nachhaltige Mobilität. *Umweltpsychologie, 11*(2), 38–68.
IEA. (2020). *Energy Technology Perspectives 2020*. IEA. https://www.iea.org/reports/energy-technology-perspectives-2020.
Ivanova, D., Barrett, J., Wiedenhofer, D., Macura, B., Callaghan, M., & Creutzig, F. (2020). Quantifying the potential for climate change mitigation of consumption options. *Environmental Research Letters, 15*(9), 093001. https://doi.org/10.1088/1748-9326/ab8589
Jochem, P., Frankenhauser, D., Ewald, L., Ensslen, A., & Fromm, H. (2020). Does free-floating carsharing reduce private vehicle ownership? The case of SHARE NOW in European cities. *Transportation Research Part A: Policy and Practice, 141*, 373–395. https://doi.org/10.1016/j.tra.2020.09.016
Jones, D. W. (2008). *Mass motorization + mass transit: An American history and policy analysis*. Indiana University Press.
Jones, P. (2011). Conceptualising Car 'Dependence.' In K. Lucas, E. Blumenberg, & R. Weinberger (Eds.), *Auto Motives* (pp. 39–61). Emerald Group Publishing Limited. Doi: 10.1108/9780857242341-002.
Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1991). Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias. *Journal of Economic Perspectives, 5*(1), 193–206. https://doi.org/10.1257/jep.5.1.193
Kumar, S., & Sinha, S. (2022). Heterogeneity based Mode Choice Behaviour for Introduction of Sustainable Intermediate Public Transport (IPT) Modes. *Civil Engineering Journal, 8*(3), 531–548. https://doi.org/10.28991/CEJ-2022-08-03-09
Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C. J. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science, 7*(S1), 25–43. https://doi.org/10.1007/s11625-011-0149-x
Lange, S., & Santarius, T. (2020). *Smart Green World?: Making Digitalization Work for Sustainability* (1st ed.). Routledge. Doi: 10.4324/9781003030881.
Le Vine, S., & Polak, J. (2019). The impact of free-floating carsharing on car ownership: Early-stage findings from London. *Transport Policy, 75*, 119–127. https://doi.org/10.1016/j.tranpol.2017.02.004
Martin, E., Shaheen, S. A., & Lidicker, J. (2010). Impact of Carsharing on Household Vehicle Holdings. *Transportation Research Record, 2143*, 150–158.
Noppers, E. H., Keizer, K., Bockarjova, M., & Steg, L. (2015). The adoption of sustainable innovations: The role of instrumental, environmental, and symbolic attributes for earlier and later adopters. *Journal of Environmental Psychology, 44*, 74–84. https://doi.org/10.1016/j.jenvp.2015.09.002
Noppers, E. H., Keizer, K., Bolderdijk, J. W., & Steg, L. (2014). The adoption of sustainable innovations: Driven by symbolic and environmental motives. *Global Environmental Change, 25*, 52–62. https://doi.org/10.1016/j.gloenvcha.2014.01.012
Noppers, E. H., Keizer, K., Milovanovic, M., & Steg, L. (2019). The role of adoption norms and perceived product attributes in the adoption of Dutch electric vehicles and smart energy systems. *Energy Research & Social Science, 57*, 101237. https://doi.org/10.1016/j.erss.2019.101237
Pearce, J. L. M. (2016). Carrying cargo and affording decarbonised urban mobility—The integration of cargo bikes into urban load-carrying practices [Doctoral dissertation, University Of Canterbury]. *UC Research Repository*. https://ir.canterbury.ac.nz/handle/10092/12915.
Rammler, S. (2018). Verkehr und Gesellschaft. Verkehrspolitik als Mobilitätsdesign. In O. Schwedes (Ed.), *Verkehrspolitik* (pp. 27–50). Springer Fachmedien Wiesbaden. Doi: 10.1007/978-3-658-21601-6.
Riggs, W. (2016). Cargo bikes as a growth area for bicycle vs. auto trips: Exploring the potential for mode substitution behavior. *Transportation Research Part F: Traffic Psychology and Behaviour, 43*, 48–55. https://doi.org/10.1016/j.trf.2016.09.017
Riggs, W., & Schwartz, J. (2018). The impact of cargo bikes on the travel patterns of women. *Urban, Planning and Transport Research, 6*(1), 95–110. https://doi.org/10.1080/21650020.2018.1553628
Rubin, M. (2021). When to adjust alpha during multiple testing: A consideration of disjunction, conjunction, and individual testing. *Synthese, 199*(3–4), 10969–11000. https://doi.org/10.1007/s11229-021-03276-4
Rüdiger, D., Kopka, J.-P., & Hohaus, C. (2016). *Das Lastenrad als regionales Mobilitätsangebot. Bearbeitung grundlegender Fragestellungen für die Einführung eines innovativen Lastenrad-Verleihsystems in der Metropolregion Frankfurt-Rhein-Main*. IML: Fraunhofer-Institut für Materialfluss und Logistik.
Ruhrort, L., & Allert, V. (2021). Conceptualizing the Role of Individual Agency in Mobility Transitions: Avenues for the Integration of Sociological and Psychological Perspectives. *Frontiers in Psychology, 12*, 623652. https://doi.org/10.3389/fpsyg.2021.623652
Schuitema, G., Anable, J., Skippon, S., & Kinnear, N. (2013). The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. *Transportation Research Part A: Policy and Practice, 48*, 39–49. https://doi.org/10.1016/j.tra.2012.10.004
Shaheen, S. A., Schwartz, A., & Wipyewski, K. (2004). Policy Considerations for Carsharing and Station Cars: Monitoring Growth, Trends, and Overall Impacts. *Transportation Research Record: Journal of the Transportation Research Board, 1887*(1), 128–136. https://doi.org/10.3141/1887-15
Sheeran, P., & Webb, T. L. (2016). The Intention-Behavior Gap. *Social and Personality Psychology Compass, 10*(9), 503–518. https://doi.org/10.1111/spc3.12265
Simsekoglu, Ö., & Klöckner, C. A. (2019a). Factors related to the intention to buy an e-bike: A survey study from Norway. *Transportation Research Part F: Traffic Psychology and Behaviour, 60*, 573–581. https://doi.org/10.1016/j.trf.2018.11.008
Simsekoglu, Ö., & Klöckner, C. A. (2019b). The role of psychological and socio-demographical factors for electric bike use in Norway. *International Journal of Sustainable Transportation, 13*(5), 315–323. https://doi.org/10.1080/15568318.2018.1466221
Spekkink, W., Rödl, M., & Charter, M. (2022). Repair Cafés and Precious Plastic as translocal networks for the circular economy. *Journal of Cleaner Production, 380*, 135125. https://doi.org/10.1016/j.jclepro.2022.135125
Steg, L. (2003). Can Public Transport Compete With the Private Car? *IATSS Research, 27*(2), 27–35. https://doi.org/10.1016/S0386-1112(14)60141-2
Steg, L. (2005). Car use: Lust and must. Instrumental, symbolic and affective motives for car use. *Transportation Research Part A: Policy and Practice, 39*(2–3), 147–162. https://doi.org/10.1016/j.tra.2004.07.001
Steg, L., Vlek, C., & Slotegraaf, G. (2001). Instrumental-reasoned and symbolic-affective motives for using a motor car. *Transportation Research Part F: Traffic Psychology and Behaviour, 4*(3), 151–169. https://doi.org/10.1016/S1369-8478(01)00020-1
Stocker, A., Lazarus, J., Becker, S., & Shaheen, S. A. (2016). *North American College/University Market Carsharing Impacts: Results from Zipcar's College Travel Study 2015. Effects on Vehicle Use and Ownership, Travel Behavior, Quality of Life, and Environmental Impacts* (TSRC Working Paper). UC Berkeley.
Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education, 48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2
Tarnovetckaia, R., & Mostofi, H. (2022). Impact of Car-Sharing and Ridesourcing on Public Transport Use: Attitudes, Preferences, and Future Intentions Regarding Sustainable Urban Mobility in the Post-Soviet City. *Urban Science, 6*(2), 33. https://doi.org/10.3390/urbansci6020033

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*, 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd
Urry, J. (2004). The 'System' of Automobility. *Theory, Culture & Society, 21*(4–5), 25–39. https://doi.org/10.1177/0263276404046059
Vergragt, P. J., & Brown, H. S. (2007). Sustainable mobility: From technological innovation to societal learning. *Journal of Cleaner Production, 15*(11–12), 1104–1115. https://doi.org/10.1016/j.jclepro.2006.05.020
Wang, K., & Akar, G. (2018). The perceptions of bicycling intersection safety by four types of bicyclists. *Transportation Research Part F: Traffic Psychology and Behaviour, 59*, 67–80. https://doi.org/10.1016/j.trf.2018.08.014
Yigitcanlar, T., Li, R. Y. M., Inkinen, T., & Paz, A. (2022). Public Perceptions on Application Areas and Adoption Challenges of AI in Urban Services. *Emerging Science Journal, 6*(6), 1199–1236. https://doi.org/10.28991/ESJ-2022-06-06-01