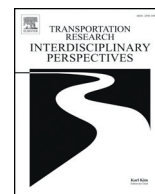




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Are women greener than men? A preference analysis of women and men from major German cities over sustainable urban mobility

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ABSTRACT

Travel patterns in daily life differ greatly between women and men, and differences in socialisation substantially impact travel mode choice. The literature has demonstrated a higher affinity towards local public transportation and sustainability for women. Men, by contrast, show a higher affinity towards cars, technology, and innovation. However, sex and gender factors have not been considered when examining innovative, sustainable urban mobility so far. A gender-sensitive perspective, therefore, is necessary to increase the possibility of using sustainable modes of transportation, including carsharing with battery-powered electric vehicles and, therefore, improve the quality of life in larger cities.

This article closes this research gap with an analysis of a representative sample of 2400 respondents from four major cities in Germany based on Robin Law's theoretical framework of gendered daily mobility from 1999. In addition to socio-demographic, economic, and mobility-related factors, attitudes towards transport modes and the preferences for e-carsharing services are analysed to provide deeper insights into gender differences of urban dwellers.

Grouped by age and gender, the presence of a child in the household is associated with different changes in preferences for specific modes of transport for women and men. Although the results indicate that urban women are more concerned about environmentally-friendly mobility in general and use cars less often than men, more women than men prefer going by car if there is a child under the age of 14 years in the household. There is unequal access to resources in mobility, which is in line with financial aspects being the main reason against car ownership for urban women. Parenthood has a positive effect on the acceptance of carsharing with battery-powered electric vehicles for women and men. In conclusion, gender differences result from different daily tasks, but there are also significant differences beyond this aspect that show a socially constructed gendered meaning of sustainable urban mobility.

This research improves the understanding of sustainable urban mobility regarding gender differences, that is, the increase of car use of women with children, and the rejection of women of new mobility services. Only when gender differences are considered in planning processes, it will be possible to improve the quality of living in urban areas by reducing urban space scarcity, local and global emissions, and noise exposure.

1. Introduction

Urban mobility is becoming increasingly more flexible, including a trend towards single-passenger transport. This development considers the consistently small or even decreasing numbers of passengers per car (infas, 2018; Truong et al., 2017). However, single-passenger transport categorically excludes individuals on the move together with others like children and individuals unable to operate a vehicle, for instance, children, elderly individuals, or individuals without a valid driving licence. Women, even in urban areas, tend to be more often responsible for others and have, accordingly, daily tasks especially because of additional household and child care tasks that lead to various requirements for transport (Kawgan-Kagan and Popp, 2018; Nobis and Lenz, 2005). The uptake of the mobility trends is more preferred by men than by women; in particular, the use of BEVs in carsharing attracts male consumers (Kawgan-Kagan,

2015a). However, is the responsibility for children the key factor for this phenomenon? To address the new developments on the mobility market, this study investigated factors to eliminate them and prevent a gender mobility gap in sustainable urban mobility at a point in time when services and products can be shaped accordingly.

A gender mobility gap has been observed in transport research (Law, 1999; Rosenbloom, 2000). Nevertheless, this gap has been repeatedly rediscovered in almost every quantitative analysis of mobility behaviour, wherever it was included in the analysis, and often without further suitable consideration. Different social roles manifest statistically in significantly divergent travel behaviour: On the one hand, differences in travel patterns have long been known because of different daily tasks for women and men especially when children live in the household (Best and Lanzendorf, 2005; Gordon et al., 1989; Nobis and Lenz, 2005); on the other hand, car use and the use of public transport (PT) have been historically developing in significantly different ways (Konrad, 2016). Gender analyses of sustainable mobility have thus far focused on women using PT more often

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concluding hastily that women are more sustainable in transport without knowing women's actual preferences (European Parliament, 2012).

The importance of general attitudes affecting an individual's intention and has been elaborated by Ajzen (1991) to predict and explain behaviour. Nevertheless, attitudes directly related to the field of respective products or services of specific target groups must be understood (Hinkeldein et al., 2015). This work, therefore, is devoted to differences between women and men with and without children to show the impact of gender in terms of access to resources and to reveal the gendered meanings of mobility that reflect distinct perceptions and attitudes. Preferences of urban women and men with and without children regarding sustainable mobility are explored. The following questions are raised: How is urban sustainable mobility shaped by gender? How does the perception of sustainable mobility differ when children live in the household?

To answer these questions, the focus of this study is the attitudes towards various aspects of electric mobility to reveal a gender-based meaning of urban mobility. Besides, the emphasis is on sustainable mobility beyond comparing PT to car use. To understand the differences between women and men, the effect of gender on various aspects of shared electric mobility is presented using profound correlation and significance testing. Instead of using gender as one of the variables, this research uses it to show significant differences that have not been analysed before.

2. Gender and sustainable urban mobility state of the field

This research is based on the framework of gendered daily mobility by Robin Law (1999) combined with current mobility trends in urban areas. In the following, the current state of research is presented to understand the relation of gendered daily mobility and innovative sustainable mobility.

Law (1999) conceptualised a gender-aligned approach of 'gender and daily mobility,' completing the picture of how gender influences these aspects:

- Activity patterns in time and space;
- Access to resources of time, money, skills, technology;
- Experience of embodiment;
- Meaning of mobility practices, settings, things (masculinity, femininity); and
- Environment of land use, infrastructure, services, public space.

These aspects lead to gender differences in daily mobility, namely, mode choice, travel behaviour, perception, and experiences of mobility and can be found all over the world. Regarding gendered experiences of embodiment and gendered environment of land use, services, and public space, the research has mainly focused on health and safety topics. Later, for instance, the research included female or pregnant crash test dummies or psychological aspects of PT stations and vehicle design (Ellaway et al., 2003; Hamilton and Jenkins, 2000; Rupp, 2001; Ulfarsson and Mannering, 2004). The present study leaves out these two aspects (experience of embodiment and environment of land use, services, and public space) and focusses on the influence of gender on (i) access to resources, (ii) activity patterns, and (iii) gendered meaning of mobility shaping daily mobility, which is elaborated in detail in the next section.

2.1. Gendered urban mobility patterns

The differences between women and men in travel patterns have been researched frequently, beginning with the question that whether gender differences are observed in travel behaviour. Although gender roles have emerged in terms of labour participation, women continue to be responsible for tasks resulting from household work and child care (Best and Lanzendorf, 2005; European Parliament, 2012; Konrad, 2016). In less traditional urban areas, women without children work full-time as often as men do; nevertheless, women tend to work part-time more often and are more often responsible for the household as soon as they have a child (Berlin-Brandenburg, 2017; Dribe and Stanfors, 2009; Nitsche and Grunow, 2016; Schneebaum and Mader, 2013). These (additional) tasks lead to significantly different travel patterns of women and men: In contrast to men,

women show complex trip chains with shorter partial routes in a rather radial area closer to their residence (Bauhardt, 1999; Kawgan-Kagan, 2015a; Knoll et al., 2009; Nobis and Lenz, 2005; Scheiner, 2016). In total, the travelled distances are smaller despite the greater number of trips (Sovacool et al., 2018). Household and childcare-related tasks are usually closer to the residence than workplaces (Fan, 2017). Because of the longer distances to work and because more men with children work full-time than childless men, they cover longer distances on average (Crane, 2007; Kawgan-Kagan, 2015a). These differences are subject to different stages of life and, therefore, occur for individuals at an age when childbirth as a key event in life is most likely (Lanzendorf, 2010; Scheiner, 2016; Scheiner and Holz-Rau, 2017; Stiewe and Krause, 2012). This gender mobility gap is visible wherever gender differences were considered in the analysis and up to date, no study anywhere has shown that there is no gender mobility gap.

2.2. Impact of gendered access to resources

A gender mobility gap has been observed in every country that analysed travel patterns. Especially in less developed countries it can be explained with a gendered access to resources (Carruthers et al., 2005; Clarke, 2012): Both genders, women and men show higher rates of car use when they work. Women tend to work less often, especially full-time, which leads to a smaller income. Because of the higher financial restriction, women, therefore, have less access to paid mobility options: Women cannot afford cars, bicycles, and public transport, especially in poorer countries, compared with men. Even in urban areas in developed countries, women earn less on average than men (Behr and Theune, 2018; Fortin et al., 2017). Parenthood has a substantial impact on financial resources in Western societies: Women with a child but without a partner have the highest risk of poverty (Damaske et al., 2017; Hübgen, 2018). Similarly, Best and Lanzendorf (2005) showed that having children leads to less car use for women but more car use for men; however, car use increased over the past 30 years in Germany for women with children (Konrad, 2016). Notably, access to a car or holding a driving licence has been observed to be a key factor of social inclusion and employment of women (Angell et al., 2018; Dobbs, 2005). Ownership of driving licences, although its acquisition is relatively expensive in Germany and, therefore, not uncorrelated to access to financial resources, grants access to carsharing schemes. In Germany, the share of driving licences remains unequal for women and men in general; nevertheless, this is expected to continue aligning because of aligned acquisition rates for young women and men (Konrad, 2016), presumably indicating a closing gender mobility gap in Germany.

In addition to financial restriction, Bauhardt (1999) argued that there is a power gap within a household that leads to men being the person to use a car; thus, women are forced to use other modes, mostly public transport. At first glance, this thought seems harsh and old-fashioned; nevertheless, it has historically evolved as has been described, for instance, by Fan (2017) or Scharff (1992). Empirical data shows that in Berlin, women use public transport more and cars less (Ahrens, 2014). A study from Cologne, Germany, by Scheiner and Holz-Rau (2012) could not, however, find evidence for this power gap and restriction of access within a household due to different financial resources. They found no evidence for a gender-affected connection between car use and participation in paid and unpaid work, contradicting many studies asserting the existence of this gap (Adeel et al., 2017; Liu et al., 2018). Although a study from Stockholm covering data from 1985 to 2015 showed that the gender gap in car use and bicycling 'closed completely' in the inner city of Stockholm, this gap continues to exist the outer areas (Bastian and Börjesson, 2018) and has been evident in many other global studies (Abasahl et al., 2018; European Parliament, 2012; Sovacool et al., 2018).

2.3. Gendered attitudes towards innovative, sustainable electric mobility

Gender differences resulting from gender-typical task divisions are not the only determinants to explain the current differences in urban mobility, especially in mode choice. Scheiner and Holz-Rau (2012) argued that there

must be more behind the different social roles affecting car use than intrahousehold differences. Robin Law's framework includes the gendered meaning of mobility practices, settings, and things (Law, 1999). Notably, the gendered meaning of cars has been studied in science and technology studies describing the ascription of masculinity to private car use and femininity to the use of public transport (Lee, 2017; Samuelsson, 2014). Historically, other ascriptions were evolving during the beginning of the automobile era: Women were supposedly limited to the feminine private, domestic sphere, whereas the public space was occupied by men (Ellaway et al., 2003; Scharff, 1992), that is, men alone was supposed to be mobile. This public masculinity was then supplemented with individual automobiles. If women needed to go somewhere, they were driven by their men and also, the private femininity was broadened by the use of public transport, and these origins continue to shape the attitudes towards and perception of mobility (Polk, 2009). The combination of publicly available and privately used cars in carsharing, however, thwarts the assignment of feminine public transport and masculine private car use. Due to the historical ascription, most of the studies revealing gender differences in the perception, meaning of, and attitudes towards modes have focused on the use of two opposites: cars and public transport.

Much research has been conducted on the adoption of electric vehicles (EVs) and carsharing. It has revealed that environmental awareness, affinity towards technology, and innovation as lifestyle are the main factors influencing the acceptance of new sustainable mobility including one-way carsharing and e-mobility (Li et al., 2017; Rezvani et al., 2015; Shaheen et al., 2015). Li et al. (2017) listed gender in their literature review of 40 studies as a socio-demographic factor influencing the intention to adopt an EV in addition to age and education, although without further consideration. Rezvani et al. (2015) comprehensively reviewed up-to-date studies about influencing attitudes and factors and elucidated their effects on the acceptance of plug-in EVs. Notably, wherever included in the analysis, gender was observed to be a crucial factor.

Nevertheless, neither Rezvani et al. (2015) nor the authors of the original studies conclude that a gender-based perspective is necessary to identify obstacles and barriers against consumer adoption of plug-in EVs. Based on numbers such as 95% being male users of BEVs in Sweden (Haustein and Jensen, 2018) or 84% male users of carsharing in Berlin (Kawgan-Kagan, 2015a, 2015b), this is clearly an understatement of the importance of this factor. Because of the more frequent use of PT, women are sometimes presumed to be more concerned about sustainable mobility than men. Other studies have provided the respective evidence: Women are willing to pay more for environmentally-friendly mobility and to change their travel behaviour (Matthies et al., 2002; Polk, 2009). Studies about acceptance of technology have observed a much higher openness to innovation for males than for females (Bain and Rice, 2006; Venkatesh et al., 2000).

A study from 2015 of early adopters of carsharing with and without BEVs revealed that female users are significantly more attracted to bicycle use than male users. However, female users show a much lower affinity towards technology and are less open to innovations (Kawgan-Kagan, 2015a). Also, the results show that male users are more interested in the excitement of driving, and women use e-carsharing more pragmatically. A complimenting study of urban women and their daily mobility preferences from 2018 confirms these findings and reveals active driving practice as another principal factor for the adoption of carsharing services and rejection of too many technical gimmicks, especially in EVs (Kawgan-Kagan and Popp, 2018). The gender differences of parenthood on sustainable and electric mobility-related attitudes have yet to be researched.

2.4. A gender-based perspective on innovative and sustainable urban mobility is necessary

Gender is evident in almost all studies about sustainable mobility as a significant variable and must be raised above the status of a control variable because of its striking potential for differences in daily and electric mobility. Gender differences in daily mobility have been rediscovered without the efforts of finding explanations beyond financial and safety topics and

different daily tasks. New forms of sustainable mobility have not been analysed regarding gender differences in attitudes that are identified to be relevant for the uptake of such services. Thus far, literature has shown that women are more concerned about the environment in general and less interested in technology in general. More detailed, gender-specific differences in attitudes towards sustainable urban mobility have received little attention in the literature, although their importance has been proven for the past decade. As Hinkeldein et al. (2015) pointed out that it is crucial to not consider general attitudes but relate them to mobility and transport, this work fills this gender gap in mobility research and feeds Law's framework with evidence regarding sustainable urban daily mobility considering new mobility services.

3. Research design

This section provides insights into the method used to understand gendered urban, sustainable mobility.

3.1. Sample

The effects of differences in attitudes and mode choice according to gender requires a quantitative approach with a representative sample for urban areas. In this case, four major cities from Germany are included in a probability sample of 2400 respondents from the centres and the outer conurbation areas of Berlin (n = 987), Hamburg (n = 548), Frankfurt (n = 450), and Munich (n = 415) (Fig. 1). All these cities have satisfactory PT coverage.

The survey was conducted in 2012, by Infas, a private and independent social research institute that conducts research for companies, academia, and politics through computer-aided telephone interviews (CATI). Data from the ADM-Mastersample (Häder-Gabler-process) (Gabler and Häder,



Fig. 1. Sample distribution in Germany, n = 2400.

Table 1
Sample description (German major cities, n = 2400, subsamples and Germany).

	Total, n = 2400	Berlin, n = 987	Hamburg, n = 548	Frankfurt, n = 450	Munich, n = 415	Average Germany, in 2012 ^a
Females	51.5%	51.5%	53.4%	50.8%	50.1%	51.0%
Average age in years	48.0	49.0	47.6	47.6	46.6	44.1
Child < 14 in household	23.9%	23.9%	19.9%	27.0%	25.2%	–
Graduated from university or technical college	35.4%	36.6%	30.2%	33.9%	32.5%	14.2%
Full-time occupation	39.3%	36.6%	36.2%	40.8%	47.0%	31.3%
Part-time occupation	12.3%	11.2%	13.2%	11.5%	14.4%	11.7%
Net equivalent household income per month in €	1827	1667	1824	1932	2042	1835

^a (Statistisches-Bundesamt, 2018).

2002) for each region was weighted according to the proportion of the population of those regions. In total, a gross sample of 130,664 telephone numbers was randomly drawn according to the population distribution and resulted in a final sample of 2400 realised interviews as the person with the last birthday (Last-Birthday-Approach) was interviewed. Finally, a second and adjusted weighting compensated the distributions proportional to the population aged 18 years and over in the selected regions. Table 1 shows the details of the respective subsamples and, as a reference, the average of Germany. Urban inhabitants have a degree from a university or a technical college. More individuals from the subsamples work full-time than the German average. The differences between the cities remain small, except for the occupation status and a high discrepancy of almost € 400 in the net equivalent household income. On average, the total sample has a similar income to the German average.

3.2. Questionnaire

Socio-demographical, socio-economical questions, as well as questions regarding travel behaviour, were included in the questionnaire. Another set of questions focussed on availability of cars and bicycles within a household, with and without battery-electric drive. Also, different items were asked regarding mode choice—the actually used modes and the preferred modes of transport; the acceptance of electric mobility was covered as well. Based on the extensive research about the impact of attitudes on mobility by Hinkeldein et al. (2015), a battery of items with a 6-point Likert-scale was included in the questionnaire to collect data about environmental concerns and attitudes towards several aspects related to mobility. A factor analysis reduced the dimensionality of the data presenting these statements to nine mobility related attitudes including reliability testing. The attitudinal indices were generated by computing the means of the variables loading on the respective factor. The benefit of these indices is their relation to mobility, instead of covering a rather abstract variable, for instance, environmental awareness. Table 2 contains examples of the questions used to generate the indices. For more details on the development of the indices please see the publication by Hinkeldein et al. (2015).

3.3. Analysis

To give an answer to the research question elaborated in Section 1, the literature review in Section 2 is combined with topics from Law's gendered daily framework: access to resources, mode choice and mode preferences,

attitudes relevant to mobility including perception of cars and car ownership, and acceptance of e-mobility. For each of these topics, various variables are analysed with inferential statistical tests to compare women and men. In particular, the relation of the affinity towards cars and public transport is of strong interest because strong differences have been observed in the literature, as described in Section 2.3.

To generate resilient results, women and men are compared, and age and the presence of children in the household must be considered as variables to distinct subsamples of women and men. Therefore, age categories are generated in steps of 10 years beginning at 18 years, and a variable was generated representing children below the age of 14 years living in the household of the respondents. Indices were generated to obtain variables that represent specific attitudes. Differences are tested to be significant (Pearson- χ^2 , binominal tests, *t*-tests according to respective variable), and results are discussed in the context of gendered sustainable mobility. Finally, conclusions are drawn from the results and provide insights into gender differences regarding sustainable urban mobilities.

4. Results

This section provides the results of the analysis covering the topics of access to mobility-related resources, differences in mode choice and mode preferences, perception of car ownership and attitudes towards environmental topics, and technology and innovation.

4.1. Access to resources

4.1.1. Descriptive overview

At first, Table 3 provides detailed information about the respondents' socio-demographics and other variables that relate to access to resources regarding mobility. The employment status is correlated with income and indirectly provides insights about the household division. Nearly 30% of the women without a child work in full-time, and with 88%, the majority of women with a child under age 14 years in the household work part-time. For male respondents, more than three quarters have a child and work full-time, and only a few respondents work part-time (3%). The net equivalent household income of female respondents is smaller than that of male respondents. Children in the household lead to a decreased household net income equivalent for women and men. Parenthood increases the work-related distances of trips only for men, which is in line with the literature (Nobis and Lenz, 2005; Skora, 2018).

Table 2
Mobility-related attitudes, Indices generated by Hinkeldein et al. (2015).

Index	Item example loading most highly on the index
Car affinity	I find driving an easy way to get around.
Bike affinity	I find cycling an easy way to get around.
PT affinity	I reach my destination without stress when using public transport.
Long-distance train affinity	I find using the train an easy way to get around.
Mobility service affinity	The use of mobility services allows me to reach all my important destinations.
Owning a car affinity	I am dependent on my car in my daily life.
Mobility-related environment affinity	Environmental protection is crucial for me in my choice of transport.
Technology affinity	I am quickly able to figure out unknown electronic devices.
Innovator scale	Other individuals often discover new travel ideas thanks to me.

Table 3
Descriptive overview (socio-demographics, mobility-related items, German major cities, n = 2400).

	Women			Men			Total		
	No child	Child in HH	Total	No child	Child in HH	Total	No child	Child in HH	Total
Age	52.4	37.0	48.7	49.8	38.8	47.8	51.1	37.9	48.0
Full-time	28.8	19.1	26.5	45.9	75.4	52.9	37.2	46.1	39.3
Part-time	14.3	38.1	20.1	3.4	6.5	4.1	9.0	23.0	12.3
University degree	31.0	27.7	30.2	37.7	37.4	37.6	34.3	32.3	33.8
HH net equivalent income	1745	1514	1690	2025	1745	1957	1888	1633	1827
Driving licence	78.5	80.9	79.0	88.5	88.0	88.0	83.4	84.3	83.6
Car HH	72.9	77.8	74.0	78.6	92.4	81.9	75.6	84.8	77.8
Car km/a	10,784	10,749	10,773	13,778	18,243	14,804	12,405	14,541	12,921
Work-home distance	16.0	13.3	15.2	20.1	19.1	19.8	18.2	16.6	17.7
% sample	39%	12%	52%	37%	11%	49%	76%	24%	100%
N	939	297	1236	889	275	1164	1822	572	2400

4.1.2. Driving licences

Most of the individuals obtain their driving licences at an age when they do not have children yet. Therefore, there is no difference for respondents with and without children expected. Fig. 2 shows the share of driving licences across age categories and differentiated according to gender. For men, the share is lowest, with almost 77.9%, in the youngest category and increases up to 94.4% for men aged between 58 and 67 years. The distribution of driving licences for female respondents also differs over age: Although the distribution increases with the lowest share in the youngest group, it is not as consistent as for men and decreases from the maximum of 90.4% between 38 and 47 years to 73% for women older than 68 years. As data from the Federal Motor Transport Authority of Germany show, young women and men started to align with the share of driving licences, and the gap continues to increase with advancing age of the respondents; this is because, in the past, fewer women obtained driving licences (Kraftfahrt-Bundesamt, 2018). Our data contradicts the findings for the whole of Germany, where for individuals aged between 18 and 27 years, similar numbers of men have a driving licence compared to women: Young adults have the highest difference between women and men. For the next age category (28 to 37), the difference has nearly vanished. For individuals aged older than 58 years, the gap increases again to almost the same difference and increases again for respondents older 68 years. The variation within the subsample of male respondents is approximately 16.4% points, and for women, the variation within the subsample is almost twice as high with 30.2% points. The differences between women and men are significant ($p < .001$).

4.1.3. Car and bicycle availability

Another relevant variable representing access to resources is the availability of cars and bicycles within a household. As presented in Section 2, traditionally, men have a higher availability of cars in the household than women. Fig. 3 shows the number of cars and bicycles available in a household. Approximately half of the respondents have one car in the household, and the values for women and men are similar, although more women have no car in the household than men. A child in the household relates to increased number of cars on the household. The share of individuals with no car in the household is bigger with 27% for women with children compared to 22% for women without children. The share of individuals with no car in the household for men differs from 21% with children to 8% without children. Women with children more often have no car or two cars in the household than men, and only a small share of men with a child have no car. Studies showed that the first car in the household is usually for the male household member, and the second car is used by the female household member (Scheiner and Holz-Rau, 2012). This result is compatible with the higher share of 12% of mothers living alone compared with the 2% of single fathers living with their child from the sample. Regarding bicycles, the distribution is similar for women and men: Nearly half the respondents have one bicycle in the household, and one-fifth of the respondents do not have a bicycle in the household. Respondents with a child have one bike significantly more often, with a plus of 10% points, and accordingly, less often no bike in the household. This effect is stronger for female respondents, indicating that women might use more bicycles than men when they have children.

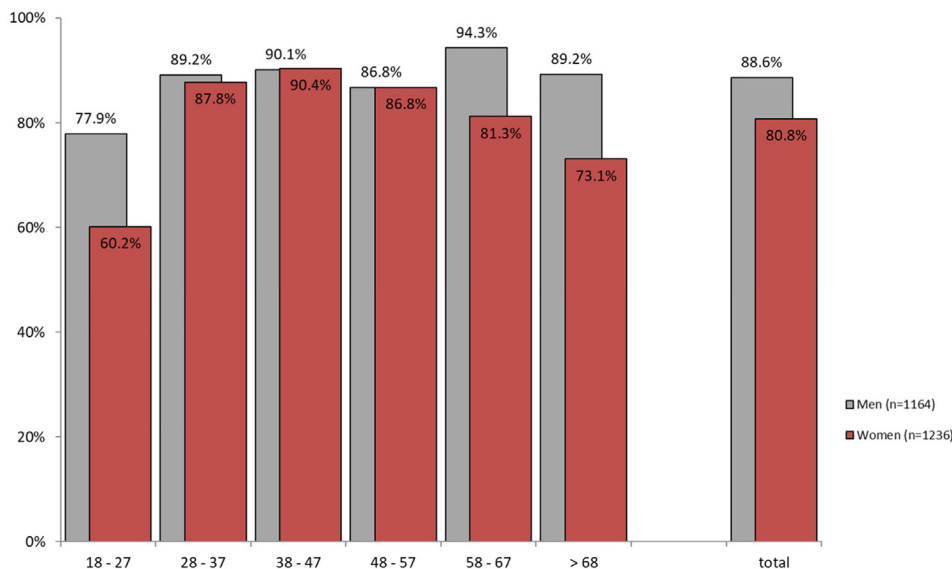


Fig. 2. Differences in distribution of driving licences of urban dwellers, n = 2400.

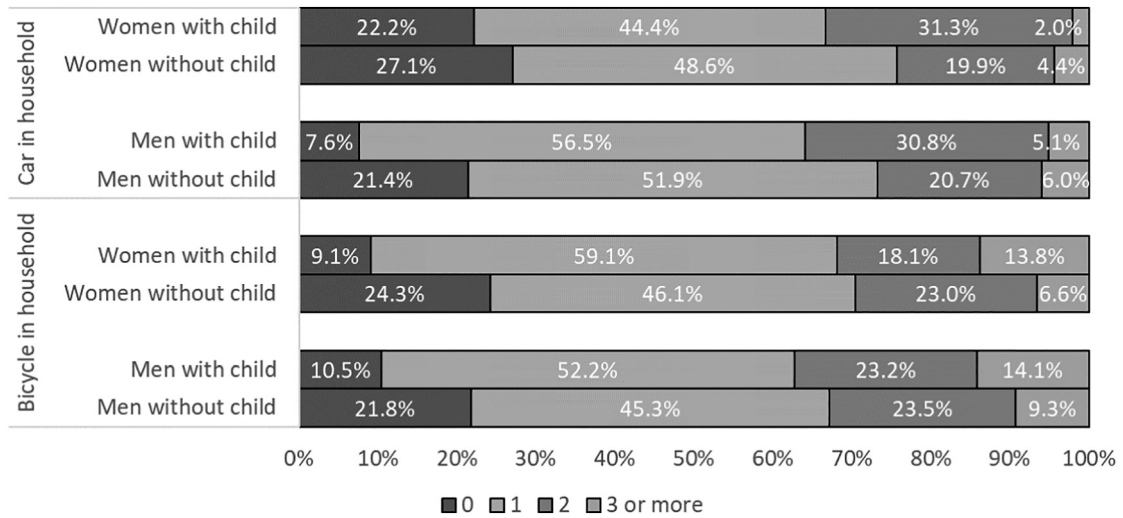


Fig. 3. Distribution of cars and bicycles of urban dwellers, n = 2400.

To understand these differences, the actual possibility of driving a car or bicycle must be analysed. Fig. 4 shows how often respondents holding a driving licence have access to a car or bicycle as a driver or passenger. There is no evidence for differences between women and men with or without children in the availability of bicycles. Regarding cars, significantly fewer women responded that they (almost) always have access to them, especially when they have a child in the household ($p < .001$). Comparing women and men, distribution of cars in the household and the availability of cars are significant with $p < .001$.

4.2. Perception of cars, of driving, and car ownership

The use of cars is less frequent in urban areas compared with Germany in general, especially in rural areas (Herget, 2013). This result is related to the satisfactory PT coverage, the affordability and efficiency of the PT, and that everyday destinations are much closer to one another in urban areas. Nevertheless, cars continue to shape the cityscape, and many dwellers have retained their private cars. This section covers what urban residents think of cars and car ownership and how they perceive travelling by this mode with respect to gender differences.

4.2.1. Meaning of cars for personal mobility and car ownership

Fig. 5 shows the agreement to several mobility-related statements comparing women and men with and without children. For each statement that can be found on the right, there are four bars representing the subsamples of the respondents, which give the share of the respective agreements to these statements. Approximately half of the male and female respondents stated that they could easily go to important destinations by car, with a marginal difference of men agreeing more than women. There are no significant differences between women and men with a child below age 14 years in the household. Nevertheless, more women than men, especially with a child, stated that they do not need a car to be flexible. This result is surprising, because children, especially, represent a factor that calls for the need for a car for spontaneous events (Dowling, 2000; Schneider and Hilgert, 2017). Agreements to the statement of only being able to manage life with a car in the household differ for women and men with and without children. More women with a child than without, but fewer men with a child than without agreed to the necessity of a car for their daily mobility. One-quarter of women said that it was true that they would not be able to manage their daily life without a car, but more women without a child disagreed with this statement.

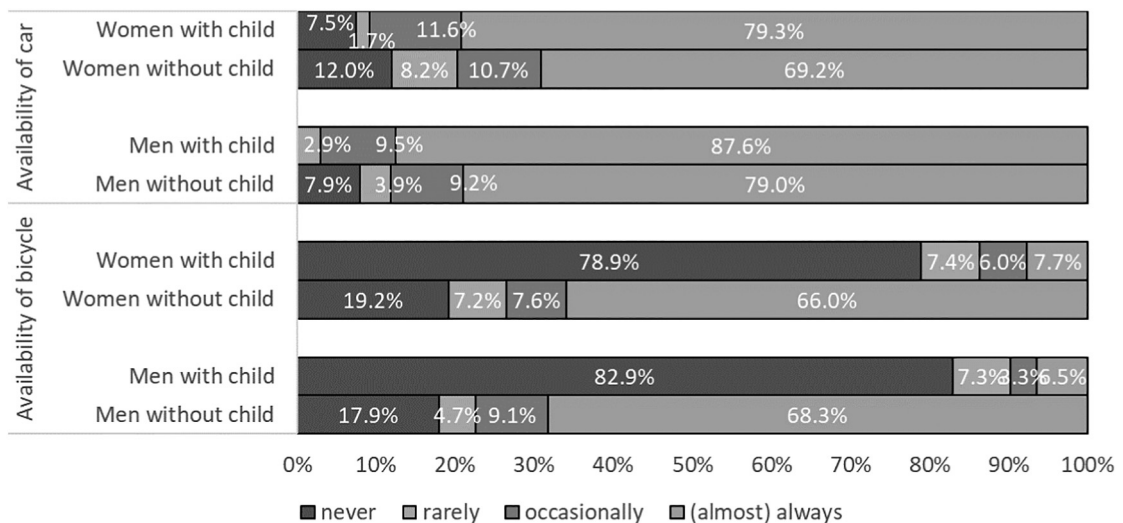


Fig. 4. Availability of cars and bicycles as driver of urban dwellers, n = 2400.

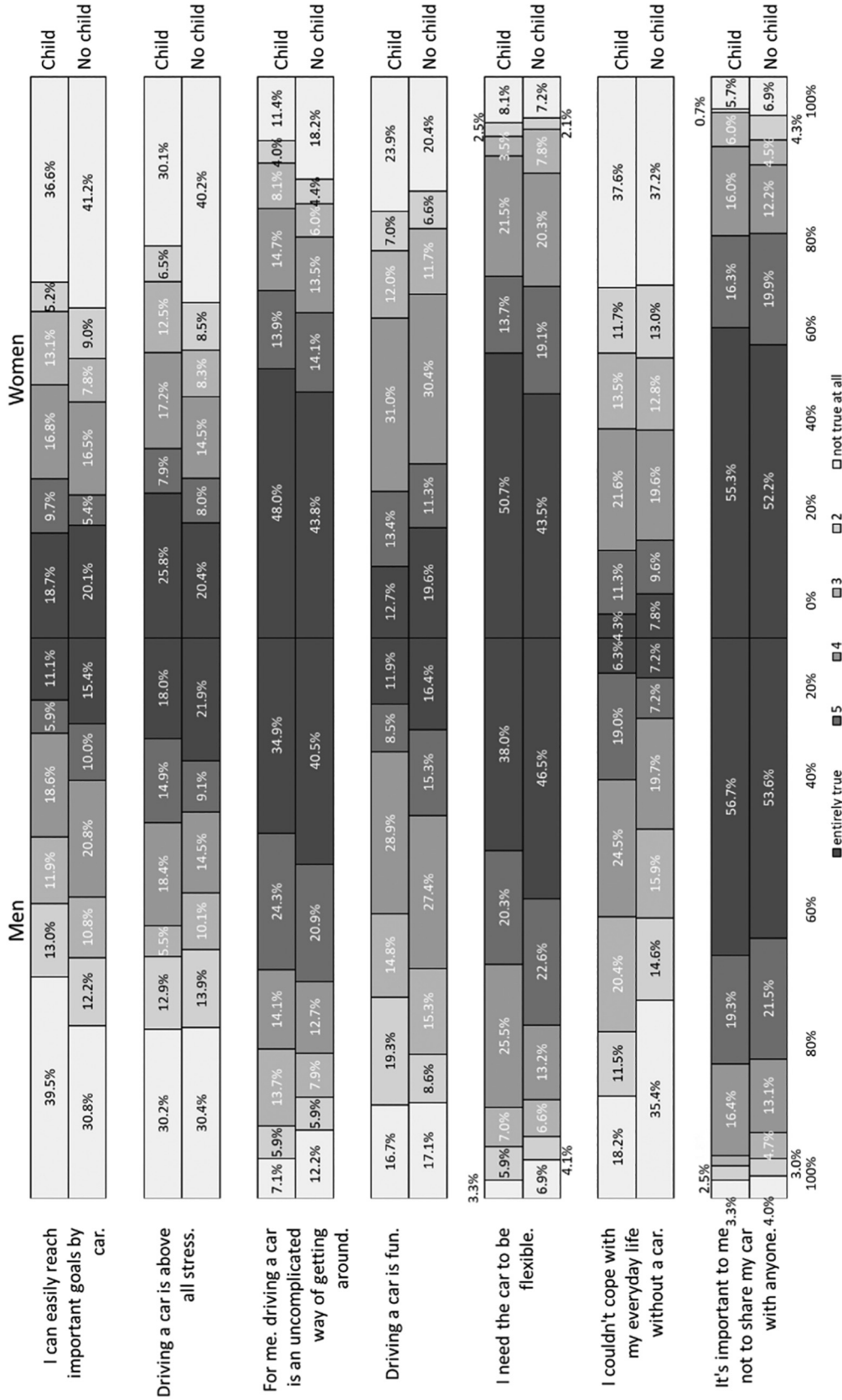


Fig. 5. Agreement to statements regarding cars, driving, and ownership, n = 2400.

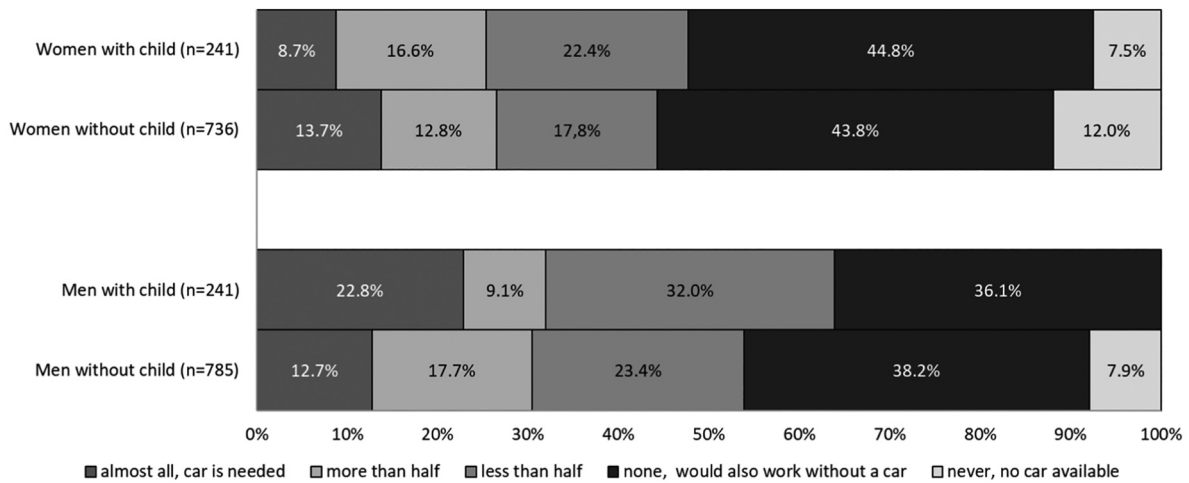


Fig. 6. Frequency of car use for daily trips, n = 2400.

Regarding the perception of driving, more women compared with men agreed that using a car is an uncomplicated manner of travelling. A young child in the household has a positive impact on the evaluation of this item. More women with a child stated that driving is more than fun than childless women. Men show the opposite effect and perceived driving to be less fun when they have a child in the household. Being asked about the stress they experience while driving, women with and without a child and men without a child answered nearly in a similar manner. Men with a child consider driving to be significantly more stressful. For more women than men, it is important not to have to share their car with anyone. For women with a child, the disagreement decreased by 4.4% points, and for men with a child, the percentage increased from 31.0% to 39.5%.

4.2.2. Reach of destinations

To understand the perception of cars of urban dwellers, respondents were asked how many of their daily trips can be covered only by car (Fig. 6). Approximately the same share of women and men without a young child stated that almost all of their trips must be taken by car. 55.8% of the female respondents without a child stated that they do not necessarily need a car or do not have access to a car compared with 46.1% of the respective male group. The strongest difference is observed for respondents with a child: None of the male respondents stated that they never have access to a car, and 36.1% of the male respondents said that they would not need a car. 7.5%, respectively, 44% of the women answered in this way. Correspondingly, significantly

more men with a child compared with women with a child in the household said that a car is needed for almost all their daily trips. Women with children said that the car is not as needed, similar to what women without a child stated.

4.2.3. Reasons for rejecting a private car

The ratio in this sample between women and men without their own car is uneven: 24% for women to 17% for men (not included in Fig. 7). The reasons why an individual renounces a car can be manifold. The interviewees were provided five possible reasons and asked for their agreement regarding each statement with the possibility of multiple answers. Fig. 7 shows the total numbers of reasons to reject a private car. More than half of the women without a car said that the high acquisition costs or maintenance costs are a reason why they do not want their own car, and 100 of the carless men named this reason. Unequal access to resources is one reason why women have fewer cars than men (Section 2). This result is reflected in the financial aspects being the main reason against car ownership for urban women. For most men, however, a car is not necessary to be mobile, although more women than men cited this reason (142 women cited this reason). The discrepancy in terms of access to resources in the form of costs is reflected in these numbers: While in relation, the conscious renunciation or the renunciation because of environmental awareness is important for more men than women, more women than men renounce their own vehicle for health reasons.

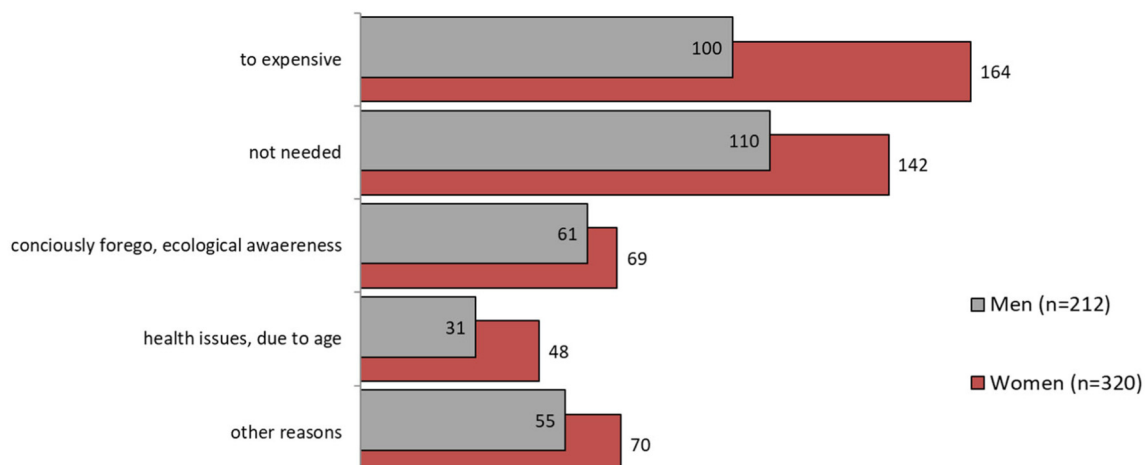


Fig. 7. Reasons for car rejection of urban dwellers, n = 532.

4.3. Mode choice

The access to different modes and the perception of cars provide indications about only the actual travel behaviour and use of specific modes. However, they provide the frame for daily mobility. To understand mode choice regarding gender aspects, it is important to correlate the preferences for a specific mode of respondents with and without a child, respectively, across different age categories.

4.3.1. Primary mode

Respondents were asked about the mode they use the most for their daily trips (Fig. 8). In general, most of the respondents stated that cars are their main mode of transport. Female respondents with a child in the household use cars significantly more often in their daily lives and less public transport than female respondents without a child ($p < .001$). For men, in general, hardly any difference is observed in their primary mode choice with or without a child, indicating that their mode choice is not affected by this factor. For women, walking is more important in their daily mobility when they have a child. Other modes do not show a crucial difference between all women and men.

Notably, these result changes when subgroups according to age categories are generated: For men between age 18 and 27 years, there is a crucial difference for the use of cars and the use of public transport is half as high for men without a young child in the household. Walking plays a bigger role for men between age 18 and 27 and with a child years with 16%. For respondents aged between 18 and 27 years, the relation to the child in the household is not clear; therefore, a gender-typical caretaking division cannot be assumed. Nonetheless, literature shows that girls more often take care of their younger brothers and sisters than boys (Wikle et al., 2018). For women between 18 and 27, the main mode of transport for most of their daily trips is public transport, that is, greater than 50% no matter whether there is a child in the household or not.

For men aged between 28 and 37 years, the same difference regarding public transport and car use can be observed, although public transport is less important than that for younger men. For 40% of the women with a young child in the household, the car is the primary mode of transport. The differences between women and men with and without children differs significantly ($p < .001$) mainly the use of cars and PT. Men with children use a bicycle less often when they live with a child. Women with a child walk significantly more across all age categories ($p < .001$). For the next two age categories of women and men, the share of respondents using cars for most of their daily trips shows is lower when there is a child in the household. This difference is balanced by more use of public transport and bicycles. Women aged between 38 and 47 years with a young child show an higher use of bicycles and walking and use fewer cars and less public transport. Women with children across all age categories use public transport approximately half as often as women without a child in the household. In addition, there is an opposite effect on the use of public transport: Women with children walk more than women without children. For the age categories 58–67 years and older than 68 years, there is a balanced ratio across the modes. Nevertheless, women older than 68 years use fewer cars than men of the same age.

4.3.2. Preferred mode of transport

By contrast with the actual primary mode of transport, Fig. 9 provides the shares of the preferred mode of transport of women and men with and without a young child in the household. Almost half of the sample said the car and approximately 20% said the bicycle was their favourite mode of transport. These values are similar for men and women; nevertheless, the differences are significant ($p < .001$). The main difference is within the acceptance of public transport, which is generally higher for women. Divided into subsamples according to having a child in the household, men show a significantly higher preference for bicycles with 31.0% and by contrast, a lower preference of cars. The

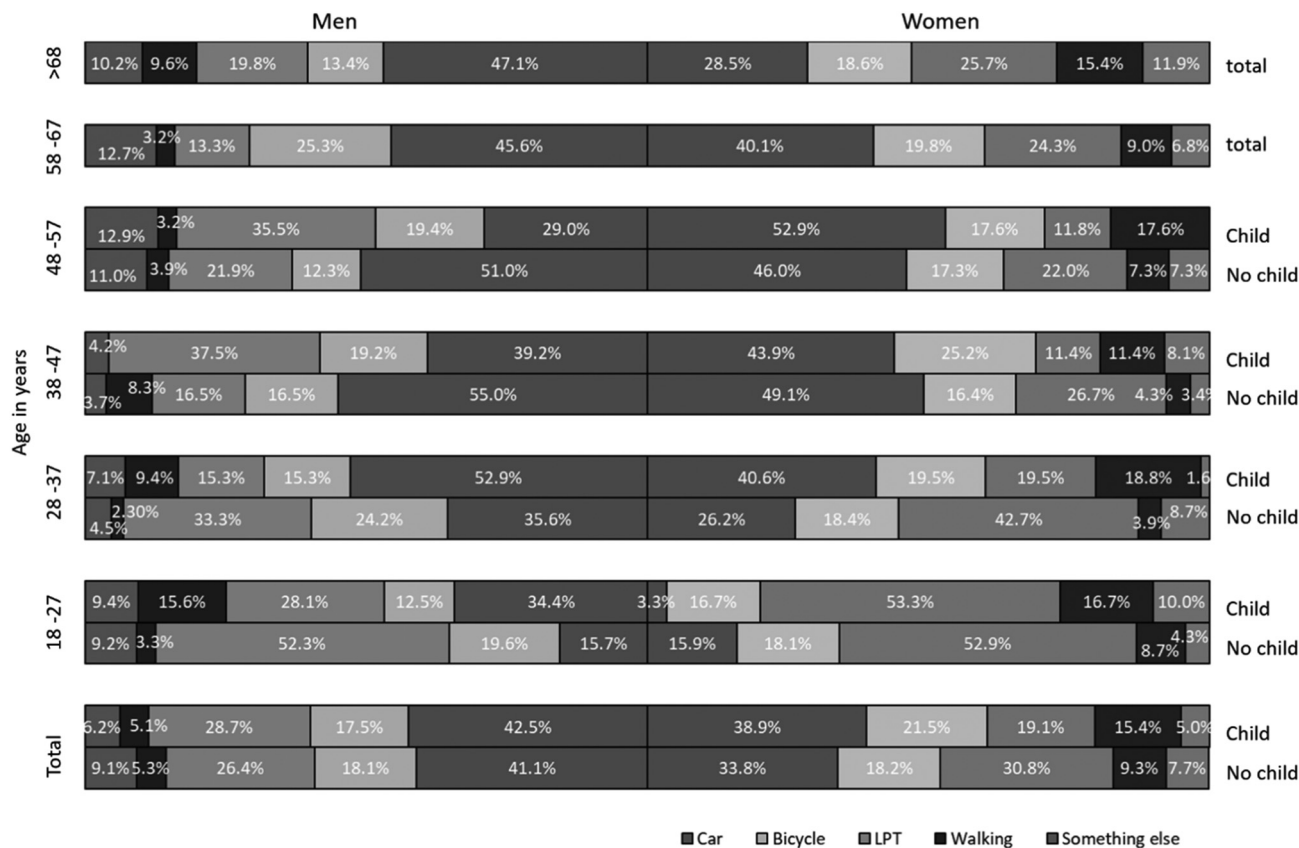


Fig. 8. Primary mode of daily trips of urban dwellers, n = 2400.

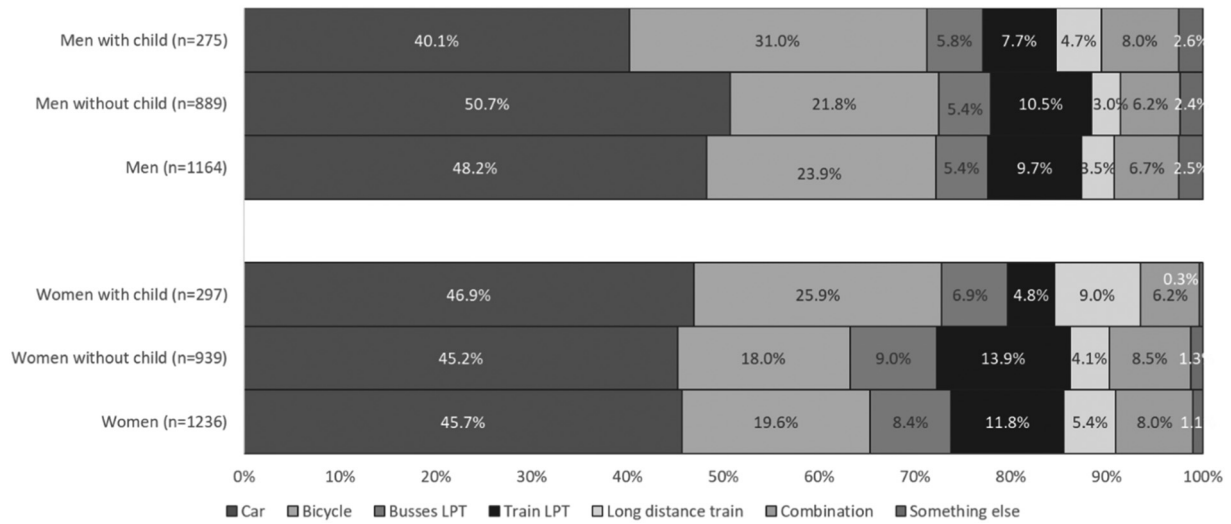


Fig. 9. Preferred mode of transport of urban dweller, n = 2400.

values of the shares remain closely equal. There is a shift in preferences for men with children from motorised private transportation to greener unmotorized private transportation, and slightly more women with a child prefer a car than women without a child. Women also show a significant shift towards bicycling when a child is in the household. Compared to men, women's preference for local public transport is lower when they have a child in the household and significant when compared to women without a child. The preferences between men and women each differ significantly between those with and without a child in the household ($p < .001$).

4.3.3. Active car driving or being a passenger

Fig. 10 shows the frequency of car use as a driver or as a passenger for women and men with and without a young child in the household. Car use must be examined from drivers' and passengers' perspectives, representing different opportunities for women and men in mode choice.

In line with the previous findings in the literature and this study, more men than women in total drive a car themselves (almost) every day (not included in the Fig. 10). For women, there is a gap between

women with and without a child of 15.5%. Fewer respondents with a child use a car actively (almost) never than respondents without a child. Regarding car use as a passenger, the daily use is nearly aligned for all groups, with values between 3.7% and 6.0%. The main differences are that approximately 40% of the male respondents (almost) never drive a car as a passenger, and women with a child are passengers less often compared to women without a car on average, accordingly to the more frequent active use of cars. The values between men and women differ significantly ($p < .001$) as well as between those with and without a child in the household for each subsample ($p < .001$).

4.4. Acceptance of sustainable and innovative mobility

Fig. 11 shows the deviation for specific shares of the overall sample of total means of the z-standardized variables representing attitudes regarding the mobility of the total sample. The attitudes are divided into three categories: attitudes towards modes, mobility-related aspects, and e-mobility. Each of these indices is generated from various statements as presented in Section 3.2.

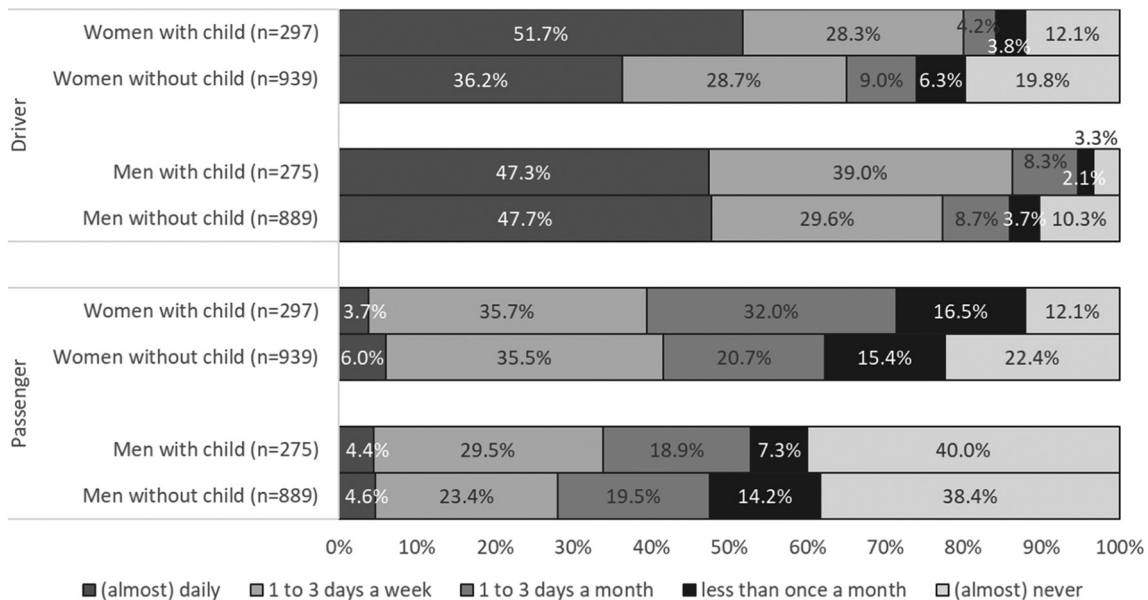


Fig. 10. Active and passive car use of urban dwellers, n = 2400.

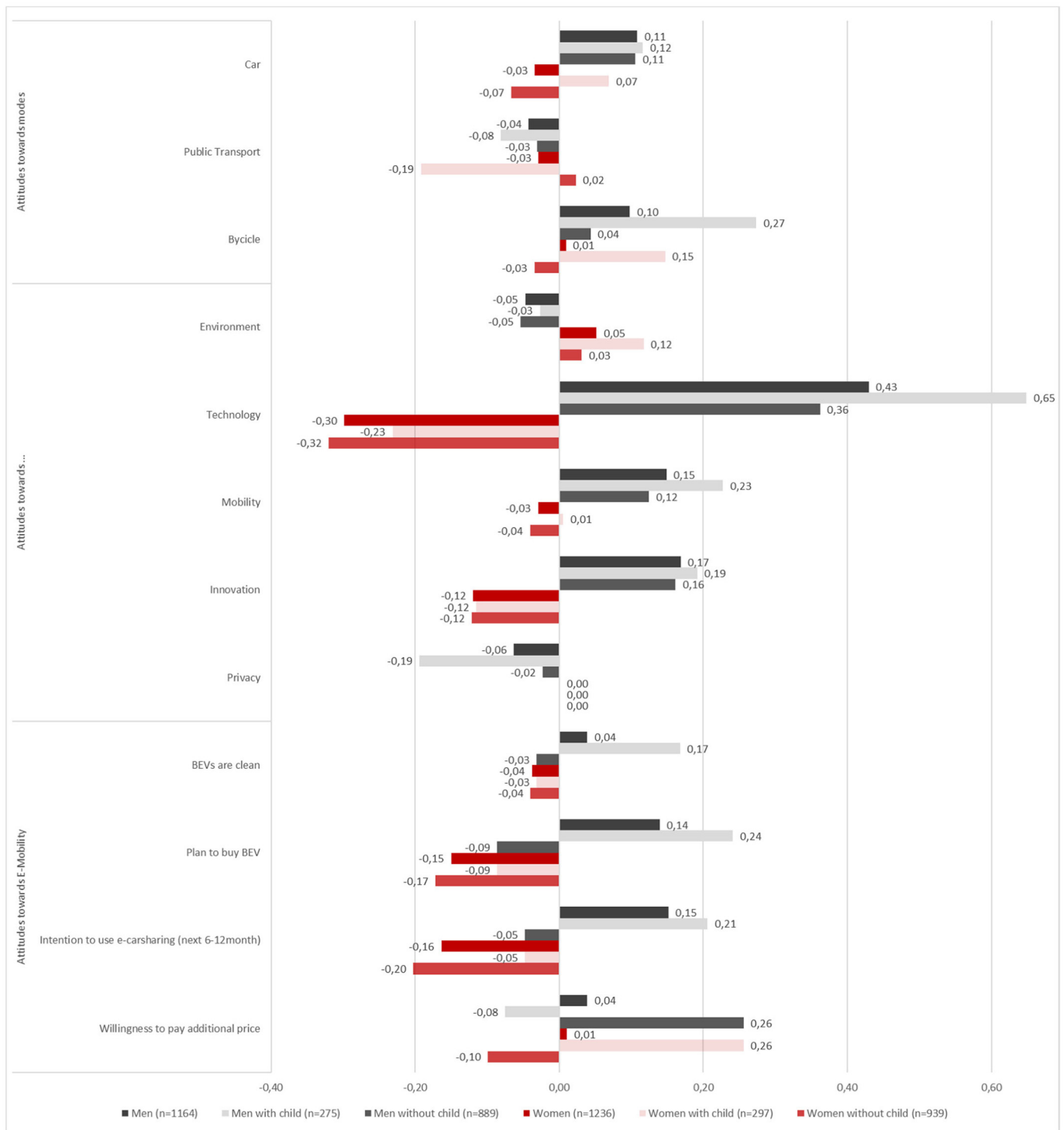


Fig. 11. Deviation of z-standardized indeces regarding sustainable and innovaite mobility, n = 2400.

The attitudes towards specific modes show that women and men differ significantly ($p < .001$). Regarding the affinity towards cars, men with and without a child below age 14 years in the household show hardly any differences, with values between 0.11 and 0.12. By contrast, for women, there is a gap of 0.15 between women without and women with a child. The value of 0.07 of women with a child is similar to the values of men in general. For PT, similar differences are observed. Men with and without a child do not differ as much regarding their affinity for PT. For women, the difference is much stronger with 0.21, compared to men with and without a child.

Women are with -0.03 slightly more PT-affine than men in general with -0.04 ; the main difference is in the factor of parenthood though. As also evident in the stated use of bicycles, there is a higher affinity for bicycling for women and men with children in contrast to without children.

The attitudes towards environmental protection, technologies and innovations, mobility as a service, and privacy differ significantly between women and men ($p < .001$). These differences are even greater than those regarding the attitudes towards specific modes of transport. When asked about environmentally-friendly mobility, women with children are

more concerned than the other subgroups. The difference between women and men with a young child in the household is greater than that for male and female respondents without a child. This result contradicts the changes in women's attitudes towards cars and PT but is in line with their higher preference and attitude for bicycling. The differences for male respondents are small: 0.02. The greatest gender gap can be found by analysing the affinity towards technology. In essence, 0.97 points is the greatest difference between women without a child and men with a child across all variables. For women and men, a child in the household relates to a higher technology affinity. This effect also occurs for the affinity towards innovations and mobility as a service, namely car rental, car and bicycle sharing, or online ticketing. Notably, the attitude towards privacy does not differ for women with or without a child, and women have a higher affinity compared with men. This factor stands for the need to have sufficient space and comfort surrounding a person while travelling. The expectation was that women would have a higher preference for privacy with a child than without a child due to security reasons; notably, this expectation cannot be confirmed. For men, an opposite effect is observed, with a minus of 0.13 for men with a child, indicating fewer concerns about strangers while travelling. The three aspects - environmental concern, affinity towards technology, and innovation - are identified as crucial variables regarding the acceptance of e-mobility, as presented in Section 2. Because these three variables differ significantly for women and men, they are key factors for the gendered acceptance of e-mobility result.

The perception of BEVs is nearly equal for men without a child and women but is significantly higher for men with a young child in the household. This difference is also reflected in the intention of using BEVs in a carsharing scheme and the desire to buy a BEV as soon as possible. Nevertheless, the willingness to spend more money on an electric engine for a car is less for men with children. Wang et al. (2017) found that women were more willing to pay a higher price for sustainable urban transport in Beijing, China (e-carsharing in their case), than men. In this study, women and men positively agreed equivalently. However, for women with a child, there is a more positive evaluation than for women without a child. For men with children in the household, there is a much more positive perception of e-mobility. By contrast, women with a child are willing to pay more for an environmentally-friendly electric car if it offers the same level of convenience as a car with an internal combustion engine.

5. Discussion and conclusion

Sustainable urban mobility remains at the beginning to enter the market and e-carsharing is mainly used by males. This phenomenon forms the basis of this investigation. Although urban women own fewer cars and use them less often than men, there remains a substantial potential to shift their mobility towards a sustainable e-carsharing.

In general, the results support that gender differences continue to exist, even in urban areas with a less traditional understanding of gender-specific roles. Across the three investigated dimensions of inequality (access to resources, mode choice and gendered meaning of mobility), the following gender differences can be observed.

First, urban women have less access to mobility-related resources in urban areas than men. Gender differences are partially not very strong; nevertheless, gender differences are significant, except for bicycle availability. The low shares and the high difference for young adults in driving licences might be a particularity of urban individuals: In larger German cities, the cheap provision of public transport is much better than in rural areas. This situation benefits an urban mobility without the necessity to drive a car, which could be even more suitable for urban women than men.

Second, the perception of cars differs significantly according to gender and parenthood: Although most of the male respondents work full-time and their mobility does not change as much as it does for women taking care of and accompanying children possibly in addition to working part-time, a young child changes how men consider the necessity of a car. This result implies a crucial difference in perception of the possibilities without a car for men with a child, despite men with a child in the household do not

tend to perform most of the care work during the day. The preference of modes is different for urban women and men even more when additional tasks occur because of a child in the household. In such cases, bicycling is more important for men, and women prefer using cars. Shorter distances related to child care such as trips to day-care or school are more suitable for bicycle use than longer trips such as work-related trips. Another reason could be that individuals with responsibility for a child show a higher awareness of environmental concerns and, therefore, prefer cycling over using a car.

The third dimension represents the importance of gendered meanings of sustainable mobility beyond the access to resources and differences in daily tasks: The attitudes towards environmental protection, technologies and innovations, mobility as a service, and privacy differ significantly between women and men. These differences are even greater than the differences regarding the attitudes towards specific modes of transport. Although women with a child have a lower income (Section 3), they are willing to spend more money than men for sustainable BEVs. Nevertheless, BEVs are not observed to present an attractive solution for most of the women. A reason could be their strong rejection of innovative technology. This result proves the importance of these factors (environment, technology, innovation) for the adoption of sustainable urban mobility and shows that a key problem is within the gendered meaning of mobility. Policy measures, therefore, must focus on attitudinal gender differences in mobility to support sustainability in urban transport and not focus only on topics resulting from family responsibilities. Child seats in every carsharing vehicle cannot be the only solution to this problem.

Although the results demonstrate that urban women are more concerned about environmentally-friendly mobility and use fewer cars than men, women with a child prefer transport by car. For men, there is an opposite effect regarding sustainable mobility. Parenthood brings different constraints for women than for men that must be considered when supporting sustainable urban mobility. Nevertheless, there is the additional gendered meaning of mobility in urban areas, which especially manifests in the attraction of carsharing with BEVs for males. Further research can provide additional details on this difference, and qualitative interviews would facilitate the achievement of that goal.

The phenomenon of male early adopters of e-carsharing is similar to the extent found in the international context and shows significant differences between women and men regarding factors that Law (1999) highlighted in the gendered daily mobility framework. Because of the representativeness of the sample for German cities, the results can be applied to other urban areas, especially within Europe. The limitation of this research is the still early state of adoption of new mobility services when the data was collected. Also, future research on gendered sustainable urban mobility must identify possible cohort effects or a change in attitudes over time. Another limitation is that the data set does not provide insights into who in the household takes care of the child. Especially for young respondents, the relation to the child in the household is not clear; therefore, a gender-typical caretaking division cannot be assumed. Nevertheless, girls more often take care of their younger brothers and sisters than boys (Wikle et al., 2018). Women as an immense potential user group are excluded if only the need of single users is addressed with e-carsharing services and innovative technological affine individuals. Women are willing to use sustainable modes but are not actually using sustainable modes due to child care related to daily tasks, the rejection of innovative technology of BEVs and the issue of active driving when using carsharing. These findings call for further investigation on how the attitudes towards aspects of e-carsharing services such as environmental awareness or innovative technology might be changed and how respective measures influence sustainable women's travel behaviour.

In conclusion, the potential for sustainable mobility in urban areas needs to be discussed in a gender-equitable manner. The perception of (electric) mobility and individual's behaviour must be understood including their underlying psychological processes (Schlag and Schade, 2007). In the current state of the introduction of new mobility forms, it is important to understand (potential) users from the start of the market entry to avoid

established obstacles and barriers that might result from gender differences in attitudes towards mobility.

CRedit authorship contribution statement

Ines Kawgan-Kagan: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Writing - original draft, Visualization, Project administration.

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