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Carpoolers' Perceived Accessibility of Carpooling

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Abstract: In order to constitute a realistic option to existing travel modes, carpooling needs to be able to offer adequate levels of accessibility. Insights into how carpooling services affect perceived accessibility up until now remain unexplored. In this study we explore carpooling experiences of 122 users in Sweden and examine a number of possible determinants of the perceived accessibility of carpooling. Results show that carpooling is not perceived by the users as particularly accessible with low levels across the sample. Moreover, multiple linear hierarchical regression analyses show that simplicity of travel, population density, years of education, and school and work-trips appear to affect perceptions of accessibility of carpooling, whereas travel time and cost appear not to. The final model explains a third of the variance in perceived accessibility of carpooling, thus nearly two thirds of the variation is still unaccounted for. Future research should explore further possible determinants of perceived accessibility of carpooling in order to explain, understand, and counteract the low levels of accessibility that appear to be linked to this specific travel mode.

Keywords: carpooling; perceived accessibility; accessibility; daily travel

1. Introduction

Carpooling has been around at a smaller scale for decades, during the second world war it was used for saving resources for the war and in the seventies the motive was to reduce the use of oil during the oil crisis. Today, growing environmental concerns have led to new solutions regarding alternatives for (single use) car travel including diverse carpooling services around the globe [1,2]. Recent research has focused on insights into what drives individuals to use carpooling services in different contexts [3,4] on demands for services, eligible business models, and related travel behaviour patterns [5,6] and on carpooling as an element of new mobility solutions, e.g., MaaS [7,8]. However, if carpooling is to be viewed as a realistic option to existing travel modes such as the private car, these services need to offer adequate levels of accessibility from the individuals' own lived experiences [9,10] and to activities which are preferred by the individual. Adequate levels of accessibility are important for the inclusion in society and ability to travel to and participate in activities of choice in daily life. Satisfying levels of accessibility to daily activities, regardless of travel mode, also constitute a main target by European countries [11], and specifically as a key target for 2030 by The Swedish Transport Administration [12]. Moreover, the individual evaluation of accessibility, also known as perceived accessibility, has been shown to play a role for the overall subjective wellbeing of travelers in a study of accessibility, travel satisfaction, and quality of life of elderly travelers in northern Europe [13].

We acknowledge that carpooling has been defined differently by different researchers (e.g., [3,14,15]). We follow the definition in which carpooling is defined as "an arrangement where two or more people [...] share the use of a privately owned car for a trip (or part of a trip), and the passengers contribute to the driver's expenses" [15]. This definition is distinguished from car sharing which includes access to a fleet of vehicles on an hourly basis for car-sharing members [3]. Even though carpooling is a growing

service concept worldwide [2], insights into how carpooling services affect perceived accessibility up until now remain unexplored. Hence, in the present study we explore a number of members of a nonprofit carpooling service in Sweden and examine a number of possible determinants of the perceived accessibility of carpooling. The originality of the study can be justified by the lack of studies addressing perceived accessibility in daily travel. In particular, while some research efforts for understanding why people carpool have been conducted, insights into how the users perceive their possibilities of engaging in daily activities with carpooling as the mean of travel are still missing.

The paper is organized as follows. In Section 2, a brief overview of perceived accessibility and previous insights of carpooling is presented, ending with a section describing the research objectives/research questions. Section 3 describes the method and materials used, and in Section 4 the results of Ordinary Least Squares (OLS) multiple linear hierarchical regression analyses are presented. In Section 5 we discuss the results and provide conclusions, policy recommendations, and areas for future research on carpooling services and accessibility.

2. Literature

2.1. Perceived Accessibility

Perceived accessibility builds on the subjective evaluation of accessibility and is influenced by both objective/environmental conditions of travel (such as service quality in terms of travel time, punctuality, information, and comfort) and the individual experience and evaluation of these conditions (based on individual preferences and prerequisites). Perceived accessibility has been defined as "How easy it is to live a satisfactory life with help of the transport system" [16] (p. 36) and differs from conventional views of accessibility (determined by objective conditions), by including the individual dimension of accessibility, as described by Geurs and van Eck [17]. Accessibility in general is important as a prerequisite for social inclusion and subjective well-being and in avoiding transport poverty and social exclusion [18]. As such, accessibility has been set as a main objective of policies around Europe that promote inclusion in society in terms of "accessibility for all" [11,12].

Moreover, accessibility is a key factor when assessing the performance of a specific travel mode in terms of its ability to offer users, or potential users, a realistic and eligible mean for travel to and participate in activities and destinations of choice. The dimension of including the individuals own preferred activities in the concept of perceived accessibility is important, as it is difficult to capture perceptions of accessibility in full if the assessed accessibility is limited to a number of predetermined destinations. Even if accessibility to the hospital or the nearest supermarket is generally important, we have no way of knowing what the preferred activities of a specific individual are, as they may range from spending time in nature to hanging out at a favored café at the other side of town with friends and family. Thus, it is important to allow for evaluations of perceived accessibility to include destinations and activities that are preferred by each individual.

Despite the fact that perceived accessibility was framed as a concept already in the seventies [19], it has not been prioritized in theories and research on accessibility. However, in recent years perceived accessibility has gained ground and researchers have explored determinants of perceived accessibility in public transport and daily travel settings [16,20,21] concluding that service quality (such as reliability or simplicity of travel), age, gender, residential area, safety and security, cost, and frequency of travel affect perceptions of accessibility with sustainable travel modes. A few studies have pointed out differences between objective conceptualizations of accessibility and individual perceptions of accessibility in the same geographical contexts [22–24]. Thus, when evaluating new mobility services such as carpooling, perceived accessibility can complement conventional evaluation methods by assessing the individuals' own expectations and experiences of accessibility in terms of the ease and possibilities of reaching preferred daily activities with the help of a designated transport mode.

For instance, Allen and Farber [18]'s overview of inaccessibility in Canada concludes that, in order to counteract low accessibility in low density areas where public transport options are scarce, other transport options may act as accessible complements to the private car. Solutions like these could include carpooling services, which would have the potential of not only addressing issues of accessibility but also of reducing the environmental impact, issues of space (parking/road space), and economical concerns for individuals using the services (in comparison to the private car). Olsson et al. [3]'s overview of factors that influence carpooling also lift density as an important factor, referring to population density. Their study found that the more densely populated an area was, the more likely that people would carpool. Thus, (population) density appears to be an important factor to include in studies of carpooling and perceived accessibility. Moreover, it is likely that the perceived accessibility of carpooling differs between different types of trips, e.g., that for some trip purposes, such as work commuting, carpooling services may be perceived as more accessible. Insights into the users perceived possibilities of engaging in daily activities with carpooling as the mean of travel is still lacking in contemporary research.

2.2. Previous Insights of Carpooling

The term carpooling includes an element of matching between driver and passenger. Ciasullo et al. [4] provide a recent overview of different types of carpooling and advantages and disadvantages with carpooling based on a large-scale text analysis of Twitter-data. Economic and environmental efficiency were the top advantages mentioned on Twitter, while (lack of) effectiveness and flexibility where considered top disadvantages.

Innovative solutions, such as carpooling, have been suggested as reasonable options (to public transport) in low density areas for work commuters [25], or for "serving the last mile" [18]. However, Wright et al. [8] research on a MaaS concept in low density areas showed that solutions offering intermodal journeys (incorporating carpooling and public transport) were a lot more successful in attracting users than were carpool-solutions alone. A combination of public transport and carpooling services was also tested in a rural area in Sweden with the aim to create more travel options and more flexible travel for the residents. The test was not a success, and a number of barriers were identified related to legal aspects, difficulties to change travel habits, and low density generating few travel options for carpooling [26].

Olsson et al. [3] meta-analysis of factors that influence travelers to carpool conclude that demographic factors have limited value in explaining carpool use or intention to use, and that judgmental motives (such as environmental concern, socializing, or cost), and other psychological motives (such as motivation to change), have recently been highlighted in the literature. Findings by Kesternich [6] on European carpoolers showed that a reduction in travel time, reduced travel costs, less CO_2 emissions, and a large community were important motives when choosing to use different carpooling platforms. Recent findings on individual subjective travel experiences of carpooling [27] conclude that motives such as socializing and economic benefits (referred to as perceived values of carpooling) alongside residential density, and work and school trip purposes were likely to affect the intention of carpooling.

Motives for carpooling can be viewed as a mindset related to carpooling, and in this sense, positively loaded motives (e.g., socializing) have been shown to affect carpooling. As these motives are important for people in their daily life, the very same motives may also be directly linked to the perceived accessibility of carpooling. For instance, motives such as reduced travel times and easier travel are more instrumental and may be more closely related to different aspects of accessibility, alongside more personally intrinsically related motives, such as those associated with social or environmental values.

The main focus of this study is to identify determinants of the perceived possibilities of living the life one wants using carpooling (referred to as the perceived accessibility of carpooling). The next section presents a hypothesized model explaining perceived accessibility by carpooling.

2.3. Hypothesized Relationships

There is still much to be understood about how different determinants (e.g., demographical factors, motives, trip purposes) relate to carpooling and accessibility. Although previous research has presented a diversity of important determinants for the use of carpooling services, none have so far related them to the perceived accessibility of carpooling, and very few studies have been applied in a nonprofit carpooling context. Figure 1 illustrates the a priori research model investigated in the present study.

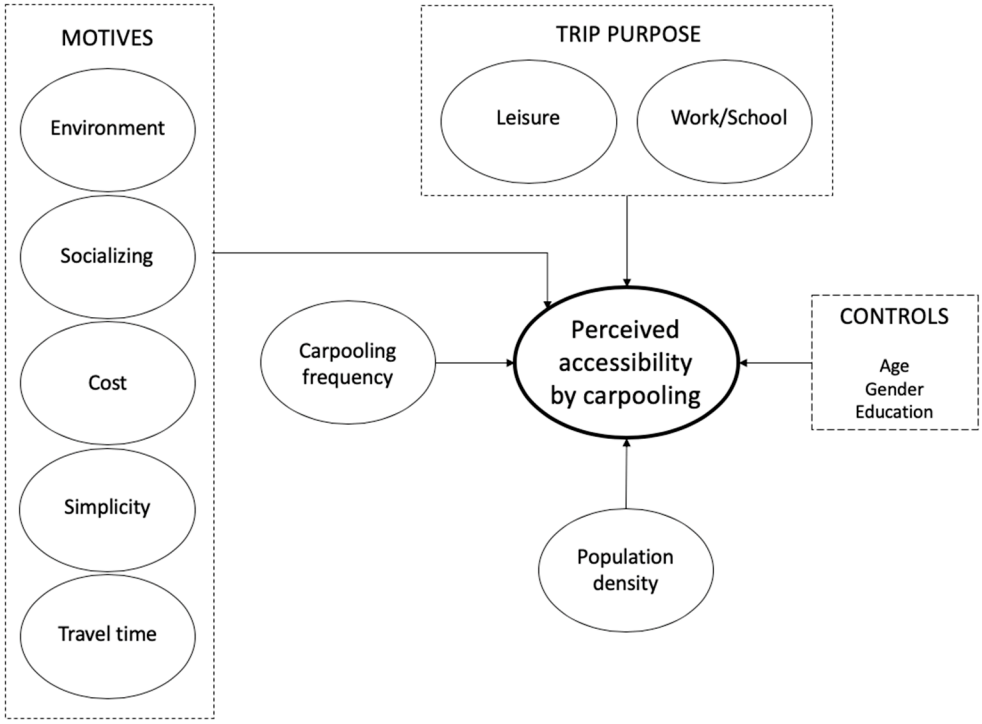

Figure 1. The hypothesized model explaining perceived accessibility by carpooling.

Based on previous research and the accompanying findings presented in the above sections, we assume the following hypotheses:

Hypothesis (H1). *Frequency of use of carpooling will be a significant antecedent to perceived accessibility by carpooling.*

This hypothesis is justified by the assumption that frequency of use is a proxy for the utility of carpooling. As the degree of use increases it is assumed that carpooling provides satisfactory conditions for engaging in daily activities.

Hypothesis (H2). *Carpooling motives will act as significant determinants of perceived accessibility.*

Previous research has identified several different motives for carpooling. However, the paths from those motives to perceived accessibility have not yet been studied. Since perceived accessibility is about the possibility to live the life one wants, several different motives may be of importance; either instrumental (cost, travel time, simplicity) or of a more personal character (social, environmental). Therefore, we intend to analyze and discuss the significance of several different motives as determinants of our outcome variable.

Hypothesis (H3). *Work/school trips (with relatively predictable departure and arrival times) works better for carpooling than other trips purposes, and hence will be positively related to perceived accessibility.*

Carpooling requires coordination of travel. It is thus hypothesized that travel coordination works better for some trip purposes than others (leisure travel).

Hypothesis (H4): *Density is positively related to perceived accessibility.*

In a previous meta-analysis [3], density was identified as an important variable for carpooling services. In more densely populated areas there can also be assumed to exist more people to carpool with, which in turn may generate more travel options. Given that accessibility is about the perceived possibilities to reach preferred activitites, we hypothesize that density is positively related to perceived accessibility.

In the hypothesized model (Figure 1), we have also included a number of sociodemographic variables as controls (age, gender, and years of education) as previous research have indicated their importance for perceived accessibility.

3. Materials and Methods

3.1. Sample

The sample consisted of 122 (65 females and 57 males) carpoolers in Sweden. Members of a nonprofit carpooling community were contacted to participate in the study; of those responding only those using carpooling at least one day a week were included in the study. Although the respondents were sampled through a nonprofit carpooling service, the study was designed for capturing experiences of carpooling in general and not exclusively of nonprofit carpooling.

3.2. Procedure

The survey was distributed to 45,000 members of the biggest nonprofit carpooling community in Sweden (www.skjutsgruppen.nu) by e-mail, via adds in a Facebook group, and by the Skjutsgruppen mobile app. Skjutsgruppen describes carpooling to their members, on their homepage, as "When we're going the same direction we offer our spare seats to each other in buses, boats, cars, bicycles and hot air balloons. We share the costs of our rides equally or offer rides for free, because friends do not make money of friends". The data collection took place during two weeks in December 2019. The respondents were informed that participation was voluntary and that all responses were anonymous. A short introduction explained the purpose of the survey. As a token of appreciation, 50 cinema tickets were allotted among those completing the survey.

3.3. Questionnaire

3.3.1. Carpooling Frequency

For carpooling frequency, the respondents indicated how often they use carpooling in general, not just carpooling through the service of the specific platform. The options for frequency ranged between 0 and 7 times a week, and respondents using carpooling less than once a week were excluded from the study as the aim was to examine the mode per se and the perceptions of actual users.

3.3.2. Trip Purpose

For trip purpose, the respondents selected one or more appropriate categories, respectively (dichotomous variables). Trip purpose categories included work/school trips, shopping trips, leisure trips, sport activities, and other (which were defined by the respondents in an open ended question, resulting in replies such as "for everything", "to the hospital", "to visit friends", "when my

bike broke down", and a number of other purposes). As there were few respondents in several of the categories we added the categories related to leisure (shopping, sports, and other) into one leisure trips category, thus creating two general categories. Furthermore, 84.4% (103 respondents) used carpooling for leisure trips and 35.2% (43 respondents) for work or school trips, indicating some overlap.

3.3.3. Carpooling Motives

Carpooling motives included simplicity, shorter travel time, alone in car is expensive (cost), and "other motives". The respondents selected one or more appropriate motives by indicating presence (yes) or absence (no) for each presented motive. When choosing "other motives" the respondents had the possibility to articulate any motive. Based on their replies it was possible to form two extra motives: environmental concerns and socializing motives. Cost was the most frequently stated motive (43.4%) followed by environmental concerns (35.2%). The least popular motive for carpooling was socializing (5.7%).

3.3.4. Sociodemographic Data

Sociodemographic data was collected by questions of age, gender, and education (number of years). The respondents were between 20 and 80 years of age (M = 41.5, sd = 15.3), and 53.3% were female. The average respondent had 16.2 years of education (primary school included), with a range between 9 and 26 years. Using years of education, rather than level of education, is common in Sweden as all education is free of charge and school is compulsory up to 9 years, although most individuals add an additional 3 years. After that, occasional courses at a university are common, as well as attending a full programme (e.g., bachelor or masters degree). Thus education is used as a continuous variable in the model.

3.3.5. Density

To evaluate density, we used six categories based on redidential area population, from 1–500 up to <100,000). Given that a city with a population of <100,000 is considered large in Sweden and that we also have vast areas with small populations (in minor villages) the categories were considered a relevant proxy for density, given the context of the study.

3.3.6. Perceived Accessibility

Perceived accessibility was measured using the Perceived Accessibility Scale—PAC [16]. The scale capture perceived accessibility by a specific mode using 4 questions, which are evaluated separately on a scale from 1 (=I do not agree) to 7 (=I completely agree) and then indexed into an overall level of perceived accessibility per participant. More specifically, the included items are: (1) It is easy to do daily activities with carpooling, (2) If carpooling was my only mode of travel I would be able to continue living the way I want, (3) It is possible to do all the activities I prefer with carpooling, and (4) access to my preferred activities is satisfying with carpooling. The sample showed low levels of perceived accessibility, with a mean of only 2.8 (on a scale of 1–7, sd = 1.8); however, a test of skewness and kurtosis provided satisfactory findings (skewness = 0.894, kurtosis = −0.319) that are well below the threshold of −2/+2 [28]. Descriptive statistics of all the included items are summarized in Table 1.

Table 1. Sample descriptives of all included variables.

Variable	Range	Mean	Sd
Perceived accessibility (PAC)	1–7	2.80	1.78
Education (years)	9–26 years	16.20	2.91
Age	21–80 years	41.54	15.31
Gender		**No of resp.**	**Percentage**
	female	65	53.3%
	male	57	46.7%
Density (residential area population)			
	1–500	12	9.8%
	501–3000	15	12.3%
	3001–8000	6	4.9%
	8001–25,000	17	13.9%
	25,001–100,000	30	24.6%
	>100,000	42	34.4%
Carpooling frequency (days per week)		M = 2.21	Sd = 1.44
	1	57	46.7%
	2	25	20.5%
	3	12	9.8%
	4	13	10.7%
	5–7	15	12.3%
Trip purpose			
	Work/school	43	35.2%
	Leisure	103	84.4%
Carpooling motives			
	Simplicity	33	27.0%
	Shorter travel time	14	11.5%
	Alone in car is expensive (cost)	53	43.4%
	Environmental concerns	43	35.2%
	Socializing	7	5.7%

4. Results

Statistical Analyses

Initially, Cronbach's alpha reliability test was performed for the four items of the Perceived Accessibility Scale (PAC). In line with previous studies of PAC, it was found to be satisfactory ($\alpha = 0.927$), with no improvement for item deletion. Hence, an index of the mean across the four items was used as the dependent variable of perceived accessibility of carpooling.

In order to assess the importance of different factors for perceived accessibility of carpooling, an OLS hierarchical multiple regression analysis was performed in three steps with perceived accessibility as the dependent variable. The analysis was chosen as the aim was to look at the relationship between each of the predictors and perceived accessibility [28]. The full estimates are presented in Table 2 and further visualized in Figure 1. In the first step, only the controls were added in form of background variables of gender, age, and education. As shown in the results table (Table 2), the model was significant and explained 7% of the variance. Years of education was the only significant predictor. As the relationship was negative, it indicates that less years of education are associated with greater PAC. Age and gender were found to be nonsignificant. The age and gender findings were stable across all three steps of the regression analyses.

In the second step, the instrumental variables density, carpool frequency, and trip purpose (work/school trip and leisure trip, respectively) were included as predictors. The model estimates were improved significantly, with an additional 11.5% explained variance. Density and trips to work/school were observed as significant predictors. The relationship for these variables was positive, showing that greater population density and the use of carpooling for work/school trips is associated with higher perceived accessibility. No significant weight was found for frequency of use of carpooling or using it for leisure purposes. With the predictors added to the model, education was found to be only marginally significant (reduced from $\beta = 0.19$ to $\beta = 0.17$).

In the third step, the five personal motives for carpooling (simplicity, time, cost, environmental concern, socializing) were added. Once again, the model estimates increased significantly, with an additionally 13% explained variance and with the full model now explaining in total almost 32% of the variance. The only motive yielding a significant weight was simplicity. Although being the only significant motive, the weight was the strongest among all variables ($\beta = 0.31$) in the model, indicating that it is a determinant of importance. Interestingly, although cost and environmental concern were frequently reported as motives for carpooling; these were not found to be related to perceived accessibility of carpooling. While the instrumental variable of work/school trips still was significant, a slight decrease in the weight for density was observed in step 3, now becoming marginally significant (reduced from $\beta = 0.22$ to $\beta = 0.18$) alongside education. Thus, the effect of density seems to be partially mediated by the motive of simplicity of travel.

An analysis of multicollinearity provided satisfying results with tolerance levels ranging between 0.57 and 0.97 and the variance inflation factor (VIF) levels ranging between 1.03 and 1.67. These levels are well within the recommendations of no tolerance level below 0.2 or VIF-level above 4.0 [29].

Table 2. Ordinary Least Squares (OLS) multiple linear hierarchical regression analyses with perceived accessibility as dependent variable, and controls (step 1), purpose, frequency and density (step 2), and motives (step 3) as independent variables.

Perceived Accessibility with Carpooling						
Step 1	**b**	**β**	**t**	***p***	**95% Conficence Interval of b**	
Gender (man 1, woman 2)	−0.483	−0.136	−1.505	0.135	−1.117	0.152
Age	−0.013	−0.114	−1.259	0.211	−0.034	0.008
Education (years)	−0.118	−0.193	−2.148	0.034	−0.227	−0.009
Model: R = 0.27; R2 = 0.07, F(3118) = 3.10, $p = 0.029$						
Step 2	**b**	**β**	**t**	***p***	**95% Conficence Interval of b**	
Density	0.231	0.223	2.432	0.017	0.043	0.419
Carpool frequency	0.174	0.140	1.612	0.110	−0.040	0.387
Trip purpose (work/school)	0.883	0.238	2.186	0.031	0.083	1.684
Trip purpose (leisure)	−0.130	−0.026	−0.247	0.806	−1.171	0.912
Gender (man 1, woman 2)	−0.387	−0.109	−1.217	0.226	−1.016	0.243
Age	−0.008	−0.069	−0.761	0.448	−0.029	0.013
Education (Years)	−0.104	−0.169	−1.918	0.058	−0.211	0.003
Increment: $\Delta R^2 = 0.14$, $F(4114) = 4.02$, $p = 0.004$						
Augmented model: R = 0.43; $R^2 = 0.19$, $F(7114) = 3.76$, $p = 0.001$						

Table 2. *Conts.*

Perceived Accessibility with Carpooling						
Step 3	**b**	**β**	**t**	***p***	**95% Conficence Interval of b**	
Simplicity	1.251	0.313	3.708	<0.001	0.582	1.919
Travel time	−0.463	−0.083	−0.968	0.335	−1.411	0.485
Cost	−0.187	−0.052	−0.596	0.553	−0.811	0.436
Environmental concern	−0.567	−0.153	−1.649	0.102	−1.249	0.114
Socializing	−0.585	−0.077	−0.877	0.382	−1.908	0.737
Density	0.182	0.175	1.924	0.057	−0.006	0.369
Carpool frequency	0.157	0.127	1.500	0.136	−0.050	0.365
Trip purpose (work/school)	1.022	0.275	2.628	0.010	0.251	1.793
Trip purpose (leisure)	0.179	0.036	0.356	0.723	−0.816	1.173
Gender (man 1, woman 2)	−0.312	−0.088	−1.020	0.310	−0.919	0.294
Age	−0.002	−0.014	−0.161	0.872	−0.022	0.018
Education (years)	−0.092	−0.151	−1.809	0.073	−0.194	0.009
Increment: $\Delta R^2 = 0.24$, $F(5109) = 4.09$, $p = 0.002$						
Augmented model: $R = 0.56$; $R^2 = 0.32$, $F(12,109) = 4.19$, $p < 0.001$						

Note: Areas marked in light grey are significant ($p < 0.05$) or marginally significant ($p < 0.10$) predictors. b = unstandardized beta, β = standardized beta.

5. Discussion

Perceived accessibility is about the perceived possibilities of living the life one wants with the help of a specific travel mode, alternatively combinations of different modes. This study set out to examine levels of perceived accessibility of carpooling, by examining a number of carpoolers in Sweden that are members of a nonprofit carpooling community and use this, and other carpooling services, regularly. Another aim was to explore determinants of the perceived accessibility of carpooling with a focus on (residential population) density, carpooling motives, and trip purposes.

In the present study, perceived accessibility was examined in light of carpooling being "the only option for travel" in order to capture perceptions of accessibility related to the specific mode exclusively. Although one could argue that carpooling for most individuals would not constitute the single, or even primary, mode for daily travel, evaluations of accessibility levels and determinants that are related to these levels for this particular mode are important to consider. This given that carpooling already constutites an option for travel today for some people and, more importantly, may become an option for more individuals that, due to climate change, policy restrictions, or even old age, may not be able to use the private car or active modes for travel in the future. As the results point out, carpooling is not perceived by these current users as particularly accessible today, with low levels across the sample. This interpretation is supported when compared to what we know of levels of perceptions of accessibility by other specific modes, such as public transport [16] and of perceived accessibility of daily travel in general [13,23]. However, given that some trip purposes (work and school trips) appear to have a positive relationship with perceived accessibility, carpooling may still be a reasonable choice for meeting some specific travel needs today, such as commuting.

A number of previous studies claim that carpooling may be best suited for addressing accessibility needs in rural areas [18,25], where public transport services are less frequent and thus alternatives of the private car travel are more or less lacking. However, in our results the perceived accessibility of

carpooling seems to increase with the density (residential population density) of an area, meaning that perceptions of accessibility with carpooling appear to be even lower in rural areas than in more densely populated areas. It is likely that this is due to a higher probability of options for carpooling in more densely populated areas, which suit individual needs better in terms of when and where to travel. A conclusion that may be drawn from the results is that, as of today, carpooling cannot be viewed as a realistic option to the private car, in particular in rural areas, when it comes to fulfilling accessibility needs in daily travel. This conclusion is in line with a recent review pointing out that carpooling services still "fail to include many potential users and to serve users adequately" [3] (p. 11). On the other hand, as in general, more densely populated areas also tend to have a wider selection of available transport modes, these areas—from a planning point of view—would perhaps benefit more from extending high-capacity services and routes for active travel, than from carpooling services, as Allen and Farber argue in a recent study [18].

Given that the aim of the study was to look into perceived accessibility levels and determinants specifically regarding carpooling, and not as a mode in combination with other modes, the low levels of accessibility found in this study are perhaps not too surprising. However, although the inadequate levels of accessibility of carpooling may not appear to be a main concern today (when other more accessible modes are still readily available to most travelers), there is a possibility that we overestimate the exchangeability of the private car and put too much faith into solutions such as carpooling. If these solutions do not offer adequate levels of accessibility, individuals who become more reliant on sustainable means of traveling will be at risk of social exclusion and of experiencing lower levels of wellbeing. Based on the fact that simplicity of travel was the most significant predictor (e.g., highest beta-value) of perceived accessibility found in this study, we could probably overcome some of these accessibility-issues by making travel by carpooling easier for the users. A recent overview of different types of carpooling services based on large-scale text analysis of Twitter data found that lack of effectiveness and flexibility were considered the two main disadvantages with carpooling [4]. Taking these carpooling findings together, we see a parallel to the early introduction of the telephone. The telephone as an innovation was not very popular at first as individuals found it unnecessary to buy a phone when there was no one to call anyway (effectiveness), and it was not perceived as easy to use. Today, it is quite different as almost everybody has their own telephone which they also bring with them at all times, being more or less constantly reachable and expecting to use it to reach others regularly (flexibility and simplicity). Thus, in line with this there may be a possibility that if more individuals start to use carpooling services, more activities become available on a more flexible basis, which in turn could make it easier for individuals to live the lives they want using such services.

A main point of capturing perceived accessibility as a complement to objective evaluations of accessibility is to incorporate the experiences and preferences of the individuals that are relying on the transport systems which are being offered. Measures such as PAC may thus help out in evaluating if and where certain transport solutions will contribute to higher levels of accessibility from the travelers´ perspective. This is important to consider, as carpooling services appear to fail in providing the level of accessibility that, for instance, The European Commission [11] aims for. Moreover, if possible, future studies should distinguish between carpooling drivers and passengers, as the motive for carpooling may differ between these groups—even though they are likely to overlap to a certain extent.

Cost, in terms of monetary costs, time-related costs, or both, is generally a substantial part of objective accessibility evaluations regardless of travel modes (e.g., [30]). Cost has also been found to predict perceived accessibility of public transport [16], thus it is somewhat surprising that neither monetary cost nor travel time turned out to be predictors of the perceived accessibility of carpooling. Hence, even though cost was found to be the main motive for using carpooling services (followed by environmental concerns), it does not appear to affect how individuals perceive their accessibility with these services.

The results also differ from other previous understandings and findings of perceived accessibility. In previous studies on the perceived accessibility of public transport and active travel modes (bike and walking), gender differences have been found where women tend to perceive their

accessibility as better than men do, and some studies have found a positive effect of age, even if earlier results are inconclusive [16,20,23]. However, except for a negative effect of years of education on perceived accessibility in step 1 of the analysis (where only sociodemographics were added as predictors), no effect of education, age, or gender on the perceived accessibility of carpooling was found. Contrary to our hypothesis, frequency of use did not have a significant relationship with perceived accessibility, which means that more frequent and less frequent users are likely to perceive their carpooling as similarly accessible. This is unlike previous studies on perceived accessibility of public transport which found that more frequent users also experience higher levels of accessibility [16]. Moreover, whereas environmental concern and socializing have been found to drive carpool use in previous studies [4], neither environmental concerns nor socializing as motives for use were found to predict perceptions of accessibility of carpooling. In fact, the only motive for use that appears to be a determinant of perceived accessibility of carpooling is simplicity, which alongside work and school trip purpose were the only predictors that came out significant in the final model (with acceptable beta-levels). Given that density was initially a significant predictor of perceived accessibility (Step 2), our findings further indicate that density and the simplicity of using carpooling tend to be related, as the inclusion of simplicity as a motive for use in the model (step 3) reduced the effect of density on perceived accessibility (beta from 0.223 to 0.175), supporting the possibility of simplicity as a mediating mechanism between density and perceived accessibility.

6. Conclusions

This study examines perceived accessibility of carpooling, framed as carpooling being "the only option for travel", when in fact, many individuals would probably consider it as one of many modes available for their daily travel. Still, in order to assess the accessibility of a particular mode and look at determinants of the accessibility of this specific mode, a frame-of-reference like this is useful.

The main findings show that levels of perceived accessibility with carpooling are low across the sample. The findings further identify a number of determinants of perceived accessibility of carpooling, which are in part coherent with previously identified determinants for using carpooling, and partly similar to previous research on perceived accessibility, but they also offer new insights in contrast to determinants of perceived accessibility by other specific modes.

The final model explains approximately a third of the variance in perceived accessibility of carpooling, with the two significant predictors being simplicity of carpooling travel and work/school trip purpose. Alas, although a few predictors turn out to be marginally significant in the final model (density and years of education), nearly two thirds of the variation is still unaccounted for. Thus, future research should take care in exploring further possible determinants of perceived accessibility of carpooling in order to explain, understand, and counteract the low levels of accessibility that appear to be linked to this specific travel mode. For instance, a review by Olsson et al. [3] showed that psychological factors are being discussed as important for actual sharing, and as little is known of perceptions of accessibility in general so far, it is likely that attitudes and other psychological attributes may also be able to add to the understanding of perceptions of accessibility in a carpooling context. Previous research on the perceived accessibility of public transport users [16,21] indicate that feelings of safety and security are important predictors of perceived accessibility. As insecurity or trust have also been identified as important factors influencing carpool usage [4], especially among women [25] and students [31], it is possible that such feelings may have affected the (low) levels of perceived accessibility found in this study. Having said that, it is also important to note that the data used for the current study were collected prior to the COVID-19 outbreak, thus feelings of insecurity and also fear of sharing a car with others may have increased since then. In light of COVID-19, Hensher [32] posits two possible future scenarios for MaaS-related services, such as carpooling, post-COVID. In the first scenario we go back to pre-COVID-behaviour with similar levels of use as before. In scenario two, however, we significantly alter our behaviors in terms of more flexible workhours and increased working from home than pre-COVID. Given that scenario two occurs, with different working hours and

days spent at work for different individuals, there is a possibility that this longterm increased flexibility will have a negative effect on travel-options for carpoolers, especially in less dense areas, even if individuals should feel secure enough to share a ride. This is important to take into consideration, as work and school trips and simplicity of travel both had positive effects on perceived accessibility of carpooling in the present study. Even leisure trips (which were the trips most commonly conducted by the carpoolers in the study) are likely to be affected if we work more flexible hours and thus have different activity schedules.

To conclude, the main point emerging in this study is that carpooling today is not perceived as very accessible by the current users, and thus does not posit as a realistic option to the private car, especially it seems, in rural areas. Based on our findings, population density, simplicity, and trip purpose should be in focus in the continued development of attractive carpooling services.

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