Transportation Research Part D 78 (2020) 102213

Contents lists available at ScienceDirect

Transportation Research Part D

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

Restricted car-use and perceived accessibility

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ARTICLE INFO

Keywords:
Perceived accessibility
Accessibility
Accessibility measure
Transport planning
Sustainable transport
Travel behaviour

ABSTRACT

In order to plan for, and achieve, a sustainable and accessible transport system, research and policies alike recognize a need to implement and enhance alternative transport options in favor of the private car. Moreover, these sustainable alternatives need to offer sufficient levels of accessibility regardless of where people live or work. We present and discuss an approach for capturing and evaluating perceived accessibility, with the ability to differentiate between individuals. Levels of perceived accessibility are compared before and after a fictive car use restriction, and between residential areas, using data from 2711 residents of Malmö, Sweden. A main conclusion is that levels of perceived accessibility become significantly lower for car users when they are limited in their options for daily travel. The difference is more substantive for frequent car users, who already travel less by sustainable modes today. There are also significant differences in levels of perceived accessibility in the restricted scenario, depending on where individuals live. These novel findings may not come as a surprise, but they emphasize the importance of including and analyzing perceptions of car users when designing accessible and sustainable transport systems. The paper ends with a discussion on how to facilitate the transition from current transport systems to an inclusive and accessible system.

1. Introduction

As is widely acknowledged today in most research fields, there exists an urgent need to find ways of reducing the environmental impact on our planet (Ripple et al., 2017). One way is to encourage a transfer from private car travel to sustainable transport modes, such as active travel (bicycle/walking), public transport, or combinations of these. Growing alternatives to the private car include flexible transport solutions such as demand-responsive travel (DRT), micro transit options, mobility-as-a-service concepts (MaaS), and autonomous and/or electric vehicles (EV́s). However, when planning for the transition from using such a flexible option as the private car for daily travel, it is important to consider the effect of alternative transport solutions on the accessibility of individuals.

According to the Swedish Transport Administration, an inclusive transport system offers satisfying accessibility to all citizens regardless of where they live or work. The goal for 2030 in Sweden is an accessible transport system that contributes to less social boundaries, increased gender equality, economic development, and which supports job creation and housing supply throughout the whole country, while also focusing on reducing emissions and environmental impact (The Swedish Transport Administration, 2018).

Accessibility has become an explicit goal in transport policy not only in Sweden, and individual experiences of accessibility are getting more attention in policy (e.g., The European Commission, 2015) as well as in research (e.g. van der Vlugt et al., 2019). Although accessibility is a central concept for transport policy, the field is still deprived of a distinct definition of, and knowledge of sufficient levels of, accessibility. One explanation is that accessibility is a multifaceted concept. This paper focuses on perceived

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https://doi.org/10.1016/j.trd.2019.102213
Received 23 September 2019; Received in revised form 20 December 2019; Accepted 20 December 2019

accessibility, departing from the individual and defined as *"how easy it is to live a satisfactory life with help of the transport system"* (Lättman et al., 2016a, p. 36). By referring to the subjective assessment and perception of accessibility, perceived accessibility focuses on the perceived possibilities of participating in daily activities and on the perceived ability to be included in society with different means of travel. These perceptions build upon individual evaluations of the transport environment, such as travel attributes, the ease of getting to and/or actual use of the transport system, and the ease of reaching activities of onés choice - all depending on what is relevant and known to the individual (Lättman et al., 2016a). When planning for sustainable travel it is essential to include perceptions, not only since the explicit goal of the transport system is to ensure sufficient accessibility for all (The Swedish Transport Administration, 2018), but also as peoplés experiences of accessibility with different travel modes are likely to affect their modal choice. A study by Scheepers et al. (2016) found, not surprisingly, that a high level of perceived accessibility by bike or walking increased the likeliness of active mode use, whereas a high level of perceived accessibility by car increased the probability of using the car.

Daily travel by car is in general perceived as accessible as it makes participation in preferred daily activities easy, and allows for travel at times of convenience. Hence, there are reasons to believe that restricted car-use or even prohibition of the private car, in favor for alternative modes, will have both instrumental and psychological consequences for individuals. This hypothesis is supported by previous research showing that people are sensitive to negative changes (Brenner et al., 2007) and that people put a greater value on giving up benefits than receiving benefits of the same magnitude (Novemsky and Kahneman, 2005). In line with Kahneman and Tversky's (1979) prospect theory that "losses loom larger than gains", individual decisions depend on if the individual expect a loss or a gain, causing a cognitive bias known as loss aversion. Hence, a loss aversion bias can be expected when a valued benefit (such as the car) is no longer available (to the same extent), and the expected substitutional benefits (alternative travel options) are not perceived as equally satisfying or even more satisfying. Confirming this argument is research observing loss aversion when negative changes are made in travel time and travel costs (Hjorth and Fosgerau, 2011; Li et al., 2016). Hence, changes in transport systems, including the availability of transport options, can severely affect people's perceived accessibility to daily activities. Research on driving cessation among the elderly reported deep and lingering feelings of loss, loss of control and independence when individuals were prohibited to drive (Adler and Rottunda, 2006; Bauer et al., 2003). Other studies highlight that it is the individual perception of substitutability between alternatives to a reference point, rather than the objective similarity between choices, that drive loss aversion (Novemsky and Kahneman, 2005; Köszegie and Rabin, 2006). This implies that negative effects are likely to affect all, regardless of age, as long as the substitutes for the car are not perceived as providing the same, or better, benefits as the car. Van Wee et al. (2019) argue that substitutability is particularly relevant for accessibility. Previous studies also show that older people who stopped driving continued as car-passengers. Thus, they still seem to rely on the car as their primary mode of transport even after driving cessation occurs (Wood and Horner, 2019; Adler and Rottunda, 2006). It may be equally true that the car is still perceived as attractive and accessible for certain trips for people mainly using alternative modes for their daily travel. This further emphasizes the importance of analyzing different levels of perceived accessibility among travelers using different travel modes.

In order to implement a sustainable and accessible transport system, it is inevitable to develop and implement alternative transport options in favor of the private car. At the same time, it is essential to ensure that these sustainable alternatives have the ability to offer sufficient levels of accessibility regardless of where people live or work. As objective approaches of assessing accessibility (refers to evaluations commonly based on travel times and distances within a specific geographical area. For a more thorough description, see Section 2 below) generally are unable to differentiate between individuals, we offer a complementary approach that capture and compare perceptions of accessibility between individuals and across geographical areas.

More specifically, in this paper, we present and discuss an approach for capturing and evaluating different car travelers' perceived accessibility, in order to address the gap in literature of whether levels of perceived accessibility differ between segments of individuals, depending on how they travel or where they live. We also compare different levels of perceived accessibility before and after a fictive car use prohibition in order to examine if, and to what extent, levels of accessibility changes between different segments of car travelers' if they no longer have the car as an option when evaluating their accessibility. The paper ends with a discussion on how to facilitate the transition from current transport systems to an inclusive and accessible sustainable transport system that may very well include new innovative modes for travel.

2. Transport accessibility

Transport accessibility is important not only as a policy goal for ensuring sufficient accessibility for populations, but accessibility is also related to individual outcomes such as social exclusion and well-being (Hui and Habib, 2014; Parkhurst and Meek, 2014; Stanley et al., 2010). Unlike mobility, which is defined as the ease of movement (Preston and Rajé, 2007), accessibility refers to possibilities and opportunities available for travel as well as actual participating in activities and reaching destinations of interest and relevance (Burns and Golob, 1976; Curl et al., 2011). Thus, limited access to different travel modes may exclude individuals from various activities and destinations and lower their well-being and inclusion in society. Recently, perspectives of social dimensions and equity in accessibility have gained in importance. Equity, referring to the geographical distribution of accessibility or accessibility as distributed between different groups of individuals (Lucas et al., 2015), has been evaluated on policy level (Lucas et al., 2015) as well as in practical assessments of car and public transport accessibility (Ben-Elia and Benenson, 2019), or both (Pucci et al., 2019). Social dimensions, such as transport disadvantage and social exclusion have also received increased attention (Martens, 2017; Schwanen et al., 2015).

The general definition and conceptualization of accessibility by Geurs and van Eck (2001) and Geurs and van Wee (2004) as comprised of four dimensions (transport, land-use, temporal, and individual) is widely accepted and acknowledged in transportation research. Given that accessibility is generally understood as this multidimensional concept, comprising physical (usually time and distances) as well as non-physical dimensions (e.g. perceptions and attitudes) (Vitman-Schorr et al., 2017), it is disadvantageous for our understanding of the concept that most accessibility studies still ignore the individual dimension in favor for objective evaluations (Lättman et al., 2016b; Vitman-Schorr et al., 2017). While objective accessibility typically includes pre-determined physical dimensions of accessibility such as time, mode, or distance, they usually leave out social travel and non-physical dimensions, as these are difficult to implement in quantitative accessibility measures (Vitman-Schorr et al., 2017). An individual's accessibility however, depends on both situational and individual factors (Pucci et al., 2019), thus objective situationally based levels of accessibility may contain little meaning for a specific individual as individuals are likely to perceive their accessibility in relation to individual prerequisites, attitudes and understandings that interact with the objective situation (Lättman, 2018). In line with this assumption, previous empirical studies have indicated a discrepancy between perceived accessibility and objectively measured accessibility (e.g. Ball et al., 2008; Lättman et al., 2018; Ryan et al., 2016, van der Vlugt et al., 2019), indicating that these approaches indeed capture different, and complementary, components of accessibility. Moreover, social outcomes, or consequences of, accessibility such as social exclusion and transport disadvantage are more closely related to individual experiences and perceptions than to their objective counterparts (Martens, 2017; Schwanen et al., 2015).

3. Perceived accessibility

The current paper focuses perceived accessibility, which is a concept that was acknowledged already in the seventies by Burns and Golob (1976) and Morris, Dumble, and Wigan (1979) in terms of perceived accessibility to opportunities for travel. This view of accessibility regards individual perceptions of accessibility in light of individual prerequisites, experiences and preferences, realized travel options and perceived possibilities for travel (Lättman et al., 2016b). The view suggests that different individuals are likely to perceive accessibility differently (Ma and Cao, 2017), which distinguishes it from objectively based accessibility. Alas, perceived accessibility may include perceptions of travel opportunities based on the information known to the individual and personal preferences or attitudes in regard to perceived abilities and ease of daily travel with different (combinations of) travel modes. In other words, perceived accessibility is not limited to the evaluation of specific travel times, distances, or even to specific activities or destinations but, on the contrary, take into account those aspects of accessibility that are important to each individual, enhancing the concept of accessibility above mere physical elements. Recent research on perceived accessibility in Sweden challenges the viewpoint of the car as (always) the most accessible option for travel, as a study on differences in perceived accessibility between main travel modes revealed that cyclists perceive their daily travel accessibility as significantly higher than car users do (Lättman et al., 2018). This despite the fact that when objectively measured, the accessibility of car users is generally regarded to be significantly higher. Another study on perceived accessibility (Lättman et al., 2016b) of bus travelers showed that individuals in their 30́s alongside elderly perceive their accessibility with public transport as significantly lower than other age groups, indicating that if public transport was their only alternative for travel, they could be at risk of social exclusion. A recent study by van der Vlugt et al. (2019) found associations between perceived accessibility and travel behaviour (walking had a positive effect on perceptions of accessibility), as well as relationships between age, income, feelings of security, environmental barriers, and perceptions of accessibility. Results like these emphasize the importance of taking in the perspective of those that are reliant on our transport systems, when evaluating accessibility and its distribution among different segments of individuals. It has further been argued that perceived accessibility is necessary to consider when stimulating a shift from car use to alternative modes (such as cycling or walking), as, in a study by Scheepers et al. (2016), the relationship between perceived accessibility and mode choice was still strong after controlling for individual and environmental factors.

4. Study objectives

In 2018, Lättman et al. (2018) established that perceived accessibility not only differs from objectively measured accessibility in a number of residential areas, but that levels of perceived accessibility also differs between main modes for travel. Current transport policies focus on an inclusive transport system with satisfying accessibility for all citizens regardless of where they live or work. Thus, in order to evaluate and monitor levels of accessibility between different (groups of) individuals there is a need to further develop and use methods with a focus on perceptions and experiences of accessibility, which are not covered by objective accessibility indicators (van der Vlugt et al., 2019). In line with this, we have identified a need for a better understanding of changes in levels of perceived accessibility among different types of travelers when transforming current transport systems. This gap includes a need for research that aim at a better understanding of how current car-users would perceive their accessibility if the car was no longer an option for daily travel, which is a probable scenario in many future urban areas given the current development towards sustainability. In light of these needs, we present three main objectives of the present study:

(1) Further development of a method for assessing levels of perceived accessibility - in a scenario with restricted car-use.
(2) Analyze and compare levels of perceived accessibility among car travelers before and during a restricted car-use scenario.
(3) Analyze and compare levels of perceived accessibility between frequent and less-frequent car travelers before and during a restricted car-use scenario.

Although the focus lie on restricted vs non-restricted travel scenarios, and at examining and comparing levels of perceived accessibility between different main modes, we also aim at examining whether levels of perceived accessibility in the restricted car-scenario differ between residential areas.

5. Material and methods

5.1. Study setting, participants and procedure

In October and November 2016, data from 2711 structured telephone interviews were collected in the city of Malmö, south Sweden. Malmö has approximately 300 000 inhabitants divided into 13 (populated) residential areas.

Besides four items measuring overall perceived accessibility in daily travel, the structured interviews included questions of main transport mode (the respondents indicated the mode most commonly used in daily travel), residential area, sociodemographic data (age, income, gender) and a number of items regarding perceptions of the built environment in Malmö. To meet the study objectives, participants were asked to declare if they use the private car for travel at least once a week, even if it isńt their main mode of use. Those who did (n = 1926) were also asked about their perceived accessibility "given that the car is no longer an option for daily travel" (four items). In this study, we include and analyze data primarily on the two versions of perceived accessibility, main travel modes, and residential areas.

Anyone living in Malmö with a registered phone number and above 18 years of age was a possible participant of the study. The sample includes participants between the ages of 18–95 (M = 49.85, SD = 18.90) who were contacted by phone in a randomly selected order until the sample was adequately representative of the population, based on residential areas. Main mode distribution (specified as which mode of transport the participants use the most for their daily travel) was, for the whole sample, as follows: Car 1141 participants (51% men), bicycle 743 participants (49% men), public transport 616 participants (38% men), and walking 176 participants (41% men). The overall gender distribution was satisfying as approximately half of the participants in the overall sample were men (46%) with a range across residential areas between 41% and 56%. The total number of participants distributed per residential area, mean and range of age, gender distribution, mode distribution per area, and comparisons to population data can be found in Lättman et al. (2018), (Table 1 and 2).

5.2. Instruments

Perceived accessibility in daily travel was measured by the previously validated Perceived Accessibility Scale, PAC (α = 0.90, Lättman et al., 2018). The perceived accessibility items assess "the ease to do daily activities", "the ability to live the life I want", "the ability to do all preferred activities", and "satisfaction with perceived access to preferred activities" with ratings from "I dońt agree" = 1 to "I completely agree" = 7. A perceived accessibility index was then received by calculating the mean from the four items.

Perceived accessibility "if the car is no longer an option" was measured by a revised version of the Perceived Accessibility Scale, designed to measure overall perceived accessibility without access to the (private) car. The modification from the previous version of the scale included an added suffix of "without the car" instead of the prefix "considering how I travel today" which is present in the daily travel version. For a more thorough comparison, see Table 1.

The variables primary transport mode, gender, income and age were measured by self-report questions included in the structured interview questionnaires. For primary transport mode, the participants stated if they use the car, the bicycle, public transport, if they walk or "other" as their main mode for daily travel. A question of car use was also included, and as mentioned previously (in Section 5.1), only those who stated that they use the car at least once a week answered the second version of the Perceived Accessibility Scale.

6. Results

6.1. Descriptive statistics

Data were initially analyzed for the four redesigned items of PAC, measuring perceived accessibility in daily travel if the car is no longer an option. A Cronbach's alpha analysis revealed satisfactory overall item correlation (α = 0.88, N = 1926), with only marginal differences for item deletion. Between-items correlations indicate that the items are related but that they also each uniquely contribute to the concept. The above statistics can be found in Table 2, alongside means, standard deviations, skewness and kurtosis.

Table 1
Items included in the two measures of perceived accessibility.

	Perceived Accessibility Scale (PAC) Daily Travel	Perceived Accessibility Scale (PAC 2) "if the car is no longer an option"
Item 1	Considering how I travel today, it is easy to do my daily activities	It is easy to do my daily activities without a car
Item 2	Considering how I travel today, I am able to live my life as I want to	I am able to live my life as I want to without a car
Item 3	Considering how I travel today, I am able to do all activities I prefer	I am able to do all activities I prefer without a car
Item 4	Access to my preferred activities is satisfying considering how I travel today.	Access to my preferred activities is satisfying without a car

Table 2
Descriptive statistics, correlations and change in Cronbach́s alpha for the Perceived Accessibility Scale (PAC).

	Item	1	2	3	M	SD	α if item deleted	Sk	Kur
1	It is easy to do my daily activities without a car	–	–	–	4.58	2.15	0.89	−0.43	−1.20
2	I am able to live my life as I want to without a car	0.61*	–	–	3.56	2.27	0.84	0.26	−1.43
3	I am able to do all activities I prefer without a car	0.53*	0.66*	–	3.78	2.26	0.84	0.13	−1.47
4	Access to my preferred activities is satisfying without a car	0.61*	0.71*	0.79*	3.77	2.12	0.82	0.11	−1.35

6.2. Statistical analyses

Main objective 1. Further development of a method for assessing levels of perceived accessibility - in a scenario with restricted car-use.

In order to evaluate the redesigned PAC travel index for capturing perceived accessibility when the car is no longer an option, an exploratory factor analysis (Maximum Likelihood) was conducted. The analysis extracted one factor with an eigenvalue over 1 and an explained variance of 74% ($N = 1926$), with a meritorious sampling adequacy (Kaiser-Meyer-Olkin) of 0.81. The scree plot confirmed the unidimensional finding. Factor loadings (Maximum Likelihood) are provided in Table 3.

The results from the factor analysis alongside the internal consistency indicator demonstrate satisfying results for the creation of a new PAC index. Thus, in order to conduct the subsequent statistical analyses a PAC index value (between 1 and 7) was calculated for each of the participants.

Main objective 2. Analyze and compare levels of perceived accessibility among car travelers before and during a restricted car-use scenario.

A *t*-test (paired samples) of the two PAC measures showed significant differences in car users perceived accessibility ($n = 1876$, $t = 4.56$, $p < .001$, $df = 1875$) when restricted to alternative modes ($M = 3.94$) compared to perceived accessibility with actual daily travel (including the car) ($M = 5.72$) (higher numbers indicating greater perceived accessibility). The correlation between the two indexes was $r = 0.38$ ($r^2 = 0.14$).

Main objective 3. Analyze and compare levels of perceived accessibility between frequent and less frequent car travelers before and during a restricted car-use scenario.

In order to examine differences between segments in the data, a number of analyses were conducted. Firstly, an independent samples *t*-test comparing differences between frequent car users (car as the main mode of travel) and non-frequent car users (other main modes, but use the car for travel at least once a week) was conducted in order to meet objective 3. This showed that frequent car users experience significantly lower accessibility in a scenario where they are limited to alternative transport choices ($n = 1103$[1], $M = 3.31$, $sd = 1.81$), than do non-frequent car users ($n = 823$, $M = 4.74$, $sd = 1.68$). ($t = 17.64$, $p < .001$).

A univariate Anova was then performed in order to further explore differences between different main modes for travel. The analysis revealed significant differences in levels of perceived accessibility in the restricted car-use scenario between participants with different main modes ($F_{WELCH}{}^{[4,1921]} = 4.88$, $p < .005$). A follow up Games-Howell post hoc test showed that frequent car users perceive accessibility as significantly lower if the car would no longer be an option ($n = 1103$, $M = 3.31$) than do cyclists ($n = 402$, $M = 4.75$), walkers ($n = 103$, $M = 5.01$), and public transport users ($n = 295$, $M = 4.71$), all at $p < .001$[2]. No significant differences between cyclists, walkers and public transport users were found, although the walkers reported the highest levels of accessibility in the restricted car-use scenario, and the cyclists in the non-restricted scenario. As the variance was unequal in the groups (Levene $p < .001$) the asymptotic F is reported (Table 4). In the restricted car-use scenario, differences between the four PAC items across different main mode travelers were also analyzed. Games-Howell and Bonferroni post hoc tests showed that the results for the separate items are similar to those for the whole PAC index, with one exception. For item number one ("It is easy to do my daily activities without a car") cyclists differed significantly from both car users and public transport users (with higher levels of perceived accessibility), whereas only car users differed significantly from any other main mode group for the remaining items (lower levels of accessibility). These results and descriptives are further reported in Table 4.

In order to look into differences in levels of perceived accessibility between residential areas (in the restricted car-use scenario), a final Anova was performed. The results ($F_{WELCH} = 10.71^{12,1913}$, $p < .001$) show that there are indeed significant differences in levels of perceived accessibility depending on where in Malmö people live. The asymptotic F is reported due to unequal variances between groups (Levene $p < .001$). A Games-Howell post hoc revealed that several of the residential areas differed significantly from each other. The results for each of the areas are provided in Table 5. Bold text represent the top 3 residential areas regarding levels of perceived accessibility, italics represent the bottom 3 areas. The locations of the thirteen areas are visualized in the map of Fig. 1. Two areas were excluded from our analyses, Norra Hamnen (harbor area), and Jägersro (mainly recreational and park area). These two areas are marked with * in Fig. 1.

[1] The original sample included 1141 main mode car travelers, 38 of these were not included in this analysis due to missing data.

[2] 23 individuals were identified as "other main modes" ($M = 3.72$) but were excluded from the analysis due to the small number and non-identified modes (could be motorbike, boat, moped, taxi or other modes).

Table 3
Factor loadings for the accessibility scales.

Item	Accessibility index (PAC)
It is easy to do my daily activities without a car	0.87
I am able to live my life as I want to without a car	0.86
I am able to do all activities I prefer without a car	0.84
Access to my preferred activities is satisfying without a car	0.75
Eigenvalue	2.74
% of variance	76.29

Table 4
Levels of perceived accessibility, and per item, for different main modes.

		Car users		Cyclists		Walkers		PT users		Anova
For all items, suffix ”without a car” is used	N	M	SD	M	SD	M	SD	M	SD	
It is easy to do my daily activities	1957	*3.81*[1]	2.16	**5.87**[2]	1.44	5.80[3]	1.60	5.34[3]	1.73	$F_{WELCH}^{[4,1952]} = 59.26, p < .001$[1]
I am able to live my life as I want to	1970	*2.84*[1]	2.01	4.49[3]	2.16	**4.84**[3]	2.24	4.58[3]	2.08	$F^{[4,1965]} = 80.55, p < .001$
I am able to do all activities I prefer	1963	*3.37*[1]	2.25	4.22[3]	2.16	**4.58**[3]	2.17	4.43[3]	2.09	$F_{WELCH}^{[4,1958]} = 3.01, p < .001$*
Access to my preferred activities is satisfying	1968	*3.25*[1]	2.05	4.44[3]	2.06	**4.80**[3]	1.99	4.49[3]	1.92	$F_{WELCH}^{[4,1963]} = 2.59, p < .001$*
PAC Index	1926	*3.31*[1]	1.81	4.75[3]	1.64	**5.01**[3]	1.66	4.71[3]	1.65	$F_{WELCH}^{[4,1921]} = 4.88, p < .005$*

* Asymptotic F reported.
[1] Significantly different from cyclists, walkers and PT-users.
[2] Significantly different from car users and public transport users.
[3] Significantly different from car users.

Table 5
Levels of perceived accessibility (sustainable scenario) for each of the Malmö residential areas.

	Place of Residence	n	Perceived accessibility		Significantly different from
			mean	SD	
1	Bunkeflostrand	131	*2.97*	1.61	Centrum[1], Fosie[1], Holma/Kroksbäck[1], Kirseberg[1], Rosengård[1], Slottsstaden[1], Västra Hamnen[1], Limhamn[4], Hyllie[2]
2	Centrum (city center)	216	**4.54**	1.86	Limhamn[1], Bunkeflostrand[1], Husie[1], Oxie[1], Tygelsjö[1]
3	Fosie	181	4.06	1.80	Bunkeflostrand[1], Tygelsjö[4]
4	Holma/Kroksbäck	146	**4.37**	1.86	Bunkeflostrand[1], Tygelsjö[1],Husie[3], Oxie[3],Limhamn[3]
5	Husie	163	3.53	1.85	Centrum[1], Holma/Kroksbäck[3], Västra Hamnen[4], Slottsstaden[4]
6	Hyllie	76	4.14	2.00	Bunkeflostrand[2],
7	Kirseberg	125	4.08	1.86	Bunkeflostrand[1], Tygelsjö[4]
8	Limhamn	217	3.61	1.87	Centrum[1], Holma/Kroksbäck[3], Västra Hamnen[4], Bunkeflostrand[4]
9	Oxie	123	*3.49*	1.81	Centrum[1], Holma/Kroksbäck[3], Västra Hamnen[4], Slottsstaden[4]
10	Rosengård/ Sorgenfri	187	4.10	2.02	Bunkeflostrand[1], Tygelsjö[4]
11	Slottsstaden	204	4.17	1.74	Bunkeflostrand[1],Tygelsjö[2], Husie[4], Oxie[4]
12	Tygelsjö	93	*3.16*	1.90	Centrum[1], Holma/Kroksbäck[1], Västra Hamnen[2], Slottsstaden[2], Rosengård/Sorgenfri[4], Fosie[4], Kirseberg[4]
13	Västra Hamnen	64	**4.49**	1.69	Bunkeflostrand[1], Tygelsjö[2], Oxie[4], Husie[4], Limhamn[4]
	Malmö	1926	3.92	1.89	

Bold text represent the top 3 residential areas regarding levels of perceived accessibility, italics represent the bottom 3 areas.
[1] $p < .001$.
[2] $p < .005$.
[3] $p < .01$.
[4] $p < .05$.

7. Discussion

The aim of this study was based on an identified need for a better understanding of levels of, and changes in levels of, perceived accessibility among different types of travelers in light of the transformation of current transport- and land-use systems towards sustainability. More specifically, the study addressed the question of how different segments of current car-users perceive their accessibility before and during a car-restricted scenario. A main conclusion is that perceived accessibility changes significantly for car users when they are limited to sustainable modes for their daily travel. This difference is less substantive for non-frequent car users, who already travel by sustainable modes to a larger extent today, compared to frequent car-users, which currently use the car as their main mode for daily travel. There are also significant differences in perceived accessibility, when restricted to sustainable modes for

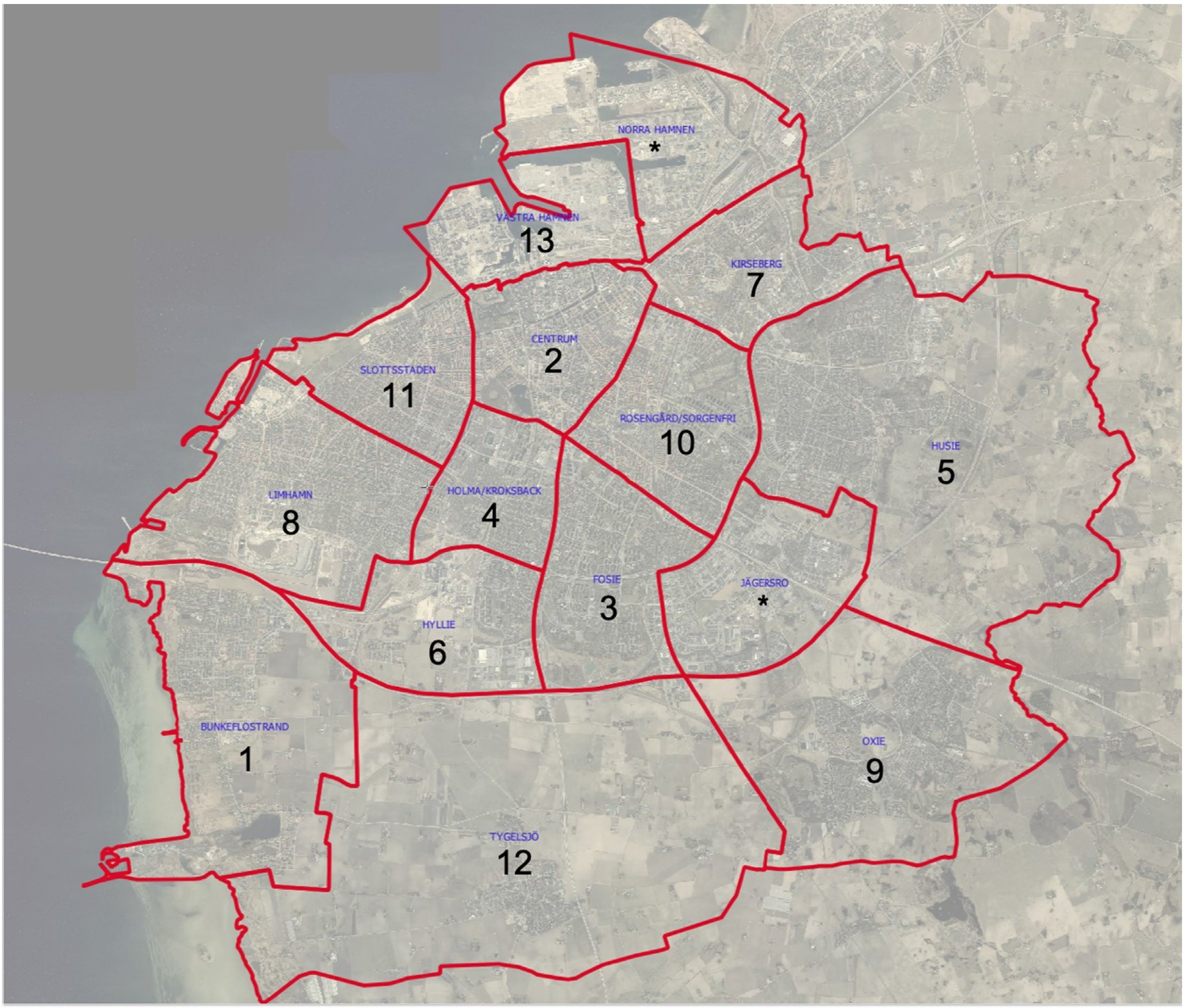

Fig. 1. The locations of the residential areas in Malmö. (More information about the residential areas, land-use and transportation options can be obtained from Malmö Stad (2017), Sustainable Urban Mobility Plan.).

travel, depending on where in Malmö individuals live. Although these novel findings may not come as a surprise, they emphasize the importance of including and analyzing perceptions of different segments of car-users when designing and evaluating sustainable transport systems. For instance, to assess the benefits of future public transport projects, where restricted car use is likely to be one element, it is important to recognize the potential negative effects it may have on accessibility from the car user perspective.

As the loss of the car as an option for daily travel was found to be greater for the frequent car users compared to those who already started a transition to more sustainable travel, an important consideration is of what can be done to counteract feelings of loss and loss aversion and improve attitudes toward other modes. However, we found that even non-frequent car-users experience significantly lower levels of accessibility when restricted to sustainable modes, indicating that the car is important for the perceived accessibility of these travelers regarding certain activities and destinations, and possibly at certain hours or days of the week when the options for travel may be more limited.

Previous research indicate that loss aversion is driven by the substitutability of alternatives compared to an individual reference point (Novemsky and Kahneman, 2005; Köszegie and Rabin, 2006). As research on behavioral decision making processes show that loss aversion is likely to occur and difficult to prevent (Milkman et al., 2009), another approach suggests designing contexts and alternatives in ways that would lead to better choices, given the known biases. This approach has provided successful results in policy research, where bundling techniques of including both losses and benefits in new policies reduced loss aversion biases, due to a reduced focus on losses and an increased focus on benefits (Milkman et al., 2012). In transportation research, loss aversion has been included in choice models, although most of the work so far is theoretical (e.g., Avieri, 2012).

Other emerging theories on travel attitudes suggest that past experiences of travel (such as the public transport environment and positive and negative experiences of public transport) affect current travel attitudes and transport behaviour (Friman and Gärling, 2001; Smart and Klein, 2018). Smart and Klein (2018) found that living in public transport areas with high levels of accessibility not only encourages actual use, but it also creates lingering attitudes and a transport behaviour which reduces future car ownership. The effect of past experiences in the early 20 s to late 30 s had the greatest effect on future behaviour. In fact, the effect was found to be greater than that of the current public transport environment (Smart and Klein, 2018), suggesting a longitudinal effect of early experiences on the individual reference point, which may be linked to perceptions of accessibility. On the other hand, recent findings by De Vos et al. (2018) suggest that both travel attitudes and travel mode choice are eligible for change when people relocate to another residential location since attitudes may adapt in accordance with the new environment. Moreover, De Vos (2018) argues that travel satisfaction also affects travel mode choice through positive reinforcement processes, where positively perceived trips improve mode attitude and use, and vice versa, suggesting that transport services that are perceived as satisfactory will increase positive attitudes, and thereby also mode use. Gärling et al. (2017) who reviewed research investigating the role of psychological factors in general and attitude in particular as determinants of travel choice and satisfaction with travel also confirm this link. When individuals are forced to use a non-preferred mode, (such as public transport instead of the car) De Vos (2019) suggests that they may also be subject to a positive attitude change towards the new mode(s), as they will want to justify their choices.

Hence, although there exists a number of promising approaches and practices that may be considered and discussed, previous research imply three particularly interesting ways for approaching the potential negative effects restricted car use may have on perceived accessibility. By affecting attitudes and perceptions, by improving the alternative transport modes and transport system, or by addressing both. Thus, we conclude this section with a discussion focusing on, but not limited to, these suggestions.

One approach would be to significantly improve the alternative transport modes so that these are perceived as satisfactory and accessible when individuals try them out, in order to affect attitudes towards these modes, and lower the risk for loss aversion due to unsatisfactory accessibility. This may be done by improving current alternative options to the car, such as the travel quality of public transport or investing in lanes for active modes. It could also include improvements of environmental aspects related to these modes, such as building better bicycle facilities or improving pedestrian or bus-stop lightning, to name a few. Another possibility is to look at new transport solutions, including Demand Responsive Travel (DRT) and Mobility-as-a-service (MaaS) concepts. These more flexible transport solutions often include possibilities to continue using a car to some extent (e.g. DRT or carpooling), while mainly traveling sustainably. If individuals feel that they are still able to use a car for some trip purposes, where they otherwise would lack accessibility, it would most likely reduce their feelings of loss and, as a consequence, the need of some improvements of other modes would likely be reduced. Originally viewed as a transport option more suitable for rural areas (Davison et al., 2014) or small cities (Cheyne and Imran, 2016), the concept of Demand Responsive Travel (DRT) has transformed in light of new technological information systems, and is now considered a functional, but expensive, transport option to the private car even in larger urban areas. Today, DRT can be integrated with public transport (such as the Kutsuplus flexible micro transit service [FMTS] in Helsinki) or included in MaaS solutions (Weckström et al., 2018). The implementation of FMTS in Helsinki between 2012 and 2015 showed that DRT attracted diverse groups of users regarding age and income levels. Moreover, both frequent car-users and less frequent car users used the service for various trip purposes, indicating that DRT may have contributed to decreasing loss aversion for frequent car users in the transition to using more sustainable modes. More research on how DRT can be part of the new transport systems is needed. We also need to examine the possibilities of MaaS and DRT to reduce the negative effects of reduced private car use on perceived accessibility. As our results point out, there are also significant differences in perceptions of accessibility depending on where individuals live. Thus, it is necessary for new transport solutions to focus on offering all individuals sufficient levels of perceived accessibility so that they may continue living the lives they want, regardless of where they are resided. Evaluations of perceived accessibility will be able to guide transport planning and new mobility solutions into areas where the loss of the private car affects accessibility the most.

There is a possibility that DRT, MaaS and/or other improvements of, or additions to, current transport systems may not sufficiently affect perceptions of accessibility. If this is the case, attitudes or loss aversion issues may be more effectively addressed. If not else, at least in terms of complementary approaches to redesigning transport systems. One suggested approach could be to amplify the positive effects expected by the transition to sustainable travel modes, to counteract loss aversion. These positive effects may be linked to new solutions, re-designing for positive travel experiences or involve re-packaging of how information about current alternatives to the car are being promoted. For instance, results from the Helsinki FMTS project showed that those who chose not to use the DRT service did so mainly due to a lack of information of the services, and how to use them. On the other hand, the actual users stated benefits such as faster travel than public transport, cheaper than taxi, easy to order and to avoid parking problems as main reasons for use (Weckström et al., 2018). We can relate this to our results which show that those who already travel mainly by sustainable modes today (non-frequent car users) are more satisfied with their accessibility without the car, indicating that they may also be more aware of potential benefits with other travel modes, than are frequent car users.

Adaptation is also important. Since travelers that mainly use sustainable options seem to be relatively satisfied with their accessibility even when the private car is no longer an option, it is likely that the car users of today also will adapt to new transport systems and sustainable travel in time. Further research should focus on ways of making this transition and the adaptation processes easier.

8. Policy considerations

How do we include a transition to sustainable travel in the overarching transport policies that are needed in order to reach ambitious goals, such as the ones stated by Sweden for 2030? According to Douglas et al. (2011) car dependency is an addiction created by society rather than an individual choice, which puts even more pressure on societies to come up with realistic and accessible alternatives that may "replace" this dependency and still offer accessibility for everyone, regardless of where they live. Previous research shows that policy applications of strategies for overcoming loss aversion, such as bundling losses and benefits, can help policymakers pass legislation that is better accepted by the people (Milkman et al., 2009). Thus, in order to minimize the negative effects of decreased mobility by car, policy makers can start by prioritizing pedestrians, cyclists, and different aspects of public transport, by developing these alternatives aiming for high quality and attractiveness based on factors that are likely to affect the perceived accessibility of these modes. Suggested areas of improvement include; building better and safer train and bus nodes, ensuring safe parking for bicycles and safe routes for pedestrians, and improving information about travel options, how to get and pay for a ticket, traffic flow and travel times by ensuring that this information is gathered in the same place and accessible for everybody. New information technology and digitalization can aid policy makers and planners in this. New and attractive transport solutions can be tested, and implemented in order to complement existing travel options if they improve accessibility demands. However, policy makers need to ensure that all available options for travel are interconnected, and that they are perceived as easy to understand and use by different segments of travelers, in order for them to be perceived as realistic options to the private car.

By assessing perceptions of sustainable modes together in evaluations of accessibility (e.g. frequent vs non-frequent car users), rather than (only) concentrating on one mode per scientific study, researchers can provide a more substantial result for planners, and avoid overlap. If only concentrating at evaluating bicycle accessibility, for instance, there might seem that an area fails in providing accessible options (to the car), although walking opportunities and public transport may be perceived as excellent. Some other issues to be considered include potential barriers that could prevent the transition to sustainable alternatives or implementation of new solutions such as MaaS and DRT. These barriers may be regulatory, at policy level, organizational, financial, or technological.

9. Conclusions

This study aimed at exploring the perceived accessibility of different segments of car-users in a restricted car scenario. In line with this, we provide a modified, validated version of a perceived accessibility measure (PAC) which has the ability to detect differences in perceived accessibility. Using this measure, we have shown that both frequent and non-frequent car users will experience a scenario with restricted car-use negatively. They feel that they will not be able to live their lives the way they want to, and reach destinations and activities of choice, without access to the car. This approach to capturing perceptions of accessibility, with its results, provide an opportunity to analyze and discuss how the transport modes of the future should be improved and designed in order to minimize the effect of loss aversion and make the adaptation process to sustainable travel easier for frequent as well as less frequent car-users.

In the future, there is a need to examine if these results hold in real situations. Researchers should also evaluate and follow up strategies and interventions in order to minimize the perceived loss in accessibility, and maximize the gain.

CRediT authorship contribution statement

Katrin Lättman: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Validation, Visualization, Writing - original draft, Writing - review & editing. **Margareta Friman:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Writing - original draft, Writing - review & editing. **Lars E. Olsson:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Validation, Writing - original draft, Writing - review & editing.

Acknowledgements

Financial support was obtained through grant #2014-05335 from the Swedish Governmental Agency for Innovation Systems. Malmö Stad supported with data. A previous form of the manuscript was presented at Thredbo16 conference in Singapore, and the authors are grateful for the valuable feedback we received in order to improve the paper.

Declaration of Competing Interest

None.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trd.2019.102213.

References

Adler, G., Rottunda, S., 2006. Older adults' perspectives on driving cessation. J. Aging Stud. 20 (3), 227–235.
Avieri, E., 2012. On the use and potential of behavioral economics from the perspective of transport and climate change. J. Transp. Geogr. 24, 512–521.
Ball, K., Jeffery, R.W., Crawford, D.A., Roberts, R.J., Salmon, J., Timperio, A.F., 2008. Mismatch between perceived and objective measures of physical activity environments. Prev. Med. 47 (3), 294–298. https://doi.org/10.1186/1471-2458-8-142.
Bauer, M.J., Rottunda, S., Adler, G., 2003. Older women and driving cessation. Qualit. Soc. Work 2 (3), 309–325.
Ben-Elia, E., Benenson, I., 2019. A spatially-explicit method for analyzing the equity of transit commuters' accessibility. Transport. Res. Part A: Policy Pract. 120, 31–42.
Brenner, L., Rottenstreich, Y., Sood, S., Bilgin, B., 2007. On the psychology of loss aversion: possession, valence, and reversals of the endowment effect. J. Consum. Res. 34 (3), 369–376.
Burns, L.D., Golob, T.F., 1976. The role of accessibility in basic transportation choice behavior. Transportation 5 (2), 175–198.
Cheyne, C., Imran, M., 2016. Shared transport: Reducing energy demand and enhancing transport options for residents of small towns. Energy Res. Social Sci. 18,

139–150.
Curl, A., Nelson, J.D., Anable, J., 2011. Does accessibility planning address what matters? A review of current practice and practitioner perspectives. Res. Transport. Busin. Manag. 2, 3–11.
Davison, L., Enoch, M., Ryley, T., Quddus, M., Wang, C., 2014. A survey of demand responsive transport in Great Britain. Transp. Policy 31, 47–54.
De Vos, J., 2018. Do people travel with their preferred travel mode? Analysing the extent of travel mode dissonance and its effect on travel satisfaction. Transport. Res. Part A: Policy Pract. 117, 261–274.
De Vos, J., Ettema, D., Witlox, F., 2018. Changing travel behaviour and attitudes following a residential relocation. J. Transp. Geogr. 73, 131–147.
De Vos, J., 2019. Satisfaction-induced travel behaviour. Transport. Res. Part F: Traff. Psychol. Behav. 63, 12–21.
Douglas, M.J., Watkins, S.J., Gorman, D.R., Higgins, M., 2011. Are cars the new tobacco? J. Public Health 33 (2), 160–169.
Friman, M., Gärling, T., 2001. Frequency of Negative Critical Incidents and Satisfaction with Public Transport Services. II. J. Retail. Consum. Serv. 8, 105–114.
Gärling, T., Bamberg, S., Friman, M., 2017. The Role of Attitude in Choice of Travel, Satisfaction with Travel, and Change to Sustainable Travel. In: Albarracin, D., Johnson, B.T. (Eds.), Handbook of attitudes: Applications. London: Routledge, (Chapter).
Geurs, K., Ritsema van Eck, J., 2001. Accessibility measures: review and applications. Evaluation of accessibility impacts of land-use transportation scenarios, and related social and economic impact. RIVM, Utrecht, the Netherlands.
Geurs, K.T., Van Wee, B., 2004. Accessibility evaluation of land-use and transport strategies: review and research directions. J. Transp. Geogr. 12 (2), 127–140.
Hjorth, K., Fosgerau, M., 2011. Loss aversion and individual characteristics. Environ. Resour. Econ. 49 (4), 573–596.
Hui, V., Habib, K.N., 2014. An investigation of transport-related social exclusion of the at-risk community (homeless people) in Toronto, Canada. Paper presented at the Transportation Research Board 93rd Annual Meeting, Washington DC.
Kahneman, D., Tversky, A., 1979. Prospect theory: an analysis of decision under risk. Econometrica 74 (2), 363–391.
Kőszegi, B., Rabin, M., 2006. A model of reference-dependent preferences. Q. J. Econ. 121 (4), 1133–1165.
Lättman, K., Friman, M., Olsson, L.E., 2016a. Perceived accessibility of public transport as a potential indicator of social inclusion. Social Inclusion 4 (3), 36–45. https://doi.org/10.17645/si.v4i3.481.
Lättman, K., Olsson, L.E., Friman, M., 2016b. Development and test of the perceived accessibility scale (PAC) in public transport. J. Transp. Geogr. 54, 257–263.
Lättman, K., Olsson, L.E., Friman, M., 2018. A new approach to accessibility–Examining perceived accessibility in contrast to objectively measured accessibility in daily travel. Res. Transport. Econom. 69, 501–511.
Lättman, K., 2018. Perceived Accessibility: Living a Satisfactory Life With Help of the Transport System. Doctoral dissertation. Karlstads Universitet.
Li, Q., Liao, F., Timmermans, H.J., Zhou, J., 2016. A user equilibrium model for combined activity–travel choice under prospect theoretical mechanisms of decision-making under uncertainty. Transportmet. A: Transp. Sci. 12 (7), 629–649.
Lucas, K., Van Wee, B., Maat, K., 2015. A method to evaluate equitable accessibility: combining ethical theories and accessibility-based approaches. Transportation 43 (3), 473–490.
Ma, L., Cao, J., 2017. How perceptions mediate the effects of the built environment on travel behavior? Transportation 1–23.
Martens, K., 2017. Transport Justice: Designing fair transportation systems. Routhledge, New York.
Milkman, K.L., Chugh, D., Bazerman, M.H., 2009. How can decision making be improved? Perspect. Psychol. Sci. 4 (4), 379–383.
Milkman, K.L., Mazza, M.C., Shu, L.L., Tsay, C.J., Bazerman, M.H., 2012. Policy bundling to overcome loss aversion: A method for improving legislative outcomes. Organ. Behav. Hum. Decis. Process. 117 (1), 158–167.
Morris, J.M., Dumble, P.L., Wigan, M.R., 1979. Accessibility indicators for transport planning. Transport. Res. Part A: General 13 (2), 91–109.
Novemsky, N., Kahneman, D., 2005. The boundaries of loss aversion. J. Mark. Res. 42 (2), 119–128.
Parkhurst, G., Meek, S., 2014. The effectiveness of park-and-ride as a policy measure for more sustainable mobility. Transp. Sustainability 5 (5), 185–211.
Preston, J., Rajé, F., 2007. Accessibility, mobility and transport-related social exclusion. J. Transp. Geogr. 15 (3), 151–160.
Pucci, P., Vecchio, G., Bocchimuzzi, L., Lanza, G., 2019. Inequalities in job-related accessibility: testing an evaluative approach and its policy relevance in Buenos Aires. Appl. Geogr. 107, 1–11.
Ripple, W. J., Wolf, C., Newsome, T. M., Galetti, M., Alamgir, M., Crist, E., 15,364 scientist signatories from 184 countries. (2017). World scientists' warning to humanity: a second notice. BioScience, 67(12), 1026-1028.
Ryan, M., Lin, T., Xia, J.C., Robinson, T., 2016. Comparison of perceived and measured accessibility between different age groups and travel modes at Greenwood Station, Perth, Australia. Eur. J. Transp. Infrast. Res. 16 (2), 406–423.
Scheepers, C.E., Wendel-Vos, G.C.W., van Kempen, E.E.M.M., de Hollander, E.L., van Wijnen, H.J., Maas, J., van Wesemael, P.J.V., 2016. Perceived accessibility is an important factor in transport choice—results from the AVENUE project. J. Transp. Health 3 (1), 96–106.
Schwanen, T., Lucas, K., Akyelken, N., Solsona, D.C., Carrasco, J.A., Neutens, T., 2015. Rethinking the links between social exclusion and transport disadvantage through the lens of social capital. Transport. Res. Part A: Policy Pract. 74, 123–135.
Smart, M.J., Klein, N.J., 2018. Remembrance of cars and buses past: how prior life experiences influence travel. J. Plann. Educat. Res. 38 (2), 139–151.
Stanley, J., Stanley, J., Vella-Brodrick, D., Currie, G., 2010. The place of transport in facilitating social inclusion via the mediating influence of social capital. Res. Transport. Econom. 29 (1), 280–286.
Malmö Stad (2017). Sustainable Urban Mobility Plan. Downloaded from: https://malmo.se/download/18.16ac037b154961d0287384d/1491301288704/Sustainable+urban+mobility+plan%28TROMP%29_ENG.pdf.
The Swedish Transport Administration. (2018). Tillgänglighet i ett hållbart samhälle - Målbild 2030 (Accessibility in a sustainable society - Target Goal 2030). Rapport 2018:235, The Swedish Transport Administration, Borlänge, Sweden.
Weckström, C., Mladenović, M.N., Ullah, W., Nelson, J.D., Givoni, M., Bussman, S., 2018. User perspectives on emerging mobility services: Ex post analysis of Kutsuplus pilot. Res. Transport. Busin. Manag. 27, 84–97.
Van der Vlugt, A.-L., Curl, A., Wittowsky, D., 2019. What about the people? Developing measures of perceived accessibility from case studies in Germany and the UK. Applied Mobilities.
Van Wee, B., van Cranenburgh, S., Maat, K., 2019. Substitutability as a spatial concept to evaluate travel alternatives. J. Transp. Geogr. 79, 102469.
Vitman-Schorr, A., Ayalon, L., Khalaila, R., 2017. Perceived accessibility to services and sites among Israeli older adults. J. Appl. Gerontol. 38 (1), 112–136.
Wood, B.S., Horner, M.W., 2019. Aging in activity spaces: how does individual accessibility compare across age cohorts? Profess. Geograp. 71 (1), 1–14.