Findings

Paulusova, Ivana, Fariya Sharmeen, and Qian Wang. 2025. "Perceived Accessibility Scale Adapted to Cycling: What Insights Can It Provide in the Context of Stockholm?" *Findings*, September. https://doi.org/10.32866/001c.143997.

TRANSPORT FINDINGS

Perceived Accessibility Scale Adapted to Cycling: What Insights can it Provide in the Context of Stockholm?

Ivana Paulusova[1], Fariya Sharmeen, Ph.D.[1], Qian Wang, Ph.D.[1]

[1] Urban Planning and Environment, KTH Royal Institute of Technology

Keywords: Perceived accessibility, cycling, sustainable mobility, perceived accessibility scale

https://doi.org/10.32866/001c.143997

Findings

The study adapted the Perceived Accessibility Scale to assess perceived cycling accessibility in Stockholm, presenting a new case study of its application. Using recent survey data and factor analysis, the scale demonstrated strong reliability in capturing perceptions. Hypothesis testing indicated limited effects of most sociodemographic factors on perceived cycling accessibility, except for gender among frequent cyclists. Mobility-related characteristics and peer influence had stronger effects, while spatial variables were insignificant. A significant positive association was also found between perceived cycling accessibility and cycling frequency. These findings align with expectations and reflect behaviour of Swedish cyclists.

1. QUESTIONS

Perceived accessibility was conceptualized decades ago, yet gaps remain in its assessment. Most accessibility research focuses on spatial measures, producing results that often differ from perceived measures (Lättman, Olsson, and Friman 2018; Pot, Koster, and Tillema 2023). The Perceived Accessibility Scale (PAC), developed by Lättman, Olsson, and Friman (2016, 2018), has been validated in various contexts (e.g., rural car accessibility (Pot, Koster, and Tillema 2023), public transport accessibility (Friman, Lättman, and Olsson 2020). However, its application to cycling accessibility is lacking (Negm et al. 2025). Although the impact of sociodemographic, mobility, and social characteristics on general perceived accessibility has been studied (e.g., De Vos et al. 2022; Pot, Koster, and Tillema 2023; van der Vlugt, Curl, and Wittowsky 2019), their specific impact on perceived cycling accessibility remains unexplored.

This paper thus presents the first empirical case study of adapting PAC to cycling, and addresses the following research questions (RQs):

- RQ1: How suitable is the adapted PAC for measuring perceived cycling accessibility?
- RQ2: To what extent do sociodemographic, mobility, social and spatial characteristics influence perceived cycling accessibility?

- RQ3: How is perceived cycling accessibility related to cycling frequency?

2. METHODS

The study used data from the Bike2Green project in Stockholm region, collected through online surveys between March and December 2024. The dataset included 491 participants. The sample was skewed towards men (66%), university-educated (85%), and frequent cyclists (87% cycling ≥3–4 times/week). Perceived cycling accessibility was measured using the 5-point Likert scale PAC, with statements rephrased to explicitly refer to cycling.

To answer RQ1, the reliability of the proposed scale was examined using factor analysis. For RQ2, perceived accessibility factor scores were computed with the built-in function in the *lavaan* package in R (Rosseel 2012), and differences in PAC scores across socio-demographic, mobility, social, and spatial characteristics were tested (see Supplementary Materials for detailed hypotheses). First, non-parametric tests (Mann–Whitney, Kruskal–Wallis, Spearman correlation, with Dunn's post-hoc and Bonferroni correction) were used due to non-normality and small sample sizes. Second, Chi-square and Fisher's exact tests assessed differences in perceived accessibility (categorized as below or above the mean) based on explanatory variables within high-frequency (≥3–4 times/week) and low-frequency (≤1–2 times/week) cyclist groups. For RQ3, binomial regressions examined the relationship between perceived accessibility and cycling frequency[1].

3. FINDINGS

Exploratory factor analysis confirmed the PAC adaptation's suitability for capturing perceived cycling accessibility, showing high factor adequacy and strong internal consistency (Table 1). The factor's performance was similar to previous findings which validated its use (e.g., Lättman, Friman, and Olsson 2020; Lättman, Olsson, and Friman 2018; Pot, Koster, and Tillema 2023; van der Vlugt, Curl, and Wittowsky 2019).

Hypothesis testing revealed that socio-demographic variables were generally not significantly associated with differences in perceived cycling accessibility, unlike mobility and social characteristics, which exhibited significant associations (Table 2). Differences in PAC associated with mobility characteristics were in the expected direction, i.e. participants without a car and public transport subscription, with shorter commutes and greater cycling confidence perceived accessibility more positively. This aligns with previous finding where active travellers perceived higher accessibility than car and public transport users (Lättman, Olsson, and Friman 2018). However, none

1 The data and code can be accessed here: https://github.com/pauiva/pac_research

Table 1. Correlations, Means, Standard deviation, change in Cronbach's alpha (α = 0.87), and factor loadings of the factor analysis. (N = 491)

PAC item (By travelling by bike, …)	1	2	3	M (SD)	Sk	Kur	α if item deleted	Factor loading
1. …it is easy to do my activities.	-	-	-	4.24 (0.89)	-1.39	2.03	0.85	0.737
2. …I am able to live my life as I want to.	0.63*	-	-	4.31 (0.92)	-1.45	1.88	0.84	0.784
3. …I am able to do all activities I prefer.	0.62*	0.69*	-	3.92 (1.03)	-0.88	0.16	0.81	0.880
4. Access to my preferred activities is satisfactory …	0.57*	0.57*	0.71*	4.07 (0.94)	-0.92	0.39	0.85	0.778
Eigenvalue								2.90
% of variance								63%
Kaiser-Meyer-Olkin sampling adequacy								0.81

M = Mean, SD = Standard deviation, Sk = Skewness, Kur = Kurtosis, *$p < 0.01$, CFI = 0.982, TLI = 0.945, RMSEA = 0.135, SRMR = 0.024.

of the relationships in this study were tested for causality, and underlying mechanisms remain unclear. A Dunn test (results not shown) further identified a significant difference in perceived accessibility between participants with one vs. three cycling peers (p-value = 0.011), and a marginally significant difference between participants with confidence to cycle in low- vs. high-traffic areas without separated bicycle paths (p-value = 0.061). These findings highlight the importance of a supportive social environment, as reflected in social descriptive norms (Bourke, Hilland, and Craike 2018), and underscore the role of cycling confidence as both an enabler or a barrier to cycling, in line with evidence on concerns and stress (Zarabi et al. 2025). Spatial characteristics showed no significant relationship with PAC, indicating that people's perceived cycling accessibility was not strongly related to objective spatial characteristics of their residential neighbourhoods. This result is likely context-specific, reflecting the relatively uniform infrastructure quality and high density of destinations in central Stockholm, as well as the role of personal experience and social context in shaping perceptions. In other urban contexts with uneven infrastructure provision or lower destination accessibility, spatial factors may play a greater role.

Conditional correlations (Table 3), given fixed cycling frequency levels (high vs. low frequency), largely reflected previous results within the frequent cyclists group but also revealed additional car-access and gender-based differences in perceived cycling accessibility. Women reported more positive perceptions. This seemingly contrasts the findings from the US where women perceived lower accessibility (Ma, Dill, and Mohr 2014), but mirrors other findings from Sweden (Lättman, Olsson, and Friman 2018). It may indicate that Swedish female cyclists have already overcome initial barriers related to low perceptions, or that cultural aspects like gender equality may lower the perception gap. Among low-frequency cyclists, only peer influence was significantly associated with perceived accessibility, suggesting that infrequent cyclists may encounter different barriers than regular cyclists. Nevertheless, the undersampling of infrequent cyclists might have limited the detection of additional differences within this group, making the results more representative of frequent cyclists. Cycling confidence was not significant within either group, suggesting it may not be independently associated with perceived bikeability, but instead linked to cycling frequency itself. A few policy recommendations can be found in Supplementary Materials.

Lastly, binomial logistic regression results (Supplementary Materials) showed that a one-unit increase in PAC factor was significantly associated with higher cycling frequency, corresponding to a 239% increase in odds in the bivariate model ($p < 0.001$). Multivariate model including socio-demographic, mobility and spatial controlling variables showed a 162% increase in the odds ($p = 0.021$). This finding aligns with previous evidence (Ma, Dill, and Mohr 2014). However, the explanatory power of perceived accessibility remained relatively low (McFadden's $R^2 = 0.10$ for bivariate model), suggesting that additional factors beyond perceived accessibility, such as travel preferences (Mehdizadeh and Kroesen 2025), may influence cycling frequency, or that PAC, in its current conceptualization, might not well capture perceived accessibility but rather capture satisfaction (De Vos et al. 2022). Alternative formulations have been recently proposed to better reflect the accessibility construct (Vafeiadis and Elldér 2024), and future research may further refine these developments in the context of active travel.

Acknowledgements

The authors would also like to thank to all reviewers whose feedback helped to improve the quality of this article. The authors also thank Ammj Traore for providing the data file containing the computed Net-A-Score, which was used as the input for the variable level of cycling infrastructure.

This research was supported by the Swedish government strategic research area funding from Transport Research Environment with Novel Perspectives (TRENoP). It also benefited from the funding received from the European Union (Grant agreement 101102553 — Bike2Green). Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or [the European Commission]. Neither the European Union nor the European Commission can be held responsible for them.

During the preparation of this work, the author(s) used ChatGPT to enhance the readability and language of the manuscript. After using this tool, the author(s) carefully reviewed and edited the content as necessary and take full responsibility for the final published version.

Submitted: July 10, 2025 AEST. Accepted: September 05, 2025 AEST. Published: September 11, 2025 AEST.

Table 2. Overview of associations between perceived cycling accessibility and explanatory variables. (N = 491, unless stated otherwise).

Variable	Category	PAC factor[a]	P-value
Socio-demographic			
Gender (N=485)	Male	0.040	0.324
	Female	-0.017	
Age (group)	0-29	0.008	0.810
	30-59	-0.007	
	60+	0.104	
Education	Lower than university	-0.029	0.339
	University	0.005	
Living with children	Yes	0.025	0.516
	No	-0.019	
Mobility			
Household car ownership (N=384)	1+ cars	-0.058	0.003***
	0 cars	0.089	
Individual car access (N=382)	Yes, own	-0.029	0.321
	Yes, other (shared, company, etc.)	0.021	
	No	0.070	
Driving license (N=384)	Yes	0.020	0.970
	No	-0.005	
Public transport subscription (N=384)	Yes	-0.234	<0.001***
	No	0.059	
Cycling confidence (N=383)	On separated bike paths	-0.053	0.093*
	In areas with low traffic, where there are no separated bike paths	-0.089	
	In areas with high traffic, where there are no separated bike paths	0.067	
Daily commute duration[b] (N=384)	Less than 30 minutes (one way)	0.096	0.003***
	More than 30 minutes (one way)	-0.105	
Social (N=384)			
Having peers who cycle (count)	0	-0.132	0.018**
	1	-0.110	
	2	0.060	
	3	0.166	
	4	0.083	
	5	0.160	
Having peers who cycle (binary)	Yes	0.033	0.147
	No	-0.132	
Spatial (N=313[c])			
Level of cycling infrastructure within individual's residential neighbourhood[d]	Ratio of suitable to unsuitable cycling infrastructure in a neighbourhood.	-0.031	0.584
Density of destinations within individual's residential neighbourhood[e]	Shops	0.034	0.543
	Amenities	0.072	0.201
	Leisure	0.074	0.192
	Office	0.087	0.126

***p < 0.01, **p < 0.05, *p < 0.1.

[a]The value shows mean for categorical variables, and correlation for numerical variables (level of cycling infrastructure and density of destionations).

[b]By the most frequently used transport mode.

[c]Spatial analyses were limited to respondents living in the city of Stockholm (N=313), in contrast to the broader Stockholm region, due to data constraints regarding the spatial variables. The city constitutes the core urban area, whereas the region covers the broader metropolitan area.

[d]The suitability of cycling infrastructure was evaluated using the bikeability Net-A-Score method (Werner et al. 2024). Infrastructure length was measured in kilometres, and a ratio was calculated by comparing the length of suitable (score ≥0.6) and unsuitable (score <0.6) segments, following the method's guidelines.

[e]Density of destinations is based on OpenStreetMap categories (OpenStreetMap Wiki contributors 2025).

Table 3. Conditional independence between perceived cycling accessibility and explanatory variables, given cycling frequency. Sample size is the same as in the previous analysis in Table 2.

Variable	Low cycling frequency[a]		High cycling frequency[b]	
	PAC factor[c]			
	Conditional independence (p-value)	Odds ratio (comparison groups) [CI]	Conditional independence (p-value)	Odds ratio (comparison groups) [CI]
Socio-demographic				
Gender	0.712		0.040**	0.644 (Male/Female) [0.419, 0.980]
Age (group)	0.522		0.240	
Education	0.667		0.245	
Living with children	0.391		0.738	
Mobility				
Household car ownership	0.585		<0.001***	0.461 (Car/No car) [0.295, 0.715]
Individual car access[d]	0.668		0.074*	0.538 (Own/No access) [0.311, 0.924]
Driving license	0.360		0.491	
Public transport subscription	0.551		0.043**	0.492 (Yes/No) [0.239, 0.991]
Cycling confidence	1		0.105	
Daily commute duration[e]	0.186		0.017**	0.579 (More/Less than 30 minutes) [0.367, 0.910]
Social				
Having peers who cycle (count)[d]	0.022**	0.137 (1 vs 3 peers) [0.019, 0.748]	0.107	
Having peers who cycle (binary)	0.295		0.143	
Spatial[f]				
Level of cycling infrastructure – ratio of suitable to unsuitable	0.760		0.241	
Shops density	1		0.806	
Amenities density	0.286		0.242	
Leisure locations density	1		0.599	
Offices density	0.178		0.377	

***p < 0.01, **p < 0.05, *p < 0.1.

[a]Cycling ≤1–2 times/week.

[b]Cycling ≥3–4 times/week.

[c]PAC factor is categorized as either below or above the mean.

[d]Other pair-wise comparisons were not included in the table as their odds were not significantly different.

[e]By the most frequently used transport mode.

[f]For all spatial variables: within individual's residential neighbourhood (categorised as below vs. above the mean).

REFERENCES

Bourke, M., T. A. Hilland, and M. Craike. 2018. "An Exploratory Analysis of the Interactions between Social Norms and the Built Environment on Cycling for Recreation and Transport." *BMC Public Health* 18 (1): 1162. https://doi.org/10.1186/s12889-018-6075-4.

De Vos, J., K. Lättman, A.-L. van der Vlugt, J. Welsch, and N. Otsuka. 2022. "Determinants and Effects of Perceived Walkability: A Literature Review, Conceptual Model and Research Agenda." *Transport Reviews* 43 (2): 303–24. https://doi.org/10.1080/01441647.2022.2101072.

Friman, M., K. Lättman, and L. E. Olsson. 2020. "Public Transport Quality, Safety, and Perceived Accessibility." *Sustainability* 12 (9). https://doi.org/10.3390/su12093563.

Lättman, K., M. Friman, and L. E. Olsson. 2020. "Restricted Car-Use and Perceived Accessibility." *Transportation Research Part D: Transport and Environment* 78. https://doi.org/10.1016/j.trd.2019.102213.

Lättman, K., L. E. Olsson, and M. Friman. 2016. "Development and Test of the Perceived Accessibility Scale (PAC) in Public Transport." *Journal of Transport Geography* 54:257–63. https://doi.org/10.1016/j.jtrangeo.2016.06.015.

———. 2018. "A New Approach to Accessibility – Examining Perceived Accessibility in Contrast to Objectively Measured Accessibility in Daily Travel." *Research in Transportation Economics* 69:501–11. https://doi.org/10.1016/j.retrec.2018.06.002.

Ma, L., J. Dill, and C. Mohr. 2014. "The Objective versus the Perceived Environment: What Matters for Bicycling?" *Transportation* 41 (6): 1135–52. https://doi.org/10.1007/s11116-014-9520-y.

Mehdizadeh, M., and M. Kroesen. 2025. "Does Perceived Accessibility Affect Travel Behavior or Vice Versa? Alternative Theories Testing Bidirectional Effects and (in)Consistency over Time." *Transportation Research Part A: Policy and Practice* 191. https://doi.org/10.1016/j.tra.2024.104318.

Negm, H., J. De Vos, F. Pot, and A. El-Geneidy. 2025. "Perceived Accessibility: A Literature Review." *Journal of Transport Geography* 125. https://doi.org/10.1016/j.jtrangeo.2025.104212.

OpenStreetMap Wiki contributors. 2025. "Map Features." OpenStreetMap Wiki. July 21, 2025. https://wiki.openstreetmap.org/w/index.php?title=Map_features&oldid=2876652.

Pot, F. J., S. Koster, and T. Tillema. 2023. "Perceived Accessibility in Dutch Rural Areas: Bridging the Gap with Accessibility Based on Spatial Data." *Transport Policy* 138:170–84. https://doi.org/10.1016/j.tranpol.2023.04.014.

Rosseel, Y. 2012. "Lavaan: An R Package for Structural Equation Modeling." *Journal of Statistical Software* 48 (2): 1–36. https://doi.org/10.18637/jss.v048.i02.

Vafeiadis, E., and E. Elldér. 2024. "Correlates of Perceived Accessibility across Transport Modes and Trip Purposes: Insights from a Swedish Survey." *Transportation Research Part A: Policy and Practice* 186. https://doi.org/10.1016/j.tra.2024.104147.

van der Vlugt, A.-L., A. Curl, and D. Wittowsky. 2019. "What about the People? Developing Measures of Perceived Accessibility from Case Studies in Germany and the UK." *Applied Mobilities* 4 (2): 142–62. https://doi.org/10.1080/23800127.2019.1573450.

Werner, C., L. van der Meer, D. Kaziyeva, P. Stutz, R. Wendel, and M. Loidl. 2024. "Bikeability of Road Segments: An Open, Adjustable and Extendible Model." *Journal of Cycling and Micromobility Research* 2. https://doi.org/10.1016/j.jcmr.2024.100040.

Zarabi, Z., J. Laviolette, O. Waygood, and K. Manaugh. 2025. “What Type of Person Is at Different Stages of Change for Cycling? A Case Study of Montreal.” *Travel Behaviour and Society* 39. https://doi.org/10.1016/j.tbs.2024.100969.

SUPPLEMENTARY MATERIALS

Supplementary information

Download: https://findingspress.org/article/143997-perceived-accessibility-scale-adapted-to-cycling-what-insights-can-it-provide-in-the-context-of-stockholm/attachment/300839.pdf