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Feeling like cycling? Psychological factors related to cycling as a mode choice

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ABSTRACT: *Despite the undeniable benefits of cycling, this mode of transport is still somewhat underdeveloped in many European countries such as in the Czech Republic. The limited number of trips by bike may be explained by the objective factors, like the natural environment inconvenient for cycling. However, objective factors play the role only to some degree. There are also subjective or psychological factors associated with choosing a mode of transport. This study focuses on the perceptions and attitudes related to riding a bicycle. The data was collected through a survey in the Czech municipality Litoměřice, as a part of Litoměřice's sustainable urban mobility plan. The sample consisted of 1 301 inhabitants of Litoměřice of the age of 6 and older. The mean age was 48 years and the median age 49 years. Women represented 52% (682 persons) of the sample. Overall, 34% (i.e. 400) respondents stated that they ride bicycles as their leisure. Another 10% (111) of them also ride a bike when they travel to work, school or shop. The remaining 57% (i.e. 671) of the respondents indicated that they do not cycle at all. Also, the respondents answered 12 statements covering their opinions related to cycling in Litoměřice based on the theory of planned behaviour. Answers of the respondents on these variables correlated and the exploratory factor analysis with the minimum residual estimator and varimax rotation indicated three underlying factors. The first one contained attitudes towards traffic safety when riding a bike and the state of cycling infrastructure in Litoměřice. The second factor represented subjective views on the landscape as a barrier for cycling in Litoměřice. The third factor reflected the normative dimension of cycling. Multinomial logistic regression included subjective views as well as sociodemography in the model predicting bicycle usage. It was found that when a person valued cycling in terms of norms, this person was more likely to ride a bicycle in comparison to a person who indicated no cycling at all. Also, respondents who cycled did not tend to see the landscape in Litoměřice as something discouraging them from riding a bike, at least in comparison to those who did not cycle at all. Finally, respondents who saw the current traffic in Litoměřice as safe for cyclists, as well as those who considered the cycling infrastructure as developed, were less likely to be those who rode a bike in reality. These findings could be used for the preparation as well as for the implementation of the transport policy as they reveal psychological barriers for riding a bike. Also, the results of this study provide support for including psychological measures in sustainable urban mobility plans, as well as in travel behaviour surveys in general.*

KEYWORDS: *Cycling; Attitudes; Factor Analysis; Mode Choice; Travel Behaviour Survey*

1. INTRODUCTION

Despite the undisputable benefits of cycling including better public as well as individual health (Oja et al., 2011; Hartog, Boogaard, Nijland, & Hoek, 2010) or cost-effective investments in cycling infrastructure (Gotschi, 2011) to name a few, this mode of transport is still underdeveloped in the Czech Republic. For example, according to the latest census (Czech Statistical Office 2013), only 1% of all trips to work and education related trips were conducted on a bicycle.

The situation is no different in Litoměřice, a town with 24 045 inhabitants (Czech Statistical Office, 2018), located on the conflux of the rivers Labe and Ohře in the Ústecký region. Recent travel behaviour survey revealed that less than 1% of all trips were done on a bicycle (Gabrhel, 2018).

This modal share is rather surprising since Litoměřice fulfils several key factors identified as incentives for cycling, especially in terms of non-

recreational trips. First of all, there is, on average, at least one bicycle per household in Litoměřice. Also, there are, on average, fewer cars in households in Litoměřice in comparison to bicycles – .87 cars per household. In other words, car ownership as such does not discourage bicycle ownership in Litoměřice. Also, 53% of respondents interviewed in the travel behaviour survey declared that they could use a bicycle anytime (Gabrhel, 2018).

Another factor related to cycling is trip distance – an increase in the length of a trip relates to the decrease in willingness to cycle (Fraser & Lock, 2010; Pucher & Buehler, 2008). According to Heinen, Wee, and Maat (2009), most of the trips on bicycles are conducted between .5 and 3.5 kilometres (km). In Litoměřice, 68 % of all trips were conducted in the distance up to 3 km. Despite this fact, only 1-2% of all trips in this distance range were travelled on a bicycle. Also, it is important to add that 85% of all trips in the distance up to 1 km were done by walking, yet inhabitants of Litoměřice drove a car in 55% of all trips between 2 and 3 km and walked only in 21% of trips (Gabrhel, 2018).

Moreover, the town's spatial distribution is monocentric with the historical centre and suburbs, and Litoměřice as such are relatively dense – with 24 045 inhabitants on 18 km^2 (Gabrhel, Kouřil, Šimeček, & Tögel, 2018). Town centre of Litoměřice contains offices, restaurants, convenience stores, housing, and other facilities implying a mixture of functions. While both higher levels of urban density and mixture of functions are related to the higher share of trips done by bicycle (Dill & Voros, 2007; Moudon et al., 2005), only 3% of all leisure-related trips were done on a bicycle.

In addition, Litoměřice region is characterized by mild and rather dry weather conditions with the annual average temperature of 9.1 °C and the annual average precipitation of 670 mm (Czech Statistical Office, 2012). Moreover, the landscape of Litoměřice is rather flat with the maximum vertical metre of 20 metres and elevation of 136 metres. In summary, the natural environment of Litoměřice as such does not represent condition discouraging from cycling (Tögel & Szabo, 2018).

On the other hand, despite the existence of tourist bicycle paths (e.g. the Elbe Cycle Route) close to Litoměřice, there are no dedicated bicycle paths or lanes in the town itself. At the same time, the cycling masterplan from 2009 recommended development of both tourist cycling routes as well as cycling routes for every-day mobility in Litoměřice. Moreover, there is a site of bicycle parking capacities in Litoměřice, including bike tower (Tögel & Szabo, 2018).

Although several objective factors in Litoměřice align with conditions encouraging cycling, there may be subjective or psychological factors associated with lower willingness to cycle. Firstly, the lack of dedicated cycling infrastructure may lead to lower levels of perceived safety while riding a bicycle. The lack of perceived safety while cycling may, in turn, may project into fewer trips on a bicycle (Klobucar & Fricker, 2007). Moreover, cycling may be perceived as through perspective of social norms – either as something limited to the recreational activity or also as something as a regular mean of transport. In other words, social norms related to the perception of cycling play an important role in bicycle usage (de Bruijn, Kremers, Schaalma, van Mechelen, & Brug, 2005). Social norms also relate to lifestyle and habits. People promoting regular exercise as well as those who strive for healthy lives incline to cycle more than those who have different perceptions (Ball, Jeffery, Abbott, McNaughton, & Crawford, 2010). At the same time, travel behaviour is habitual in a sense that if there is not an established pattern of cycling for travel, then cycling may not even be considered as a way how to travel (Rose & Marfurt, 2007).

Despite the low cycling modal share in Litoměřice, there is a strategic interest in the growth of cycling in the town, especially for non-recreational purposes (Municipality of Litoměřice, 2016). Thus, cycling was accented in the sustainable urban mobility plan (SUMP) Litoměřice that launched in 2017. In order to gain data-based insight focused on barriers as well as incentives for cycling, travel behaviour survey in Litoměřice, one of the key sources of data for the SUMP, included items on the bicycle usage, attitudes of the inhabitants related to cycling (Gabrhel, Kouřil, Šimeček, & Tögel, 2018).

These items were formulated on the basis of the theory of planned behaviour (TPB; Ajzen, 1991), a framework used to predict behaviour such as mode choice through interpersonal and intrapersonal factors like attitudes, habits, social norms or perceived control of the situation (Heinen, Maat, & van Wee, 2011; Haustein & Hunecke, 2007; Wall, Devine-Wright, & Mill, 2008). In this regard, this study extends the scope of the previous research in which the TPB was used to cover areas such as the perceived health, economic or ecological benefits of cycling (e.g. Heinen, Maat, & van Wee, 2011).

Based on the data, this paper aims to identify factors associated with bicycle use in Litoměřice, with a particular focus on psychological factors.

2. METHODS

2.1 Sampling and design

The data in Litoměřice were collected via random sampling procedure. The first step consisted of randomly selecting addresses from the register of all addresses with households. If there was only one household at the respective address point, that household was included in the sample. However, if there were more households present on one address, the appointed number of households was randomly selected from the list of all households present at that address. For example, if there were two households to be randomly selected from a block of flats with 12 households, an inquirer made a list of households on that block of flats. From this list, he or she then randomly selected two primary households to be interviewed in person through the pen-and-paper interview (PAPI).

Moreover, each of the primary households had associated three randomly selected secondary households that were interviewed after three attempts when it was impossible to interview the primary household.

Seven days before the randomly selected date of interview primary sampled households received the official letter informing them about the nature of the survey as well as about the data protection. If the scheduled date of the interview had not been convenient for members of these households, they were able to inform inquirers and rearrange the date. In case of no such request, the first attempt to interview was made on the selected date. If inquirers had not been able to conduct the interview, they inserted another copy of the official letter in the mailbox and returned to that household three days later. Only after the inquirers had yielded the total of three unsuccessful attempts to interview the primary household, the inquirers were allowed to interview one of the three associated secondary households. Then, the whole procedure repeated until one of the sampled households was successfully interviewed.

In households, all persons older than six years participated in the survey.

The data were collected between the 21st of September and 15th of December 2017. Overall, 25 inquirers interviewed 726 households in town Litoměřice. In the interviewed households, there were 1 301 persons of which 51% (682) were women. The mean age of respondents was 47 years (SD = 19.6) and median 49 years. When it comes to the achieved level of education, the most frequent answer was a high school diploma (40%, i.e. 514 persons) or vocational education (27%, i.e. 351 participants).

Table 1 provides more detailed information regarding the socio-demography of the participants:

Table 1 – Socio-demography of the sample.

Variables	Category	Sample (n = 1 301)
Gender	Men	617 (48%)
	Women	682 (52%)
Age (in years)	M (SD)	47 (19.6)
	Median	49
	Range	6 – 93
Achieved level of education	Primary	180 (14%)
	Vocational	351 (27%)
	High school	514 (40%)
	College	247 (19%)
Economic activity	Economically active	711 (67%)
	Economically inactive	354 (23%)
Household gross monthly income	Less than 370 EUR	22 (2%)
	371-600 EUR	132 (12%)
	601-880 EUR	193 (18%)
	881-1 200 EUR	311 (29%)
	1 201-2 000 EUR	324 (31%)
	More than 2 000 EUR	83 (8%)

2.2 Method

The survey consisted of a questionnaire with a part dedicated to the household as a whole and also to its members older than six years. These two parts contained mobility relevant items (e.g. ownership of a car, the number of bicycles in the household, or a possibility of home-office) and items related to the socio-economic context (e.g. size of the household, a level of education, gender or age).

The core of the questionnaire was a travel diary (Stopher, 1992) for each of the household members older than six years. The travel diary included items

related to the mode of the travel, the destination, or the trip purpose.

Lastly, respondents in the households of 15 years and older answered 12 items related to satisfaction with cycling in town Litoměřice. These statements covered areas such as perceived traffic safety while riding a bicycle ("*It is safe to ride a bicycle in Litoměřice.*"), norms related to riding a bicycle ("*The town should support cycling more.*") or perceived physical effort required for riding a bicycle in Litoměřice ("*Riding a bicycle in Litoměřice is physically challenging.*"). Respondents they could indicate whether they "disagree", "agree", or "don't know" with the statements.

These items were formulated based on the TPB (Ajzen, 1991) as the defining attitudes towards cycling. The examined attitudes cover domains such as perceived traffic safety or norms related to cycling. In this regard, the present study builds upon with the previous research (e.g. Heinen, Maat, & van Wee, 2011). At the same time, this study focus on the psychological reflection of the objective factors such as infrastructure or landscape. In addition, the content of the items was consulted with the local stakeholders. Consequently, the presented study focuses on the local context rather than on the general or more abstract perception of a certain attitude towards cycling. Individual items are presented in the Table 2.

2.3 Analyses

The data were analysed via statistical package R (version 3.5.1.; R Core Team, 2018) and imported to R via the readxl package (version 1.2.0; Wickham & Bryan, 2018). The psych package (version 1.8.12; Revelle, 2018) was used to calculate descriptive statistics as well as the exploratory factor analysis (EFA) for the exploration of the latent variables. The dplyr package (version 0.7.8; Wickham, François, Henry, & Müller, 2018) was used for data transformations. Finally, the multinomial logistic regression model predicting the bicycle usage was implemented through nnet package (version 7.3-12; Venables & Ripley, 2002) as well as RVAideMemoire package (version 0.9-71; Hervé, 2019).

3. RESULTS

Circa 34% (i.e. 400) of interviewed inhabitants of Litoměřice indicated that they use their bicycles only for recreational purposes. Another 10% (i.e. 111) also cycle to work, to school, to a shop and so on. Also, almost 57% (i.e. 671) respondents admitted that they do not cycle at all.

We can see that in many statements, there was a similar ratio of those who agreed as well as disagreed with these statements. For example, 38.1 % of respondents agreed with the statement that "*The terrain in Litoměřice makes riding a bike difficult*". At the same time, 38.9% of the sample disagreed. On the other hand, share of those who selected "don't know" varied substantially between individual statements – ranging from 10.3% ("*Riding a bike is a part of healthy lifestyle.*") to 38.5% ("*It is easy to find free and secure parking slot for bicycles in Litoměřice.*"). Detailed information is presented in Table 2.

Since the statements cover similar aspects of riding a bicycle, dimension reduction preceded answering of the central research question, i.e. to what degree psychological factors predict the bicycle usage. Firstly, the data was dichotomised to either "*Disagree*" or "*Agree*" values or levels as the responses "*Don't know*" were considered as missing values. Following the dichotomisation, a correlation matrix of tetrachoric correlations was calculated between individual statements. The pairwise approach was implemented for dealing with the missing values. The significance value levels were adjusted for a total of 66 pairwise comparisons. Despite the correction, all of the values of statistical significance were found to be lower than the usual cut-off score of .05.

The correlation matrix reveals that there is a relatively strong relationship between items concerning both perceptions of safety (e.g. "*It is safe to ride a bicycle in Litoměřice.*" and "*Drivers are considerate to cyclists in Litoměřice.*", where r = .57). The same could be said about the relationship between perceptions of safety and perceptions of infrastructure aspects (e.g. "*It is safe to ride a bicycle in Litoměřice.*" and "*Cycling infrastructure (bike lanes, bike paths, etc.) is well-developed in Litoměřice.*", where r = .39). Also, there seems to be a relationship between norms-oriented items and policy-related items (e.g. "*Riding a bike is a part of a healthy lifestyle.*" and "*The town should support cyclists more.*", r = .5). Interestingly, perceived quality of air ("*Low quality of air in Litoměřice reduces my willingness to ride a bike.*" correlates with the perceived traffic as a barrier for riding a bike ("*Number of cars in the streets of Litoměřice reduces my willingness to ride a bicycle.*") with r = .4. At the same time, the captured environmental aspects did not associate with any other dimensions, including safety or infra-

structure. Moreover, there seems to be no relation in subjective view on the difficulties of riding a bicycle because of the landscape and other subjective dimensions such as infrastructure like safety or norms (in both social and individual dimensions. Table 3 covers information from this paragraph in detail:

Table 2 – Attitudes related to cycling in Litoměřice.

	Disagree		Agree		Don't know	
	N	**%**	**N**	**%**	**N**	**%**
1) It is safe to ride a bicycle in Litoměřice.	529	44.5	387	32.5	273	23
2) Low quality of air in Litoměřice reduces my willingness to ride a bike.	443	37.3	523	44	223	18.7
3) Drivers are considerate to cyclists in Litoměřice.	452	38	445	37.4	292	24.6
4) The town should support cycling more.	117	9.8	838	70.5	234	19.7
5) It is easy to find free and secure parking slot for bicycles in Litoměřice.	457	38.5	274	23	458	38.5
6) The terrain in Litoměřice makes riding a bike difficult.	463	38.9	453	38.1	273	23
7) Riding a bike is a part of a healthy lifestyle.	99	8.3	968	81.4	122	10.3
8) The town should build a network of bike paths, even if it meant reducing the number of parking slots for cars.	402	33.8	551	46.3	236	19.9
9) Cycling infrastructure (bike lanes, bike paths, etc.) is well-developed in Litoměřice.	485	40.8	370	31.1	334	28.1
10) A bike is a convenient mode of transport in Litoměřice.	317	26.7	591	49.7	281	23.6
11) Number of cars in the streets of Litoměřice reduces my willingness to ride a bicycle.	311	26.2	695	58.5	183	15.4
12) Riding a bicycle in Litoměřice is physically challenging.	461	38.8	443	37.3	285	24

Note: n = 1 189.

Table 3 – Correlational matrix of the attitudes related to cycling in Litoměřice.

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)
1)	1											
2)	-.15	1										
3)	.57	-.12	1									
4)	-.06	-.06	-.24	1								
5)	.45	.06	.37	-.38	1							
6)	-.16	.25	.06	-.17	-.09	1						
7)	-.01	-.11	-.11	.50	-.18	-.23	1					
8)	-.03	.02	-.03	.40	.11	-.07	.00	1				
9)	.39	-.03	.32	-.23	.41	.03	-.18	-.12	1			
10)	.34	-.03	.13	.40	.28	-.17	.28	.22	.10	1		
11)	-.42	.40	-.26	.26	-.15	.17	.18	.16	-.12	-.23	1	
12)	-.07	.14	.06	-.26	.04	.72	-.16	-.07	.18	-.24	.04	1

Based on outputs of the correlation matrix, exploratory factor analysis was applied to the data. Since the environment-related item number 2 (i.e. "*Low quality of air in Litoměřice decreases my willingness to ride a bike*") correlated substantially with only one other item, it was not included in the model. As a result, values of correlation coefficients indicate reasonable factorability. Based on the content of the items as well as on the strength of their relationships, the three-factor model was estimated based on the minimum residual method and rotated with the varimax procedure. Item number 8 ("*The town should build a network of bike paths, even if it meant reducing the number of parking slots for cars.*") was removed from the factor analysis since it reached the negative value of communality in the estimation of the factor model (i.e. ultra-Heywood case). Moreover, item number 11 ("*Number of cars in the streets of Litoměřice reduces my willingness to ride a bicycle.*") was removed from the factor analysis since the value of its communality was below .3. After this procedure, KMO measure of sampling adequacy equalled to .62 and thus could be considered as suitable for conducting exploratory factor analysis. Furthermore, Bartlett's test of sphericity was significant ($\chi^2(8) = 580.67$, $p < .05$). Drawing upon eigenvalues, the first factor ("Safety and Infrastructure") explained 22% of the variance, the second factor ("Norms") 16% of the variance and the third 15% of the variance. The three-factor solution, which explained 53% of the variance, was preferred because of: (a) content of the items; (b) the cut-off score for eigenvalues of 1; and (c) the insufficient number of primary loadings and difficulty of interpreting the subsequent factors. Only one item had a cross-loading above .3 ("*Bicycle is a convenient mode of transport in Litoměřice.*"). However, this item had a strong primary loading of .53. The factor loading matrix for this final solution is presented in Table 4.

Internal consistency for each of the scales was examined using KR20 since the response alternatives for the items were dichotomous. The values were moderate to low: .6 for Safety and Infrastructure (4 items), .41 for Norms (3 items), and .68 for Landscape (2 items). No substantial increases in alpha for any of the scales could have been achieved by eliminating more items:

Table 4 – Factor loadings and communalities based on a factor analysis varimax rotation for 9 items (n = 1 189).

	Safety-Infrastructure	Lifestyle	Landscape	Communality
1) It is safe to ride a bicycle in Litoměřice.	.77			.65
3) Drivers are considerate to cyclists in Litoměřice.	.68			.48
5) It is easy to find free and secure parking slot for bicycles in Litoměřice.	.63			.4
9) Cycling infrastructure (bike lanes, bike paths, etc.) is well-developed in Litoměřice.	.54			.31
4) The town should support cycling more.	-.28	.91		.91
7) Riding a bike is a part of a healthy lifestyle.	.37	.54		.45
10) A bike is a convenient mode of transport in Litoměřice.		.51		.3
6) The terrain in Litoměřice makes riding a bike difficult.			.94	.89
12) Riding a bicycle in Litoměřice is physically challenging.		-.2	.74	.6

Note. Factor loadings < .2 are suppressed.

Table 5 – Descriptive statistics of the factors and their internal consistency.

	Number of items	M	SD	Min	Max	KR20
Safety and Infrastructure (Items no. 1, 3, 5, and 9)	4	1.69	1.34	0	4	.6
Norms (Items no. 4, 7, and 10)	3	2.43	.77	0	3	.41
Landscape (Items no. 6 and 12)	2	.96	.87	0	2	.68

Furthermore, the extracted factors were included in multinomial logistic regression as predictors of bike usage. The factor analysis scores of the items were summed to the respective factors and entered the analysis in the form of indexes. The outcome variable ("*If you ride a bike, how do you use it?*") was of nominal level of measurement and with three mutually exclusive alternatives of answer: 1) "*I ride a bike for the recreational purposes only*", 2) "*I also ride a bike to work, school, shops, etc.*" or 3) "*I do not ride a bike at all.*". The alternative number three was set as a reference category for the model. Apart from factors, there were other predictors included in the model: a) the rest of the items related to the perception of riding a bike in Litoměřice that were not parts of the factors. Those were items number 2 *("Low quality of air in Litoměřice reduces my willingness to ride a bike.")*, 8 (*"The town should build a network of bike paths, even if it meant reducing the number of parking slots for cars."*), and 11 (*"Number of cars in the streets of Litoměřice reduces my willingness to ride a bicycle."*) with "*disagree*" as the reference category. Lastly, socio-demographic variables (namely age and gender with "*men*" as the reference category) were also included in the model. The equation for the whole model was following:

$$ln\left(\frac{P(bikeuse = recreation)}{P(bikeuse = do\ not\ cycle)}\right) = b_{10} + b_1 gender(women) + b_1 age + b_1 Landcape + b_1 Lifestyle + b_1 SafetyInfrastructure + b_1 item2(agree) + b_1 item8(agree) + b_1 item11(agree)$$

$$ln\left(\frac{P(bikeuse = work\ etc.)}{P(bikeuse = do\ not\ cycle)}\right) = b_{20} + b_2 gender(women) + b_2 age + b_2 Landscape + b_2 Lifestyle + b_2 SafetyInfrastructure + b_2 item2(agree) + b_2 item8(agree) + b_2 item11(agree)$$

The proposed model successfully fitted data (-2LL = 779.5, AIC = 815.5) in comparison to the null model (-2LL = 2151.8, AIC = 2155.8). Furthermore, most of the predictors included in the model were associated with the outcome variable, both in terms of statistical and substantial importance. When it comes to the classification, it was most accurate in predicting those participants who stated that cycle for leisure. Table 6 provides more detailed information.

As for interpreting the coefficients, let us focus on the key findings. Firstly, those who agreed with statements such as "*It is safe to ride a bicycle in Litoměřice.*" were less likely actually to ride a bike. In other words, people who saw riding a bicycle as something safe and bicycle infrastructure as developed were less likely those who ride a bicycle for recreational purposes (OR .77) or who those who ride a bicycle for different purposes (OR .63).

Secondly, the landscape of Litoměřice was more likely seen as convenient for cycling in the eyes of those who cycle – either as their leisure time activity (OR .62), but also because of shopping and other purposes of riding a bicycle (OR .63).

Thirdly, respondents who agreed with statements containing accenting normative dimension of cycling ("*Riding a bike is a part of a healthy lifestyle.*"), including approval of cycling-policy oriented measures (e.g. "*The town should support cycling more.*") were more likely to cycle: 1.41 times more in case of riding a bike for recreational purposes and two times more in case of riding also to work, among other possible purposes.

Also, agreeing or disagreeing with individual items, namely item 2 ("*Low quality of air in Litoměřice reduces my willingness to ride a bike.*"), item 8 ("*The town should build a network of bike paths, even if it meant reducing the number of parking slots for cars.*"), and item 11 ("*Number of cars in the streets of Litoměřice reduces my willingness to ride a bicycle.*") was not associated with a statistically significant increase nor decrease in likeness of riding a bicycle (for any purpose) in comparison to not riding a bike at all.

Table 6 - Classification table.

Observed	Predicted			
	1)	2)	3)	Percent Correct
1) Cycling for leisure	169	0	46	78.6
2) Cycling to work	52	0	10	0
3) Not cycling at all	71	0	81	53
Overall Percentage	68.1	0.0	31.9	58.3

Table 7 – Coefficients of the predictors included in the multinomial logistic regression.

Cycling for recreational purposes versus not cycling at all					OR - 95% C.I		
Parameter	Value	Std. Err.	z-test	p	OR	Lower bound	Upper bound
Intercept	2.29	.57	4.03	<.001	-	-	-
b_1Gender(women)	-.53	.23	-2.33	.019	.59	.38	.92
b_1Age	-.02	.01	-3.38	<.001	.98	.96	.99
b_1Landscape	-.48	.14	-3.52	<.001	.62	.47	.80
b_1Norms	.34	.14	2.39	.017	1.41	1.06	1.86
b_1SafetyInfrastructure	-.26	.09	-3.02	.003	.77	.65	.91
b_1Item2(agree)	-.46	.24	-1.93	.054	.63	.4	1
b_1Item8(agree)	-.18	.24	-.74	.454	.84	.52	1.4
b_1Item11(agree)	.04	.25	.16	.871	1.04	.63	1.72
Cycling for all purposes versus not cycling at all					OR - 95% C.I		
Parameter	Value	Std. Err.	z-test	p	OR	Lower bound	Upper bound
Intercept	-.23	.85	-.27	.784	-	-	-
b_2Gender(women)	-.31	.32	-.972	.33	.73	.39	1.36
b_2Age	-.01	.01	-1.19	.237	.99	.97	1
b_2Landscape	-.47	.19	-2.43	.015	.63	.43	.91
b_2Norms	.64	.24	2.72	.007	1.9	1.2	3.02
b_2SafetyInfrastructure	-.46	.13	-3.59	<.001	.63	.49	.81
b_2Item2(agree)	-.19	.33	-.58	.559	.82	.4	1.6
b_2Item8(agree)	.14	.34	.39	.694	1.15	.58	2.3
b_2Item11(agree)	-.34	.35	-.97	.33	.71	.36	1.41

Furthermore, there was a significant overlap in comparing odds ratios for the two broader ways of bicycle usage. Confidence intervals (95%) of all predictors included both values lower than one as well as higher than this value. In some predictors, the odds ratio varied substantially. For example, in Norms, the lower bound equalled to the value .86 and the upper bound to the value 2.13. In other words, in some cases, an increase in the Norms scale led to a decrease in the likeness for riding a bike also for other than recreational purposes by .86. In other cases, the same increase led to two times higher likeness. To sum up, these two categories of bicycle did not differ in the sample.

Lastly, women were less likely than men to ride a bike for the sole purpose of cycling as a leisure activity rather than not ride a bike at all (OR .59). However, women and men were similarly likely to ride a bike for recreational as well as other purposes (e.g. cycling to work), at least in comparison to those who do not cycle at all (OR ranging from .39 to 1.38 for 95% C.I.). Although age was found as a significant predictor of bicycle use, it was again only for comparing those who cycle solely for recreational purposes to those who do not cycle at all. Moreover, the relationship was rather weak (OR .98) and played a substantial role only when comparing persons with a substantial age difference. Nevertheless, with the increasing age, it was less likely that a person would cycle for recreational purposes rather than not at all.

Table 8 provides a detailed interpretation of the individual variables in the model:

Table 8 – The description and interpretation of the parameters in the model.

	Cycling for recreational purposes versus not cycling at all
Parameter	Description and interpretation
b_{10}	Intercept
b_1Gender(women)	It is .59 times less likely that women will ride bicycles for recreational purposes rather than will not ride bicycles at all in comparison to men.
b_1Age	A one-unit increase in the age is associated with the decrease in the odds ratio by .98 of riding a bicycle for recreational purposes rather than not ride a bicycle at all.
b_1Landscape	A one-unit increase in the attitudes towards landscape is associated with the decrease in the odds ratio by .62 of riding a bicycle for recreational purposes rather than not ride a bicycle at all.
b_1Norms	A one-unit increase in the attitudes related to normative aspects of cycling is associated with the increase in the odds ratio by 1.42 for riding a bicycle for recreational purposes rather than not ride a bicycle at all.
b_1SafetyInfrastructure	A one-unit increase in the attitudes towards cycling safety and infrastructure is associated with the decrease in the odds ratio by .77 of riding a bicycle for recreational purposes rather than not ride a bicycle at all.
b1Item2(agree)	It is .63 times less likely that those who agree with the item 2 will ride bicycles for recreational purposes rather than will not ride bicycles at all in comparison to those who disagree with this statement. This predictor was not statistically significant.
b_1Item4(agree)	It is .84 times less likely that those who agree with the item 8 will ride bicycles for recreational purposes rather than will not ride bicycles at all in comparison to those who disagree with this statement. This predictor was not statistically significant.
b1Item11(agree)	It is 1.04 times more likely that those who agree with the item 11 will ride bicycles for recreational purposes rather than will not ride bicycles at all in comparison to those who disagree with this statement. This predictor was not statistically significant.
	Cycling for all purposes versus not cycling at all
Parameter	Description and interpretation
b_{20}	Intercept
b_2Gender(women)	It is .73 times less likely that women will ride bicycles for recreational and other purposes such as cycling to work rather than will not ride bicycles at all in comparison to men. This predictor was not statistically significant.
b_2Age	A one-unit increase in the age is associated with the decrease in the odds ratio by .99 of riding a bicycle for recreational and other purposes such as cycling to work rather than will not ride bicycles at all. This predictor was not statistically significant.
b_2Landscape	A one-unit increase in the attitudes towards landscape is associated with the decrease in the odds ratio by .63 of riding a bicycle for recreational and other purposes such as cycling to work rather than will not ride bicycles at all.
b_2Norms	A one-unit increase in the attitudes related to normative aspects of cycling is associated with the increase in the odds ratio by 1.9 for recreational and other purposes such as cycling to work rather than will not ride bicycles at all.
b_2SafetyInfrastructure	A one-unit increase in the attitudes towards cycling safety and infrastructure is associated with the decrease in the odds ratio by .63 of riding a bicycle for recreational and other purposes such as cycling to work rather than will not ride bicycles at all.
b_2Item2(agree)	It is .82 times less likely that those who agree with the item 2 will ride bicycles for recreational and other purposes such as cycling to work rather than will not ride bicycles at all in comparison to those who disagree with this statement. This predictor was not statistically significant.
b_2Item8(agree)	It is 1.15 times more likely that those who agree with the item 8 will ride bicycles for recreational and other purposes such as cycling to work rather than will not ride bicycles at all in comparison to those who disagree with this statement. This predictor was not statistically significant.
b_2Item11(agree)	It is .71 times less likely that those who agree with the item 11 will ride bicycles for recreational and other purposes such as cycling to work rather than will not ride bicycles at all in comparison to those who disagree with this statement. This predictor was not statistically significant.

4. DISCUSSION

This study showed that attitudes, opinions or more generally psychological factors are related to ways how people use bicycles. This study is thus aligned with the previous research in this area (e.g. Klobucar & Fricker, 2007; Muñoz, B., Monzon, & Lois, 2013).

However, this study shows that the persons who do not cycle may view traffic safer for cyclists than those who have experience with riding their bicycles. This finding differs from the conclusions of the previous research in the area (e.g. Heinen, Maat, & van Wee, 2011). At the same time, this finding does not represent a contradiction to the previous research. Since the specific interest of the stakeholder was the local context, items related to the perception of the cycling safety and quality of the cycling infrastructure were directly formulated for the town Litoměřice. On the other hand, previous research in this area used general formulations without regards to a specific context. In the latter scenario, the general idea of traffic safety tends to be associated with more willingness to cycle. One of the possible explanations thus lies in the design of the study.

It makes sense that those with experience with riding a bike may be more critical regarding traffic safety or quality of cycling infrastructure as they can appreciate or evaluate the situation from the point of a user. However, the more critical viewpoint did not pose a barrier for the same persons to cycle. On the other hand, those who have no experience with cycling in Litoměřice may underestimate the risks associated with cycling in the town. This conclusion explains why cyclists may not feel safe in towns and cities like Litoměřice, which do not have developed cycling infrastructure (Tögel & Szabó, 2018).

On the other hand, psychological barriers tend to decrease the probability of riding a bike. In Litoměřice, those who did not cycle at all saw cycling there as something physically challenging and inconvenient. Of course, some people do not cycle because of physical impairments. However, others may be physically fit yet may not perceive cycling as a way how to travel due to their habits (Rose & Marfurt, 2007). Change of the habit structure could thus lead to a decrease in their perception of cycling as something physically challenging. Consequently, this could increase their willingness to cycle.

However, those respondents who cycled held cycling in higher esteem than those who did not. The former group valued cycling not only as part of a healthy lifestyle but also viewed cycling as a policy-related matter that should be supported by the official authorities. This outcome also supports previous findings, according to which people who promote regular exercise, as well as those who strive for healthy lives, incline to cycle more than those who have different perceptions (Ball, Jeffery, Abbott, McNaughton, & Crawford, 2010).

If we focus on cycling as a hobby or a sport, socio-demography could be used as a tool to understand which groups of a population we are likely to find among cyclists. In Litoměřice, it was more likely younger men. This is also aligned with previous research on the area (e.g. Moudon et al., 2005; Stinson & Bhat, 2005; Ryley, 2006; Dill and Voros, 2007). Interestingly, it did not matter if the person was a man or a woman, a senior or a teenager, as long as he or she declared cycling also because of going to work, to school, to shop and so on.

Albeit results of this study corroborate previous research in this area as well as extend our knowledge of different contexts, there are also limits. For example, the objective measures such as the topography of a route that respondents took when travelling by bike were not directly included in the model. Thus, combining subjective and objective measures could lead to a more complex and valid picture of the factors related to cycling.

In relation to the previous paragraph, the conceptualisation of the bicycle usage in this study does not allow nuanced comparisons. Trips made by bike would serve as a more detailed source of information when examining variables associated with mode choice, e.g. in terms of trip distance (Fraser & Lock, 2010; Pucher & Buehler, 2008). However, this may be a problem in situations that expect a small number of trips by bike since models containing various sources of information are demanding when it comes to the sample size. However, a different timeframe for the data collection may tackle this problem. For example, the continual data collection procedure would give a balanced picture of bicycle use throughout the whole year.

Moreover, despite the existing relationship between analysed factors and cycling, the analytical procedure used in this paper has its limitations regarding their reliability and validity. For example, each of the extracted factors consists of relatively few items. This may negatively affect content validity of such measures as, for example, the representation of the cycling

infrastructure may contain specific aspects like bicycle lanes or protected intersections, which were not explicitly included among the presented statements. Also, the limited number of items could be the reason for rather lower levels of internal consistency of the proposed factors. The lower levels of internal consistency, in turn, decrease the precision of applied factors. In other words, the found overlap between two groups of cyclists in the variables included in the model may be related not to the actual absence of difference but rather to the measurement error. This conclusion applies especially to the variables that were analysed as individual items Thus, further research should provide more robust measures or factors of attitudes related to cycling.

Despite the presented limitations, the results of this study provide support for including psychological measures in SUMPs, as well as in travel behaviour surveys in general. For example, these findings could be used for the preparation as well as for the implementation of the transport policy as they reveal psychological barriers for riding a bike. Psychological measures thus can provide relevant insights both on the macro (SUMPs) and micro (urban street design) levels.

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