

**RESEARCH ARTICLE**

# Safety Perceptions and Cycling Frequency of Highly Educated Young People Who Grew Up in Different Mobility Cultures

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Denmark is one of the world's leading cycling countries. For most new residents coming from abroad, the Danish cycling culture strongly contrasts with the mobility culture of their country of origin. Based on an online survey including highly educated people who grew up in Denmark ( $n = 106$ ) and abroad ( $n = 148$ ), this study examined safety perception and cycling frequency of both groups. We found a significant increase of foreigners' self-reported safety perceptions and cycling frequencies after moving to Denmark. In regression analyses, we found that age of learning to cycle, experiencing anger from car drivers, stress and being unaware of cycling rules had an effect on safety perception. Stress and driving anger were significant factors for the subsample of newcomers, but not for Danes. Attitude towards cycling and cycling norm in the country of origin (measured based on a new six-item cycling norm index) were significant factors of cycling frequency. Unlike our expectations, a *low* cycling norm increased cycling frequency in Denmark. Newcomers' cycling frequency was additionally influenced by the age of learning to cycle. Based on the results, it seems advisable to help newcomers to cycling countries to get familiar with formal and informal cycling rules to reduce their stress and make them feel safer when cycling. While this will probably reduce conflicts with car drivers, greater efforts should be made to reduce car drivers' anger expression against cyclists.

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**Keywords:** cycling behaviour; traffic safety; cycling culture; travel socialisation; mobility biography

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## Introduction

Cycling is a mode for everyone, as it can be afforded and used by all income groups (Haustein, Jensen & Nielsen 2019; Pucher & Buehler 2008). Besides being a cheap alternative to motorised transport, a main individual advantage of cycling is that it improves cyclists' health and well-being through physical activity (e.g., De Geus *et al.*, 2008; Pucher *et al.*, 2010). Societal benefits include the avoidance of noise and air emissions and road congestion. Cycling takes up less space as compared to motorised modes and thereby leaves more room for creative uses of urban space (e.g., Creutzig *et al.*, 2020). Denmark is one of the leading cycling countries

in Europe with its well-established cycling culture (Haustein *et al.*, 2020). Many international students, scientists and highly educated professionals coming from countries with various levels of cycling arrive in Denmark every year. In this study, we investigate whether the specific background of these people has an effect on how safe they perceive cycling in Denmark and whether they change their cycling habits as compared to cycling in their home country. This knowledge is relevant for a better understanding of the role of mobility socialisation and cultural background on the uptake and perception of cycling and for the development of policy measures helping newcomers to adapt to a cycling culture.

Based on an online survey conducted in Denmark, this study investigates which factors influence safety perceptions of highly educated people who grew up in Denmark as compared to their counterparts who grew up in a different country. It further examines whether moving to a country with a high cycling culture facilitates the adoption of cycling. As a theoretical background of this study, we use the concept of cycling culture, travel socialisation and the mobility biographies approach, which we introduce in the following sections.

### **Cycling culture**

Klinger, Kenworthy and Lanzendorf (2013) explain the formation of mobility cultures under objective and subjective dimensions of mobility. The objective dimension is related mainly to socioeconomic factors and how the built environment is formed, for example, its density, diversity and design. Cities with high density are usually those that have higher shares of modes such as cycling and walking (e.g., Nielsen *et al.*, 2013). Diversity relates to the dispersion of different functions such as workplaces and recreational areas within the city (e.g., Christiansen *et al.*, 2016). Diverse land use implies shorter distances to destinations and increases the preference of active modes over private cars. Lastly, the planning of streets and transport networks constitute the design element. Each combination of the three elements supports different travel patterns in the city.

The subjective dimension relates to factors such as norms, attitudes and perception related to the urban form and travel modes. For example, Hunecke *et al.* (2007) show that psychological factors such as cycling autonomy, cycling excitement and weather resistance have a significant impact on mode choice and related environmental impact. In addition to these dimensions, history, topography, climate and policies also have a role in shaping the culture (Pucher and Buehler, 2008). According to the concept of mobility cultures, these factors jointly lead to common knowledge and habitual behaviour among the citizens who share the same mobility culture (Klinger, Kenworthy and Lanzendorf, 2013).

In the case of cycling culture, availability of cycling infrastructure (e.g., cycling lanes and dedicated signals), suitable geographical features and the way cycling is perceived and supported by policies are some of the main elements (Haustein, Jensen and Nielsen, 2019). In countries with high cycling cultures women and men have rather equal cycling rates, whereas men are found to cycle more in low cycling countries. Cycling is also more evenly distributed among age groups (Aldred, Woodcock and Goodman, 2016). A more established cycling culture makes it more probable to ride a bicycle (Goetzke and Rave, 2011; Aldred and Jungnickel, 2014). Safety perception is another factor that is affected from cycling culture, as shown by Chataway *et al.* (2014) in a comparison between Copenhagen, an established cycling city in Denmark, and Brisbane, an emerging cycling city in Australia.

As Ebert and Carstensen (2012) describe, cycling has been used in Denmark since the end of the 19th century, initially for leisure purposes such as racing. Its everyday use became more common until mid-1900s when the country had the lowest share of cycling. This was due to the adoption of policies and planning activities prioritising private car usage, which were abandoned in the 1970s due to its negative environmental and financial externalities.

Since then, significant efforts have been made to extend the bicycle network and promote its usage. The country's flat topography, high population density and diverse land use have been among the spatial factors contributing to the adoption of cycling. Today, cycling is considered as part of the Danish national identity, rather than just a commonly used transport mode (Ebert and Carstensen, 2012). This explains the high number of cyclists and a corresponding high modal share in Copenhagen, where this study was conducted.

In 2017, four out of five households had at least one functioning bicycle. Twenty-eight per cent of all trips and 49% of all work- and education-related trips were made by bicycle (City of Copenhagen, 2019). Currently, the cycling paths in the city cover more than 400 km. Seventy-seven per cent cyclists say that they feel safe when cycling in Copenhagen, and 72% are satisfied by the impact cycling culture has on their lives (City of Copenhagen, 2019). Along with the high sense of safety, Copenhagen ranks as the second-best city with its fatality rate of four deaths per billion passenger kilometres on average between 2014 and 2018 (International Transport Forum (ITF), 2020).

### ***Travel socialisation***

Research on travel socialisation indicates that observed travel behaviour and communication with family and peers during childhood and adolescence influence future decisions related to mode choice (Baslington, 2008; Hausteine, Klöckner and Blöbaum 2009). Welsch, Conrad and Wittowsky (2016) have demonstrated that bicycle socialisation (measured based on statement on parents' bicycle use and being accompanied by parents when riding a bicycle as a child) had a significant impact on cycling as an adult. As adults, the partner becomes a relevant agent of socialisation and it has been shown that partners influence their transport choices over time, for example, that the likelihood to start cycling increases when the partner cycles (Kroesen, 2015). Travel socialisation may also consider a wider cultural context, which relates to mobility cultures: Sherwin, Chatterjee and Jain (2014) show that having a high number of cyclists in a city increases the mode's visibility, generating indirect social influence on noncyclists. Examining social network effects on cycling for different trip purposes, Goetzke and Rave (2009) came to similar conclusions.

### ***Migration as part of the mobility biography***

The mobility biographies approach (e.g., Scheiner and Holz-Rau, 2013; Müggenburg, Busch-Geertsema and Lanzendorf, 2015) considers life-changing events such as residential relocation, childbirth or changes in car ownership as important factors for understanding changes in mobility behaviour in the life course. In stable settings, individuals do not necessarily make deliberate decisions about mode choice for each trip but rather follow their established travel habits. Life-changing events can trigger a reconsideration of these habits. When supported by mediating factors such as an intrinsic motivation and a supportive environment (e.g., an established cycling culture), this change can lead to behavioural change (Chatterjee, Sherwin and Jain, 2013; Janke and Handy, 2019). Based on this approach, life events, social and cultural contexts shape a trajectory, which represents one's 'feelings, thoughts, capabilities and actions related to cycling' (Chatterjee, Sherwin and Jain, 2013, p186). Moving to a different location can in this sense affect this trajectory and increase the probability of adopting new behaviour.

Klinger and Lanzendorf (2016) investigated the impact of moving to a city in Germany with a different mobility culture on daily travel behaviour. Their research indicates that changes in cycling can be related to observing and replicating the behaviour of existing residents as well as the perceived acceptance of cycling. For cycling the predominant mobility culture seemed to play a greater role than for other modes (car, rail), where local infrastructure was more important.

Examining travel behaviour adaptation of international students in two cities in Portugal, Monteiro *et al.* (2021) found that students who cycled in their home cities stopped or reduced cycling.

Nello-Deakin and Nikolaeva (2020) have identified factors influencing newcomers' cycling behaviour in Amsterdam and found that different factors play a role in different stages of uptake. Among the factors were the lower costs and competitiveness of cycling, seeing cycling as a way to fit into the Amsterdam lifestyle and feeling social pressure and high reliance in daily life.

Compared to studies focusing on newcomers in a city that indicate an adaption to existing cycling cultures, studies focusing on the general immigrant population find that immigrants to high cycling countries cycle less than natives, even after years of adaption (e.g., Welsch, Conrad and Wittowsky, 2016; Haustein, Kroesen and Mulalic, 2019). Differences may be based on differences in the social and cultural background, which needs further exploration.

### ***The present study***

To investigate the impact of mobility culture and mobility biography on safety perceptions and the uptake of cycling in a cycling city, we conducted a survey in Copenhagen targeting Danes as well as people who have arrived in Denmark in the recent years for education and work purposes, which we refer to as 'international newcomers'. More specifically, we aimed to answer the following research questions:

- How do self-reported safety perception and cycling frequencies of international newcomers change after arriving in Denmark?
- Does a background from a different mobility culture influence safety perception and cycling frequency when demographic factors, factors of travel socialisation and cycling norms and attitudes are controlled for?
- Are safety perceptions and cycling frequency of Danes and newcomers influenced by different factors?

Information regarding the data collection and statistical analysis is provided in 'Section 2. Methods'. 'Section 3. Results' presents the findings, which are discussed in 'Section 4. Discussion and conclusion', in the context of previous research and policy implications.

## **Methods**

### ***Measures***

The survey consists of 36 questions to gather information about demographics, cycling behaviour and different attitudinal factors. To start with, we asked the respondents whether they grew up in Denmark (1 = 'yes', 2 = 'no', 3 = 'partly'). People who grew up in another country, additionally received questions related to their country of origin.

Cycling frequency was assessed for Denmark and (if relevant) for the country of origin (1 = 'never', 2 = 'less than once a month', 3 = '1–3 times a month', 4 = 'weekly', 5 = '2–3 times a week', 6 = '4–6 times a week', 7 = 'everyday').

All participants responded to questions about when and how they learned to cycle, as well as whether their parents were cycling to measure cycling socialisation in the family. Respondents also provided information on their current safety perceptions in Denmark (1 = 'safe', 2 = 'neutral', 3 = 'unsafe'), awareness of cycling rules (1 = 'unaware', 2 = 'neutral', 3 = 'aware') and whether they felt stressed when cycling (1 = 'not stressed', 2 = 'stressed').

People with foreign origin additionally reported their safety perceptions in their home country and their first time in Denmark.

As a proxy for the predominant cycling norm in the country of origin, we asked how cycling was perceived in the respondents' home country using six adjective pairs, where 1 stands for a negative assessment and 5 for a positive one: (1) risky vs. safe; (2) strange vs. normal; (3) a mode for the poor vs. a mode for everyone; (4) a health threat vs. healthy; (5) slow vs. fast; (6) a leisure activity vs. a transport mode.

We measured respondents' attitudes towards cycling with six items based on Hunecke *et al.* (2007) and Haustein (2012) aiming to measure cycling excitement, cycling autonomy and weather resistance (see **Table 3**).

Lastly, we asked whether participants had experienced road anger by other cyclists and car drivers and whether they had expressed road anger towards other cyclists themselves (Moller and Haustein, 2017).

### ***Procedure and participants***

We distributed an online survey through e-mail lists, and the common teaching and communication platform of the Technical University of Denmark. We also shared the survey on social media groups, such as 'International Students in Denmark' and 'Expats in Copenhagen'. It took 7 minutes on average to complete the survey.

Out of the total 255 responses collected in October 2019 and March 2020, we removed one respondent who never learned to cycle from the dataset. More men (61.81%) than women participated in the survey, and the large majority was aged between 20 and 29 years (81.49%), and the highest education level of almost three quarters of the sample was a master's degree (72.44%). We asked the respondents whether they grew up in Denmark and, we merged nine respondents (3.54%) who mentioned that they grew up partly in Denmark with the subsample of Danes. In the remainder of the article, we refer to people who at least partly grew up in Denmark as Danes and people who grew up in a different country as foreigners, independent of respondents' actual citizenship.

**Table 1** shows the sample characteristics of the foreigner and Dane subsamples. The highest percentage of foreigners is aged between 20 and 24 years, whereas the sample of Danes consists of more people aged between 25 and 29 years. Both groups have a similar gender distribution. A majority of foreigners originate from countries located in Europe. More than half of the respondents have spent less than 3 months in Denmark at the time they filled in the survey.

As indicators of travel socialisation, we gathered information about when and how participants learned to cycle and whether their parents cycled during their childhood (**Table 2**). Most of both foreigners and Danes learned to cycle before they turned 6 years old; however, we find a tendency that Danes learned to cycle earlier ( $p < 0.10$ ). It was predominantly parents who taught them how to cycle. Some participants also mentioned that they learned through their grandparents or siblings. In both samples, both parents cycled for more than half of the respondents. However, for foreigners the second largest category is that in which none of the parents cycled, whereas this is the lowest category for Danes. In the case where only one parent cycled, the cycling parent was mostly the father for foreigners, whereas mothers and fathers had almost equal percentages for Danes.

We investigated whether the two subsamples differed in terms of their travel socialisation. We conducted Fisher exact test for age and the way of learning to cycle due to low number of observations in some categories. A Chi-square test was conducted for parents' cycling behaviour. We discarded the way of learning to cycle from the following analyses due to the lack of a significant difference between two groups.

**Table 1:** Sample characteristics.

Variables	Categories	Foreigners (%)	Danes (%)
Age	Less than 20 years old	1.35	2.83
	20–24 years old	56.76	33.96
	25–29 years old	29.73	40.57
	30–34 years old	6.76	8.49
	Older than 35 years	5.41	14.15
Gender	Male	60.81	63.21
	Female	36.49	36.79
	Do not wish to disclose	2.70	0.00
Level of education (Current level for students, last completed for others)	Primary + high school	0.00	2.83
	Bachelor	9.46	12.26
	Professional bachelor	1.35	9.43
	Masters	78.38	64.15
	PhD	8.11	9.43
	Postdoc	2.70	1.89
Time spent in Denmark	Less than 3 months	52.70	–
	3–6 months	6.08	–
	6 months–1 year	4.05	–
	1–2 years	22.30	–
	More than 2 years	14.86	–
Reason for coming to Denmark	Working	19.10	–
	Family	6.18	–
	Education	74.72	–
Main growing up location	Europe	68.24	–
	Asia	16.22	–
	Africa	3.38	–
	North America	2.70	–
	South America	7.43	–
	Australia	2.03	–
		N = 148	N = 106

**Factor analysis**

Cycling norms and cycling attitudes were included in two separate analyses to identify the underlying attitudinal dimensions. **Table 3** shows the factor loadings for the factor analysis on cycling norms, obtained by factor analysis with Varimax rotation. The analysis resulted in one single factor, with a high internal consistency (Cronbach's alpha = 0.88). We used the

**Table 2:** Travel socialisation comparison of foreigners and Danes.

Variables	Categories	Foreigners (%)	Danes (%)
Age of learning to cycle	0–5 years old	62.84%	75.47%
	6–10 years old	33.11%	23.58%
	11+ years old	4.05%	0.94%
	Fisher exact test <i>p</i> value		0.078
Way of learning to cycle	Parents taught me	77.70%	79.25%
	Friends taught me	3.38%	1.89%
	I taught myself	12.16%	10.38%
	At school	1.35%	3.77%
	I don't remember	2.03%	2.83%
	Other	3.38%	1.89%
	Fisher exact test <i>p</i> -value		0.288
Parents' cycling behaviour during respondents' childhood	My mother cycled	3.38%	11.32%
	My father cycled	18.92%	12.26%
	They both cycled	50.68%	66.04%
	They did not cycle	27.03%	10.38%
	Chi-square test <i>p</i> -value		0.000
	Sample size	<i>N</i> = 148	<i>N</i> = 106

**Table 3:** Factor loadings of the factor analysis for cycling norms.

	Cycling norms in home country
Q1 – risky: safe	0.785
Q2 – strange: normal	0.892
Q3 – a mode for the poor: a mode for everyone	0.806
Q4 – a health threat: healthy	0.591
Q5 – slow: fast	0.698
Q6 – a leisure activity: a transport mode	0.673

means of all six items as a proxy of cycling norms in the participants' country of origin (in the following referred to as cycling norm index).

To investigate the content validity of the cycling norm index, we listed the participants' countries of origin by cycling norm index for countries with at least five participants. As **Table 4** reveals, the index ordered the countries in line with their cycling norms and frequencies, where the Netherlands is the leading cycling country followed by Denmark and (with some distance) Germany. These three countries have previously been described as leading cycling countries (Pucher and Buehler, 2008; Ebert and Carstensen, 2012). They are followed



**Table 4:** Cycling norm index in the country/region of origin.

Country/region	Cycling norm index	Standard. deviation	N <sup>a</sup>
The Netherlands	4.8	0.1	6
Denmark	4.4	0.6	106
Germany	3.7	0.7	15
Rest of Europe	3.1	0.6	80
Asia	2.7	0.8	24
Australia	2.7	0.6	3
North America	2.5	0.4	8
South America	2.4	0.6	6
Africa	2.0	0.6	8

<sup>a</sup>: One observation is missing as the person did not state his/her country of origin.

**Table 5:** Results of the principal component analysis for cycling attitudes.

	Cycling excitement	Cycling autonomy	Weather resistance
E1. I love cycling	<b>0.82</b>	0.31	0.18
E2. Riding my bicycle is relaxing	<b>0.92</b>	0.09	0.07
A1. By bicycle I can get anywhere	0.30	<b>0.70</b>	0.25
A2. I can reach many of my important destinations by bicycle	0.12	<b>0.89</b>	0.04
W1. I don't like riding my bicycle when the weather is chilly <sup>1</sup>	0.11	0.03	<b>0.92</b>
W2. I ride my bicycle even in bad weather conditions	0.14	0.46	<b>0.63</b>
Cronbach's alpha	0.78	0.65	0.57
Eigenvalues	1.65	1.61	1.35
Proportion of explained variance	0.27	0.27	0.22
Cumulative proportion	0.27	0.54	0.77

by the remaining countries in Europe, Asia, Australia, America and finally Africa. The order of countries and regions indicate that the cycling norm index can be used as a proxy for a country's cycling norm and culture as will be done in the analyses presented in Section 3.

**Table 5** shows the three-factor solution for cycling attitudes, which represent cycling excitement, cycling autonomy and weather resistance. The solution was obtained by principal component analysis with Varimax rotation. We created three new variables based on average values of the two items with highest loadings on each factor (i.e., E1 and E2 for cycling excitement, A1 and A2 for cycling autonomy, W1 and W2 for weather resistance). It has to be noted that the internal consistency of weather resistance is very low. Previous studies with higher sample sizes found higher values (e.g., Hunecke *et al.*, 2007) or similar values (Haustein, 2012). Probably the negative formulated item was misunderstood in some cases and should thus be avoided in future studies.<sup>2</sup> Results related to that factor should thus be interpreted with care.



### ***Statistical analysis***

We performed Wilcoxon signed-rank test as a nonparametric test to find out whether moving to Denmark has made a significant difference in foreigners' safety perception and cycling frequency.

For identifying which factors influence safety perception, we constructed a binary logistic regression model. We recoded the dependent variable, current safety perception in Denmark, from three to two categories (new categorisation: 0 = 'not safe/neutral', 1 = 'safe') due to a low number of answers in the 'not safe' category in the previous setting. We used ordinal logistic regression to test for factors influencing cycling frequency in Denmark. We reduced the number of categories from seven to five as some categories had very few responses (new categorisation: 1 = 'never', 2 = '3 times a month or less', 3 = '1–3 days a week', 4 = '4–6 days a week', 5 = 'everyday').

The two regression analyses had ten explanatory variables in common. Age, gender and origin (Dane or foreigner) were included as demographic variables. We set the 'other/diverse' gender category as missing value as there were very few people in this category. We accounted for travel socialisation with questions for age of learning to cycle and parents' cycling behaviour during childhood. Furthermore, we added all factors obtained from factor analyses and whether participants felt stressed when cycling. In addition to these ten explanatory variables, the safety perception analysis also included awareness of cycling rules, cycling frequency in Denmark as well as binary variables for experiencing and expressing road anger.

We conducted both analyses with three different samples. The first model included all participants in an attempt to get an overview of which factors influenced perceived safety and cycling frequency and which role foreign origin played for both outcome variables. In a second step, we conducted separate analyses for foreigners and Danes to examine whether variables influenced both groups differently. Some of the variables were left out in these analyses due to very few responses in some categories in the subsamples.

## **Results**

### ***Cycling frequency and safety perceptions of Danes and new residents***

**Table 6** summarises the respondents' cycling frequency and safety perception in their home countries and in Denmark. The table reveals that there are very few participants who cycle less than once a week in Denmark in both groups. Actually, cycling frequency of foreigners is higher than that of Danes ( $p < 0.05$ ). However, almost half of new residents cycled less than monthly or never in their home countries. Those who used to cycle everyday come from China, Germany, India and the Netherlands.

We observed a similar trend in new residents' safety perception, meaning that they reported lower safety levels in their home countries, whereas higher levels upon arrival in Denmark. Danes and foreigners do not differ significantly in safety levels in Denmark.

We conducted Wilcoxon signed-rank tests to test whether there has been a statistically significant change in foreigners' cycling frequency and safety perception upon their arrival in Denmark. **Table 7** shows the results of the test conducted for cycling frequency. The test concluded that there has been a significant increase in the 148 respondents' cycling frequency after arriving in Denmark.

We tested for the change in safety perception in two different ways. **Table 8** includes the comparison of the home country vs. the first time in Denmark. **Table 9** shows the comparison of the first time of cycling in Denmark vs. the current safety perception. Both tests show statistically significant increases in the after scenarios.

All tests show an increase of perceived safety and cycling frequency after arriving in Denmark. The two following subsections show the results of regression analyses investigating the underlying factors of safety perception and cycling frequency.

**Table 6:** Cycling frequency and safety perception descriptions.

Variables	Categories	Foreigners (%)	Danes (%)
Cycling frequency in Denmark <sup>a</sup>	Never (1)	4.73	2.83
	Less than monthly (2)	2.03	2.83
	1–3 days per month (3)	3.38	4.72
	Weekly (4)	5.41	9.43
	2–3 days per week (5)	8.11	15.09
	4–6 days per week (6)	36.49	40.57
	Every day (7)	39.86	24.53
Cycling frequency in home country	Never (1)	20.27	–
	Less than monthly (2)	27.70	–
	1–3 days per month (3)	13.51	–
	Weekly (4)	7.43	–
	2–3 days per week (5)	9.46	–
	4–6 days per week (6)	14.19	–
	Every day (7)	7.43	–
Safety perception in home country <sup>b</sup>	Not safe (1)	50.85	–
	Neutral (2)	22.88	–
	Safe (3)	26.27	–
Safety perception first time in Denmark <sup>b</sup>	Not safe (1)	6.76	–
	Neutral (2)	18.24	–
	Safe (3)	75.00	–
Safety perception in currently in Denmark <sup>c</sup>	Not safe (1)	0.68	2.83
	Neutral (2)	7.43	10.38
	Safe (3)	91.89	86.79
		<i>N</i> = 148	<i>N</i> = 106

<sup>a</sup> Significant difference between Danes and foreigners, U-test,  $p < 0.05$ .

<sup>b</sup> The sample size for these questions is  $N = 118$ .

<sup>c</sup> Difference between Danes and foreigners not significant, Chi<sup>2</sup>-test,  $p > 0.10$ .

### **Factors of safety perceptions**

**Table 10** shows the results of the three binary logistic regression models we constructed for safety perception. Our main analysis for the factors of safety perception covers the entire sample. We did not observe any significant impact of demographic variables. Unlike our expectations, whether the respondents were of Danish origin or not also did not show a significant effect. Respondents who learned how to cycle between ages 6 and 10 felt significantly less safe than the reference category of 0- to 5-year-olds. We did not observe any other difference based on travel socialisation. Cycling attitudes and cycling norm in the home country did not have a significant impact on the sample's safety perception.

**Table 7:** Results of Wilcoxon signed-rank test for cycling frequency of foreigners.

<b>Cycling frequency</b>	<b>Before</b>	<b>After</b>
Never	30	7
Less than monthly	41	3
1–3 days per month	20	5
Weekly	11	8
2–3 days per week	14	12
4–6 days per week	21	54
Everyday	11	59
<i>N</i> = 148		
Test statistics	<i>V</i> = 318, <i>p</i> < 0.001	

**Table 8:** Results of Wilcoxon signed-rank test for safety perception of foreigners in their home countries and first time in Denmark.

<b>Safety perception</b>	<b>Home country</b>	<b>First time in DK</b>
Not safe (1)	60	8
Neutral (2)	27	20
Safe (3)	31	90
<i>N</i> = 118		
Test statistics	<i>V</i> = 236, <i>p</i> < 0.001	

**Table 9:** Results of Wilcoxon signed-rank test for safety perception of foreigners in their first time and currently in Denmark.

<b>Safety perception</b>	<b>First time in DK</b>	<b>Currently in DK</b>
Not safe (1)	10	1
Neutral (2)	27	11
Safe (3)	111	136
<i>N</i> = 148		
Test statistics	<i>V</i> = 58, <i>p</i> < 0.001	

As expected, stress is a significant factor of safety perception. Those who stated that they feel stressed while cycling felt significantly less safe when cycling in Denmark. Being unaware about rules related to cycling negatively impacts safety perception. We could not detect any significance related to cycling frequency. Out of the three questions related to road anger, only experiencing anger from car drivers had a significant negative effect on perceived safety.

**Table 10:** Results of binary regression analyses for safety perception.

Variable	Categories	All participants Parameter estimate (Std. Error) [odds ratio]	Foreigners Parameter estimate (Std. Error) [odds ratio]	Danes Parameter estimate (Std. Error) [odds ratio]
Age (Ref: 10–24 years old)	25–29 years old	-0.60 (0.70) [0.55]	-1.35 (1.05) [0.26]	0.66 (1.18) [1.93]
	30+ years old	-0.51 (0.78) [0.60]	-2.60 (1.37) [0.07]	0.36 (1.22) [1.43]
Gender (ref: male)	Female	-0.40 (0.65) [0.67]	0.01 (0.97) [1.01]	0.26 (0.96) [1.29]
Origin (ref: foreigner)	Danes	-0.85 (0.93) [0.43]	-	-
Age of learning to cycle (Ref: 0–5 years old)	6–10 years old	-1.6 (0.79) [0.20]*	-	-
	11+ years old	-1.54 (1.48) [0.21]	-	-
Parents' cycling behaviour (ref: both parents cycled)	None of them cycled	1.26 (0.92) [3.53]	-	-
	Only mother cycled	0.77 (1.12) [2.16]	-	-
	Only father cycled	0.06 (0.85) [1.06]	-	-
Cycling excitement	-	0.29 (0.46) [1.13]	-0.49 (0.60) [1.13]	1.64 (0.74) [1.56]*
Cycling autonomy	-	0.12 (0.33) [1.28]	0.12 (0.71) [0.58]	0.45 (0.43) [1.75]
Weather resistance	-	0.24 (0.30) [0.90]	-0.55 (0.65) [1.42]	0.56 (0.43) [0.92]
Cycling norm in home country	-	-0.11 (0.34) [1.35]	0.35 (0.50) [0.61]	-0.09 (0.57) [5.13]
Stress (ref: not stressed)	Stressed	-2.05 (0.65) [0.13]**	-2.78 (1.13) [0.06]*	-1.61 (0.96) [0.20]
Awareness of rules (ref: aware)	Neutral	-1.56 (0.89) [0.21]	-	-
	Unaware	-3.45 (1.61) [0.03]*	-	-

(Contd.)

Variable	Categories	All participants Parameter estimate (Std. Error) [odds ratio]	Foreigners Parameter estimate (Std. Error) [odds ratio]	Danes Parameter estimate (Std. Error) [odds ratio]
Cycling frequency (Ref: Everyday)	4–6 times a week	0.44 (0.91) [1.55]	1.02 (1.54) [2.76]	-1.03 (1.65) [0.36]
	1–3 times a week	-1.53 (0.99) [0.22]	-0.96 (1.47) [0.38]	-1.39 (1.76) [0.25]
	Less than once a week	-1.15 (1.26) [0.32]	0.60 (2.14) [1.83]	-2.19 (2.34) [0.11]
	Never	-0.91 (1.28) [0.41]	-1.76 (1.81) [0.17]	-1.15 (2.37) [0.32]
Experiencing road anger from cyclists (ref. no)	Yes	0.77 (0.69) [2.15]	0.47 (1.12) [1.61]	-0.10 (0.96) [0.91]
	Yes	-1.77 (0.71) [0.17]*	-2.56 (1.27) [0.08]*	-1.59 (0.98) [0.20]
Experiencing road anger from car drivers (ref. no)	Yes	-1.12 (0.72) [0.33]	-1.06 (0.98) [0.35]	-1.18 (1.14) [0.31]
	Dependent variable: safety perception in Denmark	Nagelkerke $R^2 = 0.43$	Nagelkerke $R^2 = 0.44$	Nagelkerke $R^2 = 0.50$
	0 = Not safe			
	1 = Safe			

\* $p < 0.05$ ; \*\* $p < 0.01$ .

The second analysis conducted with the subsample of foreigners included fewer variables. Stress and experiencing road anger from car drivers were the only significant variables in this analysis.

We conducted the last analysis with the Danish subsample. In this case, stress and road anger from car drivers were no longer significant factors. However, cycling excitement came out as a factor positively related to safety perception.

### ***Factors of cycling frequency***

Our second set of regression analyses investigated the factors influencing cycling frequency (Table 11). We tested all three ordinal regression models for the 'proportionality of odds' assumption and obtained nonsignificant  $p$ -values, implying that the models follow the assumption (Garson, 2014). In the model of the full sample, growing up in Denmark was not a significant factor, neither were other demographic variables.

All three attitudinal factors as well as the cycling norm index showed a significant relationship with respondents' cycling frequency. As expected, feeling more excited and autonomous when cycling and being able to bear harsher weather conditions increased how often participants cycled. However, an increasing cycling norm related to respondents' home country resulted in a lower cycling frequency. The effect of cycling norm, however, is quite small.

Unlike the safety perception analysis, stress and age of learning to cycle were not significant factors of cycling frequency.

In our second model with the foreigner subsample, we detected that foreign participants over 30 years of age cycled significantly less frequently compared to those up to 24 years. Another variable significant only for foreigners was one category of the age of learning to cycle. Having learnt how to cycle after the age of 11 increased cycle frequency in reference to those who learnt to cycle before they turned 6 years old. Similar to the previous analysis, attitudinal factors were significant for foreigners as well.

In our last model, we found that when Danes had a positive attitude towards cycling, they cycled more frequently. There were no other significant factors specific to Danes.

### **Discussion and conclusion**

Our main motivation was to investigate whether being a newcomer in a high cycling country has an impact on one's safety perception and cycling frequency. Even though we found a significant relationship between foreign origin and cycling frequency, this effect was no longer significant when controlling for other variables in a regression analysis. There was no significant effect of foreign origin on safety perceptions in a comparable regression analysis either.

Actually, a great share of participants in both groups reported that they felt safe, and they cycled quite often. The well-established and maintained cycling infrastructure in Denmark most probably contributes to the high perceived safety. In addition, the sample consisted only of people who knew how to cycle and most of the foreigners used to cycle in their home countries (apart from Dutch participants probably under worse conditions), which most likely also contributed to these results. As the main focus of the study was on cycling perceptions (as written in the survey announcement), the sample consist almost only of cyclists. It would have been interesting as well to learn why newcomers do not cycle and the inclusion of noncyclists would surely have changed the results. Although the included subgroups of Danes and foreigners have comparable backgrounds, which allow for group comparisons, they are neither representative for the Danish population nor for the immigrant population in Denmark, mainly due to their high level of education.

**Table 11:** Results of ordinal regression analyses for cycling frequency.

Variable	Categories	All Participants Parameter estimate (std. error) [odds ratio]	Foreigners Parameter estimate (std. error) [odds ratio]	Danes Parameter estimate (std. error) [odds ratio]
Age (ref: 10–24 years old)	25–29 years old	0.36 (0.28) [1.43]	0.56 (0.39) [1.74]	0.55 (0.45) [1.74]
	30+ years old	-0.37 (0.36) [0.69]	-1.14 (0.53) [0.32]	0.82 (0.54) [2.28]
Gender (ref: male)	Female	0.06 (0.27) [1.06]	-0.33 (0.38) [0.72]	0.81 (0.44) [2.24]
Origin (ref: foreigner)	Danes	0.01 (0.36) [1.01]	-	-
Age of learning to cycle (ref: 0–5 years old)	6–10 years old	-0.41 (0.30) [0.66]	-0.56 (0.41) [0.57]	0.04 (0.51) [1.04]
	11+ years old	1.05 (0.77) [2.86]	1.78 (0.89) [5.94]*	-1.57 (1.90) [0.21]
Parents' cycling behaviour (ref: both parents cycled)	None of them cycled	-0.53 (0.39) [0.59]	-0.45 (0.49) [0.64]	-0.38 (0.75) [0.68]
	Only mother cycled	-0.16 (0.48) [0.86]	0.46 (0.91) [1.58]	-0.63 (0.62) [0.53]
	Only father cycled	0.31 (0.38) [1.37]	0.53 (0.50) [1.69]	-0.65 (0.63) [0.52]
Cycling excitement	-	0.57 (0.15) [1.77]**	0.79 (0.22) [2.19]**	0.46 (0.21) [1.59]*
Cycling autonomy	-	0.51 (0.15) [1.66]**	0.41 (0.21) [1.5]*	0.76 (0.25) [2.14]**
Weather resistance	-	0.66 (0.15) [1.94]**	0.48 (0.19) [1.62]**	0.89 (0.25) [2.45]**
Cycling perception in home country	-	-0.44 (0.19) [0.64]*	-0.44 (0.22) [0.64]	-0.25 (0.41) [0.78]
Stress (ref: not stressed)	Stressed	-0.39 (0.35) [0.68]	-	-0.59 (0.50) [0.55]
Dependent variable: cycling frequency in Denmark	1 = Never	Threshold coefficients (std. error): 1 2: 0.18 (0.94)	Threshold coefficients (std. error): 1 2: 0.31 (1.25)	Threshold coefficients (std. error): 1 2: 1.42 (1.99)
	2 = Less than once a week	2 3: 1.55 (0.92)	2 3: 1.49 (1.23)	2 3: 3.57 (1.96)
	3 = 1–3 times a week	3 4: 3.38 (0.93)	3 4: 3.12 (1.25)	3 4: 6.08 (2.02)
	4 = 4–6 times a week	4 5: 5.71 (0.98)	4 5: 5.41 (1.30)	4 5: 8.72 (2.12)
	5 = Everyday			
		McFadden's pseudo $R^2 = 0.19$	McFadden's pseudo $R^2 = 0.20$	McFadden's pseudo $R^2 = 0.24$

\* $p < 0.05$ ; \*\* $p < 0.001$ ; \*\*\* $p < 0.01$ .



This may explain why a foreign background did not reduce cycling frequency as this would otherwise conflict with recent results, according to which people with immigrant background cycle less compared to natives in high cycling countries (Haustein, Kroesen and Mulalic, 2019). The immigrant population examined in Haustein, Kroesen and Mulalic (2019) represents the general immigrant population in Denmark. They consist to a large extent of migrants (and their descendants) who came to Denmark to work in the industry, have a lower level of education and were probably also less free in their decision on where to immigrate as compared to our subsample. These two immigrant groups are thus expected to differ in their social background and values. For example, openness to new experiences might be particularly high in international students, whereas in the general immigrant population conservative values might be predominant – going along with lower cycling levels. The sample in this study is likely to represent the 'cosmopolitan milieu', which was found to have a lower emotional attachment to the private car and a higher preference for 'green' travel behaviour as compared to people of the 'precariat' and 'middle class' (Hunecke *et al.*, 2020).

The regression analysis explaining safety perceptions for the whole sample showed that people who learned to cycle before the age of 6 years felt safer than those who learned to cycle between 6 and 10 years. The result indicates that an early start to cycling can be beneficial for safety perceptions as an adult and should thus be supported. Similarly, cycling stress reduced safety perceptions and an awareness of cycling rules increased it. In particular for foreigners, stress might be a result of their unfamiliarity with the traffic conditions in Denmark.

We found that experiencing road anger from car drivers (but not from cyclists) had a significant impact on foreigners' safety perception, but not for Danes. It can be expected that being intimidated by car drivers is more threatening for cyclists than anger by cyclists as a potential collision involves a higher risk of a severe injury. One implication of a high cycling culture is that cyclists perceive similar status as car drivers and thus also differ less in their expression of anger (Møller and Haustein, 2017). Therefore, Danes might not be as influenced from an encounter with a car driver as compared to people who come from a country, where cyclists have or perceive a lower status and may feel in a lower position in a potential escalating conflict (Delbosch *et al.*, 2019; Kaplan, Luria and Prato, 2019). It might also be possible that foreigners more often become a victim of road anger as they are less aware of existing cycling rules and thus, for example, do not indicate with their arm when they intend to stop or turn, which lead to anger in car drivers, especially if they interpret the behaviour as being reckless and not as a mistake (Møller and Haustein, 2018). In terms of cycling stress, perceived safety and road anger expression, we need to point out that our results are based on correlational data and do not allow for causal conclusions – thus it remains unclear whether higher stress leads to road anger and lower safety or vice versa.

Cycling attitudes and cycling norm were significant factors of all respondents' cycling frequency. Positive attitudes increased cycling frequency as expected in the complete sample as well as in the subsamples. However, it was surprising that a higher cycling norm index in the country of origin implied lower cycling frequency. One reason could be that the sample also included participants from the Netherlands, who had a higher cycling norm index than Danes. Another factor that contributed to the result is that our sample only included foreigners who already cycled in their home country. For most of them, the positive contrast to cycling conditions in their home country might have supported their level of cycling. However, as the effect is quite small, this should be investigated further based on a larger sample. It was also unexpected that the highest age category in learning to cycle was significant for foreigners. We had merged all categories above 11 years of age in this variable for the regression analysis but actually, a majority of these people learned to cycle first after they were 20 years old. They

might have been particularly enthusiastic towards making cycling a part of their daily lives upon their arrival to Denmark.

The small sample size needs to be outlined as the main limitation of our study. We received few answers in many categories of the explanatory variables and thus had to merge several categories. This led to a loss in detail when we conducted the regression analyses. Furthermore, a majority of the foreigner sample originated from Europe, where cycling in most countries plays a role as a transport mode. A larger and more representative sample, including more observations from lower cycling countries, could have enabled us to better evaluate the implications of being a foreigner or make more precise evaluation with regard to the specific country of origin.

Besides increasing the sample size, additional questions in the survey could also have provided more insight. Questions about the physical infrastructure of different countries could have supplemented the operationalisation of cycling culture, which was based on the cycling norm index in this study. In general, more detailed questions about how foreigners perceive the Danish cycling culture could have supported the interpretation of results. Yet, with the cycling norm index, we have developed a simple tool that might turn out to be a valid and reliable instrument to measure cycling culture, as the order of countries/regions based on the index follows empirical results about cycling levels and cultures. The usefulness of this instrument should be subject to future research in larger international studies.

In order to improve the safety perception and cycling adaption of foreign students and other newcomers to high cycling countries, we suggest measures to increase the knowledge about existing cycling rules (e.g., to raise a hand when stopping). Information could be included in instructions to the Danish culture, which is offered for foreign employees at Danish universities and could also be offered to students. Volunteering Danish cycling mentors could also introduce international newcomers to the Danish cycling culture and accompany them on their first trip to work or university.

In addition, more effort should be made to reduce driver's anger, for example, with courses that aim to reduce the hostile attribution of other road users' behaviour (Haustein *et al.*, 2021). This would not only help newcomers but also contribute to a country's overall road safety climate.

### **Data Accessibility Statement**

Although we collected the data in a form that should not make it possible to identify individuals, we cannot completely eliminate this possibility and thus do not want to make the complete data available. If required, we can provide a dataset that does not include the country of origin.

### **Notes**

<sup>1</sup> This question was recoded.

<sup>2</sup> A recent study with two positive formulated items showed a Cronbach's alpha of 0.80 (Haustein, 2021).

### **Ethics and Consent**

Data of this study were collected in a form that individuals could not easily be identified based on the dataset (e.g., postal codes and age were assessed in larger categories, the country of origin was only requested for countries where larger percentages of immigrants in Denmark originate from). Only health projects require ethical approval by the Regional Committee (VEK) in Denmark, and thus no approval was requested.

## Competing Interests

The authors have no competing interests to declare.

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