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Psychosocial and environmental correlates of cycling for transportation in Brussels

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ABSTRACT

This study examines which psychosocial and environmental factors are associated with cycling in the Brussels Capital Region (BCR) and whether these associations differ between those who never cycle for transport purposes (Non-cyclists) and those who used the bicycle at least once a week in the previous 6 months (Cyclists). Adults (18–65 year; N = 503; 47% women) living and/or working in the BCR completed an online questionnaire assessing socio-demographic, general transport, psychosocial and environmental variables. Psychosocial factors were significantly different ($p < 0.001$) between Cyclists and Non-cyclists, with Cyclists having a higher score for Modelling, Social support and perceiving more Benefits. The physical environmental factors were not significantly different between the Cyclists and Non-cyclists. Cyclists indicate more often that cycling is unpleasant because of the exhaust fumes and pressure from motorized traffic. The likelihood of a woman being a Cyclist is 1.61 times smaller compared to a man being a Cyclist. The influence of individual and social factors seems to be more predictive in distinguishing between Cyclists and Non-cyclists.

1. Introduction

Insufficient physical activity is one of the leading risk factors for death worldwide, as one in four adults do not meet the health related physical activity guidelines (WHO, 2017). In Belgium, 11.4% of all-cause mortality is associated with physical inactivity (Lee et al., 2012). Increasing physical activity levels, across all age groups, is a priority in the prevention and control of many non-communicable diseases (e.g. cardiovascular disease, hypertension, diabetes and certain forms of cancer) (WHO, 2016).

Cycling for transportation (or cycling for utilitarian purposes) represents an opportunity to incorporate physical activity into the daily life of young adults (Sisson and Tudor-Locke, 2008) and adults (Sahlqvist et al., 2012). This physical activity brings potential benefits such as lower odds of being overweight or obese (Wen and Rissel, 2008), higher levels of cardiovascular fitness (Larouche et al., 2016), decreased risk of type 2 diabetes (Rasmussen et al., 2016) and breast and colon cancer (Celis-Morales et al., 2017) and an overall reduction in cardiovascular risk (Hamer and Chida, 2008). Cycling for transportation is also associated with less sickness

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absence (Hendriksen et al., 2010; Mytton et al., 2016). Associations between cycling for transportation and physical and mental wellbeing are less clear. Martin and colleagues (Martin et al., 2014) found significant associations between overall psychological wellbeing and cycling for transportation, whereas Mytton and colleagues (Mytton et al., 2016) found that those who maintained cycling to work had higher scores on a mental wellbeing scale than those who did not cycle to work, but found no significant associations with physical wellbeing. In contrast, Humphreys and colleagues found an association between a physical wellbeing score and time spent in active commuting (cycling) but found no such relationship for mental wellbeing (Humphreys et al., 2013).

Commuters taking up cycling for transport can increase their physical fitness (de Geus et al., 2009; Møller et al., 2011), reduce body fat (Møller et al., 2011) and reduce their coronary heart disease risk factors and are likely to improve health-related quality of life parameters (de Geus et al., 2008a,b). In the longitudinal iConnect study, an increase in active travel (walking and cycling) was associated with a proportionate increase in total physical activity and not a decrease in recreational physical activity (Sahlqvist et al., 2013). This result was supported by an epidemiologic study by Donaire-Gonzalez and colleagues (Donaire-Gonzalez et al., 2015).

In addition to the direct health benefits at the population level (Mueller et al., 2015), cycling will also provide substantial environmental and economic benefits to society. A shift from car use to cycling will help to resolve transport-related issues such as congestion, air and noise pollution, climate change, land consumption, etc. resulting in a more sustainable, healthy and liveable environment (Woodcock et al., 2007).

A strong national divergence is noticeable in the three Belgian regions (Flanders (Northern part of Belgium), Wallonia (Southern part of Belgium) and the Brussels Capital Region (in the centre of Belgium)) when it comes to cycling for transportation (Vandenbulcke et al., 2011). On average, bicycle use for transportation is rather common in Flanders (14.6% and 31.5% of adults and children use the bicycle as the main transport mode for home-work and home-school commuting, respectively (OVG, 2017)), while it is relegated to a marginal role in Wallonia (cycling is mainly done for recreational purposes). The most recent national census data (2010) indicates that 18%, 5% and 1% of the commuting trips to and from work are made by bike in Flanders, the Brussels Capital Region (BCR) and Wallonia, respectively (BELDAM, 2010). Such a strong division is explained not only by culture, but also by a number of political, physical and historical factors (Rietveld and Daniel, 2004; Vandenbulcke et al., 2009).

To design effective interventions and policies that encourage adults to cycle more, it is necessary to have a comprehensive understanding of the factors associated with cycling. Ecological models state that transport choices are influenced by various factors at multiple levels, including psychosocial and environmental factors (Sallis et al., 2006; Panter and Jones, 2010). A previous study conducted in Flanders studied psychosocial and environmental correlates associated with cycling for transportation in an adult working population (18–65 years) (de Geus et al., 2008a). The results suggested that when people live in a setting with adequate bicycle infrastructure (Flanders), individual (psychosocial) correlates (Modelling, Social support Accompany, Self-efficacy, perceived Benefits and Barriers) outperform the role of environmental correlates. Another study conducted in Flanders (Simons et al., 2017) showed that working young adults (18–26 years) with a higher Self-efficacy towards cycling and walking, those perceiving more facilities at work in favour of walking and cycling and those living closer to work were more likely to cycle to work. Among those who did cycle to work, a one-unit increase in perceived benefits regarding cycling and walking and in walking and cycling facilities was associated with respectively 52% and 70% more minutes per week cycling (Simons et al., 2017). The fact that Flanders is a walking- and cycling-friendly region with adequate infrastructure and facilities to support walking and cycling could have explained the finding that psychosocial variables were more important than environmental variables.

As the BCR is (perceived as) a car oriented city in which bicycle infrastructure is sub-optimal and a limited bicycle culture or general attitude to cycling is present, one could argue that perceived psychosocial and environmental correlates differ between regions within the same country or between other countries (Pucher et al., 1999). Psychosocial and environmental factors associated with cycling should therefore be studied in a specific region, before promotion campaigns and interventions can be set up.

Therefore, the aim of this study was to investigate which psychosocial and environmental factors are associated with cycling for transportation in a car-oriented urban environment where cycling plays a limited role in daily transport and the availability of bicycle facilities (bicycle paths, bike racks, …) is still limited.

2. Methods

2.1. Research procedure and participants

A cross-sectional design was used to collect self-reported data using an online questionnaire. The study was spread through different online channels, including websites, social media accounts and newsletters from the university research groups, the Brussels Administration of Mobility, among others. Participants were required to answer each question in order to proceed to the next question. Only the personal questions such as age, gender, height, body weight and health status were not mandatory, due to restrictions from the Medical Ethics Committee. The questionnaire was accessible from April 25th to June 5th 2017.

The first page of the questionnaire explained the purpose of the study. The introductory text put an emphasis on travel behaviour in general and not specifically on cycling for transportation. The reason for this was to attract users of all different transport modes (car, bike, public transport and walking) to fill out the questionnaire. Tentative participants then went to the next page that contained the Informed Consent and Compliance information. Those who accepted the conditions of the study and complied with the inclusion criteria, which were: (1) being between 18 and 65 years and (2) living and/or working in the Brussels Capital Region, were invited to fill out the rest of the questionnaire.

The study protocol was approved by the Medical Ethics Committee of the university hospital of the Vrije Universiteit Brussel (B.U.N. 14320201732128).

2.2. Study area and cycling in the Brussels Capital Region

The Brussels Capital Region (the capital of Belgium) is a single condensed urbanized built-up area of 161 km^2 with 1.2 million inhabitants and is located in the centre of Belgium. An extensive public transport network consists of metro, tram and bus lines. The number of public transport passengers increased by 44% between 2007 and 2017 (STIB, 2017). There is a dense network of urban motorways, multi-lane avenues and boulevards, an inheritance from the 1950s and 1960s. Nevertheless, the road network is very congested. Brussels regularly appears as one of the most congested cities in Europe with high levels of air pollution as a result (INRIX, 2016). The cycling infrastructure consists of a network of physically separated bicycle paths, dedicated bicycle lanes, bus and cycle lanes and recommended cycling routes with road surface signage. The designation and construction of the cycling road infrastructure is the responsibility of the 19 municipalities of the region (local cycle routes) and the regional transport authority (regional cycling routes).

The average annual growth in the number of cyclists counted for the period 2010–2016, taking into account 26 counting points and 4 counting periods, amounts to 14% (ProVelo, 2016). The number of trips made with bikes from the Brussels sharing scheme "Villo!" almost doubled between 2010 (871,916 trips) and 2016 (1,577,811 trips) (BISA). Every Belgian company with more than 100 employees has a legal obligation to survey their employees on their home-to-work transport habits and transfer their data to the Federal Public Service (FPS) Economy. These publicly available data show that in 2005, 45.1%, 47.2% and 1.2% of commuting trips to companies in the BCR with more than 100 employees were made by car, public transport or bike, respectively. In 2014, the modal split changed in favour of public transport and cycling, with 37.9%, 53.1% and 3.0% of the total number of commuting trips made by car, public transport or bike, respectively (BISA). As a comparison, in Flanders the number of trips by car did not change between 2005 (68.7% of the total number of trips) and 2014 (68.5% of the total number of trips), but the number of trips by bike increased from 12.3% to 14.9% (BISA).

2.3. Measurements

The online questionnaire assessed sociodemographic variables, general transport data, psychosocial and environmental variables (see details below). The questionnaire used for this study was based on validated questionnaires (de Geus et al., 2008a, De Bourdeaudhuij et al., 2003; De Bourdeaudhuij and Sallis, 2002) and was adapted to the Brussels context.

2.3.1. Socio-demographic variables

Self-reported socio-demographic variables included gender and age. Educational level was used as a measure for socio-economic status (SES) and was dichotomized into non-college educated (elementary school or secondary school as highest degree) and college educated (college or university as highest degree). Self-reported distance to work (in kilometres) was assessed (0–2 km; 3–5 km; 6–8 km; 9–11 km and > 11 km) and participants had to indicate if they currently had to restrict their physical or sporting activities due to illness, injury or disability (yes/no), which was used as a measure of health status. Participants also reported their height and weight, which was used to calculate the Body Mass Index (BMI in m/kg^2).

2.3.2. General transport data

General transport data included possession of a driving license for a car (yes/no); ownership of a moped (yes/no), a (company) car/motorcycle or bicycle (yes/no), and pass ownership for public transport (yes/no), for bicycle sharing schemes (yes/no) and for car sharing schemes (yes/no). On the next question, participants had to indicate which means of transport they mainly used to travel for transport purposes (sport or leisure was not taken into account). Participants then had to indicate 'how often they cycled for transport purposes on average during the last 6 months (with or without the combination with public transport)'. They could choose between 0; 1–2; 3–5 or > 5 times per week. This question was dichotomised into (1) those that never cycle (called the Non-cyclists) and (2) those that cycle at least once per week (called the Cyclists).

2.3.3. Psychosocial variables

The following psychosocial variables in relation to cycling were assessed: Social norm, Modelling, Social support Accompany and Encourage, Self-efficacy, Benefits and Barriers. They were selected based on the Attitude-Social influence-self-Efficacy (ASE) model (De Vries et al., 1995). A summary of the measures of psychosocial variables is shown in Table 1. Averages of item scores were used for the present data analyses. Social norm was measured by asking if participants believed that a partner, children, friends or colleagues (asked separately) expect them to cycle in the BCR. Modelling was assessed by asking how frequently a partner, children, friends or colleagues (asked separately) cycle in the BCR. To investigate Social support Accompany, participants were asked how often a partner, children, friends or colleagues (asked separately) cycled with the participant in the BCR. For Social support Encourage, participants were asked how often a partner, children, friends or colleagues (asked separately) encouraged the participant to cycle in the BCR. Self-efficacy was assessed by asking participants how confident they were to choose for cycling in the BCR in 11 potentially difficult situations (i.e. bad weather, darkness, when tired, etc.). To measure perceived Benefits of cycling (indicated as Benefits), participants were asked about 19 potential benefits (i.e. health, environment, independence, …) of cycling. Perceived Barriers of cycling (indicated as Barriers) were assessed by asking participants about 23 potential barriers (i.e. time, crashes, delays, …) of cycling in the BCR.

Table 1
Summary of psychosocial, environmental and safety measures and Mean ± SD scores.

Scale (composition)		Response category	M ± SD
Psychosocial			
Social norm	4 items	5-point scale[a]	3.43 ± 1.18
Modelling	4 items	5-point scale[a]	2.69 ± 1.08
Social support Accompany	4 items	5-point scale[a]	1.69 ± 0.63
Social support Encourage	4 items	5-point scale[a]	1.97 ± 0.76
Self-efficacy	11 items	5-point scale[b]	3.27 ± 0.70
Benefits	19 items	5-point scale[a]	3.87 ± 0.73
Barriers	23 items	5-point scale[c]	2.29 ± 0.73
Environmental			
Cycling facilities	11 items	5-point scale[a]	2.57 ± 0.44
Safety	6 items	5-point scale[a]	2.97 ± 0.68

M ± SD: Mean ± Standard Deviation.
[a] 5-point scale from 1 (totally disagree) to 5 (totally agree).
[b] 5-point scale from 1 (know I cannot do it) to 5 (know I can do it).
[c] 5-point scale from 1 (never) to 5 (always).

2.3.4. Environmental variables

The following environmental variables were assessed: Cycling facilities and Safety, using questions derived from the validated European environmental questionnaire (ALPHA questionnaire, Long version) (Spittaels et al., 2010). A summary of the measures of the environmental variables are shown in Table 1. ‘Neighbourhood’ was defined as ‘the environment within a walking distance of 15 min from home’. The following Cycling facilities variables were assessed: availability of bicycle storage, bike repair shops, bicycle paths, presence of air pollution from motorized traffic, presence of other cyclists and walkers and aesthetics. The variable Safety included Safety from traffic (a high perceived safety from traffic equals feeling safe from problems such as speed of traffic in the neighbourhood) and Safety from crime (a high perceived safety from crime equals feeling safe from problems such as crime prevalence in the neighbourhood).

2.4. Data analysis

Data analysis was performed using the statistical software IBM SPSS 25.0. Descriptive statistics (mean and standard deviation) were used to analyse the responses of the socio-demographic and general transport questions. Differences between Cyclists and Non-cyclists were analysed using independent samples *t*-tests (for parametric data) and Chi-Square tests (for non-parametric data).

The scores in each item were summed to provide a total score for each category of psychosocial variables, (Social norm, Modelling, Social support Encourage and Social support Accompany, Self-efficacy, Benefits and Barriers) and environmental variables (Cycling facilities and Safety). These summed scores were then divided by the number of items in each category. To examine the likelihood of being a cyclist, logistic regression models were used. The question ‘how often have you cycled on average during the last 6 months for transport purposes (with or without the combination with public transport)’ was dichotomized in those who never cycled for transport purposes (Non-cyclist) and those who cycled at least once per week (Cyclist), and used as the dependent variable. The items from the psychosocial (Social norm, Modelling, Social support Encourage and Social support Accompany, Self-efficacy, Benefits and Barriers) and environmental (Cycling facilities and Safety) variables, as well as age, gender, BMI, SES and distance between home and work were used as independent variables.

In a first step, univariate logistic regression models were constructed to investigate the association between the dependent variable (Cyclists vs Non-cyclists) and the independent variables separately. For each univariate analysis odds ratios (OR) and 95% confidence intervals (CI 95%) were calculated.

In a second step, a multivariate logistic regression model was constructed in which all independent variables that showed a significant ($p < 0.05$) or a trend towards significant ($p < 0.10$) association with the dependent variable in the univariate analyses were included. This multivariate analysis provides the opportunity to identify which independent variables, that have a significant relation with being a Cyclist in the univariate regression analysis, increase the likelihood of being a Cyclist, controlling for all other included variables. For every independent variable included in the multivariate analysis odds ratios (OR) and 95% confidence intervals (CI 95%) were calculated.

Before the final multivariate logistic regression was conducted, collinearity analysis was performed. Although logistic regression is just as prone as linear regression to the biasing effect of collinearity, SPSS does not have collinearity diagnostics for logistic regression. This was solved by obtaining tolerance and variance inflation factor (VIF) statistics of the independent variables by running a multivariate linear regression analysis with the same dependent and independent variables. A tolerance score lower than 0.1 and/or a VIF score higher than 10.0 was interpreted as presence of multi-collinearity (Field, 2009). No cases of multi-collinearity were found.

P-values ≤ 0.05 were considered to be statistically significant.

3. Results

The URL to the questionnaire was visited 1027 times between April 25th and June 5th 2017. In 520 cases, no answers were given. Two participants did not accept the conditions in the Informed Consent and two participants were older than 65 years. Those four participants were excluded from the data analysis. The data analysis was performed on 503 participants.

3.1. Socio-demographic characteristics

Since socio-demographic questions were asked at the end of the questionnaire and were not mandatory, the results of the socio-demographic variables are based on 490 participants (97%). The mean age of the participants was 36.5 ± 10.4 years with a mean Body Mass Index of 21.1 ± 3.5 kg/m^2. Forty-seven percent were women. The gender distribution for the general working population in the BCR was: 50.2% women and 49.8% men (BISA). The age distribution of the active population was: 27.0%, 37.8% and 35.2% for those who were between 18 and 29 years, 30–44 years and 45–64 years, respectively. Sixty-nine percent of the participants had a university degree (Master) and 22% had a degree of higher – non-university (Bachelor), indicating that 91% of the cohort was classified as having a high SES. No statistical differences ($p > 0.05$) were observed for the above-mentioned socio-demographic characteristics between the Cyclists and the Non-cyclists. Fifty participants indicated that they ‘currently had to restrict their physical or sporting activities due to illness, injury or invalidity’. From these 50 participants, 32 never cycled and 3, 9 and 6 participants cycled 1–2, 3–5 or more than 5 times a week, respectively.

3.2. Transport behaviour

To the question: ‘Which means of transport do you mainly use for transportation purposes?’, 45%, 31% and 15% of the total cohort answered bike, public transport or car, respectively. From the total sample, 40% of the respondents had a car and 20% of those cars (8% of the total sample) was a company car. Another 9% of the respondents indicated that his/her partner had a company car. Twenty-two percent of the families had a subscription for a car sharing scheme such as Cambio, Zipcar, DriveNow, etc. Sixteen percent of the respondents did not own a bike and 27% had a subscription for a bike sharing scheme (Villo! or Blue bike). Just less than half (48%) of the respondents owned a season ticket for public transport.

To the question: ‘How often did you cycle for transport purposes (e.g. home-work commuting by bicycle, cycling to the grocery shop, cycling to the train station, etc) on average during the last 6 months (with or without the combination with public transport)’, 61% (48.7% women) never cycled, whereas 39% (39.7% women) cycled at least once a week. The 61% of participants that never cycled for transport purposes were defined as the Non-cyclists, and the other 39% were defined as the Cyclists. Within the Cyclists group, significantly ($p < 0.01$) more participants were men.

Participants had to indicate the distance between home and work (Table 2). Seventy-eight percent lived at less than 9 km from their work. No statistical difference ($p > 0.05$) was observed between the Cyclists and Non-cyclists for the distance between home and work.

3.3. Psychosocial and environmental variables

In the next section, the psychosocial and environmental variables were compared between the Cyclists and the Non-cyclists. In a first analysis, the mean scores of the Cyclists and Non-cyclists were compared for each of the categories (Table 3). All psychosocial variables were significantly ($p < 0.001$) different between Cyclists and Non-cyclists. A higher score for Social norm, Social support Accompany, Social support Encourage and Self-efficacy in the Cyclists group indicates that more Cyclists agree with the proposed statements (items). E.g. Cyclists receive higher Social support (Accompany and Encourage) from partners, colleagues, friends and/or children in their choice to cycle and think that the Cyclist should cycle (Social norm). A higher score for Self-efficacy means that Cyclists will not be discouraged to cycle even if e.g. it rains during their trip to work. Cyclists perceived significantly more Benefits and significantly fewer Barriers compared to Non-cyclists when cycling in the Brussels Capital Region. No statistical difference between Cyclists and Non-cyclists for the total score for Cycling facilities (mean ± SD score for the Cyclists is 2.54 ± 0.41 and 2.59 ± 0.45 for the Non-cyclists) was found. Nevertheless, for two items of the variable Cycling facilities, a significant difference was found between Cyclists and Non-cyclists. For the item ‘too much motorized traffic make cycling unpleasant’, the mean ± SD score was significantly different ($p < 0.05$) between Cyclists (2.24 ± 1.24) and Non-cyclists (1.92 ± 1.08) (indicating that Non-cyclists

Table 2
“What is the distance between your home and work”?, divided between Cyclists and Non-cyclists.

	Cyclists	Non-cyclists
0–2 km	4.3%	9.6%
3–5 km	15.3%	21.8%
6–8 km	10.8%	16.1%
9–11 km	8.2%	13.9%
Total	38.6%	61.4%

Table 3
Mean and Standard Deviation score of the independent variables.

Scale (composition)	Cyclists	Non-cyclists	t *or Chi*^{2}	p
Psychosocial (M ± SD)				
Social norm	**3.87 ± 0.92**	**3.16 ± 1.24**	**38.47**	**< 0.001**
Modelling	2.81 ± 1.05	2.62 ± 1.09	1.07	0.060
Social support Accompany	**1.90 ± 0.65**	**1.56 ± 0.58**	**1.87**	**< 0.001**
Social support Encourage	**2.22 ± 0.80**	**1.82 ± 0.69**	**7.23**	**< 0.001**
Self-efficacy	**3.56 ± 0.38**	**3.10 ± 0.79**	**67.98**	**< 0.001**
Benefits	**4.16 ± 0.52**	**3.69 ± 0.79**	**21.15**	**< 0.001**
Barriers	**2.01 ± 0.59**	**2.47 ± 0.75**	**11.69**	**< 0.001**
Environmental (M ± SD)				
Cycling facilities	2.54 ± 0.41	2.59 ± 0.45	1.40	0.213
Safety	3.03 ± 0.65	2.94 ± 0.70	0.93	0.162
Socio-demographic				
Age (M ± SD)	35.7 ± 10.6	36.9 ± 10.2	0.25	0.220
Gender[a] (%men)	**30**	**23**	**6.32**	**0.012**
SES[b] (%high SES)	91.0	92.5	0.97	0.334
BMI (M ± SD)	20.6 ± 3.2	20.7 ± 3.6	2.03	0.810
Health status[c] (%good health)	90	89	0.24	0.650
Distance home-work[d]	5.78	5.67	0.34	0.706

The items in **bold** indicate a significant difference between the Cyclists and the Non-cyclists; M: mean; SD: Standard Deviation; t: independent samples *t*-test (parametric); Chi^2: Chi-square (non-parametric); p: p-value; BMI: Body Mass Index.

[a] Reference category: man.

[b] Reference category: non-college educated.

[c] Reference category: no restriction for physical or sports activities due to illness, injury or disability.

[d] Reference category: 0–2 km.

agree more often that motorized traffic makes cycling unpleasant). For the item ‘exhaust fumes from motorized traffic make cycling unpleasant’, the mean ± SD score was significantly different between Cyclists (1.76 ± 0.89) and Non-cyclists (2.05 ± 1.07) (the lower the mean ± SD score the more they agree that exhaust fumes make cycling unpleasant). No statistical difference in the total score for Safety is present between the Cyclists and the Non-cyclists (mean ± SD score of 3.03 ± 0.65 for Cyclists and 2.94 ± 0.70 for Non-cyclists). On the item ‘car drivers pass too fast when they overtake me’, the mean ± SD score was 3.90 ± 1.02 for Cyclists and 3.82 ± 1.04 for Non-cyclists, indicating that both the Cyclists and the Non-cyclists agree that car drivers drive too fast when overtaking. On the item ‘car drivers don’t take cyclists into account’, the mean ± SD score is 4.10 ± 0.90 for Cyclists and 3.59 ± 1.05 for Non-cyclists, indicating that both the Cyclists and the Non-cyclists agree that car drivers do not take cyclists into account. Cyclists and Non-cyclists feel safe (safety from crime) to cycle during the day or at night (no significant difference between Cyclists and Non-cyclists). The mean ± SD score for the item ‘in my neighbourhood many bikes are stolen’ is significantly different ($p < 0.05$) between Cyclists and Non-cyclists (3.15 ± 1.15 and 2.88 ± 1.14, respectively), indicating that Cyclists agree more often that bikes are stolen.

In a second analysis, univariate logistic regression (ULR) models were constructed in order to give an indication of which category increased the likelihood of being a Cyclist (Table 4). All items for the psychosocial variables, except Modelling, had a significant ($p < 0.001$) Odds Ratio, meaning that the likelihood of being a Cyclist is significantly higher when participants have higher Social norm, more Social support Accompany/Encourage, higher Self-efficacy, more Benefits and less Barriers towards cycling. Modelling showed a trend towards significance ($p = 0.060$). The strongest psychosocial predictor of Cyclists and Non-cyclists was Self-efficacy towards cycling, followed by Benefits. A one-unit increase in Social norm, Social support Accompany, Social support Encourage, Self-efficacy and Benefits regarding cycling increased the likelihood by 1.83, 2.42, 2.08, 3.86 and 3.12 times to be a Cyclist, respectively. A one-unit increase in Barriers regarding cycling decreased the likelihood by 2.56 times to be a Cyclist. Gender was also a strong predictor of being a Cyclist (OR: 0.62). The likelihood of women being a Cyclist is 1.61 times smaller compared to men. Cycling facilities, Safety, Age, SES, Distance between work and home, BMI or Health status did not have an influence on the likelihood of being a Cyclist or Non-cyclist.

In the final analysis, all the significant ($p < 0.05$) variables from the ULR were entered in a multivariate logistic regression (MLR) model (Table 5). For Modelling a trend towards significance ($p = 0.06$) was found and was also included in the MLR model.

The MLR model indicates that, when introducing the significant and trends towards significance variables from the ULR into one model, a high score for Modelling, Social support Accompany and Encourage and Benefits increased the likelihood of being a Cyclist.

4. Discussion

In the current study, psychosocial as well as environmental variables were investigated simultaneously in a cohort (N = 503; 47% women) of people indicating to have never cycled or to have cycled at least once a week in the previous 6 months. The combination of both psychosocial as well as environmental variables made it possible to determine what variables influence the likelihood of being a Cyclist in a cohort where 78% lived at a distance of less than 9 km from work. The main finding of the univariate models is that the

Table 4
Univariate logistic regressions.

Scale (composition)	OR	p	95% CI
Psychosocial			
Social norm	**1.83**	**< 0.001**	**1.51–2.21**
Modelling	1.18	0.060	0.99–1.40
Social support Accompany	**2.42**	**< 0.001**	**1.77–3.30**
Social support Encourage	**2.08**	**< 0.001**	**1.61–2.69**
Self-efficacy	**3.86**	**< 0.001**	**2.57–5.79**
Benefits	**3.12**	**< 0.001**	**2.22–4.38**
Barriers	**0.38**	**< 0.001**	**0.28–0.50**
Environmental			
Cycling facilities	0.77	0.213	0.50–1.17
Safety	1.21	0.162	0.93–1.59
Socio-demographic			
Age	0.99	0.220	0.97–1.01
Gender[a]	**0.62**	**0.012**	**0.43–0.90**
SES[b]	0.73	0.327	0.39–1.37
BMI	0.99	0.809	0.94–1.05
Health status[c]	0.63	0.625	0.47–1.58
Distance home-work[d]	1.04	0.705	0.86–1.25

Values in **bold** indicate a significant relationship for the univariate logistic regression; reference category for the dependent variable = Non-cyclist; OR: Odds Ratio; CI: Confidence Interval; BMI: Body Mass Index.

[a] Reference category = man.
[b] Reference category = low SES.
[c] Reference category = no restriction for physical or sports activities due to illness, injury or disability.
[d] Reference category = 0–2 km.

Table 5
Multivariate logistic regression.

Scale (composition)	OR	p	95% CI
Social norm	1.224	0.114	0.95–1.57
Modelling	**0.752**	**0.024**	**0.59–0.96**
Social support Accompany	**1.554**	**0.050**	**1.00–2.42**
Social support Encourage	**1.469**	**0.027**	**1.05–2.07**
Self-efficacy	1.532	0.130	0.88–2.66
Benefits	**1.579**	**0.043**	**1.01–2.46**
Barriers	0.716	0.099	0.48–1.07
Gender[a]	0.812	0.376	0.53–1.25

Values in **bold** indicate a significant relationship for the multivariate logistic regression; reference category for the dependent variable = Non-cyclist; OR: Odds Ratio; CI: Confidence Interval.

[a] Reference category = man.

psychosocial variables (especially a high score for Self-efficacy and Benefits) increase the likelihood of being a Cyclist and that women are less likely to be a Cyclist. When the significant categories from the univariate models were entered into a multivariate regression model, Modelling, Social support and Benefits significantly increased the likelihood of being a cyclist. Non-cyclists agreed more strongly compared to Cyclists that 'motorized traffic makes cycling unpleasant' in Brussels. On the other hand, Cyclists showed a significantly higher score on the item 'exhaust fumes makes cycling unpleasant' compared to Non-cyclists. Cyclists also had a significantly higher score for the item 'in my neighbourhood many bikes are stolen', compared to Non-cyclists. The vast majority of the Cyclists and Non-cyclists indicated that they 'agree' or even 'strongly agree' with the statement that 'car drivers pass cyclists too fast' or 'car drivers do not take cyclists into account'.

Studies conducted in Flanders (Northern part of Belgium), using the same kind of questionnaires in a working population (composed of Cyclists and Non-cyclists (de Geus et al., 2008a)), in a cohort of young adults (18–26 year) (Simons et al., 2017) and in older adolescents (17–18 year) (Verhoeven et al., 2016) came to similar conclusions. Compared to the Brussels Capital Region, Flanders is a more bicycle friendly region with a better adapted cycling infrastructure and a cycling mentality (Vandenbulcke et al., 2009). The results in the study of de Geus and colleagues suggested that when people live in a setting with adequate bicycle infrastructure, individual (psychosocial) correlates (Modelling, Social support Accompany, Self-efficacy, perceived Benefits and Barriers) outperform the role of environmental correlates (de Geus et al., 2008a). The present study now adds to the existing literature that these same results hold true in a less-optimal cycling setting, such as the Brussels Capital Region.

Within the psychosocial factors that differentiated between the Cyclists and the Non-cyclists, a higher Self-efficacy towards cycling was strongly associated with being a Cyclist. Hence, it would be useful to enhance self-efficacy of the non-cycling population in order to increase cycling levels. Enhancing self-efficacy is a complex task, but not impossible as was shown by Badland and colleagues. They showed that, as part of the RESIDE study, interventions focusing on enhancing self-efficacy and generating social support positively influenced cycling for transportation (Badland et al., 2013). A gradual increase in cycling among individuals living close to work who never cycle may permit avoidance of adverse emotional states threatening self-efficacy (De Bourdeaudhuij and Sallis, 2002). Williams and French conducted a systematic review to study the association between specific intervention techniques used in physical activity interventions and change obtained in both self-efficacy and physical activity behaviour (Williams and French, 2011). The results showed that 'action planning', 'provide instruction' and 'reinforcing effort towards behaviour' were associated with significantly higher levels of both self-efficacy and physical activity. 'Relapse prevention' and 'setting graded tasks' were associated with significantly lower self-efficacy and physical activity levels. Cycling together with colleagues or friends (forming buddy groups for cycling) has the potential to increase social norm, modelling and social support towards cycling for transportation (Mcauley et al., 1994).

This study showed that, although only significant in the univariate analyses, gender was one of the strongest predictors of being a Cyclist, which has been observed in other studies (Vandenbulcke et al., 2009; Winters et al., 2007; Dickinson et al., 2003; Garrard et al., 2008). In the present study, the likelihood of a woman being a Cyclist is 1.61 times smaller compared to a man being a Cyclist. The 'Fietsobservatorium in het Brussels Hoofdstedelijk Gewest (Brussels Bike Observatory) - Pro Velo asbl' counts cyclists in January, May, September and November at identical geographical locations between 8 am and 9 am spread out over the BCR (N = 27). They showed that between 2008 and 2015, 44% of the cyclists were women (ProVelo, 2016), while in 2016, the number of observed female cyclists increased to 52%. The number of trips made with the bike sharing scheme "Villo!" by women increases at a faster rate compared to men (66% for women and 58% for men between 2011 and 2015, respectively). Although the absolute number of women cycling in the BCR is increasing, the difference between men and women is still present. The percentage of women cycling is an important indicator of the 'cycleability' ('bike-friendliness') of a city or a country. The higher the modal split for cycling, the higher the percentage of women cycling (de Geus et al., 2014).

In order to increase the number of female cyclists, we need to know why they cycle less compared to men (in the BCR) and how interventions should be tailored specifically for women. van Bekkum and Heesch showed that women not only hold stronger perceptions compared to males of risk-orientated barriers but also of more general barriers associated with cycle commuting (van Bekkum and Williams, 2011; Heesch et al., 2012). Issues such as taking children to school and carrying belongings are likely to pose objective barriers to cycling for women as they have more complex trips (e.g. juggling childcare responsibilities and grocery shopping) (Dickinson et al., 2003). van Bekkum showed that women's heightened concerns regarding physical effort involved in cycling, natural terrain (hilliness), and wearing casual clothing, are perhaps in part explained by culturally ingrained gender stereotyping and norms (van Bekkum and Williams, 2011). Horton proposes that cycling is a 'gendered activity' and that women may be discouraged to take up cycling, not only because of fears related to cycling in traffic (bicycle crashes) but because of fear linked to being seen by others of exercising in public and harassment and violence from strangers (Horton, 2007). Heesch and colleagues pointed out that lack of confidence in bicycle maintenance and in their own cycling skills are also elements that could explain the gender difference in cycling (Heesch et al., 2012).

One of the most important factors associated with cycling for transport is the distance (Heinen et al., 2010). In this study sample, 78% of the participants lived at less than 9 km from work, with no statistical difference between the Cyclists and the Non-cyclists. Figures show that 62.5% of journeys (independent of transport mode) in Brussels are less than 5 km and 25% are even less than 1 km, which are distances that could be covered with alternative means of transport (to driving) (IRIS2, 2011). As shown in a prospective study of de Geus et al., the mean cycling speed in the BCR is 19.5 km/h for men and 15.5 km/h for women (de Geus et al., 2014). Taking the present study results into account, this would mean that 78% of men and women would spend a maximum of 25 and 31 min on their bike to cycle to work (calculated with distance = 8 km), respectively.

With this type of cross-sectional study design, it is not possible to make any statement on the causality between the psychosocial and environmental factors and cycling behaviour. Nevertheless, the question of 'which causes which' is important for policy makers and transportation planners. Kroesen and colleagues conducted a longitudinal study with a 'true probability sample' of Dutch households (N = 1376) (Kroesen et al., 2017). The results indicate that the use of a mode (car, bicycle or public transport) and the attitude towards that mode mutually influence each other over time. People with a dissonant attitude-behaviour travel pattern (e.g. high car use, but negative attitude towards the car) are less stable and are more inclined to change transport mode. They also showed that the effects of behaviours on attitude are much larger than vice versa. The latter suggests that dissonant travellers are more inclined to adjust their attitudes to align with their behaviour. For policy makers and transportation planners, these results imply that in order to change peoples' travel behaviour, the focus should be on the dissonant travellers. Specifically for cyclists, the results from Kroesen and colleagues also indicate that there are sizeable groups of dissonant cyclists who would like to increase their bicycle use, indicating scope for behavioural change in desired directions.

In order to increase the number of cyclists and decrease the number of car drivers, population-wide policy actions should be multi-layered and contain both hard and soft policy measures (Berg, 2006). Hard policy measures focus on enforcement and infrastructure, such as infrastructural improvements, increasing the cost of vehicle use, etc. (Bamberg et al., 2011), while soft policy measures cover communication and education, such as travel awareness campaigns, workplace travel plans, personalised travel planning, etc. (Cairns et al., 2008). As Sallis showed, ecological models suggest that the combination of psychosocial and environmental variables will best explain physical activity in general (Sallis et al., 2006). Although the present study showed that the difference between Cyclists and Non-cyclists can be explained by a difference in psychosocial variables (e.g. Social norm, Modelling, Social support, Self-efficacy, Benefits and Barriers), rather than environmental variables, efforts should still be made to provide a safe and coherent bicycle infrastructure if a modal shift from car to active transport is on the agenda, especially in an urban environment where the cycling infrastructure is not optimal. A well designed bicycle infrastructure will protect those already cycling and will attract those planning to start cycling, especially women (Garrard, 2003). Separated bicycle lanes (Schepers et al., 2015) and traffic calming measures (30 km/h zones) (Grundy et al., 2009) clearly showed their effectiveness in increasing the safety of cyclists. Another important measure for a modal shift is discouraging the use of the car. Simons and colleagues showed that Modelling and Social norm towards passive transport (e.g. car driving) were also positively associated with passive transport (Simons et al., 2017). Especially among employed people, image and social status (e.g. mirrored to co-workers) have shown to be important motives for driving a car (Steg, 2005). It is important to improve the image of active transport (cycling and walking with or without a combination with public transport) and to create a positive social climate (Modelling and Social support) towards these transport modes in order to increase active transport and decrease passive transport. In the past, car drivers felt that the car provided freedom and control (Stradling et al., 1999). In the study of Gatersleben however, it was found that 'a lack of control' (e.g., in terms of getting stuck in traffic jams) was an important source of stress for drivers (Gatersleben and Uzzell, 2007). Only a few of those who did not experience any commuting stress (i.e., cyclists and walkers) mentioned control or flexibility, such as not getting stuck in traffic jams, as one of the most important positive aspects of their journey. As the number of cars on the roads increases, it may be expected that both actual and perceived control is likely to decrease.

As the limited place in urban areas will never allow a total separation of all road users, cyclists, car drivers and pedestrians will have to cohabit in the same environment and have to accept and respect one another. In this study, both the Cyclists and the Non-cyclists indicated that 'car drivers pass cyclists too fast' and 'car drivers don't take cyclists into account'. Even when overtaking drivers do not collide with cyclists, close-passing motor vehicles can create a subjective experience of being unsafe which is a disincentive to travel by bicycle (Parkin et al., 2007). Therefore, strategies to effectively deal with traffic, such as being vigilant and alert, clear signalling, making eye contact with other drivers, wearing high visibility clothing, and developing knowledge of alternative cycling routes should be adopted by all cyclists. Walker and colleagues suggested that the optimum solution to avoid the closest near misses will not lie with bicyclists themselves, and instead we should focus on changes in infrastructure, education or the law to prevent drivers from getting dangerously close when overtaking bicyclists (Walker et al., 2014). Police forces should put more emphasis on compliance with the federal law (that indicates that, in Belgium, a distance of 1 m between the motorized vehicle and the bicycle while overtaking a cyclist should be observed) in order to protect cyclists and punish more severely those who violate traffic laws that are designed to protect cyclists.

Study limitations include the cohort in this study that is not a representative sample of the Brussels population, limiting the generalization of the results of this study to other populations with other characteristics. Young adults (mean ± SD age: 36.5 ± 10.4 years), cyclists and white-collar workers are over-represented in this study. Over 90% of our sample was college educated (college or university as highest degree) and defined as high SES. In Brussels 44% of the Brussels population between 25 and 64 years of age have a college or university degree (Welzijnsbarometer, 2017). As every city or region has its own characteristics (hilliness, climatological conditions, …), caution should be taken when extrapolating the results outside of Brussels.

The 'Cyclist group' was composed of people whose frequency of cycling for transport purposes ranged from once a week to every day. We thereby recognise the potential for large differences within the Cycling respondent group. The decision to take 'at least once a week' as cut-off was based on the assumption that those who cycle at least once a week for transport purposes during the past 6 months have a good perception of the environment and underlying psychosocial aspects, compared to those who 'never' cycle of transport purposes.

5. Conclusions

The results of this study suggest that physical environmental factors are not essential in predicting cycling for transportation in a population living in the Brussels Capital Region. The influence of individual and social factors seems to be more predictive in distinguishing between Cyclists and Non-cyclists.

Although more and safer cycling infrastructure is needed in order to make cycling more pleasant and safe and attract car drivers to take up cycling, the focus should shift more to creating a positive social climate towards cycling, increasing benefits and reducing barriers towards cycling. More emphasis should be put on encouraging women to take up cycling, using tailored interventions. Simultaneously, car drivers should be educated and sensitized to respect the distance between them and the cyclists while overtaking, and slow down when approaching and overtaking cyclists. Measures should be taken to decrease the number of cars or at least improve the environmental friendliness of cars since cars are largely responsible for the deteriorating air quality (in the BCR), road congestion and motorized traffic discourages people to cycle.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.tra.2018.09.005.

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