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Orientation towards the common good in cities: The role of individual urban mobility behavior

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ABSTRACT

Orientation towards the common good is considered as a building block of social cohesion and has been shown to benefit both social communities and their residents. Mobility behavior (e.g. cycling) is associated with many positive psychological variables, but little is known about its relationship with the orientation towards the common good. This study examined the relationships between mobility behavior and four facets of orientation towards the common good: political participation, social participation in organizations, neighborhood solidarity, and neighborly helpfulness. Using a longitudinal multilevel analysis, annual surveys between 2014 and 2019 of a representative sample of the German general population (GESIS PANEL, N = 410) were analyzed. Cycling rather than driving was positively associated with orientation towards the common good in all models. Cycling was the only variable that was a significant positive predictor for all four facets of orientation towards the common good after controlling for possibly confounding variables (homeownership, personal income, education, sex). This research demonstrated that mobility behavior is associated with the orientation towards the common good. These findings are significant for policy and planning because the benefits of cycling over driving are more profound and sustainable than previously thought.

1. Introduction

"A pronounced focus on the common good" (Dragolov et al., 2016, p. 1) is considered an essential component of social cohesion and has therefore gained prominence in recent years, especially during the pandemic (Delhey et al., 2018, 2021; Larsen et al., 2023). One reason for this is that the focus on the common good is associated with wellbeing across diverse communities and multiple social levels (Prilleltensky et al., 2022; Quinn et al., 2020). To date, however, little is known about the conditions that promote a focus on the common good as a cohesive element (Delhey et al., 2018) nor how citizens themselves can create conditions for a common good orientation at different societal levels (Di Martino et al., 2022).

Orientation towards the common good is experienced and lived primarily in distinct spaces: in cities and communities, neighborhoods, and districts (Fu, 2019; Wickes et al., 2018). In the fields of community- and social psychology there is an increasing interest in the psychological effects and social meanings of public space and places (Essien & Rohmann, 2023; Lewicka et al., 2019), but there is still relatively little research on the psychological effects of the use of public spaces. This is important, especially since the use of public places is constantly changing. In particular, urban public spaces, have increasingly become traffic spaces predominantly used by people to bridge distances as part of their commute, for recreational transportation, or to purchase and distribute goods (Nobis et al., 2019).

In the context of use of public spaces, the concepts of *walkability* or *bikeability* are relevant: Deitrick and Ellis (2004) describe walkability as an urban design concept that characterizes high-quality public space (with parks, open space, potential for gathering) with easily accessible destinations and diverse land uses, and moderate to higher density housing. The concept of bikeability is based on the concept of walkability: the level of analysis was applied to bicycles as a mode of transportation (Castañon & Ribeiro, 2021; Porter et al., 2020). Transportation science and urban planning have addressed the psychological impact of mobility in the context of walkability or bikeability and confirm a positive effect of walkability on self-reported sense of well-being and resilient social relations (Curl & Mason, 2019; Kingham et al., 2020; Weijs-Perree et al., 2019). Likewise, Henriksen and Tjora (2013) found that parks or neighborhoods associated with walkability have a positive impact on perceptions of experiences of community in

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the urban neighborhood. Furthermore, Wickes et al. (2018) demonstrated that the degree of diversity of land use and the resulting type of social interaction significantly influenced the perceived social cohesion. Accordingly, Hipp et al. (2014) showed that land uses that impede local, active mobility and hinder face-to-face encounters with neighbors, such as rivers, highways, or industrial areas, reduce perceptions of cohesion with fellow residents.

It is likely that the different ways in which people use and interact with their environment lead to differences in the perception of orientation towards the common good. We assume that the frequency and directness of interaction with the neighborhood environment influences the extent of perceived orientation towards the common good. For instance, when neighbors have the opportunity to talk to each other or have the opportunity to see positive changes in the neighborhood directly this might positively affect perceived orientation towards the common good. People's mobility behavior might increase these opportunities in a way that people who walk or cycle through the neighborhood have more opportunities to meet, talk and interact with their environment. This may increase their experience of orientation towards the common good. In the present study, we examine how mobility behavior relates to the orientation towards the common good.

1.1. Orientation towards the common good

In a seminal study of social cohesion, Schiefer and Van der Noll (2016) aimed to theoretically capture the construct. In a comparison of 26 definitions, orientation toward the common good was mentioned most often (16 times, followed by social relations: 12 times and identification/belonging: 6 times). In this paper, we therefore approach orientation towards the common good via the specification proposed by Schiefer and Van der Noll (2016). According to this, orientation toward the common good describes how people feel responsible for others and are willing to help them, how people abide by basic rules of society and finally how people participate in social and political life and engage in public discussions. Orientation towards the common good includes actions and attitudes that enable community organization. These actions are expressed through active social participation, neighborly solidarity, and helpfulness (Arant et al., 2016). Dekker and Halman (2003) define local social participation as voluntary actions performed for the benefit of the community and to improve conditions for others. Fu (2019) adds that local social participation represents actions that occur at the neighborhood level as individual and collective actions that strengthen neighborhood solidarity. These actions include both individual volunteer activities and participation in organized social and political space (Lannegrand-Willems et al., 2018). Activities within the framework of helpfulness and neighborhood solidarity describe local actions that are carried out to improve the conditions for other people (Dekker & Halman, 2003). Greater neighborhood solidarity is associated with greater civic engagement (Lenzi et al., 2013). In a similar vein, a sense of solidarity that develops in local places is associated with a greater willingness to engage in voluntary, environmentally protective activities (e.g., water conservation) (Forsyth et al., 2015). Neighborly helpfulness has - likewise - a component that does not rely on government institutions or agencies (Arant et al., 2016). According to Arant et al. (2016) the focus of helpfulness is on the sense of responsibility for fellow human beings and the willingness to help them, regardless of whether people know each other. Hence, social engagement, experienced neighborly solidarity, and helpfulness can contribute to the orientation towards the common good in narrowly defined geographic units. To understand orientation towards the common good as a structural dimension of social cohesion, a further preliminary consideration is important. Schiefer and Van der Noll (2016) conceptualize social cohesion as a feature of a higher social level, a community, rather than a characteristic of individual citizens. Manifestations of the elements in the multidimensional construction of social cohesion are experienced at different societal levels and affect individual outcomes (Coleman, 1988, 1990). This can cause measurement inconsistencies (Sampson & Raudenbush, 1999). The focus on orientation towards common good offers a key advantage in this context, as it evaluates how people individually (can) participate politically or socially in their immediate (local) living environment. It is therefore possible to examine orientation towards the common good on an individual level. This approach is consistent with theoretical considerations of Aruqaj (2023), according to which the attitudes that foster social cohesion are manifested in the corresponding orientations of individuals.

Since we wanted to focus on a local and neighborhood perspective, we chose orientation towards the common good as our key element in this study. Precisely because urban neighborhoods are characterized by great diversity (Sturgis et al., 2014), it is important to explore antecedents for orientation towards the common good on the ground, especially with regard to prosocial behavior and the participation of people in the (local) social and political life. Orientation towards the common good describes how people participate politically or socially, act helpfully and in solidarity.

1.2. Urban mobility behavior

Previous research showed that increased walkability and bikeability improved perceptions of aspects of orientation towards the common good (Hassen & Kaufman, 2016; Rogers et al., 2010). To examine this relationship, we focus in our study on individual mobility behavior. In doing so, we apply an inclusive concept of individual mobility. From this perspective mobility corresponds to the variety of everyday out-of-home location changes that people perform to pursue their activities, such as commuting to work, shopping, meeting friends, walking the dog, or walking alone. It thus encompasses the entire spectrum of human movement in everyday urban individual life (Aldred, 2015; Spinney, 2007; te Brömmelstroet et al., 2017).

1.2.1. Motorized individual transport

The private car remains the most popular mode of transport in industrialized nations. In 2017, private motorized transport accounted for around 57 percent of the modal split in passenger transport in Germany, 49 percent in the Netherlands, 80.3 percent in the US. (BAG, 2021; European Commission, 2021; Nobis et al., 2019). Motorized individual mobility allows drivers to go to places that are more difficult to reach because they are farther away from the starting point of the trip, are topographically unfavorable, or are poorly connected to public transit. However, even in cities, where distances are often short and good alternatives are available, private motorized transport is the mode of transport mostly used by the greatest number of people. Up to 60% of people in urban areas of the EU mostly choose private motorized transport (European Commission, 2021; Nobis et al., 2019). The car therefore dominates public space and has become the dominant norm for urban mobility.

Because of the design of cars, the interactions car passengers have with their direct environment are significantly reduced. Sheller and Urry (2000) emphasize that no interaction with the spatial environment can take place from inside a passenger car because acoustic backdrops and smells of the city are not captured and distinctive buildings or urban artifacts are reduced to two dimensions by a perception from inside through the windshield of the car. Te Brömmelstroet et al. (2017) add that interaction with the spatial environment beyond visual channels occurs mainly at the point of origin and destination, and that there are few opportunities for interaction between the driver and the environment while en route, such as when stopping at a traffic light or standing in a traffic jam.

Slovenko (2001) comes to a similar conclusion when considering the social aspects of interactions, i.e. between car users and people who are not in the same vehicle, as limited and usually only brief visual contact through the windscreen glass leads to isolated mobility experiences. Slovenko (2001) notes that the perceptions of the social "outside world"

can be lost through the capsule of the car and that therefore the interactions with other road users would be limited. According to Bauman (2000) this relative isolation can reinforce individualistic behaviors and cause drivers to neglect collective actions. Te Brömmelstroet et al. (2017) complement that driving a car in its current form requires the user's active attention and involvement in controlling the motor vehicle - to navigate, to make tactical decisions, and to prevent harm to self and others, which subsequently reduces the opportunities for social and spatial interaction.

1.2.2. Non-motorized individual transport

In contrast to motorized individual transport, non-motorized individual transport means active transportation (walking, cycling). Research has shown that this mode of transportation is beneficial for communities (reducing traffic, decreasing noise, and reducing pollution) as well as individuals (increased physical and mental well-being) (Cohen et al., 2014; Gössling et al., 2019; Rojas-Rueda et al., 2016). For example, in 2017 in the Netherlands one-fourth of all trips were by bike and one-fifth by foot, in Germany, 11% of all the trips were by bike and 22% by foot (European Commission, 2021; Nobis et al., 2019). Non-motorized individual transport is relatively uncommon in the US. In the 50 largest U.S. cities, only 5.0 percent of the US-Americans walked to work and another 1.0 percent used their bike (Mckenzie, 2016).

Walking is the only mode of transportation, for which no vehicles are necessary. While walking, pedestrians are immersed in the sensory environment of the physical environment and are invited to fully experience the place (Middleton, 2016). Pedestrians do not move as quickly; they have the most degrees of freedom available to them when navigating and therefore can make immediate path changes. The potential for social interaction is increased by immediate exposure of the pedestrian, providing more opportunities for spontaneous contact (Leyden, 2003). Almost every trip starts with walking. For distances of less than 1 km, walking is the most common modality in Germany (62%); for longer distances, cycling is increasingly chosen (Nobis et al., 2019). Cycling is also characterized by the fact that cyclists interact directly with the spatial environment, because there is no passenger cell around them. Thus, not only urban but also topographical impressions are more immediate. Like pedestrians, cyclists are directly exposed to the terrain. Through direct interaction with the geographic and topographic environment (different road surfaces, hills and valleys, parks or play streets, etc.), bicyclists develop a rich and extensive cognitive "picture of the city" (Lynch, 1960).

Jungnickel and Aldred (2014) state that cyclists, especially in urban areas, directly experience the breadth of social diversity and cultural heterogeneity that make up urban life and cannot escape these impressions due to sensory density. This direct experience of the neighborhood environment leads to a stronger emotional bond between people and their neighborhood. This emotional attachment of people to their neighborhood is considered a mediator for civic activities (Stefaniak et al., 2017). We expect, therefore, that people who move non-motorized, experience a greater orientation towards the common good than people who move motorized.

1.3. The present study

In this study, we use German data to examine how urban mobility behavior is related to orientation toward the common good. Different modes of transportation allow travelers to interact with their environment to varying degrees. We focus on urban areas because in these environments motorized and non-motorized transportation are valid alternatives. Urbanity in our definition includes urban agglomeration, especially urban fringes with socio-spatial segregation areas (Alisch, 2018). This model of urbanity corresponds to the considerations presented by Simon (1990) for capturing the demographic and socio-economic characteristics of urban-rural areas.

An important structural condition is roughly equal path lengths: According to the study Mobility in Germany (Nobis et al., 2019), the average car trip length in the city is 11 km and 50 percent of trips are under 6 km. In Germany's largest city, Berlin, the average trip lengths of residents are slightly shorter: residents in the outer city travel an average of 8.4 KM at 2.9 trips/person, while residents in the center travel an average of 5.9 KM/trip at 3.3 trips per person (Jarass, 2018). These distances of less than 10 km can easily be covered by bicycle as well as by car on a daily basis and thus the general conditions are similar. Therefore, we focus on bicycling for non-motorized mobility. Another structural comparative condition is age. In Germany, people are not allowed to drive a car on their own until they are 18 years old. The free choice of mode of transport within the sample is a condition, which is why only people over 18 are included in this study.

Previous research has shown that homeownership is positively associated with civic engagement (Fu, 2019). Education, personal income, and sex can also influence a person's active participation in civic engagement (Comstock et al., 2010; Dang et al., 2021; Stroope, 2021). With regard to sex and socioeconomic status, the reported associations are partly contradictory, especially when German contexts (where the data were collected) are also taken into account (Simonson et al., 2021). However, these variables are related to mobility behavior (Flade, 1999; Gauvin et al., 2020; Hudde, 2022; van Leuvensteijn & Koning, 2004). For instance, Hudde (2022) showed that individuals with a college degree were almost 50 percent more likely to use bicycles in German cities than those without a college degree. Therefore, we control for these variables in this study. We hypothesize that in an urban context, people who use bicycles experience a greater orientation towards the common good than those who use cars.

2. Methods and measurements

This study's hypotheses and planned analyses were preregistered on aspredicted.org.[1] The study is based on data collected by the German research institute GESES. The GESIS Society Monitor dataset (Gesis, 2020) provides a comprehensive, longitudinal data set from a representative sample of the German population. The initial cohort comprised 4900 panelists at the beginning of 2014. At the time of the first wave, it comprised German-speaking respondents between the ages of 18 and 70 who were permanent residents of Germany. The GESIS Panel is a probability-based mixed-mode access panel, for which both personal computer-assisted telephone interviews and computer-assisted mobile surveys as well as computer-assisted web interviews and self-completed paper interviews were used.

2.1. Sample

For the current analyses, we selected participants who indicated to live in, or less than 10 km away from the nearest metropolitan center with more than 100,000 inhabitants, resulting in a sample of 410 respondents, including 53 percent ($n = 218$) women.

More than one-third (36 percent, $n = 142$) were homeowners and 64 percent were tenant or subtenant ($n = 258$). Compared to average homeownership in German cities in 2018 (27%), homeowners were slightly overrepresented in our sample (Kortmann & Kriege, 2021). The urban sample was relatively highly educated: In the 2014 wave, 50 percent of the respondents had a general qualification for university entrance ($n = 200$) as the highest school degree at the beginning of the survey, compared to the German average (30.0 percent for people over 20 years in 2014) (Statistisches Bundesamt, 2015). The income distribution of the sample was slightly above the income distribution in Germany. In 2019, 51% of the sample received an income above EUR 2000, while the median income in Germany in 2019 was EUR 1960 (Statistisches Bundesamt, 2021).

[1] #72525, https://aspredicted.org/vn2eq.pdf

2.2. Predictor

Mobility behavior was measured in the GESIS Society Monitor (Gesis, 2020) directly over the course of six years between 2014 and 2019 via the frequency of bike and car use. Respondents were asked, *how often do you normally use the following means of transportation?* Responses were recorded using a 5-point Likert scale ranging from *(almost) daily* to *(almost) never*. For analysis, the variables were recoded so that higher scores were associated with more frequent use.

2.3. Outcomes

The focus of this paper is on local societal participation, neighborly solidarity, and helpfulness as facets of the construct of common good orientation. In the GESIS Society Monitor dataset (Gesis, 2020) societal participation was recorded longitudinally over the same period as mobility behavior from 2014 to 2019. Two batteries were used for this purpose: Social participation in organizations and political participation. *Social participation* in organizations was measured with the following question "*During the last* 12 months*, how often did you participate in the following federations, associations, clubs and organizations?"* and these nine items: *Sport or recreational organization, Church or religious organization, Art, music or cultural organization, Social movement, Political party, Labor Union, Youth organization, Humanitarian or charitable organization, Parents' or school association.* A 4-point Likert scale with the response options *No; Yes, once; Yes, sometimes; Yes, often* was used. We formed the mean of the nine items as an index of social participation in organizations *(α = .63)*. Higher scores reflect more societal participation.

Political participation was measured using the following question "During the last 12 months, have you done any of the following? Have you …" and these eight items: *Contacted a politician, Worked in a political party, Signed a petition, Took part in a public demonstration, Bought or boycotted certain product, Worked in another organization, Discussed with friends about politics, Sent a letter to a newspaper*. A 4-point Likert scale was used with the response options No; Yes, once; Yes, sometimes; Yes, often. The items "*worked in a political party*" (item difficulty = .27 and item discrimination = .31) and "*sent a letter to a newspaper*" (item difficulty = .27 and item discrimination = .36) were excluded from further calculations due to the item analysis. In addition, the content of the item "*worked in a political party*" overlaps with the item "*participation in a political party*". We formed the mean of the six remaining items as an index of political participation (α = .65). Higher scores reflected more political participation.

Local helpfulness and *neighborhood solidarity*. A proxy for the construct local helpfulness is *people in local area help one another*. The response scale was a 7-point Likert scale ranging from *Not at all* to *a high degree*. This variable was only collected in 2013. In the GESIS Society Monitor dataset (Gesis, 2020) *neighborhood solidarity* was recorded with the proxy-item *I feel close to people in the area where I live*. The response scale was a 4-point Likert scale ranging from *Does not apply at all* to *Fully applies*. This variable was only collected in 2018.

2.4. Control variables

Homeownership (owner of the building or owner of the apartment, main tenant or subtenant) and *sex* (men = 0, women = 1) were considered constants across all years in the model. Homeownership was recoded (owner of the building or apartment = 1, main tenant or subtenant = 0). The *personal monthly income* was divided in six factor levels: up to 900 EUR (as the reference category), 900 up to 2000 EUR, 2000 up to 3200 EUR, 3200 up to 4000 EUR, 4000 up to 5000 EUR, 5000 EUR and more. *Education* was categorized according to the International Standard Classification of Education (ISCED 2011): low (lower secondary, as the reference category), mid (upper secondary) and high (bachelor or equivalent and higher). The classification of the German educational qualifications is based on Bohlinger (2012). Low education was set as the reference category. The pupil category was excluded because there was only $n = 1$ pupil in the sample. As the university degree variable was not collected in 2019, it was imputed using the last-observation-carried-forward (LOCF) method.

2.5. Statistical analyses

The association between mobility behavior and social participation in organizations and political participation were tested using a longitudinal linear multilevel model. The longitudinal linear multilevel model allows modeling of interindividual differences over time. In our study the Intra Class Correlation *(ICC)* in the null model for political participation was .69, which indicates that a multilevel analysis should be used (Chen & Chen, 2021). The *ICC* in the null model for social participation in organizations was 0.71, which again suggests a multilevel analysis. Maximum likelihood was chosen as the estimation method. The R package nlme (Pinheiro et al., 2022) was used for model fitting.

To be able to better interpret the values for frequency of bike and car use and as a cross-level interaction between frequency of bike and car use and time should be estimated, the values of frequency of bike and car use were centered on the individual person mean over time (Centering within Cluster, CWC). Another advantage of CWC is a more accurate estimate of the variance of the slope (Enders & Tofighi, 2007). Through this procedure, the variance components are decomposed into a contextual component (Cluster Mean, CM) and a component for development over time within person. Bell et al. (2018) were able to dismiss Kelley et al.'s (2016) statistical concerns arising from the disaggregation of the within effect and the contextual effect at different levels. To illustrate the decomposition of the components (frequency of bike and car use, Centering within Cluster and frequency bike and car use, Cluster Mean) and the cross-level interactions over time, we have listed the related R code for both longitudinal models in appendix (A.1 and A.2).

Four models were estimated. The first model was a null model to estimate the fixed effects at the population level. In the second model, the longitudinal time variable was included, both fixed and random. In the third model, the conditional factor was added as fixed effect. Finally, the control variables and the interaction between respectively frequency of bike and car use and time were added in the fourth model. The deviance statistic showed that the model fit improved significantly both for political participation and for social organizational participation from the unconditional second model to the conditional, extended fourth model.[2]

Since effect sizes in social psychology are usually rather small, significant results were tested for a type S error (sign error) and a type M error (magnitude or exaggeration ratio error) (Gelman & Carlin, 2014). Based on the panel data, MCAR can be assumed, i.e., that the distribution of the occurrence of missing values is independent of the expression on the observed and missing values. Therefore, a pairwise exclusion is a suitable method for the treatment of missing values (Lüdtke et al., 2007).

As we only have data from one year each, the association between mobility behavior and the proxies for helpfulness and neighborhood solidarity were tested using a hierarchical linear regression. Due to

[2] The model comparisons for political participation are: null model and the unconditional model ($p < .001$), unconditional model 2 & conditional model 3 ($p < .001$), conditional model 3 & conditional, extended model 4 ($p = .021$), unconditional model 2 & conditional, extended model 4 ($p < .001$). and for social organizational participation: null model & unconditional model ($p < .001$), unconditional model 2 & conditional model 3 ($p = .001$), conditional model 3 & conditional, extended model 4 ($p = .421$), unconditional model 2 & conditional, extended model 4 ($p = .032$). Although for social organizational participation, Model 4 did not improve over Model 3, we decided to use the same covariates to be comparable to political participation.

multicollinearity in both regressions, the factor level pupil was excluded in the control variable highest school leaving certificate.

3. Results

Means and standard deviations for the relevant variables are reported in Table 1 and the percentages of the highest school leaving certificate levels are shown in Table 2. As can be seen from Table 1, the mean values of the variables recorded longitudinally show relative constancy over time. Both car and bicycle are used regularly by the sample. On average, people used the bike slightly more than on one to three days per month, but less than on one to three days per week. As expected, drivers used their cars modestly more often, but still less than on one to three days per week on average.

3.1. Longitudinal multilevel model for political participation

In all four models of the multilevel longitudinal model of political participation ($n = 387$), the intercept was significantly different from zero. As can be seen from Table 3 in the null model, the overall mean of political participation across years was 1.79. The unconditional Model 2 showed that there was no fixed effect of time on political participation ($\beta = -0.00$, $p = .524$) and a small significant random effect of time ($\tau_{11\ \text{person.year}} = 0.00$, $SD = .04$). Thus, there were significant interindividual differences over time. All corresponding confidence intervals can be found in Table 3. In Model 3, we included the predictors frequency of bike use (CWC), frequency of car use (CWC), frequency of bike use (CM), and frequency of car use (CM) in the model. The conditional Model 3 showed a significant effect for the individual mean for frequency of bike use (CM) on political participation ($\beta = .06$, $p = <.001$) and no significant effect for frequency of car use (CM) ($\beta = -0.02$, $p = .314$). The effect for person-mean centered frequency of bike use (CWC) was close to zero and not significant and the effect frequency of car use (CWC) was slightly negative and not significant. The small significant random effect of time remained unchanged ($\tau_{11\ \text{person.year}} = 0.00$, $SD = .040$).

Final hypothesis testing took place in Model 4. For the predictors, the pattern was like that in model 3. The main effect for frequency of bike use (CM) on political participation was significant ($\beta = .06$, $p = <.001$). The effect of frequency of car use (CM) on political participation was negative and not significant ($\beta = -0.03$, $p = .113$). For the predictors centered on the personal mean (Frequency of bike and car use CWC), we found no variation over time. None of the four interaction terms (Frequency of bike and car use CWC and CM * Year), were significant or had an effect. This means that the frequency of driving or cycling does not influence the development of political participation over time, which indicates that the significant main effect for frequency of bike use (CM) on political participation is stable over time.

Among the control variables, personal income and education were significant. Persons with a medium personal incomes 2000 up to 3200 EUR ($\beta = .08$, $p = .017$), 3200 up to 4000 EUR ($\beta = .09$, $p = .049$), and 4000 up to 5000 EUR ($\beta = .14$, $p = .009$) in contrast to low income (up to 900 EUR) reported significantly higher scores for political participation. Compared to low education, high education was also significant. ($\beta = .11$, $p = .002$), but mid level of education was not.

The significant estimator for frequency of bike use CM had a power of .96, the possible misestimation of the type sign error was 0.0000009% of the time, and the overestimation of the type magnitude error was 1.027 times the effect size, thus the results can be considered quite robust.

3.2. Longitudinal multilevel model for social organizational participation

As can be seen from Table 4, the overall mean value of social organizational participation over the years in the null model was 1.38. The unconditional model 2 showed that there is a significant fixed negative effect of time on social organizational participation ($\beta = -0.01$, $p = .049$) and a small significant random effect ($\tau_{11\ \text{person.year}} = 0.00$, $SD = 0.03$).

Table 1
Descriptive statistics.

	min	max	2014			2015			2016			2017			2018			2019		
			n	*mean*	*sd*	*n*	*mean*	*sd*	*n*	*mean*	*sd*	*n*	*mean*	*sd*	*n*	*mean*	*sd*	*n*	*mean*	*sd*
Frequency of bike use	0	4	389	2.23	1.54	388	2.23	1.55	385	2.14	1.58	393	2.14	1.57	391	2.17	1.56	387	2.22	1.57
Frequency of care use	0	4	395	2.73	1.34	396	2.78	1.33	391	2.75	1.38	394	2.77	1.38	398	2.70	1.42	395	2.75	1.37
Political participation	1	4	383	1.81	.48	391	1.78	.47	379	1.78	.46	381	1.75	.47	382	1.77	.48	386	1.79	.47
Social participation	1	4	385	1.40	.38	381	1.37	.35	383	1.36	.37	390	1.36	.39	382	1.37	.38	382	1.36	.35
Local helpfulness	1	4	401	2.89	.81															
Neighborhood Solidarity	1	4													400	2.5	.77			
Homeownership (owning = 0, tenant = 1)	0	1				400	.36	.48												
Sex (men = 0, women = 1)	0	1	410	.53	.5	410	.53	.5	410	.53	.5	410	.53	.5	410	.53	.5	410	.53	.5

Note.: The min and max values represent the scales bandwidth respectively.

Table 2
Descriptive Statistics Education and Personal income.

	2014		2015		2016		2017		2018		2019	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Education (*N*)	390		390		392		391		393		389	
Low (lower secondary)	120	31	131	34	130	33	126	32	126	32	122	31
Mid (upper secondary)	77	20	74	19	63	16	69	18	66	17	66	17
High (Bachelor or equivalent and higher)	193	49	185	47	199	51	196	50	201	51	201	52
Personal income (*N*)	381		385		385		379		380		369	
up to 900 EUR	89	23	84	22	67	17	69	18	64	17	55	15
900 up to 2000 EUR	136	36	142	37	148	38	139	37	135	36	121	33
2000 up to 3200 EUR	101	25	96	25	107	28	108	28	115	30	119	32
3200 up to 4000 EUR	29	9	36	9	33	9	27	7	27	7	31	8
4000 up to 5000 EUR	14	3	11	3	17	4	23	6	25	6	27	7
5000 EUR and more	12	4	16	4	13	3	13	3	14	4	16	4

In the conditional Model 3, all predictors were included. The conditional Model 3 showed a significant effect for the individual mean for frequency of bike use (CM) on social organizational participation ($\beta = .04, p < .001$) and no significant effect for frequency of car use (CM) ($\beta = .02$, $p = .133$). The effects for person-mean centered frequency of bike use and car use (CWC) were close to zero and not significant. The non-significant fixed effect ($\beta = -0.01, p = .051$) and the significant random effect ($\tau_{11\ \text{person.year}} = 0.00$, $SD = 0.03$) of time remained unchanged.

Final hypothesis testing again took place in Model 4 after adding the control variables homeownership, personal income, education, and sex. Year remained not significant ($\beta = .00, p = .988$) and the main effect for frequency of bike use (CM) on social organizational participation significant ($\beta = .04$, $p = .001$). The effect of frequency of car use (CM) on social organizational participation was not significant ($\beta = .01$, $p = .395$). Again, we found no variation over time for the predictors centered on the personal mean (Frequency of bike and car use CWC), and all four interaction terms (Frequency of bike & car use CWC & CM * Year) were also not significant. This means that the frequency of driving or cycling does not influence the development of social organizational participation over time.

Among the control variables, homeownership was significant. House or apartment owners reported significantly higher scores for social organizational participation than tenants ($\beta = .08$, $p = .031$). In addition, high education in contrast to low education was significant ($\beta = .07$, $p = .014$).

The results can be considered to be quite robust, as the significant estimator for frequency of bike use (CM) had a power .91, the misestimate of type sign error was 0.000006% of the time, and the possible overestimate of type magnitude error is 1.05 times the effect size.

3.3. Hierarchical regression on helpfulness of people and on neighborhood solidarity

As can be seen from Table 5, in the hierarchical regression on helpfulness of people in local area in 2014, after controlling for homeownership, personal income, education, and sex, again frequency of bike use was significant ($b = .14, p = .017$) and car use was not significant ($b = -0.00, p = .983$). Among the control variables, mid educational level in contrast to the reference level of low education ($b = .69$, $p = .006$), and mid personal income ($b = 1.11, p = .039$) in contrast to the low level (up to 900 EUR) were significant.

A similar picture emerges from the hierarchical regression on neighborhood solidarity in 2018, again controlling for homeownership, personal income, education, and sex (Table 6). Frequency of bike use was again significant ($b = .06, p = .041$) and frequency of car use was not significant ($b = .04$, $p = .166$). Among the control variables, homeownership and education were significant. The dummy variable homeownership indicated that owning a house or an apartment has a positive influence on neighborhood solidarity ($b = .29$, $p < .002$).

Since the effect can theoretically have another direction, we estimated four additional alternative multilevel longitudinal models by using means of political participation and social organizational participation and years as estimators for the uncentered means of frequency of bike use and frequency of car use. The comparison of model fits showed a distinct symmetry: As can be seen in Table 7, in contrast to all hypothesized models, the four alternative models with political participation and social organizational participation as predictors for frequency of bike use (uncentered) and frequency of car use (uncentered) did not fit the data well.

4. Discussion

The aim of the present study was to examine how urban mobility behavior (cycling and car use) is related to the orientation towards the common good. Based on annual surveys between 2014 and 2019 of a sample of the German general population we found that cycling rather than driving was positively associated with orientation towards the common good. Our chosen analysis procedure for the longitudinal analysis, the decomposition of the variance components, allowed us to disaggregate the temporal component from the contextual component and evaluate both separately. In simpler terms, this procedure allowed us to control for change over time and determine the effect for the individual person mean. While the temporal effects (interaction terms, random slopes) showed no significant variance, the personal mean in frequency of bike use over time had a small positive and significant effect on social organizational participation and on political participation, even after controlling for the confounding variables. In contrast, the frequency of car use did not have such an effect in any of the models. A similar picture emerged for local helpfulness and neighborhood solidarity, which represent the two other facets of common good orientation. Again, a more frequent use of the bike, had a significant positive effect, whereas the use of the car had no significant effect. In all models, bike use remained significant even after controlling for homeownership, personal income, education, and sex. In fact, bike use was the only variable that had a positive effect and was significant in all four models. Hence, our expectation that people in urban environments have a greater orientation towards the common good when using bicycles than when using cars was supported.

These findings are in line with the findings of an earlier study from Wisconsin, USA, that active transportation participation (walking or cycling) is associated with greater community involvement (Stroope, 2021). Our results show that mobility behavior is associated with participatory activities, helpfulness, and solidarity in the neighborhood. On an individual level, cycling can contribute to the direct experience of the neighborhood environment, which might motivate people to be helpful, to get engaged in social organizational participation and in political participation.

However, the psychological process, thus why this is the case and under which circumstances needs to be further studied. The latest research comes to mixed conclusions about which psychological processes lead to more orientation towards the common good. Current research findings suggest that trust is a mediator for a stronger

Table 3
Longitudinal multilevel regression Political Participation.

Predictors	Null Model Intercept only			Unconditional Model 2 Years as fixed and years as random			Conditional Model 3 Years as fixed and years as random Frequency of bike & car use as fixed			Conditional, extended Model 4 Random Intercept, Random Slope		
	Estimates (SE)	95% *CI*	*p*	*Estimates (SE)*	95% *CI*	*p*	*Estimates (SE)*	95% *CI*	*p*	*Estimates (SE)*	95% *CI*	*p*
Fixed Effects												
(Intercept)	1.79 (.02)	[1.75, 1.83]	<.001***	1.80 (.02)	[1.75, 1.84]	<.001***	1.72 (.06)	[1.60, 1.84]	<.001***	1.69 (.07)	[1.54, 1.83]	<.001***
Years				−.00 (.00)	[-.01, .01]	.524	−.00 (.00)	[-.01, .01]	.527	.00 (.01)	[-.03, .03]	.999
Frequency of bike use CWC							.00 (.01)	[-.02, .02]	.658	−.02 (.02)	[-.06, .02]	.274
Frequency of car use CWC							−.01 (.01)	[-.03, .02]	.546	−.00 (.02)	[-.04, .04]	.976
Frequency of bike use CM							.06 (.01)	[.03, .09]	<.001***	.06 (.02)	[.03, .09]	<.001***
Frequency of car use CM							−.02 (.02)	[-.05, .02]	.314	−.03 (.02)	[-.06, .01]	.113
Homeownership										−.01 (.04)	[-.09, .08]	.884
Personal income (factor)												
up to 900 EUR (ref)												
900 up to 2000 EUR										.02 (.03)	[-.04, .08]	.464
2000 up to 3200 EUR										.08 (.03)	[.01, .15]	.017*
3200 up to 4000 EUR										.09 (.04)	[.00, .17]	.049*
4000 up to 5000 EUR										.14 (.05)	[.04, .24]	.009**
5000 EUR and more										.04 (.06)	[-.08, .17]	.474
Education (factor)												
Low (ref.)												
Mid (upper secondary)										.08 (.04)	[-.00, .16]	.053
High (Bachelor or equivalent and higher)										.11 (.04)	[.04, .18]	.002**
Sex										−.07 (.04)	[-.15, .01]	.091
Year * frequency of bike use CWC										.01 (.01)	[-.00, .02]	.127
Year * frequency of car use CWC										−.00 (.01)	[-.02, .01]	.669
Year * frequency of bike use CM										−.00 (.00)	[-.01, .00]	.154
Year * frequency of car use CM										.00 (.00)	[-.01, .01]	.687
Random effects												
σ^2 (*SD*)	.07 (.26)			.06 (.24)			.06 (.25)			.06 (.24)		
$\tau_{00\ person}$ *(SD)*	.15 (.39)			.16 (.40)			.15 (.39)			.14 (.38)		
$\tau_{11\ person.year}$ *(SD)*				.00 (.04)			.00 (.04)			.00 (.04)		
$\tau_{11\ person.frequency\ bike\ use\ cwc}$ *(SD)*										.00 (.04)		
$\tau_{11\ person.frequency\ car\ use\ cwc}$ *(SD)*										.00 (.00)		
ρ_{01}				−.25			−.22			−.21		
										.22		
										.01		
logLik	−596.6094			−586.391			−576.6644			−559.2433		
AIC	1199.219			1186.782			1175.329			1180.487		
BIC	1215.877			1225.651			1236.409			1352.622		
ICC	.69			.72			.71			.71		
Marginal R^2/Conditional R^2	.000/.694			.000/.724			.037/.724			.066/.726		

Note: N = 387, Observations = 1906, *$p < .05$, **$p < .01$, ***$p < .001$, CWC=Centering within Cluster, CM= Cluster Mean, CGM=Centering Grand Mean.

Table 4
Longitudinal multilevel regression Social Organizational Participation.

Predictors	Null Model Intercept only			Unconditional Model 2 Years as fixed and years as random			Conditional Model 3 Years as fixed and years as random Frequency of bike & car use as fixed			Conditional, extended Model 4 Random Intercept, Random Slope		
	Estimates (SE)	95% *CI*	*p*	*Estimates (SE)*	95% *CI*	*p*	*Estimates (SE)*	95% *CI*	*p*	*Estimates (SE)*	95% *CI*	*p*
Fixed Effects												
(Intercept)	1.38 (.02)	[1.35, 1.42]	<.001***	1.40 (.02)	[1.36, 1.43]	<.001***	1.25 (.05)	[1.15 1.35]	<.001***	1.18 (.06)	[1.06, 1.30]	<.001***
Years				−.01 (.00)	[-.01, −.00]	.049*	−.01 (.00)	[-.01, −.00]	.051	.00 (.01)	[-.02, .02]	.988
Frequency of bike use CWC							.01 (.01)	[-.00, .02]	.179	.01 (.01)	[-.02, .04]	.406
Frequency of car use CWC							.01 (.01)	[-.01, .02]	.403	.01 (.011)	[-.02, .04]	.636
Frequency of bike use CM							.04 (.01)	[.02, .07]	<.001***	.04 (.01)	[.02, .07]	.001**
Frequency of car use CM							.02 (.01)	[-.01, .05]	.133	.01 (.01)	[-.02, .04]	.395
Homeownership										.08 (.04)	[.01, .15]	.031*
Personal income (factor)												
up to 900 EUR (ref)												
900 up to 2000 EUR										−.00 (.02)	[-.04, .04]	.976
2000 up to 3200 EUR										−.01 (.03)	[-.06, .04]	.687
3200 up to 4000 EUR										.00 (.03)	[-.06, .07]	.965
4000 up to 5000 EUR										.05 (.04)	[-.03, .13]	.261
5000 EUR and more										.01 (.05)	[-.08, .11]	.764
Education (factor)												
Low (ref.)												
Mid (upper secondary)										.05 (.03)	[-.01, .11]	.126
High (Bachelor or equivalent and higher)										.07 (.03)	[.01, .12]	.014*
Sex										.05 (.03)	[-.02, .11]	.149
Year * frequency of bike use CWC										−.00 (.01)	[-.01, .01]	.821
Year * frequency of car use CWC										−.00 (.01)	[-.01, .01]	.919
Year * frequency of bike use CM										−.00 (.00)	[-.01, .00]	.308
Year * frequency of car use CM										−.00 (.00)	[-.01, .00]	.821
Random effects												
σ^2 *(SD)*	.04 (.20)			.03 (.18)			.03 (.18)			.03 (.18)		
$\tau_{00\ person}$ *(SD)*	.10 (.31)			.11 (.32)			.10 (.32)			.10 (.31)		
$\tau_{11\ person.year}$ *(SD)*				.00 (.03)			.00 (.03)			.00 (.04)		
$\tau_{11\ person.frequency\ bike\ use\ cwc}$ *(SD)*										.00 (.02)		
$\tau_{11\ person.frequency\ car\ use\ cwc}$ *(SD)*										.00 (.02)		
ρ_{01}				−.20			−0.18			−.19		
										.50		
										−.09		
logLik	−38.75885			−29.33077			−20.47495			−10.17956		
AIC	85.5177			72.66155			62.9499			82.35912		
BIC	107.7497			111.5675			124.0878			254.657		
ICC	.71			.76			.76			.75		
Marginal R^2/Conditional R^2	.000/.712			.001/.764			.031/.764			.051/.766		

Note: N = 387, Observations = 1916, *$p < .05$, **$p < .01$, ***$p < .001$, CWC=Centering within Cluster, CM= Cluster Mean, CGM=Centering Grand Mean.

Table 5
Hierarchical Regression Local helpfulness, 2014

Predictor	*Estimates*	*Estimates*	*p*	sr^2	sr^2
		95% CI			*95% CI*
(Intercept)	3.27	[2.63, 3.92]	<.001***		
Frequency of bike use	.14	[.03, .26]	.017*	.02	[-.01, .06]
Frequency of car use	.00	[-.13, .13]	.983	.00	[-.00, .00]
Homeownership	.08	[-.29, .46]	.662	.00	[-.01, .01]
Personal income (factor)					
up to 900 EUR (ref)					
900 up to 2000 EUR	.04	[-.39, .48]	.846	.00	[-.00, .00]
2000 up to 3200 EUR	.04	[-.50, .57]	.895	.00	[-.00, .00]
3200 up to 4000 EUR	−.09	[-.94, .76]	.837	.00	[-.00, .00]
4000 up to 5000 EUR	1.11	[.06, 2.17]	.039*	.02	[-.01, .05]
5000 EUR and more	−.69	[-1.90, .52]	.264	.00	[-.01, .02]
Education (factor)					
Low (ref.)					
Mid (upper secondary)	.69	[.20, 1.19]	.006**	.03	[-.01, .07]
High (Bachelor or equivalent and higher)	.28	[-.14, .69]	.193	.01	[-.01, .03]
Sex	.24	[-.14, .61]	.217	.01	[-.01, .02]

Note: N = 254, R^2/R^2 adjusted = .090/ .049, *$p < .05$, **$p < .01$, ***$p < 0.001$, sr^2 represents the semi-partial correlation squared.

Table 6
Hierarchical Regression Neighborhood solidarity, 2018

Predictor	*Estimates*	*Estimates*	*p*	sr^2	sr^2
		95% CI			*95% CI*
(Intercept)	2.26	[1.96, 2.57]	<.001***		
Frequency of bike use	.06	[.00, .11]	.041*	.01	[-.01, .03]
Frequency of car use	.04	[-.02, .11]	.166	.01	[-.01, .02]
Homeownership	.29	[.11, .46]	.002**	.03	[-.01, .06]
Personal income (factor)					
up to 900 EUR (ref)					
900 up to 2000 EUR	.11	[-.15, .36]	.412	.00	[-.01, .01]
2000 up to 3200 EUR	−.02	[-.29, .25]	.900	.00	[-.00, .00]
3200 up to 4000 EUR	−.08	[-.46, .31]	.700	.00	[-.00, .00]
4000 up to 5000 EUR	.30	[-.09, .69]	.136	.01	[-.01, .02]
5000 EUR and more	−.27	[-.77, .23]	.291	.00	[-.01, .01]
Education (factor)					
Low (ref.)					
Mid (upper secondary)	−.13	[-.38, .12]	.301	.00	[-.01, .01]
High (Bachelor or equivalent and higher)	−.19	[-.39, .00]	.055	.01	[-.01, .03]
Sex	−.05	[-.22, .12]	.546	.00	[-.01, .01]

Note: N = 339, R^2/R^2 adjusted = .080/ .049, *$p < .05$, **$p < .01$, ***$p < .001$, sr^2 represents the semi-partial correlation squared.

orientation towards the common good. Mattisson et al. (2014) were able to establish a link between general trust, active transportation participation, and social participation. Lanero et al. (2017) state that higher levels of trust in others increase citizens' willingness to contribute to the common good. In this context, social trust acts as a constitutive element for coordination and cooperation and brings about a stronger community orientation and, as a consequence, active civic engagement. As early as 1961, Jacobs (1993) showed that social trust is formed over time from many small public contacts. The multitude of mostly casual public contacts would give rise to helpfulness and a social identity of people, associated with respect and trust. People who travel by bike experience the local infrastructure more directly, recognize social grievances and see people in need of help earlier. Cycling in big cities not only offers a high potential to experience the social environment, but also enables spontaneous interaction with other mobile people, such as cyclists, pedestrians or lingering people. Te Brömmelstroet et al. (2017) state that cyclists are in no way visually or physically shielded from their environment and therefore have all modalities of perception at their disposal. This is a structural prerequisite for social interactions in public space. In addition, Wickes et al. (2018) were able to show that regular, frequent neighborhood contact contributes to the development of a shared identity and that these interactions are associated with greater orientation towards the common good and attachment to place.

These bindings to a place, *place attachment,* could represent another alternative explanation. Place attachment captures an individual's emotional attachment to their social and physical environment (Brown et al., 2003). The localized form of attachment to a place provides a sense of security and maintains group identities (Hays, 2016). Leyden (2003) was able to show for Ireland that neighborhood walkability was associated with a larger social network and higher *neighborhood attachment*. In addition, Dang et al. (2021) were able to demonstrate that place attachment and civic responsibility mediate the effect of neighborhood trust on intention to engage locally. Anguelovski (2013) confirmed this relationship between local neighborhood attachment and willingness to engage in community well-being and improve local conditions. This is consistent with findings by Manzo and Perkins (2006), which indicate that there is a strong relationship between attachment to a place and willingness to engage in community development. Through environmental and community psychology these findings are replicated (Lewicka, 2005; Scannell & Gifford, 2010; Simonson et al., 2021). Accordingly, place attachment is associated with civic engagement, citizen participation, and environmentally friendly behavior. Following Wickes et al. (2018), regular, frequent interactions with the social and spatial environment lead to the development of more place attachment. Because cyclists interact particularly frequently with the social and spatial environment, it is conceivable, following Wickes et al. (2018), that place attachment is a mediator between cycling and the focus on common good.

Table 7
Modell fit comparison between alternative multilevel longitudinal models.

	Modell comparison with social organizational participation and frequency of bike use		Modell comparison with social organizational participation and frequency of car use		Modell comparison with political participation and frequency of bike use		Modell comparison with political participation and frequency of car use	
	soc. part. (Y) bike use (X)	bike use (Y) soc. part. (X)	soc. part. (Y) car use (X)	car use (Y) soc. part. (X)	pol. part (Y) bike use (X)	bike use (Y) pol. part (X)	pol. part (Y) car use (X)	car use (Y) pol. part (X)
AIC	50.501	5379.088	54.036	4841.778	1278.387	5344.879	1283.208	4925.427
BIC	95.525	5424.112	99.060	4886.783	1323.392	5389.884	1328.213	4970.451
logLik	−17.250	−2681.544	−19.018	−2412.889	−631.193	−2664.440	−633.604	−2454.71

Note: bike use = frequency of bike use (uncentered), car use = frequency of car use (uncentered), soc. part. = social organizational participation, pol. part. = political participation, Y = dependent variable, X = independent variable incl. years. The models with social organizational participation and political participation as the dependent variable represent the final models.

When looking at the control variables, homeownership deserves special attention. House ownership was significant for social organizational participation and solidarity, but not for helpfulness or political participation. It is conceivable that people who own apartments or houses invest more resources in shaping their own environment, but not in personal help or more general political activity. This is consistent with findings by Wood et al. (2010), which showed that homeownership, but not length of residence in the neighborhood, is a primary predictor of neighborly sense of community.

4.1. Limitations

A limitation of this study is that pedestrian traffic was not considered in the study, although walking accounts for between 30 and 40% of German urban traffic movements (Nobis et al., 2019). Data on pedestrian traffic was not collected by GESIS (Gesis, 2020). Future studies should therefore include pedestrian traffic, but also all other transport modalities, such as public transport, scooters, skateboards or motorcycles in the models. It should also be mentioned that GESIS (Gesis, 2020) recorded mobility behavior as a self-assessment and that this does not represent the behavior actually observed or documented. In future studies, experience sampling methods with mobile devices would be conceivable for this purpose (Pejovic et al., 2016).

Another limitation is that the results are not necessarily transferable to other contexts and countries. The impact of individual mobility behavior on orientation towards the common good is influenced by many confounding conditions, such as different modal splits, different urban, social or topographic conditions in local cities. Nevertheless, one advantage of this study is the large longitudinal sample with representative data for adult residents of major German cities.

Our analyses are restricted to the level of participants. However, it can be expected that mobility behavior is to some extent also influenced by (topographical) characteristics of the city. For further research, multidimensional models would be conceivable to investigate the effects of transport participation for the different mobility modes on orientation towards the common good - both at the level of individuals and at the level of cities and society. Dang et al. (2021) were able to show that the sociography of neighborhoods plays an important role in social participation. Therefore, future studies should consider social origins and migrant situations within cities or even neighborhoods to better reflect social inequalities within local structures.

Finally, due to the study design, we cannot rule out reverse causality. Even if the theoretical process model suggests a direction of action as described above, it is possible that people who help others or are socially involved are more likely to cycle. Our assumed causal direction receives some confirmation because the model fit was worse for the inverse relationship (Table 7). However, it would also be conceivable that the effect works in both directions. Despite these limitations, this study contributes to previous research by using longitudinal, representative data from Germany, because it allows for robust estimates at the individual level by disaggregating variances, because it controls for confounding variables, and because it captures common good orientation on three dimensions.

4.2. Conclusion

This research examined the psychological effects of car and bicycle use on social participation, solidarity, and helpfulness in large cities. This research project shows that transportation participation is associated with orientation towards the common good. Orientation towards the common good is an effective means against the progressive loss of social structures, against constant urban isolation, against the social divisive potential of pandemics and needed for better migrant inclusion. The findings of this work can be used by policy makers and planners in public administration to implement measures related to the experience of orientation towards the common good. Such measures could include steps to move away from car-oriented design of neighborhood environments and increase cycling possibilities. As a result, people can stay there and feel comfortable, or removing obstacles in public spaces. Local governments could view neighborhoods not as administrative geographically delineated places, but as small-scale spaces designed to provide the potential for high levels of interaction.

The benefits of cycling over driving are more profound and sustainable than previously thought, underscoring the importance of promoting green transportation.

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Author statement

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We further confirm that any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct

email address which is accessible by the Corresponding Author.

Appendix

R-Code for the longitudinal multilevel models

A.1 (political_participation)

```
lme(political_participation ~ year
      + frequency_of_bike_use_cm + frequency_car_use_cm
      + frequency_of_bike_use_cwc + frequency_of_car_use_cwc
      + Frequency_of_bike_use_cm*year + frequency_of_car_use_cm*year
      + frequency_of_bike_use_cwc*year + frequency_of_car_use_cwc*year
      + homeownership + personal_income + education + sex,
      random = ~ year
      + frequency_of_bike_use_cwc + frequency_of_car_use_cwc | person_ID)
```

A.2 (social_organisational_participation)

```
lme(social_organisational_participation ~ year
      + frequency_of_bike_use_cm + frequency_car_use_cm
      + frequency_of_bike_use_cwc + frequency_of_car_use_cwc
      + Frequency_of_bike_use_cm*year + frequency_of_car_use_cm*year
      + frequency_of_bike_use_cwc*year + frequency_of_car_use_cwc*year
      + homeownership + personal_income + education + sex,
      random = ~ year
      + frequency_of_bike_use_cwc + frequency_of_car_use_cwc | person_ID)
```

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