Erratum: Climate change and air pollution: the connection between traffic intervention policies and public acceptance in a local context

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During the production process errors were introduced to the figures in tables 1 and 2. The following are the corrected figures.

Table 1. Shows the within-cluster distribution of active mobility variables (car, bike and public transit use). A v.test value greater than 1.96 corresponds to a p-value less than 0.05; the sign of the v.test indicates if the mean of the cluster is under or over-expressed for the category. Only items with a p-value less than 5% are included as this shows that one category is significantly linked to the other categories.

| Variable | Category                  | C1—unconcerned car-oriented policy-rejecters | C2—multimodal policy-skeptics | C3—green-travel policy-optimists | C4—dedicated-cyclists and policy-enthusiasts |
|----------|---------------------------|---------------------------------------------|-------------------------------|---------------------------------|---------------------------------------------|
|          |                           | Mod.Cla (%) | v.test     | Mod.Cla (%) | v.test     | Mod.Cla (%) | v.test     | Mod.Cla (%) | v.test     |
| Car use  | Daily                     | 95          | 33.543     | 61          | −6.229     | 25          | −18.941    | 2           | −24.263    |
|          | 1–3 d/week                | 3           | −24.643    | 33          | 13.141     | 55          | 16.442     | 13          | −3.080     |
|          | 1–3 d/month               | 1           | −12.340    | 15          | 7.887      | 17          | 7.701      |             |            |
|          | Less than monthly         | 0           | −7.382     | 1           | −5.243     | 20          | 14.222     |             |            |
|          | Never                     | 1           | −10.436    | 0           | −9.871     | 47          | 23.392     |             |            |
| Bike use | Daily                     | 4           | −26.726    | 28          | 4.172      | 41          | 8.718      | 25          | −3.118     |
|          | 1–3 d/week                | 29          | −2.944     | 41          | 8.718      | 25          | −3.118     | 14          | −7.003     |
|          | 1–3 d/month               | 26          | 8.229      | 10          | −5.507     | 7           | −3.671     | 4           | −8.085     |
|          | Less than monthly         | 20          | 12.758     | 8           | −6.722     | 4           | −6.004     | 2           | −6.628     |
|          | Never                     | 20          | 14.266     | 4           | −10.680    | 7           | −3.671     | 4           | −4.807     |
| Public transit use | Daily | 6           | −16.836    | 16          | −2.089     | 56          | 18.752     | 37          | 7.741      |
|          | 1–3 d/week                | 4           | −14.493    | 15          | 4.701      | 22          | 6.232      | 29          | 7.984      |
|          | 1–3 d/month               | 13          | −11.065    | 33          | 12.338     | 13          | −4.424     | 28          | 2.814      |
|          | Less than monthly         | 30          | 8.804      | 12          | −15.411    | 3           | −11.392    | 5           | −8.430     |
|          | Never                     | 47          | 26.211     | 6           | −11.332    | 2           | −11.522    |             |            |
Table 2. Shows the within-cluster (Mod.Cla) and across-cluster (Cla.Mod) distributions of active environmental and measure-related variables. A v.test value greater than 1.96 corresponds to a $p$-value less than 0.05; the sign of the v.test indicates if the mean of the cluster is under or over-expressed for the category. Only items with a $p$-value less than 5% are included as this shows that one category is significantly linked to the other categories.

| Variable | Category | C1 | C2 | C3 | C4 |
|----------|----------|----|----|----|----|
|          | Cla. Mod (%) | Mod.Cla (%) | v.test | Cla. Mod (%) | Mod.Cla (%) | v.test | Cla. Mod (%) | Mod.Cla (%) | v.test | Cla. Mod (%) | Mod.Cla (%) | v.test |
| Effect of Potsdam AQ measure on mobility | Improve a lot | 2 | 0 | −10.262 | 15 | 1 | −4.532 | 68 | 26 | 15.745 |
| | Improve | 3 | 0 | −10.696 | 18 | 2 | −4.125 | 23 | 7 | 3.512 | 57 | 24 | 14.080 |
| | No change | 9 | 2 | −14.248 | 22 | 16 | 5.569 | 29 | 31 | 11.455 |
| | Worsen | 58 | 88 | 22.223 | 32 | 65 | −4.896 | 9 | 54 | −7.581 | 1 | 12 | −21.077 |
| | Worsen a lot | 56 | 55 | 11.026 | 32 | 41 | −3.444 | 1 | 8 | −13.85 |
| Effect of Potsdam AQ measure on life quality | Improve a lot | 4 | 0 | −10.842 | 18 | 2 | −4.212 | 21 | 7 | 3.251 | 57 | 27 | 14.847 |
| | Improve | 11 | 2 | −12.733 | 43 | 43 | 17.221 | 5 | 9 | −3.064 |
| | No change | 59 | 2 | −3.064 | 18 | 19 | 5.028 | 4 | 13 | −6.144 |
| | Worsen | 41 | 34 | 5.028 | 25 | 25 | 11.026 | 32 | 65 | −4.896 | 9 | 54 | −7.581 |
| | Worsen a lot | 56 | 55 | 11.026 | 32 | 41 | −3.444 | 1 | 8 | −13.85 |
| Support for Potsdam AQ measure | Yes, I support it | 4 | 1 | −19.045 | 24 | 7 | −4.808 | 20 | 18 | 5.201 | 52 | 70 | 25.374 |
| | No. I don’t support it | 52 | 98 | 20.964 | 36 | 88 | 2.205 | 10 | 75 | −6.154 | 2 | 22 | −25.498 |
| | I am Undecided | 12 | 1 | −8.216 | 50 | 5 | −3.514 | 20 | 6 | 2.880 | 18 | 8 | 3.724 |
| Investments in traffic-reducing measures | I strongly support it | 13 | 6 | −20.452 | 21 | 37 | 8.591 | 32 | 82 | 23.217 |
| | I support it | 36 | 19 | −6.911 | 47 | 33 | 8.625 | 14 | 11 | −5.597 |
| | I don’t support it | 58 | 29 | 7.671 | 29 | 33 | 8.625 | 14 | 11 | −5.597 |
| | I don’t support it at all | 70 | 42 | 17.275 | 24 | 19 | −8.274 | 6 | 14 | −6.623 | 1 | 1 | −12.307 |
| | I am Undecided | 42 | 6 | 2.030 | 42 | 6 | 2.030 | 42 | 6 | 2.030 | 42 | 6 | 2.030 |
| Traffic reducing measures improve air quality | Yes | 14 | 6 | −19.681 | 19 | 32 | 6.571 | 32 | 80 | 22.757 |
| | No | 54 | 94 | 19.681 | 10 | 68 | −6.571 | 2 | 20 | −22.757 |
| Consideration of environment in mobility decisions | 1 = absolutely important | 25 | 6 | −9.306 | 22 | 7 | −5.772 | 17 | 18 | 3.799 | 35 | 53 | 17.808 |
| | 2 | 36 | 19 | −6.608 | 17 | 33 | 4.979 | 11 | 31 | 3.257 |
| | 3 | 51 | 39 | 4.036 | 38 | 39 | 2.778 | 9 | 29 | −3.031 | 2 | 11 | −9.729 |
| | 4 | 52 | 15 | 2.749 | 39 | 15 | 1.994 | 8 | 9 | −2.807 | 1 | 3 | −6.432 |
| | 5 | 58 | 9 | 3.741 | 7 | 5 | −2.059 | 2 | 1 | −4.219 |
| | 6 = not important at all | 63 | 10 | 5.878 | 28 | 6 | −2.438 | 1 | 1 | −5.393 |
| Aim of Potsdam AQ measure to improve mobility alternatives | | | | | | | | | | | | |
Table 2. (Continued.)

| Variable                         | Category          | Cla. Mod (%) | Mod.Cla (%) | v.test | Cla. Mod (%) | Mod.Cla (%) | v.test | Cla. Mod (%) | Mod.Cla (%) | v.test | Cla. Mod (%) | Mod.Cla (%) | v.test |
|----------------------------------|-------------------|--------------|-------------|--------|--------------|-------------|--------|--------------|-------------|--------|--------------|-------------|--------|
|                                 | Very high priority| 17           | 2           | -8.167 | 27           | 4           | -2.252 | 17           | 16          | 3.365  | 10           | 27          | 2.175  |
|                                 | High priority     | 27           | 6           | -8.226 | 38           | 18          | -5.245 | 40           | 25          | 3.629  | 55           | 74          | 13.242 |
|                                 | Low priority      | 38           | 18          | -5.245 | 55           | 74          | 13.242 | 10           | 54          | -3.840 | 2            | 13          | -17.410 |
|                                 | Very low priority | 55           | 74          | 13.242 |              |              |        |              |              |        |              |              |        |
|                                 | Air quality concern|              |              |        |              |              |        |              |              |        |              |              |        |
|                                 | 1 = unconcerned   | 62           | 24          | 8.781  | 28           | 14          | -4.298 | 9            | 14          | -2.154 | 2            | 4           | -7.293 |
|                                 | 2                | 52           | 28          | 4.312  | 3            | 9           | 2.381  | 8            | 17          | -3.823 | 3            | 8           | -7.090 |
|                                 | 3                |              | 39          | 30      | 2.854  | 9            | 22       | -2.458 | 5            | 17          | -4.193 |
|                                 | 4                | 33           | 10          | -6.560 | 39          | 16          | 2.201  | 14           | 18          | 1.991  | 14           | 26          | 5.302  |
|                                 | 5                | 23           | 4           | -8.845 | 20          | 16          | 4.831  | 24           | 27          | 9.424  |              |              |        |
|                                 | 6 = very concerned| 18           | 2           | -7.377 | 27           | 3           | -2.205 | 28           | 11          | 5.848  | 27           | 16          | 7.420  |
|                                 | Air quality (aq) rating|              |              |        |              |              |        |              |              |        |              |              |        |
|                                 | 1 = aq is very good|              |              |        |              |              |        |              |              |        |              |              |        |
|                                 | 2                |              |              |        |              |              |        |              |              |        |              |              |        |
|                                 | 3                |              | 37          | 40      | 2.081  | 10           | 33       | -2.156 | 14           | 21          | 4.928  |              |              |        |
|                                 | 4                |              | 41          | 10      | -1.986 |              |          |        | 22           | 9           | 3.890  | 20           | 12          | 5.160  |
|                                 | 5                |              | 30          | 3       | -4.437 |              |          |        | 25           | 4           | 3.116  |              |              |        |
|                                 | 6 = aq is very bad|              |              |        |              |              |        |              |              |        |              |              |        |
|                                 | Climate change concern|              |              |        |              |              |        |              |              |        |              |              |        |
|                                 | 1 = unconcerned   | 60           | 8           | 4.366  | 27           | 5           | -2.381 | 4            | 3           | -2.105 | 2            | 4           | -4.742 |
|                                 | 2                | 53           | 13          | 2.911  | 31           | 22          | -2.680 | 9            | 20          | -2.407 | 2            | 8           | -7.490 |
|                                 | 3                | 57           | 31          | 7.672  | 31           | 22          | -2.680 | 9            | 16          | -2.280 | 5            | 12          | -3.376 |
|                                 | 4                | 39           | 22          | 2.762  | 9            | 16          | -2.280 | 5            | 12          | -3.376 |              |              |        |
|                                 | 5                | 36           | 15          | -5.630 | 40           | 22          | 3.018  | 11           | 27          | 3.230  |              |              |        |
|                                 | 6 = very concerned| 29           | 11          | -9.255 | 19           | 29          | 5.831  | 20           | 46          | 11.340 |              |              |        |
|                                 | Affected by climate change|              |              |        |              |              |        |              |              |        |              |              |        |
|                                 | Yes              | 35           | 30          | -10.204 | 37           | 42          | 2.181  | 15           | 53          | 5.668  | 12           | 63          | 8.115  |
|                                 | No               | 55           | 49          | 8.742  | 33           | 39          | -2.049 | 8            | 30          | -4.675 | 4            | 20          | -7.461 |
|                                 | Air pollution effect on health |              |              |        |              |              |        |              |              |        |              |              |        |
|                                 | Yes              | 38           | 47          | -10.600 |              |              |        |              |              |        |              |              |        |
|                                 | No               | 56           | 53          | 10.600  |              |              |        |              |              |        |              |              |        |
|                                 | Allocation of funds to environmental protection|              |              |        |              |              |        |              |              |        |              |              |        |
|                                 | Very high priority| 30           | 11          | -8.738 | 28           | 14          | -3.807 | 18           | 28          | 5.522  | 23           | 53          | 13.855 |
|                                 | High priority    | 38           | 64          | 4.129  | 10           | 52          | -2.982 | 6            | 43          | -5.584 |              |              |        |
Table 2. (Continued.)

| Variable                      | Category        | C1 Cla. Mod (%) | C1 Mod.Cla (%) | C1 v.test | C2 Cla. Mod (%) | C2 Mod.Cla (%) | C2 v.test | C3 Cla. Mod (%) | C3 Mod.Cla (%) | C3 v.test | C4 Cla. Mod (%) | C4 Mod.Cla (%) | C4 v.test |
|-------------------------------|-----------------|----------------|----------------|-----------|----------------|----------------|-----------|----------------|----------------|-----------|----------------|----------------|-----------|
| Low priority                  |                 | 55             | 15             | 3.920     | 8              | 9              | −2.369    | 2              | 3              | −5.845    | 1              | 0              | −2.123    |
| Very low priority             |                 | 61             | 3              | 2.492     |               |               |           | 2              | 1              | −4.295    | 10             | 10             |          |
| Intention to increase bicycle use | Yes           | 10             | 6              | −28.063   | 47            | 36             | 9.097     | 21             | 49             | 10.033    | 23             | 80             | 18.869    |
|                               | No              | 71             | 77             | 30.046    | 20            | 28             | −18.886   | 8              | 34             | −6.876    | 2              | 10             | −14.295   |
| Intention to increase public transit use | Yes | 10             | 4              | −20.801   | 28            | 42             | 12.761    | 27             | 61             | 16.970    | 2              | 17             | −15.099   |
|                               | No              | 62             | 82             | 24.878    | 28            | 48             | −10.346   | 7              | 37             | −9.817    | 2              | 17             |           |
Climate change and air pollution: the connection between traffic intervention policies and public acceptance in a local context

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Keywords: air quality, climate change, policy attitudes, travel behaviour, sustainable urban transport, cluster analysis, transdisciplinary

Abstract

Urban mobility is the main source of air pollution in Europe and accounts for 25% of greenhouse gas emissions. In order to address this, a range of interventions and policies are being implemented across major European cities and studies in sustainable urban transport have proliferated. One such mitigation strategy involves redesigning urban form through ‘hard’ traffic policies, with a view of decreasing emission levels and therefore mitigating the effects of air pollution and climate change. However, efforts to assess public response to such interventions and the effectiveness of policy instruments in promoting sustainable travel in cities remain sparse. The city of Potsdam, Germany implemented a trial traffic measure aimed at reducing motorized traffic and promoting the use of bicycles and public transport systems. This study analysed data from 3553 survey participants who responded to a survey conducted prior to the implementation of the traffic measure. We aimed to identify mobility behaviours and underlying attitudes within the context of a ‘hard’ policy instrument, in order to obtain insight into the opportunities to more effectively define policy priorities that improve air quality and upscale climate mitigation. An exploratory cluster analysis identified four groups, characterised by mobility habits, their attitudes towards the measure, and general level of environmental concern. By identifying and understanding the differing attitudes and perceptions across population groups we are able to highlight group-specific barriers and opportunities, as well as potential transition pathways to encourage more sustainable transportation use. This study exemplifies how context can help to further shape mobility group typologies, identify policy-related priorities useful for decision-makers and assess the feasibility of policy instruments to facilitate a transformation towards more sustainable cities.

1. Introduction

In 2018, the road transport sector contributed 25% of the total carbon dioxide emissions in Europe (International Energy Agency 2018), and was the largest contributor to air pollutant emissions, such as total nitrogen oxides (NO\textsubscript{x}), and a significant contributor to particulate matter (European Environment Agency 2018). Improving air quality by reducing emissions not only improves human health and the health of ecosystems and agriculture, but also mitigates climate change (Shindell \textit{et al} 2012, Melamed \textit{et al} 2016). In order to improve air quality, holistic solutions involving technological developments, structural changes and societal behaviour changes are needed to transform and decarbonise the transport sector, particularly in cities (European Environment Agency 2018).

While the solution lies heavily in redesigning urban form by making cities more compact and providing greater space for sustainable transport modes (Banister 2011, Hickman \textit{et al} 2013, Creutzig \textit{et al} 2016), understanding and transforming individual mobility behaviour is vital to the success of transport policies (Banister 2011, Mattauch \textit{et al} 2015). Mattauch \textit{et al} (2015) indicate that transport policy instruments fall into four general categories: (i) bans and direct regulations,
(ii) monetary incentives, (iii) education and information, and (iv) changes to the built environment. Implementing these policies, however, remains challenging and there is evidence that policy interventions utilizing only a single instrument are often ineffective at modifying mobility behaviour (Graham-Rowe et al. 2011). Combining so-called ‘hard’ instruments (i.e. bans and regulations) with ‘soft’ interventions (i.e. education and communication) is recommended as an effective strategy when designing interventions (Gärling and Schuitema 2007). The most difficult question, though, seems to be when to implement such policies (Bemelmans-Videc et al. 1998), and for whom? As such, identifying underlying mobility behaviours and attitudes of the target population is a crucial step in tailoring policies to more effectively influence the mobility patterns of different sub-groups.

Segmentation techniques have often been used to identify mobility groups based on travel behaviour, sociological constructs, and environmental perceptions (Anable 2005, Hunecke et al. 2010, Prillwitz and Barr 2011, Kandt et al. 2015, Nilsson et al. 2016). Such analyses can be done at a variety of scales and are useful for discerning context-specific differences in mobility habits and preferences to enhance the effectiveness of transport policy and better guide its evaluation (Matzau et al. 2015). Although previous studies have built high-quality typologies based on mobility attitudes and behaviour, such studies are rarely tested in the context of a mobility intervention policy seeking to improve air quality and are therefore often limited in scope with regards to giving an estimation of how different groups would behave under such policy regimes. This study takes an explorative approach to analyse and identify patterns in reaction to policies by contextualising these typologies within an air quality related traffic-reducing measure. We thereby aim to contribute to the knowledge about sustainable transformation of the transport sector, the improvement of air quality, and the mitigation of climate change.

In the city of Potsdam, Germany, air pollution on one of the most heavily-trafficked streets, the Zeppelinstrasse, exceeded the European Union (EU) and World Health Organization limit-value of 40 μg m⁻³ for nitrogen dioxide (NO₂) concentrations for almost a decade. In June 2017, the city implemented a series of traffic-reducing measures to improve air quality and comply with EU law. These measures were designed to encourage more sustainable transportation use through greater uptake of active and public transport and involved a reduction in the number of lanes available for cars, the re-allocation of road space for a dedicated bike lane and increased frequency of public buses. For the purpose of this study they will hereafter be referred to as the ‘Potsdam Air Quality (AQ) Measure’. Prior to and after the implementation of the Potsdam AQ measure, online surveys were conducted in the region. These were specifically designed to assess the attitude of respondents towards the measure specifically and similar types of measures more generally, and their general level of environmental concern, particularly in relation to air quality and climate change. This study aimed to identify and describe specific groups within the population based on the survey responses, to improve understanding of these groups, their mobility behaviours and underlying values. This can provide valuable insight useful for designing similar policies targeting behavioural change more effectively in the future. Moreover, because of the recent ruling in the German Federal Administrative Court in 2018 approving bans on diesel vehicles to improve air quality on heavily polluted streets (Bundesverwaltungsgericht 2018), ‘hard’ transport measures may become more common in German cities. Thus, this study also seeks to exemplify how scientific research can be coupled with urban transport policy to assist in evaluating the effectiveness of such measures in changing underlying mobility behaviours to improve air quality and mitigate climate change.

2. Methodology

In coordination with the Potsdam AQ measure, an online survey was conducted seeking to assess varying aspects of public perceptions regarding the traffic measure, mobility habits, and air quality and climate change. The questionnaire was developed in collaboration with the traffic development, city planning, and civic participation departments of the Potsdam city council and informed by previous survey research conducted by the Potsdam city council (Landeshauptstadt Potsdam 2015), the German Environment Ministry (Benthin et al. 2016), and the European Commission (European Commission 2013), and other studies on environmental perceptions (Bickerstaff and Walker 2001, Brody et al. 2004, BMVI 2010, Simone et al. 2012, Oltra and Sala 2018, Valeri et al. 2016). Further detail on study context and data collection methods can be found in Schmitz et al. (2018).

2.1. Multiple correspondence analysis (MCA)

MCA is a commonly-used method in analysing survey data for reducing the high number of variables in a categorical dataset into more precise ‘factors’ or ‘dimensions’ for the purpose of exploratory data analysis (Benzécri 1973, Greenacre and Blaisius 2006, Di Franco 2016). It can be likened to a principal component analysis for categorical data due to similarities in interpretation and purpose. In order to break down the categorical data from the survey into a smaller number of dimensions, an MCA was performed using the FactoMineR package (Husson et al. 2010, Husson et al. 2018), conducted in R Version 1.0.153. Owing to the voluntary nature of surveys, a common and challenging problem is the occurrence of missing responses in the questionnaire data. Due to the large size of the dataset (~3500 observations of...
100 + items), and the occurrence of cells with missing values (5.6% of the cells in the observation by variable matrix produced by this questionnaire), the missMDA package was used to impute missing values (Josse and Husson 2016). This allowed for a complete dataset to be passed on for analysis using the MCA. Categories with low counts were then ‘ventilated’ by randomly distributing individual responses across the other categories of a particular variable (Di Franco 2016), while retaining the proportions associated with each variable (Husson et al 2010).

A crucial component of MCA is the initial designation of variables as ‘active’ or ‘supplementary’ when creating the dimensions. ‘Active’ variables and their categories contribute directly to the formation of the dimensions. ‘Supplementary’ variables and categories do not exert an influence on dimension construction, however, they can still be useful to analysis as they will appear on the factorial axes in relation to the dimensions (Di Franco 2016). As this analysis sought to assess mobility behaviours of survey respondents, only those variables directly related to mobility behaviours were designated as ‘active’. These included (1) car and bike ownership; (2) perceived access with, frequency of use of, and perceived future use of four modes of transport (car, bike, public transit, and walking); (3) frequency of use of the Zeppelinstrasse for private and work transport with those same four modes; (4) commute distance (km) to place of work or study; and (5) which routes belong to their daily routines (to work, to school/university, etc). All other variables were classified as ‘supplementary’ and were used for further analysis and characterisation of each dimension.

2.2. Agglomerative hierarchical clustering
Following completion of the MCA, the FactoMineR package was used to complete a cluster analysis on the MCA object using the HCPC function. This function uses an agglomerative hierarchical clustering method with Ward’s algorithm to group respondents using the dimensions identified from the MCA analysis (Husson et al 2010). Further details on the incorporation of this method into the HCPC function in R can be found in Husson et al (2010). Once created, the relationships between each cluster and variable categories, MCA dimensions, and individuals were scrutinized to determine the defining characteristics of each cluster. These were then represented graphically in a Euclidean space with the top two-dimensions on the x and y axes.

3. Results

3.1. Cluster variables
Four groups were derived from the hierarchical cluster analysis: cluster 1 ‘unconcerned car-dependent policy-rejecters’; cluster 2 ‘multimodal policy-sceptics’; cluster 3 ‘green-travel policy-optimists’, and cluster 4 ‘bike-dedicated policy-enthusiasts’. The hierarchical clustering performed on the MCA found the following variables to have the largest influence on the characterisation of the clusters: (i) support for investments in traffic-reducing measures and the Potsdam AQ measure, (ii) the objectives and diverse effects of the Potsdam AQ measure, and (iii) the importance of the environment when making mobility decisions. As presented in tables 1 and 2, the cluster results are described according to their within-cluster membership i.e. the percentage of respondents within a cluster that selected the respective category (Mod.Cla) and by their across-cluster membership i.e. the percentage of respondents belonging to a cluster that selected the respective category (Cla.Mod). Only statistically significant categories were included in tables 1 and 2. Sociodemographic characteristics are presented in table 3, grouped according to their cluster assignment. Corresponding question codes and categories are presented in the supplementary information, available online at stacks.iop.org/ERL/14/085008/mmedia.

3.2. Within-cluster characteristics

3.2.1. Cluster 1—unconcerned car-dependent policy-rejecters
Cluster 1 is characterised by high car use and strong rejection of the Potsdam AQ measure (table 1). This group had the highest proportion of members across the four clusters, with 46% of all respondents assigned to this cluster. This group was characterised by frequent and largely exclusive car usage relative to other mobility options. 95% travelled by car on a daily basis and 81% commute daily by car on the Zeppelinstrasse, while bicycles are used less than once a month or never by 40%, and public transit by 77%. While bicycles and public transit are used less than once a month or never by 40% and 77%, respectively. More than half answered that they have no future intentions to cycle or increase public transport usage (71% and 62%, respectively).

The majority of this group opposed the Potsdam AQ measure, with 98% indicating that they did not support the Potsdam AQ measure (table 2). This group also had the highest share of individuals that believe reducing traffic in polluted cities would not be an effective measure to improve air quality (94%) and that the measure would worsen their own mobility ‘a lot’ (88%). They also displayed a relatively low concern for air quality and climate change, with 24% and 8% indicating they were ‘unconcerned’ about these issues. Furthermore, 49% of participants in this group believed they would not be affected by climate change, and 53% stated that air pollution is not a major health threat.

3.2.2. Cluster 2—multimodal policy-sceptics
Cluster 2 was the second largest cluster (35% of total respondents) and displayed the greatest mixed use of mobility options of identified clusters (table 1). The
respondents in this group showed some support for the Potsdam AQ measure, but were mostly undecided. Their mobility tendencies are diverse; on 1–3 d a week, 33% use a car, 41% use a bike and 15% use public transit, while 28% stated daily bike use. Access to bicycles and public transit were mostly ‘good’ while car access was ‘moderate’, although two-thirds of the cluster members owned a car (67%), suggesting car use for convenience.

This group had the second highest proportion of individuals that rejected the measure (88%) (table 2). As was the case with cluster 1, 65% of this group perceived that the Potsdam AQ measure would worsen their own mobility. Along with this group’s tendency to use environmentally friendly modes of mobility more often, they show a moderate concern for climate change (20%). The importance of the environment when making mobility decisions was only moderate, as 39% selected category 3 (where 1 = absolutely important – 6 = not important at all). However, 64% of this group supported a ‘high priority’ for the allocation of public funds for environmental protection.

### 3.2.3. Cluster 3—green-travel policy-optimists
Cluster 3 was composed predominantly of daily bike and public transit users that showed high acceptability for the Potsdam AQ measure and a high level of concern for air quality and climate change. This group represented only 11% of all respondents, considerably smaller than clusters 1 and 2. Just over half of this group (54%) cycle daily and 56% use public transit daily, while 22% use it 1–3 d a week. Over half (55%) of the cluster members also stated a car use of 1–3 d a week and the majority owned a car (81%).

Compared to the clusters 1 and 2, this group had relatively higher level of support for the Potsdam AQ measure (18%). Similarly, more than half of the cluster members were supportive or highly supportive of investments in traffic-reducing measures (29% and 37%, respectively). This cluster showed a high concern for air quality and climate change, however, the share of participants who selected category 6 (very concerned) was larger for climate change than air quality (29% and 11%, respectively). This was further reflected in the moderate importance of the environment when making mobility-related decisions, as 66% selected categories 1 or 2 (where 1 = absolutely important – 6 = not important at all).

### 3.2.4. Cluster 4—bike-dedicated policy-enthusiasts
Cluster 4 was characterised by dedicated bicycle users who have a high acceptability for the Potsdam AQ measure, as well as a high level of concern for air quality and climate change. This group included only 8% of total participants, and was therefore the smallest group. Bike usage was high, 77% of this group cycle on a daily basis, while 22% use it 1–3 d a week (table 1). 67% of the individuals in this cluster stated that they never use a car or use it less than once a month, which is reflected in the high share of individuals that do not own a car (71%). Their willingness to use alternative forms of

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**Table 1.** Shows the within-cluster distribution of active mobility variables (car, bike and public transit use). A v.test value greater than 1.96 corresponds to a p-value less than 0.05; the sign of the v.test indicates if the mean of the cluster is under or over-expressed for the category. Only items with a p-value less than 0.05 are included as this shows that one category is significantly linked to the other categories.

| Variable          | C1— unconcerned car-oriented policy-rejecters | C2— multimodal policy-skeptics | C3— green-travel policy-optimists | C4— dedicated-cyclists and policy-enthusiasts |
|-------------------|---------------------------------------------|-------------------------------|----------------------------------|-----------------------------------------------|
|                   | Mod. Cla (%) v.test                         | Mod. Cla (%) v.test           | Mod. Cla (%) v.test              | Mod. Cla (%) v.test                          |
| Car use           | Daily                                       | 95                            | 33 543                           | 61 −6229                                      |
|                   | 1–3 d/week                                  | 5                             | 24 643                           | 33 13 141                                     |
|                   | 1–3 d/month                                 | 1                             | 12 340                           | 15 7887                                       |
|                   | Less than monthly                           | 0                             | 7382                            | 1 −5243                                       |
| Bike use          | Daily                                       | 1                             | −10 436                         | 0 −9871                                       |
|                   | 1–3 d/week                                  | 4                             | 26 726                           | 28 4172                                       |
|                   | 1–3 d/month                                 | 29                            | −29 44                          | 41 8718                                       |
|                   | Less than monthly                           | 26                            | 8229                            | 10 −5507                                      |
| Public transit    | Daily                                       | 20                            | 12 758                           | 8 −6722                                       |
|                   | 1–3 d/week                                  | 24                            | 14 266                           | 4 −10 680                                     |
|                   | 1–3 d/month                                 | 6                             | −16 836                         | 16 −2089                                      |
|                   | Less than monthly                           | 4                             | −14 493                         | 15 4701                                       |
|                   | 1–3 d/month                                 | 13                            | −11 065                         | 33 12 358                                     |
|                   | Less than monthly                           | 30                            | 8804                            | 12 −15 411                                    |
|                   | Never                                       | 47                            | 26 211                           | 6 −11 332                                     |
|                   | v.test                                       |                               |                                 | v.test                                       |
Table 2. Shows the within-cluster (Mod.Cla) and across-cluster (Cla.Mod) distributions of active environmental and measure-related variables. A v.test value greater than 1.96 corresponds to a p-value less than 0.05; the sign of the v.test indicates if the mean of the cluster is under or over-expressed for the category. Only items with a p-value less than 5% are included as this shows that one category is significantly linked to the other categories.

| Variable | Category | C1 C2 C3 C4 |
|----------|----------|-------------|
|          | Mod. (%) | Mod. (%) | Mod. (%) | Mod. (%) | Mod. (%) |
| Effect of Potsdam AQ measure on mobility | Improve a lot | 2 | 0 | −10 262 | 15 | 1 | −4532 | 68 | 26 | 15 745 |
|        | Improve | 3 | 0 | −10 696 | 18 | 2 | −4125 | 23 | 7 | 3512 | 57 | 24 | 14 080 |
|        | No change | 9 | 2 | −14 248 | 22 | 16 | 5569 | 29 | 31 | 11 455 |
|        | Worsen | 29 | 10 | −8527 | 52 | 23 | 8665 | 15 | 20 | 2780 | 4 | 8 | −3778 |
|        | Worsen a lot | 58 | 88 | 22 223 | 32 | 65 | −4896 | 9 | 54 | −7581 | 1 | 12 | −21 077 |
| Effect of Potsdam AQ measure on life quality | Improve a lot | 4 | 0 | −10 842 | 18 | 2 | −4212 | 21 | 7 | 3251 | 57 | 27 | 14 847 |
|        | Improve | 11 | 2 | −12 733 | 43 | 43 | 17 221 |
|        | No change | 41 | 34 | 5028 | 4 | 13 | −6144 |
|        | Worsen | 56 | 55 | 11 026 | 32 | 41 | −3444 |
| Support for Potsdam AQ measure | Yes, I support it | 4 | 1 | −19 045 | 24 | 7 | −4808 | 20 | 18 | 5201 | 52 | 70 | 25 374 |
|        | No, I do not support it | 52 | 98 | 20 964 | 36 | 88 | 2205 | 10 | 75 | −6154 | 2 | 22 | −25 498 |
|        | I am Undecided | 12 | 1 | −8216 | 50 | 5 | 3514 | 20 | 6 | 2880 | 18 | 8 | −3724 |
| Investments in traffic-reducing measures | I strongly support it | 13 | 6 | −20 452 | 21 | 37 | 8591 | 32 | 82 | 23 217 |
|        | I support it | 36 | 19 | −6911 | 47 | 33 | 8625 | 13 | 29 | 2027 | 4 | 11 | −5597 |
|        | I do not support it | 58 | 29 | 7671 | 7 | 13 | −4470 | 1 | 3 | −9368 |
|        | I do not support it at all | 70 | 42 | 17 275 | 24 | 19 | −8274 | 6 | 14 | −6623 | 0 | 1 | −12 307 |
|        | I am Undecided | 42 | 6 | 2030 | 3 | 2 | −2357 |
| Traffic reducing measures improve air quality | Yes | 14 | 6 | −19 681 | 19 | 32 | 6571 | 32 | 80 | 22 757 |
|        | No | 54 | 94 | 19 681 | 10 | 68 | −6571 | 2 | 20 | −22 757 |
| Consideration of environment in mobility decisions | 1 = absolutely important | 25 | 6 | −9306 | 22 | 7 | −5772 | 17 | 18 | 3799 | 35 | 53 | 17 808 |
|        | 2 | 36 | 18 | −6608 | 17 | 33 | 4979 | 11 | 31 | 3257 |
|        | 3 | 51 | 39 | 4036 | 38 | 39 | 2778 | 9 | 29 | −3031 | 2 | 11 | −9729 |
|        | 4 | 52 | 15 | 2749 | 39 | 15 | 1994 | 8 | 9 | −2807 | 1 | 3 | −6432 |
|        | 5 | 58 | 9 | 3741 | 7 | 5 | −2059 | 2 | 1 | −4219 |
|        | 6 = not important at all | 63 | 10 | 5878 | 28 | 6 | −2438 |

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| Variable Category                              | C1 Cla. Mod (%) | C1 Mod.Cla (%) | v.test | C2 Cla. Mod (%) | C2 Mod.Cla (%) | v.test | C3 Cla. Mod (%) | C3 Mod.Cla (%) | v.test | C4 Cla. Mod (%) | C4 Mod.Cla (%) | v.test |
|---------------------------------------------|----------------|---------------|--------|----------------|---------------|--------|----------------|---------------|--------|----------------|---------------|--------|
| **Aim of Potsdam AQ measure to improve mobility alternatives** |                |               |        |                |               |        |                |               |        |                |               |        |
| Very high priority                          | 17             | 2             | -8167  | 27             | 4             | -2252  | 40             | 26            | 12     | 256            |               |        |
| High priority                               | 27             | 6             | -8226  | 17             | 16            | 3365   | 24             | 34            | 10     | 1774           |               |        |
| low priority                                | 38             | 18            | -5245  | 40             | 25            | 3629   | 10             | 27            | 21    | 2175           |               |        |
| Very low priority                           | 55             | 74            | 13     | 242            | 10            | -3840  | 2              | 13            | -17   | 410            |               |        |
| **Air quality concern**                     |                |               |        |                |               |        |                |               |        |                |               |        |
| 1 = unconcerned                             | 62             | 24            | 8781   | 28             | 14            | -4298  | 9              | 14            | -2154 | 2              | 4             | -7293  |
| 2                                           | 52             | 28            | 4312   | 39             | 30            | 2854   | 9              | 22            | -2458 | 5              | 17            | 4193   |
| 3                                           | 33             | 10            | -6560  | 39             | 16            | 2201   | 14             | 18            | 1991  | 14             | 26            | 5302   |
| 4                                           | 23             | 4             | -8845  | 20             | 16            | 4831   | 24             | 27            | 9424  |               |               |        |
| 5                                           | 18             | 2             | -7377  | 27             | 3             | -2205  | 28             | 11            | 5848  | 27             | 16            | 7420   |
| 6 = very concerned                          |                |               |        |                |               |        |                |               |        |                |               |        |
| **Air quality (aq) rating**                 |                |               |        |                |               |        |                |               |        |                |               |        |
| 1 = aq is very good                         |                |               |        |                |               |        |                |               |        |                |               |        |
| 2                                           |                |               |        |                |               |        |                |               |        |                |               |        |
| 3                                           |                |               |        |                |               |        |                |               |        |                |               |        |
| 4                                           |                |               |        |                |               |        |                |               |        |                |               |        |
| 5                                           |                |               |        |                |               |        |                |               |        |                |               |        |
| 6 = aq is very bad                          |                |               |        |                |               |        |                |               |        |                |               |        |
| **Climate change concern**                  |                |               |        |                |               |        |                |               |        |                |               |        |
| 1 = unconcerned                             | 60             | 8             | 4366   | 27             | 5             | -2381  | 4              | 3             | -2105 |               |               |        |
| 2                                           | 53             | 13            | 2911   | 31             | 22            | -2680  | 9              | 20            | -2407 | 2              | 8             | 4742   |
| 3                                           | 57             | 31            | 7672   | 31             | 22            | -2680  | 9              | 16            | -2280 | 5              | 12            | 3576   |
| 4                                           |                |               |        |                |               |        |                |               |        |                |               |        |
| 5                                           |                |               |        |                |               |        |                |               |        |                |               |        |
| 6 = very concerned                          | 36             | 15            | -5630  | 40             | 22            | 3018   | 2              | 11            | 27    | 3230           |               |        |
| **Affected by climate change**              |                |               |        |                |               |        |                |               |        |                |               |        |
| Yes                                         | 35             | 30            | -10    | 204            | 37             | 42     | 2181           | 15            | 53    | 5668           | 12            | 63     | 8115           |
| No                                          | 55             | 49            | 8742   | 33             | 39             | -2049  | 8              | 30            | -4675 | 4              | 20            | -7461  |
### Table 2. (Continued.)

| Variable                              | Category                  | C1 Cla. Mod (%) | C1 Mod.Cla (%) | v.test | C2 Cla. Mod (%) | C2 Mod.Cla (%) | v.test | C3 Cla. Mod (%) | C3 Mod.Cla (%) | v.test | C4 Cla. Mod (%) | C4 Mod.Cla (%) | v.test |
|---------------------------------------|----------------------------|-----------------|----------------|--------|-----------------|----------------|--------|-----------------|----------------|--------|-----------------|----------------|--------|
| Air pollution effect on health        | Yes                        | 38              | 47             | -10 600| 14              | 68             | 4968   | 12              | 90             | 12 350 |
|                                       | No                         | 56              | 53             | 10 600 | 8               | 32             | -4968  | 2               | 10             | -12 350 |
| Allocation of funds to environmental protection | Very high priority | 30              | 11             | -8738  | 28              | 14             | -3807  | 18              | 28             | 5522   | 23              | 53             | 13 855 |
|                                       | High priority              | 38              | 64             | 4129   | 10              | 52             | -2982  | 6               | 43             | -5584  |
|                                       | low priority               | 55              | 15             | 3920   | 8               | 9              | -2369  | 2               | 3              | -5845  |
|                                       | Very low priority          | 61              | 3              | 2492   | 1               | 0              |        | 1               | 0              | -2123  |
| Intention to increase bicycle use     | Yes                        | 10              | 6              | -28 063| 47              | 36             | 9097   | 21              | 49             | 10 033 | 23              | 80             | 18 869 |
|                                       | No                         | 71              | 77             | 30 046 | 20              | 28             | -18 886| 8               | 34             | -6876  | 2               | 10             | -14 295 |
| Intention to increase public transit use | Yes                       | 10              | 4              | -20 801|                  | 28              | 42     | 12 761          | 27             | 61     | 16 970          |
|                                       | No                         | 62              | 82             | 24 878 | 28              | 48             | -10 346| 7               | 37             | -9817  | 2               | 17             | -15 099 |
transport was moderate to high, such as carpooling, car sharing, public transit and bicycling (21%, 26%, 61%, and 80%, respectively).

Compared to the other clusters, this group had the highest proportion of respondents who showed support for the Potsdam AQ measure (70%). They also showed the greatest support for investments in measures that would reduce car traffic (82%). As with cluster 3, this cluster showed a high concern for air quality and climate change. The share of participants who selected category 6 (very concerned) was larger for climate change than air quality (46% and 16%, respectively). It also included the highest proportion of individuals who stated that the environment is ‘absolutely important’ when making mobility decisions (53%), which was reflected in the high share of individuals (90%) in this cluster that perceived air pollution as a major threat to human health.

3.3. Across-cluster characteristics

The clusters were found to be heterogeneous and generally showed a progressive increase from clusters 1 through 4 with regards to their concern for the environment, their positive attitude towards the Potsdam AQ measure and their level of environmentally-friendly mobility use. Across all four groups, cluster 1 exhibited the greatest rejection of the policy (52% of those that did not support the measure belong to cluster 1), followed by cluster 2 (32%). Furthermore, cluster 2 had the largest share of ‘undecided’ individuals (50%). Cluster 4 showed the highest support for the Potsdam AQ measure (52%). Regarding their belief that the Potsdam AQ measure would improve their life quality, the across-cluster membership shows the same progressive increase from clusters 1 through 4 (4%, 18%, 21% and 57%). Contrary to clusters 1 and 2, cluster 3 had a high share (23%) of respondents that believed the Potsdam AQ measure would ‘improve’ their own mobility, or would have ‘no effect’ at all (22%). Cluster 2 showed the highest across-cluster membership that perceived they were indeed affected by climate change (37%), however, cluster 4 was the most overrepresented for that category, despite the lower proportion (11%). It should be noted that this is likely due to cluster 4 having lower respondant counts. When asked about the importance for the environment when making mobility decisions, 63% of the respondents that stated the environment ‘is not important at all’ belonged to cluster 1.

3.4. Socio-demographic characteristics

The four identified clusters were relatively homogeneous across socio-demographic items including gender, education, income, and household size (table 3). The hierarchical clustering found residency, vocation, education, and age to be the sociodemographic variables that provided the best characterisation of the groups. The proportion of youngest age group increases from cluster 1 through to cluster 4. The more environmentally-conscious groups (cluster 3 and 4) had a greater proportion of younger respondents, which was reflected in the high proportion of university students. The majority of the respondents in the last two clusters lived in Potsdam (>80%), and a large share lived on the Zeppelinstraße (36% for cluster 3 and 53% for cluster 4). Although the majority of individuals in cluster 1 live outside of Potsdam, of the participants

| Variable          | Category | C1  | C2  | C3  | C4  | Variable          | Category | C1  | C2  | C3  | C4  |
|-------------------|----------|-----|-----|-----|-----|-------------------|----------|-----|-----|-----|-----|
| Gender            | Male     | 50  | 59  | 50  | 60  | Kids at home      | 0        | 57  | 57  | 63  | 66  |
|                   | Female   | 50  | 41  | 50  | 40  |                  | 1        | 24  | 22  | 18  | 16  |
| Age               | 18–34 years | 27  | 32  | 40  | 47  |                  | 2        | 16  | 17  | 14  | 14  |
|                   | 35–54 years | 56  | 51  | 39  | 47  |                  | 3        | 3   | 4   | 5   | 4   |
|                   | >55 years | 17  | 17  | 21  | 6   | Household size    | 1 person | 11  | 14  | 12  | 23  |
| Residence         | Not Zeppelinstraße | 12  | 23  | 64  | 47  |                  | 2 people  | 42  | 41  | 47  | 33  |
|                   | Zeppelinstraße | 88  | 77  | 36  | 53  |                  | 3 people  | 25  | 21  | 22  | 18  |
| Region            | Potsdam region | 43  | 71  | 86  | 90  |                  | 4 people  | 17  | 19  | 14  | 18  |
|                   | Surrounding regions | 57  | 29  | 14  | 10  |                  | 5 people  | 4   | 4   | 6   | 5   |
| Education         | Vocational training | 40  | 27  | 23  | 17  | Income < 10.000 EUR | 6 people  | 1   | 1   | 1   | 3   |
|                   | High school | 8   | 8   | 10  | 10  | 10–19.999 EUR     | 2         | 2   | 7   | 11  |     |
|                   | Secondary school | 1   | 1   | 1   | 0   | 20–29.999 EUR     | 13        | 12  | 18  | 14  |     |
|                   | Middle school | 7   | 3   | 3   | 2   | 30–39.999 EUR     | 23        | 25  | 26  | 19  |     |
|                   | Other       | 4   | 4   | 3   | 3   | 40–49.999 EUR     | 11        | 12  | 9   | 11  |     |
|                   | University (Bachelor) | 12  | 13  | 22  | 16  | 50–59.999 EUR     | 8         | 10  | 9   | 10  |     |
|                   | University (Master) | 27  | 44  | 38  | 53  | >70.000 EUR       | 29        | 24  | 12  | 17  |     |
| Occupation        | Student     | 3   | 5   | 14  | 17  |                  | 60–69.999 EUR | 5   | 8   | 5   | 6   |
|                   | Pensioner   | 2   | 4   | 15  | 1   |                  | >70.000 EUR | 29  | 24  | 12  | 17  |
|                   | Other       | 3   | 4   | 4   | 4   |                  |           |     |     |     |     |
|                   | Part-time employee | 9   | 11  | 12  | 23  |                  |           |     |     |     |     |
|                   | Full-time employee | 82  | 76  | 55  | 56  |                  |           |     |     |     |     |

Table 3. Socio-demographic differences between clusters.
that do live in Potsdam, 88% live near the Zeppelinstraße. More than half of the participants in each cluster had no children and only two people living in the household. Clusters 1 and 2 included the largest proportion of participants residing outside of the city of Potsdam (57% and 29%, respectively) and of those living in Potsdam, only 12% of cluster 1 were residents of the Zeppelinstraße or lived within a two-street radius. Furthermore, cluster 1 also made up the largest share of full-time employees (82%) and participants with an education in vocational training.

4. Discussion

Our study identified four clusters with distinct characteristics regarding mobility behaviour as well as attitudes towards the Potsdam AQ measure, air pollution, and climate change. Perceptions of the measure and current mobility habits are important discriminators between the clusters and can also act as a barrier for the uptake of environmentally friendly travel, especially for groups sceptical of such measures. The analysis reveals a complexity behind implementing measures intended to induce a mobility switch. Overall, the results suggest that socio-demographic information and mobility behaviour profiles alone are insufficient to design policies targeting persistent car use, but rather that attitudes towards policies of the affected communities are a major aspect of attempting to develop and upscale effective interventions. While Anable (2005) suggested potential interventions to influence modal split based on psychographic groups and Kandt et al (2015) summarized policy options based on mobility attitudes and behaviour, in this paper we exemplify how local context can further shape population-based typologies and the implications it has for the feasibility of potential transition pathways towards a more sustainable society. This paper summarizes the current perceptions and behaviours for each cluster, based on the survey results, as well as potential transition pathways that could be considered when designing future interventions, formed on deductions from the statistical segmentation results (for detailed information, see supplementary information table S1).

As daily car drivers are the most disadvantaged by the Potsdam AQ measure in this study, car-oriented policy-rejecters had the most negative perception of the measure, a perception that is anchored in their distrust regarding the effectiveness of the measure and a general lack of concern for improving air quality. This group is characterised by a negative perception of alternative transport modes and an unwillingness to change their regular mode of transport. This is likely related to residing in locations outside of core urban areas that lack reasonable access to public transport, where switching to alternative transport methods would significantly reduce convenience and lengthen the perceived commute time. As seen in previous segmentation analyses (Steg 2005, Kandt et al 2015), these habits are likely to have been formed over a longer period as this cluster has the lowest share of young participants attributed to it. Car use is perceived as highly convenient and regarded as a daily necessity; inhibiting car use consequently reduces their perceived quality of life and increases hostility toward such policies. It is therefore unlikely that car usage will be reduced solely based on measures that encourage reductions in car use such as road infrastructure changes. Instead, mitigation efforts should be responsive to this group’s motivation and constraints by improving accessibility to local alternative mobility services convenient for commuters, and reducing hostility towards policies by coupling them with contextualised ‘soft’ policies (table S1). In addition, a technological solution would be to motivate this group to switch from fossil-fuel cars to alternatives fuelled vehicles.

Car-oriented policy-rejecters and multimodal policy sceptics both exhibit similar behaviour patterns. However, their perceptions towards the Potsdam AQ measure and environmental concern differ, as does their willingness to switch mobility. This group’s mixed mobility tendencies, moderate environmental concerns and uncertainty about the effectiveness of the measure makes them interesting for mobility management strategies as the characteristics provide favourable grounds for policy implementation. Given the pragmatic approach to mobility use in this group, similar to types found by Kandt et al (2015), alternative options should be highlighted with a focus on convenience and feasibility motives. However, even if environmental concerns are present, they do not bring about enough self-motivation for favourable behaviour change (Anable 2005) and scepticism towards policies further inhibit responsiveness. Due to multimodal policy-sceptics’ high propensity for car use and large share of members, this group shows significant potential to positively influence air quality if sustainable forms of transport are effectively encouraged.

Bike-dedicated policy-enthusiasts perceive the measure’s improvement of bicycling infrastructure the most positively, which is reflected in their high acceptability of the measure. While this group shares similar sustainable mobility behaviours with the green-travel policy optimists, their attitudes towards the measure and their environmental obligations differ. This implies that although groups show the same environmentally-friendly mobility behaviour and intentions, these do not necessarily create high acceptance of the measure, but rather shows the complexity behind implementing air quality and climate policies. Given the green-travel policy-optimists high concern for the environment and its relatively high importance when making mobility decisions, this group expresses a high moral obligation and therefore high responsiveness to more sustainable travel. For bike-dedicated policy-enthusiasts, policy design should thus focus on
further enhancing and supporting bicycle infrastructure to improve safety and connectivity.

Measures may be more successful coupled with informing and educating the affected population about the policy objectives to avoid counterproductive responses (Anable 2005). It should be noted that there is no strong evidence for the effectiveness of value-matching arguments to induce acceptability, but rather that biospheric value-oriented groups have a higher acceptability of suggested instruments (Nilsson et al 2016), as seen in clusters 3 and 4. Moving away from strategies comparable to the deficit-model, ‘soft’ policy communications should rather incorporate contextual models, tailored to group specific social climates (Gross 1994, Miller 2001). Considering the car-oriented policy-rejecters lack of environmental and health concerns related to driving, acceptability will likely not increase if ecocentric arguments are used to encourage a switch in mobility. It would be appropriate to decouple such arguments from environmental values and health, and reframe the policy objectives with regards to economic advantages and congestion relief (Tapp et al 2016).

5. Conclusions

It is crucial to explore how to link social perspectives and transition pathways towards sustainable cities. This exploratory cluster analysis exemplifies how implementation contexts can further shape mobility typologies and the implications they have for the feasibility of policy instruments and the resulting opportunities for group-specific policy options. It is clear that perceptions of policy measures are an important discriminator between mobility groups and that these can leverage or be a barrier for the transition to environmentally friendly mobility options that such policies aim to promote. The complexity of characteristics and attitudes of these groups reveal the need for policies to be responsive to the different motivations and constraints of the groups to react to ‘hard’ infrastructure changes in terms of both mobility behaviour and public perceptions, possibly differentiated according to comparable segments identified in this study. German and European cities that continue to exceed air quality limit-values will likely need to implement similarly disputed measures in the near future. Coupling cluster analyses outcomes with urban transport policy can more effectively define policy priorities and help identify the most feasible transition pathways for different sub-groups. Consequently, further research should assess potential transition pathways tailored to the social environment to contribute to the success of climate and air quality policies.

Acknowledgments

This work has been supported by the Institute for Advanced Sustainability Studies (IASS) e.V., Potsdam. The authors would like to thank Landeshauptstadt Potsdam, for their collaboration in co-designing this research, including the departments of Public Participation ‘WerkStadt’, Traffic Development, and Press and Communication. The Institute for Advanced Sustainability Studies (IASS) e.V., Potsdam, is funded by the German Federal Government’s Ministry of Education and Research as well as the Federal State of Brandenburg’s Ministry for Science, Research, and Culture.

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