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Gauging interventions for sustainable travel: a comparative study of travel attitudes in Berlin and London

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Abstract

So-called 'soft' policy instruments that respond to the psychological aspects of travel are regularly acknowledged as necessary complements to 'hard' infrastructure investments to effectively promote sustainable travel in cities. While studies investigating subjective orientations among travellers have proliferated, open questions remain including the role of recent technological advances, the expansion of alternative mobility services, locally specific mobility cultures and residential selection. This paper presents the methods, results and policy implications of a comparative study aiming to understand mobility attitudes and behaviours in the wider metropolitan regions of Berlin and London. We specifically considered information and communication technology (ICT), new types of mobility services such as car sharing, electric cars and residential preferences. In each region, we identified six comparable segments with distinct attitudinal profiles, socio-demographic properties and behavioural patterns. Geocoding of the home address of respondents further revealed varying contextual opportunities and constraints that are likely to influence travel attitudes. We find that there is significant potential for uptake of sustainable travel practices in both metropolitan regions, if policy interventions are designed and targeted in accordance with group-specific needs and preferences and respond to local conditions of mobility culture. We identify such interventions for each segment and

region and conclude that comparative assessment of attitudinal, alongside geographical, characteristics of metropolitan travellers can provide better strategic input for realistic scenario-building and ex-ante assessment of sustainable transport policy.

Keywords

Travel attitudes, travel behaviour, cluster analysis, comparative study, transport policy

Highlights

- We segment travellers into attitudinal types based on travel and related attitudes.
- We consider ICT, car sharing, electric cars and residential choices.
- Six attitudinal segments that are comparable across Berlin and London emerge.
- The segments differ in potential uptake of sustainable modes and mobility services.
- Segment-specific interventions to promote sustainable travel are proposed.

1 Introduction

Increasing the share of environmentally friendly urban mobility - above all walking, cycling and public transport - is a central policy target to promote more sustainable development in cities. While the means to achieve this comprise 'hard' policy measures such as the provision of transit or cycling infrastructure, complementary 'soft' interventions addressing the subjective dimensions of travel can respond to differential travel needs and constraints of heterogeneous groups of travellers. The last two decades have witnessed an increase in transport studies applying psychological models that move away from the 'average traveller' and explain mobility choices instead in terms of subjective orientations (Li et al 2013; Diana and Mokhtarian 2008; Bamberg et al 2007; Anable 2005; Handy et al 2005; Götz et al 2003; van Wee et al 2002). Customer segmentation techniques have often been used to identify different groups of travellers and in so doing help inform policy interventions that encourage and sustain desirable travel practices (Li et al 2013; Hunecke et al 2008; Anable 2005).

Most of these studies are based on the theory of planned behaviour (TPB), which was developed in the context of behavioural psychology and states that individual behaviour is an outcome of beliefs as to anticipated consequences, based on subjective and social norms as well as the perceived feasibility of behaviour (Ajzen 1991). By employing TBP-related psychological constructs in questionnaire items in order to measure attitudes towards specific aspects of modes and travel experience, a number of researchers have demonstrated that the theory and its constructs can improve the study of travel behaviour. Anable (2005) articulates the policy relevance of market segmentation studies particularly clearly, when she observes that "the combination of instrumental, situational and psychological factors affecting travel choice will differ in distinct ways for distinct groups of people" (ibid, 65).

Some studies extended the approach of measuring travel-related attitudes by including wider, sociological constructs of lifestyles (Prillwitz and Barr 2011; Scheiner and Kasper 2005; Lanzendorf 2002), social values and environmental attitudes (Barr and Prillwitz 2012; Li et al 2013; Hunecke et al 2008; Nilsson and Küller 2000). Important limitations notwithstanding (see Prillwitz and Barr 2011; Parkany et al 2004), researchers and critics acknowledge that psychological factors play an important role in shaping travel and need to be understood, if policy interventions are to be effective in encouraging sustainable travel.

By drawing on a representative survey of residents in Berlin, Germany, and London, UK, this study seeks to contribute to the field in three ways. First, we considered a hitherto under-acknowledged aspect in the study of travel behaviour: information and communication technology (ICT). Recent evidence in transport suggests that ICT plays a crucial part in improving access to alternative transport options and mobility services (Nyblom 2014; Dacko and Spalteholz 2013; Parvaneh et al 2012). Real-time information on arrival and departures, electronic journey planners, booking systems transmitted through smart phone applications and online platforms are widespread services facilitating instant

access to information and inter-modal travel. Capturing attitudes towards technology may therefore provide important insights into appropriate interventions to spur behavioural change.

Second, we included detailed geographic information in our study along with items on residential preferences. Studies of travel attitudes rarely consider residential selection, although it appears to be an important determinant of travel practices, particularly in relation to attitude-neighbourhood mismatch (De Vos et al 2012; Scheiner 2010; Schwanen and Mokhtarian 2010; Mokhtarian and Cao 2008). We therefore included residential preferences and considered them alongside respondents' actual location, with a view to discriminating contextual opportunities and constraints to behavioural change.

Third, we conducted a comparative study that puts into context city-specific, distinct mobility cultures and, in so doing, helps develop context-sensitive policy options. By formally comparing prevailing attitudes in London and Berlin, we propose a method (replicable in multiple contexts) to identify different types of travellers and gauge the potential for policy interventions.

2 Research design

Computer Aided Telephone Interviews (CATI) were conducted with 987 individuals in Berlin and 1,184 individuals in London aged 18 years or over. Sampling routines differ in Germany and the UK. In Germany it is common to use random sampling with random digital dialling (RDD) as the sampling frame. In the UK representative samples are typically achieved by quotas.

The samples were drawn from the two administratively defined cities as well as the wider metropolitan region, which in London roughly corresponds to the inner commuter belt (Figure 1). The samples represent a population of approximately 12 million people in London and 4 million people in Berlin. Sample weights ensured that respondents were representative of our sampling regions.

Figure 1. Sampling regions in Berlin and London

The questionnaire generated 63 items on various attitudinal dimensions, including driving, cycling, public transport use, the use of mobility services and technology, the importance of the environment, and general statements revealing travel competence and interest in mobility. We ran principal component analyses (PCA) with Varimax rotation on these items separately for the Berlin and London samples, in order to construct the scales for subsequent segmentation. Table 1 shows the individual scales as identified through PCA and their reliability, measured by Cronbach's alpha.

Table 1. Scales derived from PCA.

Scales and questionnaire items		**No. of items**	**Cronbach's alpha**		**Comments**
			Berlin	London	
1	auto: affinity towards driving	5	.799	.816	-
2	cycling: affinity towards cycling	3	.827	.855	-
3	transit: affinity towards public transport travel	7	.855	.862	-
4	trains: affinity towards train travel over long distances (inter-city travel)	6	.865	.881	-
5	mobility services: affinity towards using mobility services (car rental, rental bicycles, transport maps, online tickets)	5	.890	.923	-
6	innovation: competence and interest in travel, e.g. *"I like trying out new mobility services*".	7	.868	.903	-
7	technology: propensity to use digital technology (e.g. smart phones)	2	.780	.790	-
8	environment: importance of the protection of the environment	4	.782	.856	-
9	central: preference for living in central urban areas	1	-	-	binary
10	residential: preference for living in purely residential urban areas	1	-	-	binary
11	outskirts: preference for living in the city outskirts	1	-	-	binary

	Scales and questionnaire items	No. of items	Cronbach's alpha		Comments
			Berlin	London	
12	countryside: preference for living in the countryside, outside the city	1	-	-	binary
13	auto fun: degree of enjoyment from driving	2	.487	.232	excluded
14	apps: propensity to use apps	3	.747	.812	excluded
15	data protection: importance of data privacy	3	.672	.751	excluded
16	personal space: importance of personal space during travel	2	.799	.751	excluded
17	social norm: importance of what friends or relatives think about one's behaviour	3	.769	.815	excluded

We ran a series of PCAs and iteratively excluded items with low communalities (h <0.5). Communalities indicate the extent to which the principal components 'explain' an item's variance; and thus are useful in identifying items that can form highly consistent scales that discriminate well in the clustering procedure (Gorsuch 1983, 102). We selected 13 out of 17 components in both settings for further analysis (Table 1). Each component was evaluated by reliability test of Cronbach's alpha, an effective measure of scale consistency on items which load on the same principal components (Cronbach 1951; Cortina 1993). Most scales showed high reliability (alpha >= 0.5) except the scale of auto fun, which we excluded. We also excluded four scales pertaining to diverse aspects of travel due to a high number of missings in both cities. We included residential preferences which were captured in a multi-nomial variable of five categories, each representing an 'ideal' residential environment respondents had to choose from (including a category 'other'). The variable was recoded into binary variables representing each of the categories (except 'other'), and were processed in further analysis separately.

We ran a two stage clustering procedure for the segmentation of the sample, combining a hierarchical clustering algorithm (HCA) with Ward linkage and k means clustering. HCA helps decide a suitable number of clusters which can inform the cluster initialisation of the iterative k means algorithm. The k means clustering takes the cluster centres of the HCA cluster solution as input and re-clusters the sample according to the squared Euclidean distance from the centres. Since HCA does not correct cluster assignments, k means can generate more homogeneous groups and hence improved solutions, as measured by the ratio between within-cluster and between-cluster variance (see Everitt 1974). The identified segments were then investigated with respect to their socio-demographic composition, observed travel behaviour, residential location and selected indicators pertaining to future intentions and behavioural change. Significance of differences was tested through one-way ANOVAs and Tukey post-hoc tests, where we compared means; and chi-square tests, where we compared relative frequencies of categorical variables across clusters. The software used for data management and statistical analysis was the base package of R statistical software (R Core Team 2013). PCAs have

been run using the *princomp* function of R's *stats* package. The *alpha* function (package: *psych*, Revelle 2013) was used to calculate Cronbach's alpha. The clustering was perfomed using R's *hclust* function (package: *stats*), whose resulting cluster centres were fed into the *kmeans* algorithm. The clusters were investiaged by means of weighted statistics, chi-squared-based tests, oneway ANOVA and Tukey post-hoc tests (packages: *Hmisc*, Harrell et al 2014 and *car*, Fox and Weisberg 2011). Spatial characteristics of respondents' residences were estimated using packages *rgeos* and *maptools* (Bivand & Rundel 2013; Bivand & Lewin-Koh 2013).

3 Results

3.1 Attitudinal profiles of mobility types

We derived two six-cluster solutions for each of the two metropolitan regions, Berlin and London. A closer look at the attitudinal profiles of all clusters revealed a high degree of similarity across the regions. Each cluster in one region could be matched with an equivalent cluster in the other. Table 2 lists the six types found in each region, as well as their relative frequency. The table also provides a short description of the common attitudinal properties across all samples.

Table 2. Cross-comparison and short description of six attitudinal profiles emerging from a six cluster solution of the Berlin and London samples.

Type incl. short description		**Tag**	**Frequency (%)**	
			Berlin	London
1	Traditional car-oriented: driving is preferred mode with little inclination to use other modes, services or technology	tradcar	16.0	12.8
2	Pragmatic transit-sceptics: driving is generally preferred, but other modes are not necessarily rejected	prascep	19.1	17.9
3	Green travel-oriented: transit use is preferred and importance of protection of the environment is high.	greentra	17.2	15.5
4	Pragmatic transit-oriented: transit use is preferred, private modes are rejected, low inclination to use technology	pratrans	8.7	9.9
5	Technology-focused individualists: driving and cycling preferred and high inclination towards technology use	techind	24.3	28.8
6	Innovative access-oriented: open to all modes including moblity services, modest desinclination towards driving, high degree of confidence and travel competence	innov	14.7	15.0

Despite minor differences, the psychographic profiles of the Berlin and London clusters are remarkably similar. Table 3 summarises the average scores for each scale, which we evaluated by means of Tukey post-hoc tests. The attitudinal profile of each type can be characterised as follows:

Table 3. Six cluster solutions for Berlin and London, measured in standard scores except where noted.

	tradcar (1)	prascep (2)	greentra (3)	pratrans (4)	techind (5)	innov (6)	F (df=5)	p
Berlin (n=987)								
auto	.494 ^{3,4,5,6}	.548 ^{3,4,5,6}	-1.100 ^{1,2,4,5,6}	-.534 ^{1,2,3,5,6}	.238 ^{1,2,3,4,6}	-.197 ^{1,2,3,4,5}	108	.000
cycling	-.893 ^{2,3,4,5,6}	.197 ^{1,3,4,6}	.631 ^{1,2,4,5}	-1.410 ^{1,2,3,5,6}	.235 ^{1,3,4,6}	.631 ^{1,2,4,5}	173	.000
transit	-1.330 ^{2,3,4,5,6}	-.180 ^{1,3,4,6}	.473 ^{1,2,4,5}	.944 ^{1,2,3,5,6}	-.275 ^{1,3,4,6}	.642 ^{1,2,4,5}	191	.000
trains	-1.480 ^{2,3,4,5,6}	.057 ^{1,3,4,5,6}	.279 ^{1,2,4,5,6}	.704 ^{1,2,3,5}	-.225 ^{1,2,3,4,6}	.779 ^{1,2,3,5}	194	.000
mobility services	-.552 ^{3,5,6}	-.318 ^{5,6}	-.147 ^{1,5,6}	-.254 ^{5,6}	.312 ^{1,2,3,4,6}	1.030 ^{1,2,3,4,5}	68.2	.000
innovation	-.700 ^{3,4,5,6}	-.696 ^{3,4,5,6}	-.370 ^{1,2,4,5,6}	.409 ^{1,2,3,6}	.486 ^{1,2,3,6}	1.230 ^{1,2,3,4,5}	194	.000
technology	.228 ^{2,3,4,5}	-.630 ^{1,5,6}	-.480 ^{1,5,6}	-.472 ^{1,5,6}	.822 ^{1,2,3,4,6}	.488 ^{2,3,4,5}	98.6	.000
environment	-.759 ^{3,4,5,6}	-.535 ^{3,4,5,6}	.626 ^{1,2,4,5}	-.193 ^{1,2,3,6}	-.022 ^{1,2,3,6}	.783 ^{1,2,4,5}	91.7	.000
central*	.124 ^{3,4,6}	.113 ^{3,4,6}	.253 ^{1,2,5}	.281 ^{1,2,5}	.131 ^{3,4,6}	.339 ^{1,2,5}	9.79	.000
residential*	.180 ^{4,5}	.274 $^{-}$	.304 $^{-}$	.431 ^{1,6}	.345 ^{1}	.211 ^{4}	5.33	.000
outskirts*	.272 $^{-}$	.276 $^{-}$	.243 $^{-}$	.195 $^{-}$	.240 $^{-}$	.196 $^{-}$	.941	.453
countryside*	.393 ^{3,4,6}	.309 ^{4}	.188 ^{1}	.075 ^{1,2,5,6}	.275 ^{4}	.239 ^{1,4}	7.66	.000
London (n=1184)								
auto	.649 ^{3,4,5,6}	.496 ^{3,4,5,6}	.182 ^{1,2,4,6}	-1.86 ^{1,2,3,5,6}	.289 ^{1,2,4,6}	-.155 ^{1,2,3,4,5}	223	.000
cycling	-.848 ^{2,3,4,5,6}	-.146 ^{1,4,5,6}	.051 ^{1,4,6}	-.506 ^{1,2,3,5,6}	.146 ^{1,2,4,6}	.770 ^{1,2,3,4,5}	65.9	.000
transit	-1.75 ^{2,3,4,5,6}	.058 ^{1,3,4,5,6}	.712 ^{1,2,4,5}	.481 ^{1,2,3,5}	-.318 ^{1,2,3,4,6}	.617 ^{1,2,5}	289	.000
trains	-1.59 ^{2,3,4,5,6}	-.069 ^{1,3,6}	.700 ^{1,2,4,5}	.109 ^{1,3,5,6}	-.188 ^{1,3,4,6}	.723 ^{1,2,4,5}	226	.000
mobility services	-.920 ^{2,3,4,5,6}	-.389 ^{1,3,5,6}	.575 ^{1,2,4,5}	-.517 ^{1,3,5,6}	.009 ^{1,2,3,4,6}	.721 ^{1,2,4,5}	97.2	.000
innovation	-.911 ^{3,4,5,6}	-.876 ^{3,4,5,6}	.464 ^{1,2,4,5,6}	-.481 ^{1,2,3,5,6}	.102 ^{1,2,3,4,6}	1.10 ^{1,2,3,4,5}	226	.000
technology	-.112 ^{2,3,5,6}	-.897 ^{1,4,5,6}	-.796 ^{1,4,5,6}	-.298 ^{2,3,5,6}	.635 ^{1,2,3,4,6}	.952 ^{1,2,3,4,5}	236	.000
environment	-.767 ^{3,4,5,6}	-.857 ^{3,4,5,6}	.500 ^{1,2,4,5,6}	-.110 ^{1,2,3,6}	.082 ^{1,2,3,6}	.776 ^{1,2,3,4,5}	119	.000
central*	.051 ^{4,6}	.097 ^{4,6}	.136 ^{6}	.251 ^{1,2,5}	.106 ^{4,6}	.271 ^{1,2,3,5}	11.2	.000
residential*	.234 $^{-}$	.258 $^{-}$	.224 $^{-}$	.274 $^{-}$	.365 $^{-}$	.300 $^{-}$	3.4	.005
outskirts*	.318 ^{6}	.282 $^{-}$	.296 $^{-}$	.277 $^{-}$	.313 ^{6}	.171 ^{1,5}	2.73	.018
countryside*	.367 ^{4,5,6}	.337 ^{4,5}	.312 ^{4,5}	.172 ^{1,2,3}	.200 ^{1,2,3}	.227 ^{1}	6.1	.000

Superscripts on values indicate the cluster number against which the value is significant (based on Tukey post hoc test). Auto fun is not used as input in the cluster solution for London, due to low scale reliability. Values marked with * show averages of binary values 0 and 1. All other values show z scores, i.e. – the number of standard deviations a cluster mean lies away from the scale mean. † The significance of between-cluster differences of means was assessed by F-tests, which measures the ratio of between-cluster and within cluster variability summarised by the F score and its corresponding p-value indicating the probability that the F score is equal to zero (i.e. no statistical differences between clusters). The only scale that is non-significant under the F test is *outskirts* in Berlin; all other scales differ significantly between clusters.

Traditional car-oriented (1). Among respondents of this type, driving is the preferred mode with little inclination to use other modes, alternative services or technology. Driving is considered to be the best and easiest way of getting around and tends to be accompanied with an experience of pleasure. All other modes are rejected, implicitly, as either impractical or uncomfortable. Respondents of this type prefer living on the city's outskirts or in the countryside. They are less inclined to use technology and to be innovative in travelling, although this tendency is stronger in the London than in the Berlin cluster.

Pragmatic transit-sceptics (2). The second type comprises individuals that also prefer automobile use but who show diverse tendencies with respect to other modes. They strongly reject technology and do

not exhibit innovativeness; in both cities this is the segment with the least favourable attitudes towards digital technology. In Berlin, these individuals are more open to cycling than in London.

Green travel-oriented (3). The third type stands out because it attaches a lot of importance to environmental protection. Individuals rate public transport travel positively, including travel by train over long distances. They tend to reject the use of technology. In London, this is the most public transport-favouring segment and yet there is no clear trend as regards automobile use. This contrasts with the Berlin counterpart, where respondents of this type show the strongest rejection of driving among all Berlin segments, as well as the strongest approval of cycling. Members of the London cluster are more interested and competent in travel (innovation scale) and more inclined to use alternative mobility services such as car sharing, online services to book tickets or rental bicycles.

Pragmatic transit-oriented (4). The fourth type consists of individuals that positively rate various aspects of transit use but negatively rate the use of technology. It differs from the previous type 3 in that environmental protection is not considered to be important. Again there is a Berlin-London split with regard to innovation: this time, the cluster in Berlin is more innovative than the London cluster. In both cities, members of this traditional, transit-favouring cluster prefer central urban locations and do not favour the countryside.

Technology-focused individualists (5). Members of the fifth type feel positive about the use of private modes of transport, driving and cycling, as well as technology. They reject collective modes of travel and exhibit indifference towards mobility services. Their strong preference for private modes suggests a desire for individual independence and autonomy; further evidence supporting this interpretation will be presented below. In both cities, these individuals favour locations in central areas and on the city's outskirts.

Innovative access-oriented (6). Respondents of the last type are open to using modes of travel other than the car and, most importantly, they are inclined to be innovative in travel. They are most informed about the latest developments in transport, they know about new products and services and enjoy trying them out. They are supportive of technology use and of the protection of the environment. Their residential focus is urban, with a strong preference for that location compared to all other types.

3.2 Socio-demographic characteristics

The socio-demographic composition of the clusters differs significantly. Table 4 shows descriptive statistics for each cluster with respect to age, sex, employment, income, education and household composition.

Table 4. Socio-demographic differences between clusters. Significance of differences have been tested by chi-square tests or one way ANOVA/Tukey post-hoc test where noted.

	Berlin	**London**

	1	2	3	4	5	6	p	1	2	3	4	5	6	p
Average age	47.2	56.4	50.5	54.6	42.7	46.6	.000	51.0	58.1	56.5	48.9	43.0	40.5	.000
Sig. difference to clusters	2,4,5	1,3,5,6	2,5	1,5,6	2,3,4	2,4		2,3,5,6	1,4,5,6	1,4,5,6	2,3,5,6	1,2,3,4	1,2,3,4	
Sex (%): female	43.5	65.1	65.6	61.3	33.9	49.3	.000	48.3	53.8	64.7	59.8	42.6	45.5	.000
Employment (%) FT/PT	56.2	38.9	36.1	34.6	63.7	45.9	.000	54.9	39.4	44.6	59.3	62.9	61.8	.000
... pensioners	18.5	46.9	32.9	42.0	12.6	23.7		25.5	43.7	34.2	24.6	13.7	11.8	
... other	25.3	14.3	31.0	23.5	23.8	30.4		19.6	16.9	21.2	16.1	23.4	26.4	
Household income (%)														
…< 2000	28.2	42.6	44.0	47.7	30.0	32.8	.016	31.3	42.2	44.7	26.5	25.0	36.5	.000
... > 2000 to < 4000	53.0	44.9	41.8	47.7	52.1	47.9		37.5	22.7	26.3	33.7	31.5	40.0	
... > 4000	18.8	12.5	14.2	4.6	17.9	19.3		31.3	35.2	28.9	39.8	43.5	23.5	
Education (%)														
… primary or none	16.2	14.1	11.5	25.0	6.0	14.1	.002	7.2	10.0	13.8	3.5	6.1	3.6	.000
... secondary or higher	53.5	48.8	44.9	47.5	56.7	45.2		41.7	37.9	36.5	36.3	21.3	26.7	
... university degree	30.3	37.1	43.6	27.5	37.2	40.7		51.1	52.1	49.7	60.2	72.6	69.7	.000
Average household size	2.64	2.36	2.50	2.27	2.55	2.71	.076	2.58	2.24	2.29	2.41	2.77	2.97	.000
Sig. difference to clusters	-	-	-	-	-	-		-	5,6	5,6	-	2,3	2,3	
1 child under 14 (%)	23.1	19.4	24.1	11.3	31.8	25.0	.005	15.1	9.0	17.4	16.2	28.6	33.1	.000

Group labels: 1 = *traditional car-oriented*, 2 = *pragmatic transit-sceptics*, 3 = *green travel-oriented*, 4 = *pragmatic transit-oriented*, 5 = *technology-focused individualists*, 6 = *innovative, access-oriented*

The average age of clusters ranges between 40 and 60 years in both cities, which reflects the minimum age of 18 in this survey. The technology-averse *pragmatic transit-sceptics* (type 2) are older than other clusters, with an average age of 56 and 58 in Berlin and London respectively. The youngest clusters are those that support technology use and show more inclination towards innovation in travel (type 5 and 6). The *traditional car-oriented* (type 1) are younger than *pragmatic transit-sceptics*, with an average age of 47 in Berlin and 51 in London. *Green travel-oriented* (type 3) are younger in Berlin than in London: in London they are the group with the second highest mean age. In both cities, men predominate among *technology-focused individualists* (type 5), whereas *pragmatic transit-sceptics* and *green travel-oriented* have a higher share of female respondents.

Private mode-favouring and more innovative clusters (types 1, 5 and 6) are younger and tend to be in full or part-time employment. In contrast the more traditional and technology-averse clusters, *pragmatic transit-sceptics, green travel-oriented and pragmatic transit-oriented* (types 2, 3 and 4) are more often pensioners. This distribution of economic activity corresponds to the distribution of income groups. Transit-oriented clusters have a higher share of individuals earning lower household incomes, whereas the clusters favouring private modes, innovation and technology or urban locations consist of individuals with higher incomes. In Berlin, the more environmentally conscious clusters *green travel-oriented* and *innovative access-oriented* (3 and 6) more often encompass individuals with a university degree. In London, where the proportion of degree holders is generally higher, the segments with the

highest share of people with university degrees are the two younger and urban segments (5 and 6); the segment with the lowest share are *green travel-oriented* (3).

In Berlin, the average household size does not differ across segments whereas in London, members of the two younger and urban segments (5 and 6) live in significantly larger households. Although this may indicate house or flat sharing, the percentage of individuals with at least one child under 14 is higher in those segments too. A similar pattern can be observed in Berlin, but it is much more pronounced in London.

3.3 Travel behaviour

An investigation of actual travel behaviour of the clusters reveals a strong correspondence between attitudes and behaviour. Table 5 summarises the selected indicators of travel behaviour per cluster in Berlin and London.

Table 5. Selected indicators of travel behaviour per cluster in Berlin and London. Significance of differences have been tested by chi-square tests or oneway ANOVA/Tukey post-hoc test where noted.

	Berlin							**London**						
	1	**2**	**3**	**4**	**5**	**6**	**p**	**1**	**2**	**3**	**4**	**5**	**6**	**p**
Driver's licence (%)	93.2	81.1	66.2	63.0	87.5	71.1	.000	93.4	84.4	61.4	44.4	83.9	57.9	.000
Car ownership (%) 1 or more	86.3	86.3	53.8	62.5	79.0	58.6	.000	94.7	88.3	71.2	41.0	80.5	54.8	.000
Main mode (%) car	68.2	51.7	5.1	14.8	47.8	17.0	.000	78.1	56.3	27.2	5.1	42.3	13.6	.000
... cycling	8.8	13.6	31.8	2.5	13.8	29.6		0.7	0.9	1.6	4.3	5.0	7.3	
... other	6.1	6.8	9.6	7.4	7.6	9.6		4.0	9.4	7.1	3.4	7.0	2.3	
... transit	11.5	20.5	38.9	71.6	23.7	34.8		9.9	26.3	51.6	65.0	37.6	68.4	
... walking	5.4	7.4	14.6	3.7	7.1	8.9		7.3	7.0	12.5	22.2	8.2	8.5	
Median annual vehicle kilometres ('000) †	15.0	10.0	2.6	12.0	12.0	6.0	.003	12.9	9.2	6.4	1.6	9.7	7.8	.023
Sig. difference to clusters	2,6	1	-	-	-	1		all other	1	1	1	1	1	
Car dependency* (%)	50.8	44.8	4.8	18.6	37.0	23.2	.000	65.0	40.5	38.7	2.9	36.2	20.7	.000

*At least half of daily travel would not be possible without car. · † p-values derived from oneway ANOVA tests. In London vehicle kilometres were asked in miles. · Group labels: 1 = *traditional car-oriented*, 2 = *pragmatic transit-sceptics*, 3 = *green travel-oriented*, 4 = *pragmatic transit-oriented*, 5 = *technology-focused individualists*, 6 = *innovative, access-oriented*

Private mode-affine clusters (types 1, 2 and 5) have the highest share of driver's licence possession and the highest car ownership rates, while the opposite applies in the case of the two transit-oriented clusters (types 3 and 4). Consistent with their preferences, the *traditional car-oriented* and *pragmatic transit-sceptics* (types 1 and 2) as well as the *technology-focused individualists* (type 5) use the car most often as their main mode, although car use among *traditional car-oriented* is far higher than among other ones. The *innovative access-oriented* show a different pattern: the car is much less frequently the main mode than car ownership and driver's licences would suggest. The frequency of car use also translates into median annual vehicle kilometres. The *traditional car-oriented* (type 1)

cluster stands out, with annual vehicle kilometres 15,000 in Berlin and 12,900 in London, this cluster travelling much more frequently by car than members of other clusters. As noted earlier, respondents of this type prefer living in the countryside and may therefore accept and perhaps enjoy daily travel over longer distances.

Cycling is more common in Berlin than in London, with 17 per cent of the Berlin sample reporting that cycling is their main mode of travel. In London, only 3 per cent of respondents report the same. Nearly three out of 10 *green travel-oriented* in Berlin (cluster 3) have cycling as their main mode, as opposed to just over 1 per cent in the equivalent London cluster. This clearly reflects the distinct cultures around cycling in both metropolitan contexts. The share of cyclists is highest among *innovative access-oriented* in London (type 6); in Berlin it is the segment with the second highest share of cyclists. *Technology-focused individualists* (type 5) has cycling as a main mode more often too, which supports the interpretation that this cluster comprises individuals who value autonomy in travel and motorisation may not be a requirement to pursue this desire.

The share of transit users is higher among the transit-oriented clusters (types 3 and 4), demonstrating again the close tie between attitudes and behaviour. In London as many as two thirds of *innovative access-oriented* respondents (cluster 6) additionally report using transit in their main trips. Four out of ten *technology-focused individualists* (cluster 5) travel by transit, bearing testimony to the generally higher dependency of Londoners on public transport, particularly in central locations.

Respondents were also asked to rate their own car dependency by indicating what proportion of daily travel could only be managed by automobile use. In Berlin half, and in London nearly two thirds of *traditional car-oriented* respondents indicated that at least half of their daily travel depended on car availability, which probably results from their residential choice.

3.4 Residential context and accessibility

We examined differences in residential situation between clusters to explore the interaction between attitudes, context and behaviour and again found that residential preferences correlate with the actual residential situation of respondents (see Table 6).

Table 6. Selected indicators of subjectively perceived and objective accessibility in Berlin and London. Significance of differences have been tested by chi-square tests or oneway ANOVA/Tukey post-hoc test where noted.

	Berlin							**London**						
	1	**2**	**3**	**4**	**5**	**6**	**p**	**1**	**2**	**3**	**4**	**5**	**6**	**p**
Satisfaction with current location high (%)	26.9	17.3	7.0	12.5	15.0	9.0	.000	33.1	17.2	18.2	15.2	28.5	18.0	.001
Transit accessiblity important (%)	53.7	70.3	87.9	88.8	73.2	88.9	.000	54.3	74.8	83.2	91.5	76.4	92.0	.000

Proximity to shops and services important (%)	74.1	70.7	86.1	80.2	73.1	88.1	.000	64.2	73.5	81.5	88.9	77.1	83.1	.000
Tenancy: owner occupier (%)	38.6	42.5	24.1	21.3	30.8	23.0	.000	81.9	80.5	73.7	58.3	68.6	45.9	.000
Average distance from centre (km)	15.3	14.0	10.4	12.1	13.2	10.8	.000	26.8	25.1	22.5	17.1	21.0	12.4	.000
Sig. difference to clusters	3,6	3,6	1,2,5	-	3	1,2		4,5,6	4,5,6	4,6	1,2,3,6	1,2,6	all other	
Average distance from rail network (km)	1.09	1.00	0.64	0.72	0.76	0.67	.000	1.28	1.10	1.01	0.67	1.16	0.81	.000
Sig. difference to clusters	3,4,5,6	3,6	1,2	1	1	1,2		4,6	4	-	1,2,5	4,6	1,5	

Group labels: 1 = *traditional car-oriented*, 2 = *pragmatic transit-sceptics*, 3 = *green travel-oriented*, 4 = *pragmatic transit-oriented*, 5 = *technology-focused individualists*, 6 = *innovative, access-oriented*

The level of satisfaction with residential situation is low overall but tends to be higher in London. In both cities the *traditional car-oriented* (type 1) report the highest level of satisfaction. In London the level of satisfaction is similarly high among *technology-focused individualists* (cluster 5). These clusters are also the wealthier ones; thus what we observe here may be the result of their economic capacity to actualise their residential preferences. They also rate transit accessibility least often as important. In both cities, among the transit-oriented and the more innovative clusters (types 3, 4 and 6), approximately 90 per cent report that access to transit would be an important criterion in relocation decisions. Similarly, members of clusters favouring transit and alternative travel attach more importance to proximity to shops and services.

As an objective indicator of location, we measured distance from the centre as the Euclidean distance from the Brandenburg Gate in Berlin and Trafalgar Square in London. Although these two landmarks may not represent the centre of urban activity, they represent the geographic centre of both cities and can serve as an indicative reference point for centrality. *Traditional car-oriented* (type 1) live signficantly further away from the city centre, whereas those clusters that favour collective modes - the *pragmatic transit-oriented* (type 4) and the *innovative access-oriented* (type 6) - live more centrally, which seems consistent with their overall residential preferences. *Technology-focused individualists* (type 5) are different in this regard: although they tend to prefer central locations they live, on average, further away than other segments. This divergence may indicate that members of this group are not able to satisfy their needs in central locations and therefore live elsewhere. Perhaps less central environments may be more conducive to autonomous forms of travel, which certainly is the case for London where the financial strain of keeping a car and the difficulties of finding a parking space may encourage their settling towards the outskirts.

In order to include an objective measure of transit accessibility, we measured the distance to the rail network for each respondent. This measure is incomplete, since it was confined to rapid commuter rail and the network itself rather than stations. Nevertheless, the observed pattern across the clusters is consistent with what we would expect based on the groups' attitudinal profiles.

The *traditional car-oriented* (type 1) have the highest home ownership rates relative to other clusters. It is well known that home ownership is more common in the UK than in Germany. In the London questionnaire we included an additional question on how long respondents had lived at their present address. The *traditional car-oriented* (type 1) and *pragmatic transit-sceptics* (type 4) were the most settled, with nearly 60 per cent having lived at their address for 10 years or more, whereas the majority of the younger clusters (type 5 and 6) had lived at their present address for less than ten years.

3.5 Amenability to new forms of travel

Since the success of promoting behavioural change depends on attitudes towards, and use of, alternative modes and mobility services, we tested the six cluster types' amenability to ICT and mobile use as well as alternative and future mobility options such as electric cars. Group and region-specific preparedness to use these forms of travel and associated services may offer clues as to the direction of future behaviour and the targeted interventions that could support this. Figure 2 summarises responses per cluster by selected indicators for both samples. The higher the clusters score on each indicator, the more potential there is to effect behavioural change. Visually, clusters at the far top of the 3D plots indicate more amenability to use alternative modes and moblity services. Conversely, if clusters locate at the bottom of the graphs, there is less potential for behaviour change through psychological interventions.

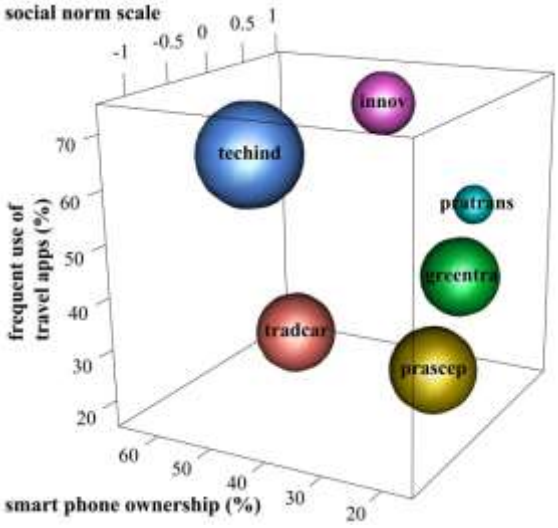
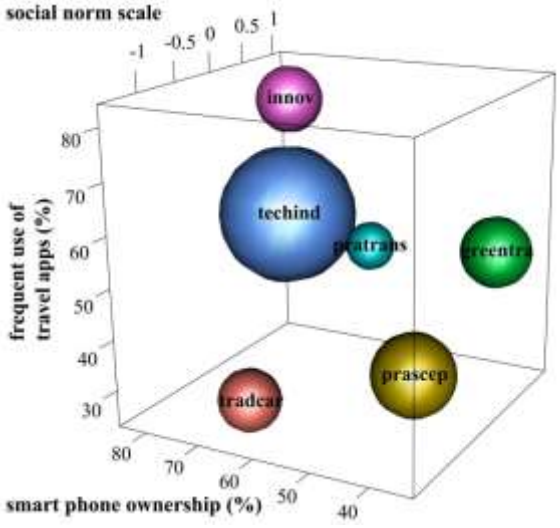
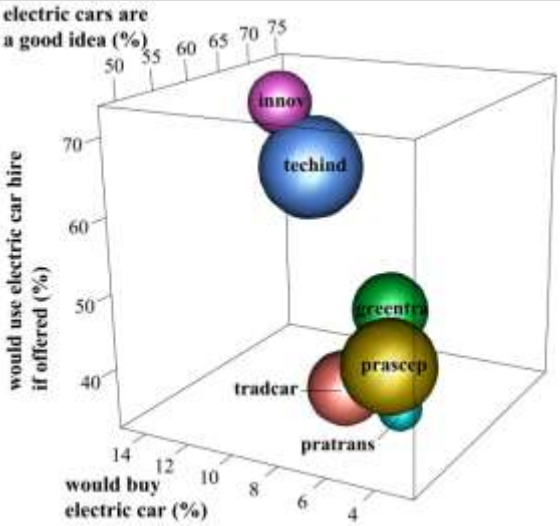
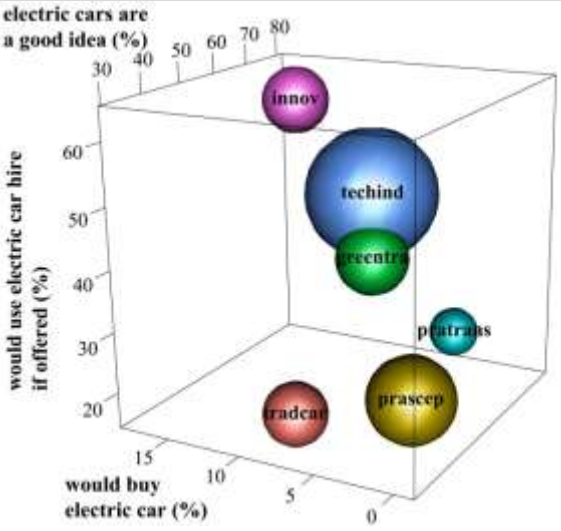
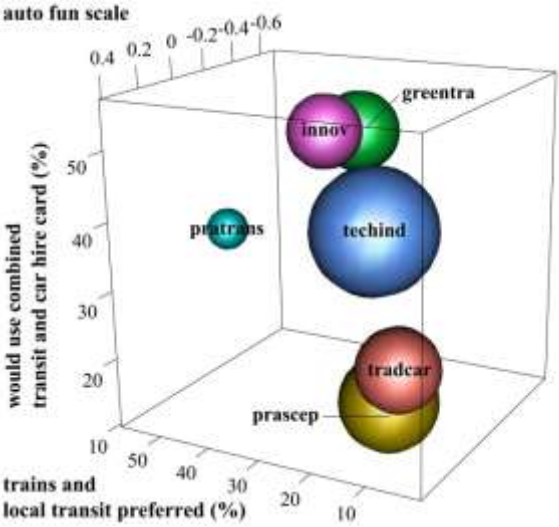
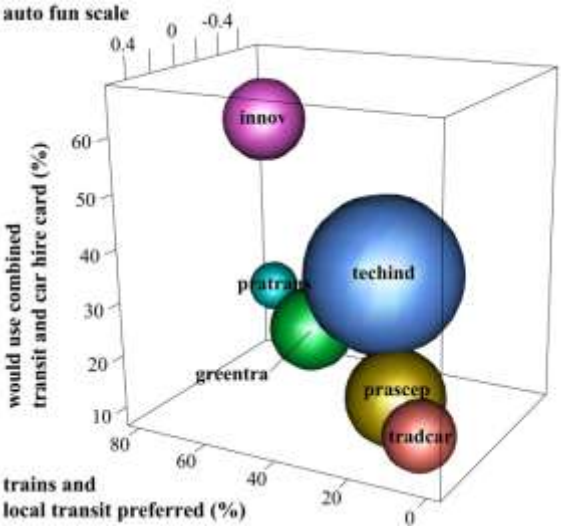
Berlin	London
	
	
	

Figure 2. Intentions and attitudes towards alternative modes of travel and mobility services by cluster. Significance of differences have been tested by chi-square tests or oneway ANOVA/Tukey post-hoc test. The size of the points is proportionate to the relative size of clusters in the sample.

The top set of charts in Figure 2 shows how the clusters relate to variables that reflect potential modalities for interventions. Questionnaire items related to social norm were not included in the cluster analysis, yet they reveal significant differences between clusters. The construct underscores the difference between the *traditional car-oriented* (tradcar) and *innovative access-oriented* (innov) clusters: the latter rate the importance of what friends and relatives think about one's travel behaviour highly whereas the former do not respond strongly on this point. The construct correlates closely with the perceived importance of environmental protection and indicates whether behaviours could be influenced through interventions with a moral content.

Smart phone ownership represents a channel for communicative interventions; it differs between clusters and is considerably higher in London than it is in Berlin. In London, 59 per cent of respondents possess a smart phone; in Berlin this share is just 37 per cent. Smart phone ownership is more widespread in technology-valuing segments, in particular among *technology-focused individualists* (techind) and *innovative access-oriented*. *Pragmatic transit-sceptics* (prascep) and the transit-oriented segments (greentra and pratrans) show the lowest levels of smart phone ownership. Among smart phone users, those that belong to pro technology clusters use the phone more often: the vast majority of *technology-focused individualists* and the *innovative access-oriented* report using travel apps daily or several times a week.

Another set of questions pertained to electric cars as an alternative future mode of individual travel. The response patterns of clusters differed strongly. The *innovative access-oriented* are most aligned to the idea of electic cars (around 70 per cent in both regions) and this cluster is most open to using an electric car if it were offered as part of a car sharing scheme. 15 per cent in both regions revealed a willingness to buy an electric car as soon as possible. This strong degree of openness towards electric car use is not matched by any of the other clusters. *Technology-focused individualists* came the closest: in general, they show a higher degree of openness to electic car use, albeit some 12 percentage-points behind the *innovative access-oriented*. In London, the attitudes of *green travel-oriented* towards electric cars were similar to *technology-focused individualists*. The stated intention was lowest among one transit-oriented cluster in each city, which reflects their general rejection of private modes. Even the *traditional car-oriented* seemed to be more open to purchasing electric cars than transit-oriented groups. Purchase intentions, however, were rare overall.

In addition to the psychographic items of the questionnaire, which were designed to capture different affective and evaluative aspects of modes, we included a question that asked directly about mode preference. The preference for different modes is consistent with the psychographic profiles of the clusters. The car is widely preferred by the *traditional car-oriented*, cycling is the most preferred

mode among the *innovative access-oriented* and *green travel-oriented* in Berlin. One quarter to one third of these and the transit-oriented cluster pairs (greentra and pratrans) prefer rail transit.

The bottom set of charts in Figure 2 shows the relationship between respondents' enjoyment of driving (auto fun scale), their preference for trains and local transit as well as their willingness to use a smart travel card that combines both transit travel and car sharing, a service that may encourage the use of alternative modes of travel. *Traditional car-oriented* and *technology-focused individualists* (and to a lesser degree *pragmatic transit-sceptics*) reveal in both cities higher affective dimensions of car use: they score higher on the auto fun scale than other clusters. In both cities, three in ten respondents indicated that they could imagine using a combined travel smart card within the next year, but the variation between clusters is significant. The *innovative access-oriented* show the highest openness to using the smart card, whereas traditional groups show less inclination to do so. *Technology-focused individualists*, however, respond more positively to this question than might be expected: four in ten in this group could envisage using such a smart card if it was offered. We can speculate that this card potentially offers flexibility and therefore appeals to segments that value autonomy in travel.

4 Policy implications: designing group and context sensitive inverventions

The attitudinal profiles of respondents and their specific contextual opportunity and constraints provide starting points for defining policy priorities and designing potential interventions. Table 7 summarises the salient characteristics of attitudinal type, assesses what drives and constrains potential use of alternative modes and suggests what kinds of targetted interventions may be expedient to sustain and encourage greener urban mobility. Anable (2005) infers in her study the potential switchability of attitudinal groups from their psychographic and demographic characteristics. We took a similar approach and summarised current behavioural drivers and resulting opportunities for change in order to identify potential group-specific alternatives that support sustainable travel. Interventions to support these distinct shifts towards sustainable travel include psychological interventions as well as structural interventions (road pricing, congestion charging, vehicle bans), if the former are likely to fall short of effecting change. Yet it should be noted that there is to date no strong evidence for the effectiveness of various interventions (Graham-Rowe et al 2011; Gehlert et al 2013). Robust evaluation studies of interventions aimed at behaviour change remain scarce and there is a considerable need for research in this area. Here we focus on formulating strategic policy goals that are most likely to sustain and promote sustainable travel as an aggregate outcome across all groups.

Traditional car-oriented (1). In short, the policy priority for this group is first to compensate for the environmental impact of their travel, second to mitigate their impact and third, to reduce driving and car ownership where possible. Because this type will strongly resist mode-switching, not least since the residential context of this group often limits alternatives, fiscal policy mechanisms (congestion

charge, parking fees) may leverage funds for compensatory environmental improvements. In terms of mitigation, the main focus should be on encouraging the use of low emission vehicles. Since this group indicates an affective dimension to their car use, switching to low emission vehicles may not be achievable through fiscal incentives alone (i.e. tax benefits upon purchase of low emission vehicles). Extra charges for, or bans of, high emission vehicles in city centres may be necessary to mitigate the environmental impact in this group. A softer option would be to provide guidance on eco-driving.

Pragmatic transit-sceptics (2) are less reluctant to use other modes than the *traditional car-oriented,* but their strong rejection of technology inhibits access to alternative mobility services and multi-modal travel. They are likely to be influenced by firm habits formed over a longer time – the mean age of this cluster is highest in both cities – and linked perhaps to generation-specific orientations that favour pragmatism over social, environmental, symbolic or affective values. In fact, this is reminiscient of Steg's research in the Netherlands (Steg 2005), who found that valuing affective functions of cars is more common among younger respondents. Thus interventions should aim at reducing the environmental impact of their current habits by improving access to electric cars, where this is feasible. Given the pragmatic orientation of this group, interventions should focus on practical testing. Promotions that allow users to test for free alternative modes (electric cars, car sharing, public transit) for a period of time – and thus highlight aspects of feasibility, easy access and convenience – may be the most effective way to make this group switch to low emission travel. These interventions may be even more successful in combination with fiscal policy instruments. Given their high car ownership rates yet greater openness towards other modes, (increased) congestion charging may help alter mobility practices sustainably, since they affect the functional value of cars.

Green travel-oriented (3) favour transit and therefore already show much inclination towards more sustainable travel. The major policy objective should be to support these individuals maintain the practice of cycling and transit riding, in particular when biographical events such as new parenthood and relocation may induce a conscious or unconscious reorientation in travel. In this case, information about mobility services that enhance flexible travel need to be made available to this group in order to help them travel in ways that are consistent with their environmental awareness. It may also be worth encouraging more openness towards technology use and innovation in the long run. Financial penalities may discourage future car use but are not as relevant for this group, given their current travel habits.

Table 7. Policy priorities and interventions by attitudinal type of respondent.

(1) Traditional car-oriented	(2) Traditional, pro private modes	(3) Green travel-oriented
Policy goal: mitigate and compensate * compensate for environmental impact * reduce environmental impact * reduce driving and car ownership where possible _____ **Current behavioural drivers** * driving most practicable and convenient * driving is necessary to manage daily life * enjoyment of driving * conscious residential location in car-dependent environments * low moral obligation _____ **Opportunities for change** * overall very low inclination to change * general openness towards car sharing and electric cars * London: moderate affinity to technology _____ **Potential alternatives** * electric cars _____ **Interventions** * fiscal, compensatory policy instruments (congestion charging, parking fee) to pay for ecological impact * regulatory instruments to coerce use of low emission vehicles (low emission zone) * tax benefits upon purchase of low emission vehicles * structural interventions to improve access to electric cars where feasible	**Policy goal: mitigate** * reduce environmental impact * reduce driving and car ownership where possible _____ **Current behavioural drivers** * driving most practicable and convenient * low inclination to test alternatives * conscious residential location in car-dependent environments * firm habits * income constraints _____ **Opportunities for change** * overall low inclination to change * Berlin: moderate openness to cycling and social norm * London: moderate openness to transit _____ **Potential alternatives** * electric cars * car sharing * cycling (Berlin) * transit (London) _____ **Interventions** * programmes that allow gratuitous testing of electric cars, car sharing schemes or public transit (e.g. free monthly pass) * expand network of electric cars * promote flexible car sharing schemes * fiscal incentives to purchase electric cars (e.g. tax benefits) * congestion charging to prompt orientations towards more sustainable travel * Berlin: promote cycling and highlight health and social benefits * London: promote transit use e.g. through special fares	**Policy goal: affirm and encourage** * maintain and expand cycling and transit use * London: reduce car use and ownership further _____ **Current behavioural drivers** * environmental awareness * London: social norm _____ **Opportunities for change** * high responsiveness to interventions * existing experience with alternative modes _____ **Potential alternatives** * walking * cycling * transit _____ **Interventions** * keep group informed about alternative modes, mobility services to improve travel experience * target with specific offers to test new services * promote use of technology in travel

Table 7 (cont'd). Policy priorities and interventions by attitudinal type of respondent.

(4) Pragmatic transit-oriented	(5) Technology-focused individualists	(6) Innovative access-oriented
Policy goal: affirm and encourage * maintain and further encourage cycling and transit use * Berlin: reduce car use and ownership further _____ **Current behavioural drivers** * absence of driver's licence * low car ownership * rejection of private modes * low technology use _____ **Opportunities for change** * high responsiveness to interventions * existing experience with alternative modes * overall low likelihood to use alternative and innovative services _____ **Potential alternatives** * transit * cycling, park and ride * car sharing _____ **Interventions** * promote transit experience through traditional channels rather than ICT * target with specific offers to test new services * transit should be kept affordable * encourage future technology use	**Policy goal: switch** * reduce driving and car ownership * reduce environmental impact _____ **Current behavioural drivers** * appreciation of autonomy * hedonistic orientation _____ **Opportunities for change** * overall medium to high chance of change * propensity to use technology and apps * experience with cycling * modest amenability towards alternative services _____ **Potential alternatives** * cycling * electric cars * car sharing _____ **Interventions** * highlight autonomy and fun aspects of alternatives, including transit modes through free testing * target through technology channels, smart phone travel apps and electronic services * encourage cycling through campaigns highlighting personal benefits (health, fitness, fun)	**Policy goal: inform and encourage** * encourage further use of alternative modes * further reduce car use _____ **Current behavioural drivers** * travel competence * conscious location in central neighbourhoods * social norm and environmental awareness _____ **Opportunities for change** * overall high likelihood to change and try out new options * experience with alternative modes * curiosity * acceptance of collective modes * use of technology _____ **Potential alternatives** * walking * cycling * transit * electric car hire _____ **Interventions** * promote mobility services to improve travel experience, particularly online services * inform instantly about new options and services

Pragmatic transit-oriented (4). The major policy objective for the *pragmatic transit-oriented* should be to support maintenance and extension of current travel behaviour. Although general campaigns increasing environmental and moral consciousness may be useful in targeting this cluster, moral appeals may not be effective in preventing driving at a later life stage. The emphasis should therefore be on policy options that highlight aspects of feasibility and convenience of alternative modes, notably car sharing. Their general preference for living centrally, their low car ownership rates and their existing experience with collective modes provide a favourable ground for these interventions. In

addition, promoting technology use may further support their long-term travel patterns. Fiscal measures should not affect this group's travel; nevertheless, public transit should be kept affordable, given that this group comprises lower income households.

Technology-focused individualists (5) promise a number of opportunities for change. The psychographic profiles indicate a desire for autonomy and hedonistic orientations, supported by the socio-demographic composition of this cluster, in particular age, sex and income. The policy priority should be to reduce the practice of driving and car ownership in this group. Interventions should aim at highlighting the flexibility, individuality and fun of alternative modes, in particular ways to easily combine transit riding with car sharing or cycling across the metropolitan region. This may be best achieved through programmes that allow this group to directly test those alternatives and discover smart and creative aspects of travelling while also caring about health and fitness. Their amenability to new forms of travel suggests that these services may increase the sense of autonomy that is so important to this group; quick information and the innovative use of new information technology as a channel for durable interventions are crucial. Higher incomes among this group render fiscal measures less effective, although the means for compensatory measures may be leveraged. Overall, policy should emphasise choice rather than coercion here.

Innovative access-oriented (6). Policy objectives should focus on encouraging further uptake of alternative modes and reduction of car ownership and driving. There is a high chance of this group trying new modes and services, based on their curiosity and confidence in travel; thus, the most effective policy option may be to keep this group informed about latest developments in transport options and mobility services in their area and in the city. ICT may be an effective channel for interventions as this group, too, responds well to technological developments and innovative applications. Electric car sharing may be a serious alternative to car ownership, when circumstances change; thus, information tools facilitating the use of this service may be effective in consolidating the sustainable profile of this group. Fiscal measures are likely to have little impact on this group's travel patterns.

5 Discussion

Our study confirms that attitude-based typologies are useful in characterising the subjective dimensions of travel behaviour and wider choices affecting travel. The results suggest that neither socio-demographic aspects of residents nor travel behaviour alone are sufficient to develop effective interventions that help attain sustainability goals in transport and wider urban policy. It would be unrealistic to assume, for example, that the more established car oriented groups (*traditional car-oriented, pragmatic transit-sceptics*) would readily reduce car use based on either fiscal or communicative interventions. In London, congestion charging has existed since 2003 and Berlin's

Umweltzone (low emission zone), banning high emitting vehicles from the city's centre, was introduced in 2008. Consequently, our survey already captures possible changes in attitudes and travel habits that those instruments might have induced. While a potential introduction of congestion charging in Berlin and an expansion of congestion charging in London could help authorities manage the impact of change-resistant groups, changes in actual travel patterns as a result of these fiscal measures are likely to be marginal. Research by others suggests that car-oriented groups would need to experience drastic financial consequences before habits change (Schuitema 2007 et al, De Groot & Steg 2006). In addition, for those groups it is likely that non-instrumental values, such as affect and symbolic status, play a strong part in their reluctance to use other modes (Steg 2005, 2007). Thus, a clever combination of mitigation (electric cars) and compensation (fees) seems more appropriate. Compensatory measures can then support alternative means to attain carbon emission goals that cannot be achieved solely through the voluntary or fiscally incentivised reduction of car use.

The role of affect in driving, however, may be transposable into a substitute sense of autonomy among more technology-valuing clusters. The openness among *technology-focused individualists* towards potentially technology-driven services (smart cards, travel apps, electric car hire) may indicate that promoting ICT use could expose unfeigned car users to alternatives. This could be important for influencing the travel choices of younger individuals from milieus with more hedonistic orientations. For these individuals ICT may itself constitute a channel for communicative interventions. The role of ICT and technology in altering the affective dimensions of car use should be explored further in future research.

The relatively low car ownership rate and infrequent car use among *innovative access-oriented*, who comprise young families with higher incomes, would be surprising if they had not been identified as innovative and flexible through their attitudinal profile. Similarly, *green travel-oriented* and their motivations would not have been identified and policies may have missed the specific contexts and constraints of this group. Although a specific combination of social and demographic properties seems to be associated with pro-environmental attitudes, it was found in other studies that these attitudes constitute independent and important drivers in travel intentions, choices and behaviours in both the UK (Hess et al 2013) and Germany (Bamberg et al 2007).

Consistent with these findings, our study shows that pro-environment attitudes vary with socio-demographic factors. In London, *green travel-oriented* are older than in Berlin and the London cluster express more innovativeness and openness to alternative mobility services while also having the lowest share of people with university degrees. This relationship is reversed for *pragmatic transit-oriented* (type 4): in Berlin they are older, have fewer degrees and are more innovative than the London equivalent. Thus while older car-averse clusters are more innovative, innovation in London is combined with pro-environment attitudes and decoupled in Berlin. In general, studies by others tend to

confirm that education is positively related to green travel orientation (Hess et al 2013; Bamberg et al 2007; Anable 2005), but in the case of London those who are highly educated seem to be absorbed in the *innovative, access-oriented* cluster.

The comparative research design of our study also added more insight into possible group-specific scenarios of sustainable travel. High car ownership rates among *pragmatic transit-sceptics* and *technology-focused individualists* would not suggest the high uptake of cycling (14% each) that we observe in Berlin. This finding indicates that the London equivalent types might cycle too, if cycling conditions were more conducive. Here, the comparative method of this study suggested an important potential for change within two car-focussed groups that would have remained concealed otherwise. This hypothesis is further corroborated by the fact that cycling is uncommon even among London *green travel-oriented*, while in the Berlin equivalent nearly one third are cyclists. This points towards significant potential for alternative mode use in various London segments.

The relationship between psychographic profiles, travel behaviour and long-term mobility choices (residential location, car ownership) correspond strongly. Conforming to findings from other studies, we cannot reject the existence of multi-directional causal relationships between context, individual preferences and travel choices. Attitudes towards travel are shaped by context but, at the same time, attitudes towards travel drive residential decisions and distinctively confine behavioural possibilities. The *traditional car-oriented* illustrate this point best: they do not just emerge out of their residential situation, their attitudes also arise from their preference for living in the countryside. Given that they are constrained by their car-dependent environments, behavioural interventions can only be successful if they respond to the attitudes of this group very closely.

In future applications of this work, attitudinal dimensions could be used in choice modelling to explain and predict travel behaviour (Hess et al 2013; Hurtubia et al 2014; Vredin Johannson et al 2006). Attitudinal classes can emerge in latent class models using the scales identified in our factorial analysis. A hybrid choice modelling framework could account for preference heterogeneity by class membership and integrated into random utility models. While this is beyond the objectives of this paper, such application of our attudinal scales could provide a promising enhancement of conventional travel demand models, simulating the impacts of interventions on travel choices once policy evaluation studies have yielded more conclusive results.

6 Concluding remarks

Overall, the attitudinal profiles and behavioural characteristics in the two cities reveal significant potential for continued and future uptake of sustainable forms of travel. This potential may be unlocked by smart mobility services that allow easy and flexible multi-modal travel, if solutions and interventions encouraging their use are tailored to group-specific preferences, needs and constraints.

The role of context is crucial here, as it determines the feasibility of interventions in general (e.g. competitive travel times and operating efficiency of alternative modes) and commands a sensitive interplay of 'hard' and 'soft' policy instruments. Future research should evaluate further the extent to which context shapes attitudes and how these attitudes affect choices about future context. Viewing and evaluating policy interventions, not only in terms of their physical and financial aspects, but also in relation to the prevailing drivers of behaviour, is crucial if we are to build realistic scenarios and devise strategies that effectively encourage sustainable forms of urban mobility.

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