Dimensions of urban mobility cultures – A comparison of German cities

Thomas Klinger [a, *], Jeffrey R. Kenworthy [a,b], Martin Lanzendorf [a]

[a] Goethe-University Frankfurt/Main, Department of Human Geography, Frankfurt/Main, Germany
[b] Curtin University, Sustainability Policy Institute, Curtin University, Perth, Western Australia

ABSTRACT

In the context of the immense economic and social challenges urban transport faces in the near future, the analysis of city-specific differences in supply and usage of urban transport systems is a promising approach for identifying potential strategies for establishing more sustainable transport systems and mobility patterns. This study aims to address such differences by a comparative approach and is, to our best knowledge, the first one capturing the subjective dimension of urban mobility by integrating satisfaction and perception-related indicators at a city-level. Drawing on the socio-technical concept of urban mobility cultures, which combines socio-economic and urban form characteristics, mode-specific infrastructure supply, as well as the travel behaviour and underlying attitudes of a city's inhabitants, we collected a set of 23 indicators from several sources, mainly from the early 2000s. These data have been applied to a sample of 44 German cities. As a result of a factor and cluster analysis we identified six groups of cities ranging from relatively mature and homogenous socio-technical settings, referred to as 'cycling cities' or 'transit metropolises', to urban mobility cultures such as 'transit cities with multimodal potential', whose forthcoming development is not yet directed towards a specific future and, therefore, is open for political debate. The mismatch between objective and subjective indicators of urban mobility culture that has been shown for some city groups is another starting-point for changing urban mobility cultures in terms of taking people's perceptions and evaluations of the local transport system more seriously.

Keywords:
Cluster analysis, Germany, Mobility culture, Mode choice, Perception, Travel behaviour

[*]Corresponding author. Address: Department of Human Geography, Goethe-University Frankfurt/Main, Grüneburgplatz 1, PEG building, D-60323 Frankfurt/Main.
Tel.: +49 69 798 35172; fax: +49 69 798 35180.
E-mail address: klinger@geo.uni-frankfurt.de

1. Introduction

Climate change, peak oil and unsustainable traffic volumes are serious challenges for the future development of metropolitan areas worldwide. While the international debate still discusses the role and contribution of the transport sector in these issues and, furthermore, appropriate policies for guiding future development in certain directions, an international comparison of metropolitan areas suggests that even under the same regulatory framework, cities have options for shaping their own future developments. For example, some cities like Copenhagen (Denmark), Groningen (Netherlands) or Münster (Germany) are well-known 'good practice' communities with high shares of bicycling usage, while others are named "transit metropolises" (Cervero, 1998). To explain these differences in travel patterns at the city-level two main approaches have been established: Whereas some researchers have highlighted the impact of objective criteria such as urban form and socio-economics, others focus more on the subjective dimension represented by individual preferences and attitudes towards mobility.

To bridge the explanatory gap between these perspectives, the approach presented here is to test empirically the mobility culture concept, which is a theoretical and integrated framework including both objective and subjective parameters. The term urban mobility cultures encompasses both material and symbolic elements of a transport system as part of a specific socio-cultural setting, which consists of mobility-related discourses and political strategies on the one hand and institutionalised travel patterns and the built environment on the other hand (Deffner et al., 2006, p. 16; Götz and Deffner, 2009).

Consequently, we capture the concept of urban mobility cultures by developing a set of 23 indicators, which reflects particular elements of the concept. Furthermore, we apply the indicator set to a sample of 44 German cities by undertaking a factor and cluster analysis and eventually identifying six groups of similar mobility cultures within our city-sample. This approach is, to our best knowledge, the first one to quantify subjective parameters such as mobility-related evaluations and perceptions at a city-level and combine them with rather common objective data, such as land use and socio-economic characteristics. The categorisation suggested in our analysis reveals that there are mature mobility cultures such as a group of cycling cities with all indicators pointing in the direction of a cycling-friendly environment and other rather heterogeneous clusters indicated by discrepancies, e.g. between objective and subjective indicators. Moreover, some groups of cities such as the 'transit cities with multimodal potential' do not show a clear orientation towards one mode of transport, which highlights the important potential influence of planning and political action for the future of these cities.

The paper is structured as follows. After reflecting on work which has been done on both the objective as well as the subjective dimensions of mobility (section 2), we introduce the mobility culture concept in section 3. In section 4 we discuss the aforementioned set of objective and subjective indicators, which has been used as a starting point for a factor and cluster analysis resulting in six groups of urban mobility cultures (section 5). We conclude by discussing the developed typology of German cities concerning the similarities and dissimilarities of their mobility cultures,

especially with regard to the typology's policy and planning implications and pointing out the need for further in-depth-research on urban mobility cultures.

2. Objective and subjective determinants of travel behaviour – a literature review

2.1. The objective dimension: urban form, transport infrastructure and socio-economics

It is a prominent debate within transport geography whether and how far spatial and material characteristics such as urban form or transport infrastructure influence individual travel behaviour. Early work by Thomson (1977) shows the interdependence between specific means of transport and their corresponding infrastructure systems on the one hand and urban form characteristics on the other hand. His work identified for the first time, different levels of car-dependence and transit-effectiveness.

Although the debate has been on-going for decades now, no agreement regarding the impact of urban design on travel behaviour has been reached yet (for an overview refer to Boarnet and Crane, 2001; Hickman and Banister, 2005; van Wee, 2002). One group of scholars states that urban form features, often referred to as the 3 D's density, diversity and design (Cervero and Kockelman, 1997), do explain travel behaviour to a considerable extent (Frank and Pivo, 1994; Gordon, 1997; Newman and Kenworthy, 1989a, 1999; Stead, 2001), whereas other researchers are very sceptical about such an impact (especially Gordon and Richardson, 1997; Snellen, 2001). Regarding the policy implications, the two parties have been described as 'interventionists' and 'sceptics' respectively (Breheny, 1992; Hickman and Banister, 2005, p. 103; Schwanen et al., 2001), since the former argue that planning policies and urban design measures such as rail-based settlement development are important tools to change travel behaviour and thus lead to more sustainable mobility patterns, while the latter doubt the usefulness of such policy strategies and prefer a free-market-oriented approach. As a starting point we want to summarise the main arguments, which have been put forward in the context of density, diversity and design.

Density, diversity and design

The indicator probably most often referred to when analysing spatial influence on mobility is the density of the urban fabric (Banister, 1997; Frank and Pivo, 1994; Næss, 1993, 1995; Newman and Kenworthy, 1989a, 1999; Stead, 2001). Well-known are several comparative city studies which have identified relatively high shares of environmentally friendly modes like walking, cycling and public transport correlating with low rates of transport-related energy consumption (Apel et al., 1997; Næss, 1993, 1995; Newman and Kenworthy, 1989a, 1999). Urban density has been quantified in several ways, such as calculating the number of persons per hectare of urbanised land (Newman and Kenworthy, 1999) or by the share of particular dwelling types (Ryley, 2006).

A second component of urban form, which is often referred to in the context of mobility patterns, is the diversity of different land uses, e.g. measured by the average

distances from place of residence to workplace (Fouchier, 1998; Næss and Jensen, 2004; Schipper et al., 1994). It is assumed that a more dispersed distribution of destinations such as workplaces, schools and shops throughout the area of a city leads to lower travel distances and thus to higher shares of 'slow modes' such as walking and cycling compared to a more centralised distribution pattern (Banister, 1996; van Wee, 2002).

On the other hand some authors point out that 'salt and pepper' dispersal of jobs actually increases car dependence, and that it is only 'decentralised concentration' of jobs that shortens trip lengths and causes modal shifts from cars to bicycles, foot and public transport (Newman and Kenworthy, 1999, 2006). The principles of density and diversity are core elements of planning strategies such as the 'compact city' and 'decentralised concentration', which are applied in the context of sustainable urban planning (Jenks et al., 2000; Williams, 2005).

Design, the third D, although not as well-known as the former two, has also been analysed regarding its impact on travel behaviour. It refers to the spatial configuration of street systems or public transport networks (Curry and Loader, 2010). Studies have addressed its influence, for example, by simulating travel distances in two fictional neighbourhoods, one with an open grid-like street pattern and one with a rather inaccessible network of dead ends (Boarnet and Crane, 2001; Handy, 1992; Khattak and Rodriguez, 2005; Kulash et al., 1990; McNally and Ryan, 1993).

As a factor, which is highly related to density, diversity and design, the population size of a city has regularly been interpreted as a reason for differentiated mobility patterns. For example, it has been argued that the implementation of more efficient infrastructure and transport systems becomes more likely in larger cities, which in many cases influences travel behaviour as can be seen in relatively high modal shares of public transport and rather low transport-related energy consumption per capita in big metropolises (Barrett, 2000; Newman and Kenworthy, 1999). However, Newman and Kenworthy (1989b) also found that city population size *per se* was not a significant correlating factor in explaining aggregate urban travel patterns. For example, many quite small European cities such as Graz (Austria) and Freiburg (Germany) have very high rates of green mode usage because they are dense and planned around these non-auto modes. Conversely, virtually all US cities of similar population size are mostly totally automobile dependent because they have almost no public transport systems and are too low density and spread out for walking and cycling to be viable modes.

Socio-economics

Another group of indicators, relatively easy to quantify and regularly referred to in analyses of urban mobility and travel behaviour, are socio-economic attributes such as wealth, age distribution or labour-market characteristics (Newman and Kenworthy, 1999; Pucher and Lefèvre, 1996; Ryley, 2006; Schafer and Victor, 2000). These features are analysed in several ways. For example, it has been suggested by an international comparison using data from the US and Great Britain, that lower household income and higher costs of car ownership in Great Britain lead to more economising behaviour indicated by shorter travel distances and more use of alternative transport modes (Giuliano and Dargay, 2006). Furthermore, socio-

economic aspects have been described as restrictions on the activities and mobility of the individual (Chapin, 1974), which refers to the concept of constraints developed by Hägerstrand (1970). Moreover, socio-economic and demographic characteristics are often described as structural factors influencing individual lifestyles and attitude patterns, e.g. by using the notion of the life situation (Scheiner and Holz-Rau, 2007; Simma and Axhausen, 2001).

2.2. The subjective dimension: lifestyles, attitudes and perception

The emphasis on the discussed spatial characteristics, which has been described as "urban form euphoria of transportation research" (Scheiner and Holz-Rau, 2007) has been followed since the 1990ies by a considerable disillusionment. A growing number of researchers have stated that non-urban form characteristics might be at least as important to understand travel behaviour, which is said to be strongly influenced by the attitudes of residents, often in a self-selecting way. These considerations led to the concept of residential self-selection, which basically assumes that people choose their residential location as a consequence of their preferences towards features like residential environment, provision of local services, local accessibility or specific means of transport (Mokhtarian and Cao, 2008; Scheiner and Holz-Rau, 2007, pp. 491; Schwanen and Mokhtarian, 2005; van Acker et al., 2010, p. 224; Waddell et al., 2001). In this perspective urban form, means of transport and the related infrastructure are not anymore exclusive factors to explain travel behaviour, but attitudes and preferences towards these aspects become the focus of interest.

Consequently, a growing number of authors include preferences towards urban form and travel characteristics in addition to the rather objective variables such as urban density or socio-economic data (e.g. Bagley and Mokhtarian, 2002; Collantes and Mokhtarian, 2007). Other studies have aimed to prove the assumed relevance of underlying attitudes and lifestyles by analysing travel behaviour before and after a residential relocation (Handy et al., 2005; Krizek, 2003; Scheiner, 2005). Scheiner, for example, showed that the motorisation rate of city residents who moved to the outskirts was already higher than the one of their neighbours who stayed in the inner city, even before the relocation (Scheiner, 2005, 2009a). This result leads to the assumption that even among the residents within the same neighbourhood different mode orientations and consequently different travel behaviours can be found. Schwanen and Mokhtarian identified some people within their sample of residents of the San Francisco region, who represent a mismatch between the spatial characteristics of the neighbourhood they live in and the neighbourhood setting they actually prefer. Consequently, they achieved a "continuum ranging from well-matched urbanites through dissonant urban and suburban residents to consonant suburbanites (Schwanen and Mokhtarian, 2005, p. 96), whereas the modal shares of public transport and non-motorised modes are declining continuously towards the latter.

All this acknowledgement of individual preferences and attitudes towards land use and travel can be referred back to the concept of lifestyles. The notion of lifestyles has been developed out of a critique of conventional models of social differentiation such as classes and ranks. The debates of modernisation (Giddens, 1990) and individualisation (Beck, 1992) raised the consideration of taste, attitudes and values. Consequently, lifestyles have been analysed as a factor influencing travel behaviour in

several studies (Anable, 2002; Bagley and Mokhtarian, 2002; Collantes and Mokhtarian, 2007; Lanzendorf, 2002).

Furthermore, research on the subjective dimension of mobility has shown that attitudes and preferences often significantly influence the perception and evaluation of transport aspects, such as transport modes or infrastructure supply. For instance, Schuitema et al. (2013, p. 39) found that people with a pro-environmental self-identity are more likely to have a positive perception of electric vehicles. This is not to equate attitudes and perceptions: a person might perceive a city as car-friendly while preferring to cycle. However, in many cases perceptions are mirroring the underlying attitudes.

Although we can conclude that our understanding of travel behaviour has benefited from the notion of relatively autonomous decision-making and individuality as part of the lifestyle perspective, objective criteria remain an important framework for individual action. For example, even members of a lifestyle group, which share positive attitudes towards rail based public transport are not able to use any rail-based services, if they don't exist in the city they live in (for more examples Scheiner, 2009b, p. 44). Therefore, for the remainder of this paper we aim to analyse how objective and subjective indicators interact with each other within an integrated framework. Consequently, we will introduce the concept of urban mobility cultures and use it as a starting point for our own empirical research.

3. Integrating objective and subjective components – the concept of urban mobility cultures

As argued before, the concentration on either objective characteristics such as urban form in isolation or merely subjective concepts such as attitudes or lifestyles is not sufficient to understand travel behaviour properly. Focusing only on spatial characteristics tends to neglect the processes of perception and evaluation, which might lead to different forms of travel behaviour, although the objective framework is constant. Contrariwise, an overestimation of individual preferences suggests that the individual is able to act and travel nearly freely and independent from objective framings such as urban form and infrastructure supply, overlooking that these conditions are changeable only in the long term and that their present state limits or promotes individual preferences.

Therefore, we argue that both lines of reasoning can be understood as embedded in a broader socio-cultural context of community-based priorities, values and beliefs. Consequently, we refer to a concept of culture, defined as commonly shared knowledge which facilitates the organisation of day-to-day life by suggesting particular practices as feasible and signifying others as not feasible (Hörning, 1999, p. 99; Janowicz, 2006, pp. 5-7).

This integrative view is also promoted by the *mobility turn* in Anglo-American social research. Besides arguing for the growing importance of mobile forms of social organisation in general, authors representing the "new mobilities paradigm" (Sheller and Urry, 2006) also discuss cultural differentiation of mobility. This is addressed, for example, as 'flows of meanings' and 'cultures of movements' (Jensen, 2009), as well

as ‘constellations of mobility as historically and geographically specific formations of movements, narratives about mobility and mobile practices’ (Cresswell, 2010, p. 17).

This international debate is mirrored by German research, such as the promising and newly developed concept of urban mobility cultures (Deffner et al., 2006; Götz and Deffner, 2009). This concept serves as a theoretical framework for our analysis, because it integrates objective and subjective elements on a city-level. In this perspective, urban form and transport infrastructure are conceptualised as the materialised extension of cultural priorities. This cultural setting can be interpreted as a complex configuration of different preferences and lifestyles represented by a city’s population, which even might develop common conventions and habits. This illustrates that objective and subjective components of urban mobility are highly connected and dependent on each other.

Hence, the concept of urban mobility cultures can be understood as an integrative approach incorporating both habitual practices, including underlying preferences and lifestyles, as well as rather objective and structural components such as infrastructure and spatial characteristics. Moreover, city-specific discourses and transport policy are added to the concept of urban mobility cultures. These two components can be best considered as hybrid forms combining objective and subjective elements. We cannot discuss them in detail here and refer to Bratzel (1999), Haefeli (2008) and Stone (2009) for analyses of urban transport policy as well as to Cresswell (2010) and Vigar (2002) for mobility-related discourses (Fig. 1).

The idea of the city-specific socio-material formations presented here, is partly mirroring recent approaches in urban sociology, as the following quote illustrates: “Each city develops along its own unique lines of historically motivated narrative, or the interpretation of various forms of materiality, as well as political and economic figurations – with each unique city logic rooted in early-defined practices, and yet not limited to them.” (Löw, 2008, p. 285). In this context it has to be mentioned that the city-specific patterns are embedded in and connected to various other socio-spatial configurations such as national frameworks on the one hand and neighbourhood and milieu characteristics on the other. Even though it is also worthwhile to apply the concept to these spatial scales, we concentrate here on the city-level since most measures such as infrastructure provision or political strategies are related to this framework.

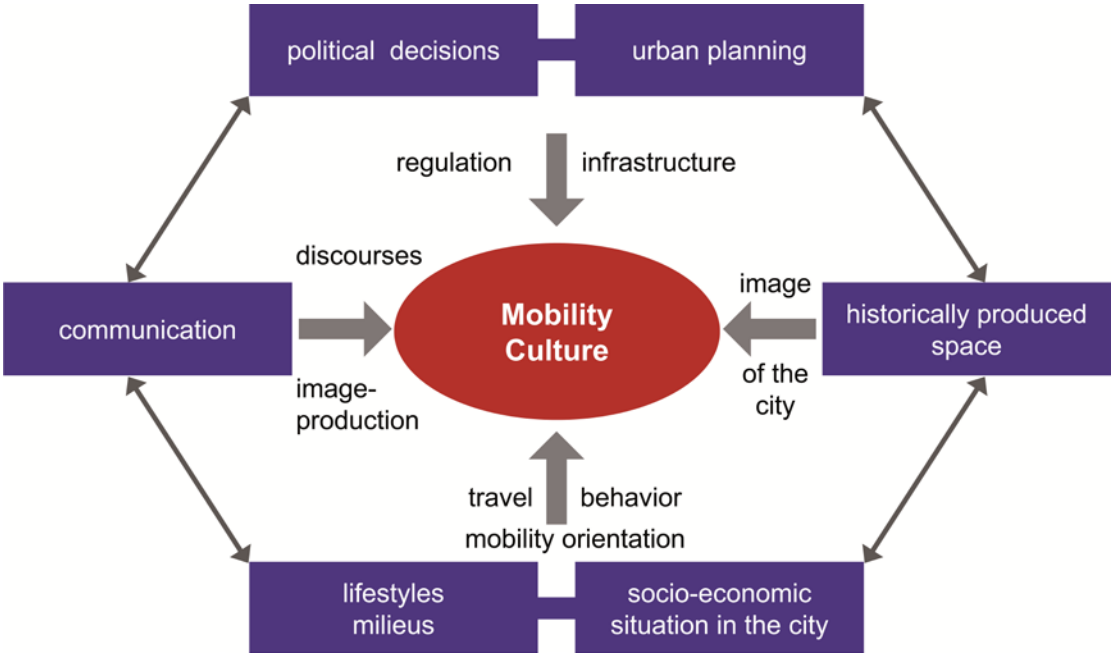

Fig. 1. Concept of urban mobility cultures (Source: Deffner et al., 2006, p. 16. Own translation and modification)

It is important to note that the concept is neither fixed nor homogenous, but is a model which includes dynamic processes, competing interests and conflicts and is able to be modified over time and space. Similarly, mobility cultures are not consistent and uniform but highly differentiated configurations of dominant cultural patterns and various sub- and countercultures. Metaphorically, this specific mixture of routes more and "routes less travelled" (Vannini, 2009) is a crucial indicator of any urban mobility culture.

In sum, although urban mobility cultures are not fixed but contingent, they are regarded as rather inertial structures which show a high level of path dependence. This is mainly because two of the core elements of mobility culture, urban form and lifestyle patterns, are also rather long-lasting constructs, which are far from being significantly changed in a short period.

It is crucial to analyse the configuration and interdependencies of the particular components of the concept in order to understand how specific types of mobility culture emerge and become persistent. Moreover, in a policy perspective the understanding of mobility cultures may help to identify key factors for influencing the cultural setting in a certain way, whereas this should not be understood as a direct determination, but rather as a creative and flexible governance process. Deffner et al. suggest doing so by either a historical reconstruction of the development of specific mobility cultures or by the comparison of different cultural settings. Our research is inspired by the latter and aims to generate a comparative data set, which is presented in the next section.

4. Indicators of urban mobility cultures

In the following section we aim to increase the understanding of urban mobility cultures by quantifying them with an adequate set of indicators, which include

objective and subjective variables. Such a specific quantification has, to our best knowledge, not been published elsewhere. The integration of subjective indicators is especially a rather new approach, given that most other transport- and mobility-related comparisons of urban areas concentrate more on objective indicators (Cervero, 1998; Newman and Kenworthy, 1999; Pucher and Buehler, 2006). To sum up, we included urban form, socio-economics, transport infrastructure, travel behaviour and transport-related attitudes in our analysis.

On the contrary, in this explorative study, we excluded further elements of the mobility cultures concept such as discourses and transport policy. This is for pragmatic reasons since these features are difficult to quantify, meaning that a qualitative policy analysis might be more appropriate here. Moreover, policy and discourse aspects are excluded because they are not clearly related to either the objective or the subjective dimension of mobility, a differentiation which is central to this study. However, some of the variables used, such as infrastructural or modal choice indicators, are highly reflective of political priorities and discourse formations.

Furthermore, we are aware that this indicator-based approach leads to mean values which fall short of the complex reality of diverse sub- and counter-cultures within an urban community. However, we believe that some mainly socio-economic variables point to the importance of particular mainstream or sub-cultural patterns within a specific city, even if only in a very general way.

Additionally, our study would clearly benefit from a more comprehensive and more detailed assessment of subjective data. However, already four variables are explicitly representing the subjective dimension of urban mobility, this low number being due to a very limited availability of subjective data on a city-level. Altogether, we drew on 23 variables (Table 1), which we then used as a starting point for a principal component analysis in order to reveal the underlying dimensions of urban mobility cultures in Germany (see section 5.1).

Table 1
Applied indicators - overview

Indicator	Description	Source	Year
Urban form indicators *(representing "historically produced space" and " urban planning" in the mobility culture concept, see fig. 1)*			
1. Population size	No. of inhabitants	Federal Statistical Office	2008
2. Settlement density	No. of people living per sq.km. of urbanised land (settlement and transport-related land uses)	BBSR (Federal Institute for Research on Building, Urban Affairs and Spatial Development, division 'spatial monitoring') / Federal Statistical Office	2000
3. One- and two-family houses	Share of one- and two- family houses in the building stock of a city	BBSR, 'spatial monitoring'	2007
Socio-economic characteristics *(representing "socio-economic situation in the city" in the mobility culture concept, see fig. 1)*			
4. Share of elderly	Percentage of people, aged 65 years and older	Ditto	2007
5. Household income per capita	Average net monthly income of all households divided by number of inhabitants	Ditto	2006
6. Share of single-	Percentage of single households	Ditto	2006

households			
7. Unemployment rate	Percentage of unemployed people ('Erwerbspersonen')	Ditto	2007
Transport infrastructure and supply (representing "infrastructure" in the mobility culture concept, see fig. 1)			
8. Bike related businesses	No. of entries for cycle-related businesses in local yellow pages per 1,000 people	Own research	2009
9. Tramway	Existence of a tramway system (binary variable) (criteria: surface-based, no light-rail or train-tram system)	Ditto	2010
10. Other than bus service	Existence of a public transport system additional to bus services	Ditto	2010
11. Price public transport season ticket	Price for a season ticket for public transport	Stakeholder group 'INSM' / Institut der deutschen Wirtschaft	2008
12. Car related businesses	No. of entries for car-related businesses in local yellow pages	Own research	2009
Transport demand indicators / travel behaviour (representing "travel behaviour" in the mobility culture concept, see fig. 1)			
13. ADFC members per capita	No. of ADFC members per 1,000 people	ADFC	2010
14. Motorisation rate	Registered cars per 1.000 people	Federal Motor Transport Authority	2009
15. High powered cars	Share of high powered cars (> 2.000 cc)	Ditto	2009
16.-19. Modal split	Proportion of walking, cycling, public transport and private car trips	National survey 'Mobility in Germany', regional and local surveys	1997-2010
Mobility-related perceptions and evaluations (representing "mobility orientation" and indirectly "lifestyles, milieus" in the mobility culture concept, see fig. 1)			
20. Cycling climate I – cycling is fun	Is cycling fun?, average response	ADFC survey 'Cycling climate test'	2003, 2005
21. Cycling climate II – all population groups cycle	Do all population groups cycle?	Ditto	2003, 2005
22. Perceived quality of public transport	How big is the demand for improving public transport?	'Perspektive Deutschland' survey	2005
23. Perceived quality of streets	How big is the demand for improving road network?	Ditto	2005

For the quantification of urban mobility cultures, we analysed a set of 44 out of 80 German cities with more than 100,000 inhabitants. The sample includes cities varying considerably in terms of size, geographical location (Eastern and Western Germany) and socio-economic structure.

4.1. Spatial indicators

With this group of indicators we focus on spatial characteristics of each city at an aggregate level. Referring to the discussion in the previous section, we consider *population size* as a relevant indicator. Although not a spatial variable on its own, it is representing the urban form dimension of the mobility culture concept indirectly since it has various spatial implications such as the extent of the urban area or the average distance to the city centre. Consequently, we assume a correlation between population size and mode choice. Nonetheless, a pure focus on population size is still an insufficient indicator regarding the relative demand for space and mobility. To close

this conceptual gap we have added density-related characteristics to our model of urban mobility culture. We chose three indicators to characterise urban density as one component of mobility culture, which is in several ways linked to travel behaviour of people as well as to transport policies of city governments:

Settlement density, which is calculated as the number of persons per hectare of urbanised land, is a widely applied and well-accepted indicator to define urban density (for many Newman and Kenworthy, 1999; Siedentop et al., 2006). In our sample of German cities, settlement density correlates positively with public transport use and walking confirming earlier findings (Goetzke, 2008). Therefore, settlement density is another important indicator representing the urban form dimension of the mobility culture concept.

The *share of one- and two-family-houses* can be seen as another indicator of urban density in that a high percentage of these housing types indicate a rather low-density, sprawling urban structure. Furthermore, it can be interpreted as either a materialised result of socio-cultural preferences towards specific types of housing and the corresponding mobility implications, or a reflection of political and economic factors that have favoured and subsidised this form of housing (or a combination of both). Within our sample of German cities the assumed relation between the share of low density housing types and mobility patterns could be confirmed with reasonably strong correlations for the modal shares of walking and public transport use (r=-0.45) and car use (r=0.22), as well as for the level of motorisation (number of cars per 1,000 persons) (r=0.24). Furthermore, the proportion of these housing types might point to the importance of values such as family-orientation and privacy (Collen and Hoekstra, 2001). These orientations can be either dominant or sub-cultural patterns within an urban community. Nonetheless, we acknowledge that indicators such as the one used here capture the complex realities of mainstream and sub-cultural configurations only in a very general way.

4.2. Socio-economic characteristics

Besides spatial and density-related characteristics, the socio-economic situation of a city is another element of the urban mobility culture concept (Fig. 1), which we introduced as an objective condition of travel behaviour in urban regions. Although our analysis is mainly focusing on urban form and lifestyle configurations, we included some typical socio-economic variables in our analysis. As already discussed in section 2.1, the economic situation of a household can be interpreted as restricting or facilitating for the mobility of each household member. In this view the *average household income per capita* has an impact on the use of particular means of transport and the access to specific destinations.

The *share of single households* is related to the household income per capita (r=0.20) and therefore also indicates the wealth of an urban population. Furthermore, it might point to specific mobility cultures, since this relatively young and well-educated population group tends to be more active and mobile compared to the majority of people. Moreover, this group of people is often associated with the notion of the ‘creative class’ (Florida, 2004) as well as specific sub-cultural patterns and values such as professional orientation, tolerance and environmental awareness. Conversely, the average *unemployment rate* in a city indicates relative poverty and economic

weakness. Again, impacts on modal choice and the range of activities are possible and will be analysed in our case study (see section 5).

The influence of age on the intensity and quality of travelling is well-known and documented by a lot of studies. For example, results of the German national travel survey 'Mobility in Germany', show that people aged 65 years and older, make less trips per year (approx. 1,000 compared to approx. 1,500 by middle-aged people) and are less mobile, both in terms of distance and duration (infas and DIW, 2004, pp. 115-118). Furthermore, the elderly require particular qualities in a transport system, e.g. high accessibility and user-friendliness. Therefore we included the *share of people aged 65 years and more* in our set of indicators.

4.3. Transport infrastructure and supply

The indicators introduced in this section refer to the design-aspect of urban transport systems as discussed in section 2.1, as well as to the aspects of urban planning and infrastructure, which are essential for the mobility cultures approach (Fig. 1). Since data regarding the extent and layout of infrastructure systems are hard to generate we decided to focus on mode-specific indicators, which can be interpreted as indicators of socio-culturally established priorities towards specific means of transport.

As a first approach to capture the quality and standard of public transport systems in the analysed city sample, we decided to incorporate two binary variables, which are '*existence of a tramway system*' and '*existence of another public transport system except bus service*'. We have chosen these indicators because many examples of local public transport planning illustrate that the existence of rail services and especially of surface-based tramway systems usually make a big difference in both the capability and perception of the public transport system, compared to only bus-based public transport supply. This finding applies to different aspects of public transport systems, such as maximum number of passengers (e.g. Hesse and Nuhn, 2006, p. 190; Kenworthy, 2008), average speed (Hass-Klau et al., 2003; Kenworthy, 2008, pp. 22; Newman and Kenworthy, 1999), image and reputation of particular transport modes and vehicles (Bratzel, 1999; Haefeli, 2008; Schiefelbusch, 2009) as well as their impact on the design and quality of public space (Groneck, 2003, 2009), such as the frequent combination of tramways with attractively designed pedestrianised streets.

Furthermore, we argue that the number of services and shops related to particular means of transport, function as a reliable indication for the major orientation of people towards a specific mode of transport. To identify the *number of bicycle and car-oriented services* such as dealers, garages and rental firms, we counted the related entries in the yellow pages of each city. We confirmed through correlation analysis the expected link between number of services and travel behaviour indicated by modal share of cycling ($r=0.49$) as well as motorisation and car ownership ($r=0.27$). Naturally, there is something of a 'chicken and egg' nature to these variables, which is typical for the mutual strengthening of demand and supply characteristics.

A further interesting attribute, which either enables or restricts access to transport supply, is the *price of a season ticket for public transport*. We took data from a study, which refers to the absolute price of an annual ticket, which covers the area of approx. 20km around the central railway station of a city (IW Consult, 2008).

4.4. Transport demand indicators / travel behaviour

Measures of travel behaviour such as modal choice are central to each description of urban mobility. They are highly linked to both objective indicators such as urban form and socio-economics, as well as subjective indicators such as attitudes and lifestyles. The behavioural characteristics themselves are best regarded as objective variables, though they might be biased by respondents' self-reporting.

The *level of motorisation* expressed by the number of cars per 1,000 people as well as the percentage of high powered cars are definitely wealth-related features, but we argue that they also indicate the socio-cultural value of individual transport in general and especially well-equipped vehicles, since earlier studies have shown that these figures clearly differ even within comparable economic circumstances (Lötscher et al., 2001; Newman and Kenworthy, 1999).

Modal split variables distinguished by the most common modes of transport (walking, cycling, public transport, car use) are central for analysing urban mobility and travel behaviour. Several studies illustrate that modal split characteristics differ to a significant extent, even within the same political and socio-economic framing (e.g. Lötscher et al., 2001 for German cities and Apel et al., 1997 for a sample of international cities), due to varying planning and policy priorities or differing lifestyle patterns. This conclusion can be confirmed for our sample of 44 German cities, based again on data taken from the 'Mobility in Germany' survey, as well as several regional and local surveys. For the cities of Herne and Leverkusen the modal split variables have been estimated by regression analyses in order to replace missing values.

It has been argued that a reinforcing positive feedback exists between the modal split in a city and the individual decision to use a particular mode. In this view, a high share of a specific transport mode can be interpreted as an indicator of high quality and reliability, "just as a full restaurant is a sign of good food and satisfied customers" (Goetzke, 2008, p. 416, see also Goetzke and Rave, 2011), which makes the choice of this means of transport more likely (see also Sherwin et al., 2012).

The biggest and most influential federation in Germany, which promotes the interests of cyclists, is called ADFC ('Allgemeiner Deutscher Fahrrad Club' / General German Cycle Club) and has nationwide approximately 136,000 members. We added the *number of ADFC members per capita* in each city to our set of attributes following the assumption that it could serve as an indicator for the bicycle-orientation of the particular urban community.

4.5. Mobility-related perceptions and evaluations

It has been argued that preferences and attitudes are crucial to the subjective dimension of mobility cultures. We aim to capture this dimension by including perceptions and evaluations, which have been identified by mobility-related surveys. This is because perceptions are often considered to be an adequate indicator for underlying attitudes (Schuitema et al., 2013).

The mentioned stakeholder group ADFC has repeatedly conducted surveys among its members and other cyclists, asking them to evaluate the 'cycling climate' in the city they live in. In sum, more than 20,000 cyclists participated in each of the two surveys in 2003 and 2005, so that even on a city-level a sufficient number of cases have been recruited (ADFC, 2003, 2005). Besides infrastructure and security related questions, it has also been asked how accepted cycling is among the inhabitants of the city. Explicitly it has been asked *if cycling is rather fun or rather stressful* and if *only children and tourists or all population groups are cycling*. Respondents could choose from a scale between 1 and 6. Both variables correlate significantly with the modal share of cycling (r=0.37 and 0.61 respectively). This finding reveals a close link between attitudes and behaviour.

Also in 2005 McKinsey Germany, together with media partners, conducted a nationwide online survey regarding perceived quality of life. Within an extensive set of questions it has also been asked, how people *perceive and evaluate* the *quality of the road network and the public transport system* in their city or region (McKinsey et al., 2006). Again, the link between attitude and behavioural patterns has been confirmed in so far that, interestingly, a negative perception of road infrastructure correlates significantly with a high share of car trips (r=-0.30). The opposite is true for perception and use of public transport (r=0.52). However, the factor and cluster analysis presented in section 5 reveals interesting discrepancies between perception-based indicators and other variable categories for some city groups, which illustrates how the analysis benefits from integrating subjective indicators.

When interpreting these four perception-related variables, it has to be borne in mind that the situation has changed since 2003 and 2005 when the data were collected. Many cities experienced a cycling boom (Lanzendorf and Busch-Geertsema, 2012) as indicated by an increased modal share of cycling e.g. from 9.7% to 13.4% in Hamburg and from 17.5% to 20.2% in Bremen between 2002 and 2008 (own analyses based on infas and DIW, 2004, infas and DLR, 2010).

In this context it is not surprising that in the newest edition of the ADFC cycling climate index (ADFC, 2012) the agreement with the statement "all population groups are cycling" has slightly increased within our sample of 44 cities (mean value of 2.97 compared to 3.04 in 2005). On the contrary, respondents reported more often that cycling is no fun (3.24 compared to 2.93 in 2005). This might reflect the partly critical media coverage (Der Spiegel, 2011) and the fact that cycling infrastructure is not yet prepared for the growing demand. Although there are no updated data on the evaluation of streets and public transport, we assume that these indicators have not changed to a great extent. This is because the modal shares of driving and public transport remained rather stable (infas and DLR, 2010) and our data show that modal choice and perception correlate.

The resulting set of indicators fairly represents the main modes of transport and includes proxies for planning and policy priorities on the one hand and commonly shared attitudes and behaviour patterns on the other hand. Clearly these 23 indicators could have been more detailed in terms of measuring the supply and usage of urban transport systems. For example, the analysis would benefit from more metric variables, such as the length of public transport networks or vehicle miles travelled by mode, as well as additional demand variables like average distance and speed of trips.

Most obviously, there are only four variables to reflect the subjective perception and evaluation of urban transport. These shortcomings are a consequence of limited data availability, since especially attitude-based data are difficult to obtain.

5. A Typology of mobility cultures in German cities – Methodology and results

5.1. Factor Analysis – Dimensions of urban mobility cultures

In order to reveal the underlying dimensions of urban mobility cultures, we used the 23 indicators presented previously. This enabled us to apply a principal component analysis including a varimax rotation in order to group highly related variables and to identify hidden 'background factors' which determine the distribution of the data (Tabachnick and Fidell, 2009). Following the Kaiser-criterion (eigen-value higher than 1), we derived seven factors named as follows: wealth, density and general public transport orientation, cycle-friendliness, metropolitan character, individual and ecological mobility, walkability and rail transport orientation (Table 2).

The model explains 81.7% of the variance of all variables and the particular factor loadings are shown in table 2. This overview helps to identify the different parameters of urban mobility cultures. Firstly, it becomes apparent, that the orientation towards particular means of transport seems to play a prominent role since five out of seven factors are mainly determined by mode-specific infrastructure supply, the modal share of and the commonly shared attitudes towards particular modes. Other aspects generating different mobility cultures could be identified in the socio-economic resources available to a city's population (factor 'wealth') as well as in the population size and the corresponding social and infrastructure characteristics (factor 'metropolitan character'). To sum up, urban mobility cultures are obviously complex configurations of material, symbolic and socio-economic elements.

Table 2
Factors of urban mobility cultures in German cities

Factors of urban mobility cultures	**Indicators**	**Loadings**[a] (sorted by value)
1 – Wealth	high powered cars	**.915**
	unemployment rate	**-.848**
	household income per capita	**.784**
	elderly people	**-.783**
	perceived quality of street network	**.755**
	number of ADFC members per capita	**.671**
	price of public transport season ticket	**.436**
2 – Density and public transport orientation	one and two family houses	**-.789**
	settlement density	**.758**
	modal share public transport	**.740**
	more than bus service	**.618**
	motorisation rate	**-.520**
	is cycling fun?	**-.454**
3 – Cycle-friendliness	do all population groups cycle?	**.815**
	car-related businesses	**-.806**
	modal share cycling	**.782**

	is cycling fun?	**.659**
	motorisation rate	**-.624**
4 – Metropolitan character	perceived quality of public transport	**.784**
	population size	**.712**
	single households	**.517**
	modal share public transport	**.449**
	household income per capita	**.447**
5 – Individual and ecological mobility	cycle businesses	**.654**
	price public transport season ticket	**-.649**
	single households	**.526**
6 - Walkability	modal share walking	**.970**
	modal share private car	**-.598**
7 – Rail transport orientation	Tramway	**.899**
	other than bus service	**.545**

[a] sorted by value, factor loadings below 0.4 were cut off

5.2. Cluster analysis – Which urban mobility cultures exist?

Based on the extracted factors discussed above, we applied a hierarchical cluster analysis to our sample of 44 German cities for which all data were available. This city-sample is a selection out of 80 cities with a population of more than 100,000 inhabitants. Big, dense and affluent cities with a rail-based public transport system are over-represented in our sample. In terms of socio-economics the sample is a fair representation of all 80 cities (table 3).

Table 3
Selected urban form, transport and socio-economic variables (study sample and all German cities)

Indicator (year of reference: 2009)	**Sample** (n = 44)	**German cities** (> 100,000 people, n = 80)
Location, size and urban form		
Located in Eastern Germany (proportion)	11.4%	13.8%
More than 500,000 people (prop.)	25.0%	17.5%
Settlement density > 4,000 people/km^2 of urbanised land (prop.)	34,1%	22,5%
Transport		
Rail-based public transport system (prop.)	70.5%	58.5%
Socio-economics		
Household income per capita > 1,500€/month (prop.)[a]	65.0%	56.1%
Unemployment rate (average)[a]	9.8%	9.8%
Proportion of single households (av.)[b]	41.0%	40.9%
Proportion of students (av.)[a]	7.3%	7.7%
Proportion of elderly (>65 years) (av.)	20.3%	20.5%

[a] data only available for 66 cities, of which 40 are included in the sample
[b] year of reference is 2007

We generated six clusters including four with up to ten cities each (Table 4) by using the Ward method and subsequently the k-means procedure. A high increase of the error sum of squares suggests a number of six to eight clusters (elbow-criterion) (Bacher et al., 2010, pp. 305-316; Backhaus et al. 2011, pp. 436). We chose the six

cluster solution, because it is clearly and plausibly structured. In consequence of the k-means procedure, the city of Aachen was transferred from cluster 1 to cluster 3. Fig. 2 illustrates the deviation between the mean of the cluster elements and the mean of the entire city-sample for each variable.

Table 4
Cluster-set: cluster names and cities per cluster

Cluster	No. of cities	Cities
1 – Cycling cities	8	Bremen, Hamm, Leverkusen, Lübeck, Oldenburg, Osnabrück, Münster, Neuss
2 – Transit metropolises[a]	4	Cologne, Düsseldorf, Hamburg, Munich
3 – Auto-oriented cities	10	Aachen, Duisburg, Essen, Fürth, Herne, Mönchengladbach, Offenbach, Wiesbaden, Reutlingen, Wuppertal
4 – Transit cities with multimodal potential[a]	8	Bielefeld, Bochum, Heidelberg, Karlsruhe, Krefeld, Mülheim, Nürnberg, Oberhausen
5 – Walking cities with multimodal potential	7	Bonn, Darmstadt, Frankfurt am Main, Ludwigshafen, Mainz, Mannheim, Stuttgart
6 – Transit cities[a]	7	Augsburg, Chemnitz, Dresden, Halle (Saale), Leipzig, Potsdam, Saarbrücken

[a] For these cluster names we used American English, since they refer to the term “transit metropolis” (Cervero, 2008).

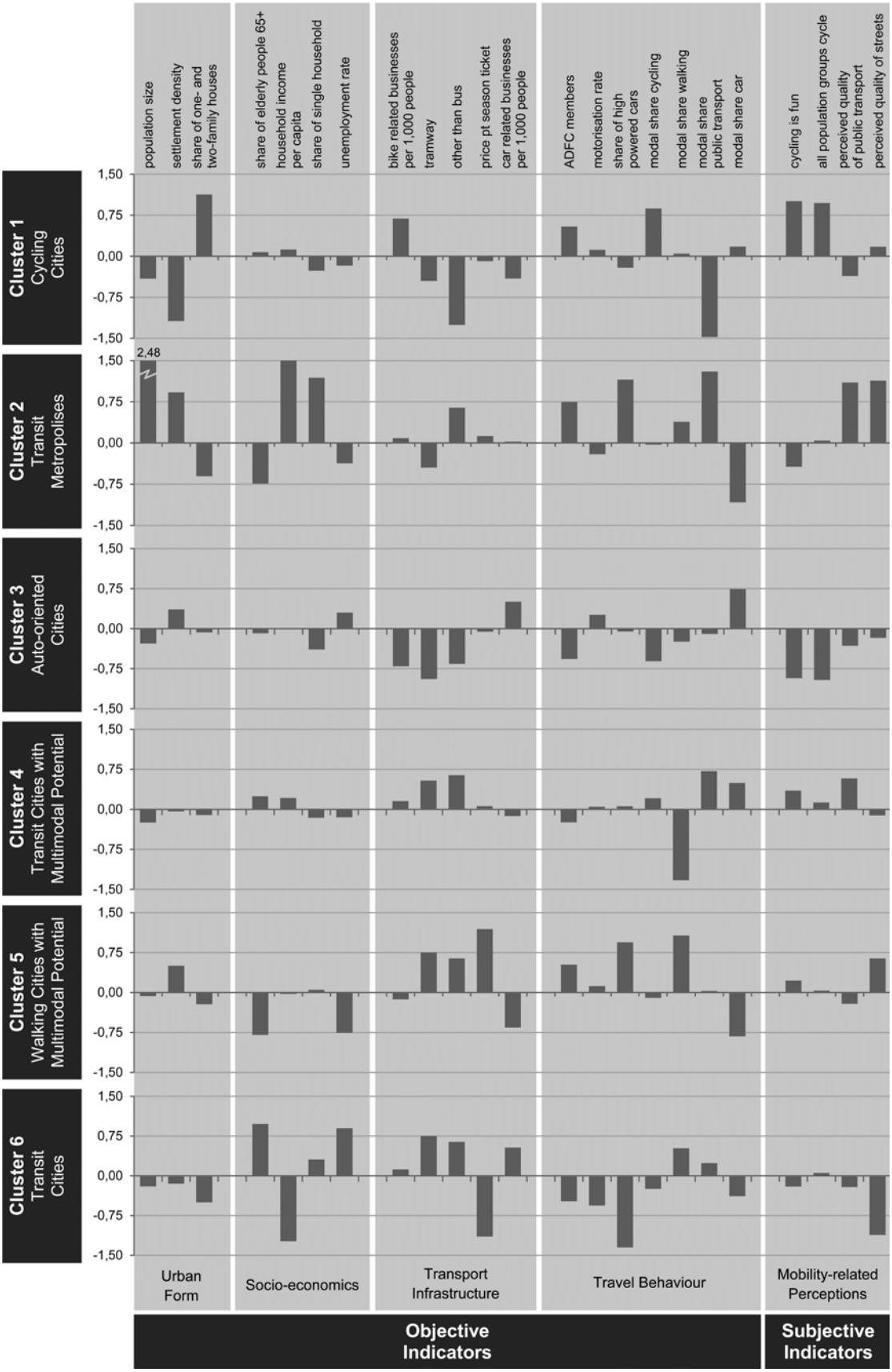

Fig. 2. Mean deviation by cluster and variable

6. Discussion

The multi-faceted approach presented here allows us to obtain a more complex picture of urban mobility and transport as well as to identify matches and mismatches between the different dimensions of mode orientation represented by the chosen indicator-set (infrastructure and service, travel behaviour, perceptions and evaluations). In this perspective it is, for example, possible to reveal if transport infrastructure in a city is 'high quality' only in terms of 'hard facts' like extent of network and service, or if it is at the same time perceived as high quality by its users. Similarly, the generated dataset helps to analyse interdependencies between travel behaviour and mobility-related perceptions. For example, the integration of subjective variables enables us to identify inconsistencies, e.g. between a high modal share of a specific means of transport and a negative evaluation of this mode. Such contradictions point to a rather involuntary mode usage, which is more likely to be a result of socio-economic or infrastructure-related constraints. This could indicate a high propensity for behaviour change in the event of changed circumstances.

The first city cluster, called *cycling cities*, shows a strong and consistent propensity towards cycling among all analysed dimensions of mode orientation (infrastructure, travel behaviour, perceptions). Moreover, there is a clear trade-off between cycling and public transport use, since all public transport indicators show under average values. Interestingly, *cycling cities* are smaller and less dense than average. This confirms findings from European and US contexts, although the link between cycling and density is still highly debated. Whereas the good accessibility of destinations supports cycling in dense areas, the high volumes of traffic are a possible barrier (Heinen et al., 2010, Pucher et al., 2011).

Similarly, the second group of cities, named *transit metropolises,* is characterised by high and consistent values for all public transport-related indicators in terms of infrastructure, travel behaviour and perceptions. Remarkably, car use and cycling play a minor role in this cluster, whereas walking is slightly more popular than in the whole sample. Most obviously, *transit metropolises* are bigger, denser and more affluent than the average. These spatial and socio-economic attributes indicate the differences between this and the two other public transport-related city-clusters (transit cities with multimodal potential and transit cities). An interesting detail in this group is the contrast between low car use and a positive evaluation of the street network. This shows that perception of a mode does not always lead to its usage, especially if there are attractive alternative mobility options.

The third city group, labelled *auto-oriented cities*, shows above average values in terms of car related supply (car related businesses) and car use (motorisation rate and modal share car). In contrast to this, the quality of the street network is evaluated rather negatively. This finding might point towards a well-known vicious circle of car use leading to congested roads and frustrated drivers who demand construction of new roads stimulating further car use. For all other modes the corresponding indicators show below average values in terms of supply, usage and perception. Furthermore, there are no specificities regarding urban form and socio-economics.

The fourth city cluster is called *transit cities with multimodal potential* and shows above average values for all dimensions of public transport orientation. In contrast to

the two other public transport oriented clusters, this group is characterised by a very low share of walking trips, whereas the proportions of cycling and driving are slightly above average. This is indicating a potential for combining public transport with bike use and car use, although mode choice is still dominated by public transport. This cluster is average in terms of urban form and socio-economics.

The fifth group of cities, named *walking cities with multimodal potential*, is characterised by a high share of walking trips as well as a low share of car trips. However, we believe there is potential for more public transport trips indicated by an above average supply with high quality rail based public transport service. The same is true for cycling indicated by a slightly positive evaluation of the 'cycling climate' in these cities and an above average number of ADFC members. Similar to the transit metropolises, this cluster shows a strong discrepancy between a low share of driving and a positive perception of the street network. In terms of urban form and socio-economics *walking cities with multimodal potential* are rather dense and affluent. Consequently, wealth related transport attributes such as the price of a season ticket or the share of high powered cars are above average.

The sixth cluster, labelled *transit cities*, is the third cluster characterised by a public transport orientation. Differently to cluster 2 and 4, the negative evaluation of the public transport system contrasts with the positive values for public transport supply and usage. This result is complemented by socio-economic attributes such as a low household income per capita and a high unemployment rate. This points towards a population which is less affluent than the average and leads to the assumption that many of the public transport users are captive riders who would use other modes if they could afford them.

Finally, an impact of both urban density and socio-economic features could be verified for some city groups, whereas in other clusters mobility patterns and mode orientation seem to be relatively independent of those variables. This is especially true for the third, fourth and partly for the fifth cluster (*auto cities, transit cities with multimodal potential, walking cities with multimodal potential*). The findings lead to the assumption, that those city types are characterised by urban mobility cultures which are less dependent on objective constraints and more influenced by policy and cultural preferences and therefore are easier to change. This assumption certainly needs to be tested by further in-depth analysis which offers potential for identifying situations and windows of opportunity for developing mobility patterns in one direction or another (Bratzel, 1999).

7. Conclusion and prospects

The aim of this paper was to empirically test the theoretical concept of urban mobility cultures, which is described as a combination of objective and subjective characteristics such as spatial, socio-economic and political structures on the one hand, and mobility-related preferences and practices on the other hand. Furthermore, we intended to identify the underlying dimensions of different mobility cultures.

In order to quantify the described concept we chose a set of 23 indicators which we applied to a sample of 44 German cities with more than 100,000 inhabitants. Drawing from elements of the mobility cultures concept such as lifestyles, travel behaviour,

transport policy and infrastructure, we collected or developed our own data from a wide range of sources. The applied indicators can roughly be divided into urban form and socio-economic characteristics, transport infrastructure and transport behaviour, as well as mobility-related perceptions and evaluations. This indicator-based approach is limited insofar that it produces mean values which cannot reflect the complex mixture of mainstream, sub- and countercultures existing in an urban community.

Conducting a factor and cluster analysis, we obtained six clusters differing in mode orientation as well as in socio-economic and spatial characteristics. An analysis of the mean values for each variable revealed the character and configuration of the clustered city groups. This approach is at the forefront in the field of analysing urban mobility patterns, since it is to our best knowledge, the first one capturing subjective indicators in a study on a city-level.

Nonetheless, the analysis has several shortcomings. Most importantly, the subjective dimension is represented by only four perception-related variables. This is due to a limited availability of adequate data, e.g. in national or regional household surveys. Therefore, we recommend adding perception and attitude-related questions to future editions of those surveys. Furthermore, future work should find ways to quantify transport policy and discourses, which are missing in our implementation. In this regard, a potential indicator is the voting behaviour of a city's population.

The particular value of our findings is that they describe how and to what extent urban mobility patterns vary within the same political and national context. A further result is that cities having the same historical and socio-economic starting position such as the traditional industrial centres of the Ruhr, nonetheless vary so much that they are included in different clusters. This finding supports the initial assumption of the mobility cultures concept that these social structures are not fixed and homogeneous entities, but dynamic and clearly changeable social fabrics. This argument leads to the further research question of what determines the significantly different priorities found in the mobility culture of a wide range of cities.

We believe that this study is relevant for mobility related research, planning practice and policy formulation. For practitioners in transport, urban planning and policy it offers an opportunity to identify cities with a similar mobility culture than the one they are working for. Thus, it can be used as a benchmarking instrument. Consequently, the results might be used for an exchange of ideas and strategies how to face common challenges. With regard to mobility research, we hope that our findings can inspire more in-depth case studies of particular cities or city groups, which are able to shed light on how specific mobility cultures emerge and change over time.

Acknowledgements

This research has been made possible by a grant of the Rhein Main Verkehrsverbund (RMV) and the Integriertes Verkehrs- und Mobilitätsmanagement Rhein-Main (ivm), the founders of the professorship for mobility research at Goethe University Frankfurt. The authors are grateful to Marit Rosol, Peter Endemann, Jon Shaw, Mathias Wilde and two anonymous reviewers for their helpful comments on a previous version of the paper. They also thank Elke Alban and Markus Menge for the figures in this article. Earlier versions of this paper have been presented at WCTR 2010 in Lisbon, at ETC 2010 in Glasgow and at the Forschungskolloquium at TU Dortmund, Fakultät Raumplanung. The authors thank the participants of these presentations for their constructive feedback.

References

ADFC, 2003. Ergebnisse ADFC-Fahrradklimatest 2003. Präsentation vom 12.03.2004, gehalten in Potsdam.

ADFC, 2005. Gesamtübersicht Fahrradklimatest 2005. ADFC: Bremen.

ADFC, 2012. ADFC-Fahrradklima-Test 2012 – Ergebnistabelle Städte ausführlich. http://www.adfc.de/fahrradklima-test/ergebnisse/adfc-fahrradklimatest-2012---die-ergebnisse Accessed April 26, 2013.

Anable, J., 2002. Picnics, pets, and pleasant places: The distinguishing characteristics of leisure travel demand. In: Black, W. R., Nijkamp, P. (Eds.), Social change and sustainable transport. Indiana University Press: Bloomington, pp. 181–190.

Apel, D., Lehmbrock, M., Pharoah, T., Thiemann-Linden, J., 1997. Kompakt, mobil, urban: Stadtentwicklungskonzepte zur Verkehrsvermeidung im internationalen Vergleich. difu: Berlin.

Bacher, J., Pöge, A., Wenzig, K., 2010. Clusteranalyse – Anwendungsorientierte Einführung in Klassifikationsverfahren. 3rd ed. Oldenbourg: Munich.

Backhaus, K., Erichson, B., Plinke, W., Weiber, R., 2011. Multivariate Analysemethoden – eine anwendungsorientierte Einführung. 13th ed. Springer: Berlin, Heidelberg.

Bagley, M., Mokhtarian, P., 2002. The impact of residential neighborhood type on travel behavior. A structural equations modeling approach. Annals of Regional Science 36 (2), 279–297.

Banister, D., 1996. Energy, quality of life and the environment: The role of transport. Transport Reviews 16 (1), 23–35.

Banister, D., 1997. The theory behind the integration of land use and transport planning. Proceedings, Waterfront Conference, April, 5-9 1997, 1997: London.

Barrett, G., 2000. The transport dimension. In: Jenks, M., Burton, E., Williams, K. (Eds.), The compact city. A sustainable urban form? E & FN Spon: London, pp. 171–180.

Beck, U., 1992. Risk society: Towards a new modernity. Sage: London.

Boarnet, M., Crane, R., 2001. The influence of land use on travel behavior: specification and estimation strategies. Transportation Research Part A 35 (9), 823–845.

Bratzel, S., 1999. Conditions of success in sustainable urban transport policy - Policy change in ‘relatively successful’ European cities. Transport Reviews 19 (2), 177–190.

Breheny, M. J., 1992. Sustainable development and urban form. Pion: London.

Cervero, R., 1998. The transit metropolis: A global inquiry. Island Press: Washington D.C.

Cervero, R., Kockelman, K., 1997. Travel demand and the 3Ds: Density, diversity and design. Transportation Research Part D 2 (3), 199–219.

Chapin, F. S., 1974. Human activity patterns in the city: Things people do in time and in space. Wiley: New York.

Collantes, G., Mokhtarian, P., 2007. Subjective Assessments of Personal Mobility: What Makes the Difference between a Little and a Lot? Transport Policy 14 (3), 181–192.
Collen, H., Hoekstra, J., 2001. Values as determinants of preferences for housing attributes. Journal of Housing and the Built Environment 16 (3-4), 285-306.
Cresswell, T., 2010. Towards a politics of mobility. Environment and Planning D 28 (1), 17-31.
Curry, G., Loader, C., 2010. Bus network planning for transfers and the network effect in Melbourne, Australia. Transportation Research Record 2145, 181–192.
Deffner, J., Götz, K., Schubert, S., Potting, C., Stete, G., Tschann, A., Loose, W., 2006. Schlussbericht zu dem Projekt „Nachhaltige Mobilitätskultur“. Entwicklung eines integrierten Konzepts der Planung, Kommunikation und Implementierung einer nachhaltigen, multioptionalen Mobilitätskultur. Projekt 70.0749/04(FOPS) BMVBS Referat A 32. ISOE: Frankfurt am Main.
Florida, R., 2004. The rise of the creative class – and how it’s transforming work, leisure, community and everyday life. Basic Books: New York.
Fouchier, V., 1998. Urban density and mobility in Ile-de-France Region. Paper presented at The UN-ECE 8th conference on Urban and Regional Research June, 8-11 1998. UN. Conference on Urban and Regional Research, 1998: Madrid.
Frank, L. D., Pivo, G., 1994. Impacts of mixed use and density on utilization of three modes of travel: single occupant vehicles, transit, and walking. Transportation Research Record 1466, 44–52.
Giddens, A., 1990. The consequences of modernity. Stanford University Press: Stanford, California.
Giuliano, G., Dargay, J., 2006. Car ownership, travel and land use: A comparison of the US and Great Britain. Transportation Research Part A 40 (2), 106–124.
Goetzke, F., 2008. Effects in Public Transit Use: Evidence from a Spatially Autoregressive Mode Choice model for New York. Urban Studies 45 (2), 407–417.
Goetzke, F., Rave, T., 2011. Bicycle use in Germany: explaining differences between municipalities with social network effects. Urban Studies 48 (2), 427–437.
Gordon, P., 1997. Densities, urban form and travel behavior. Town and Country Planning 66 (9), 239–241.
Gordon, P., Richardson, H. W., 1997. Are compact cities a desirable planning goal? Journal of the American Planning Association 63 (1), 95–106.
Götz, K., Deffner, J., 2009. Eine neue Mobilitätskultur in der Stadt - praktische Schritte zur Veränderung. In: Bundesministerium für Verkehr, Bau u. Stadtentwicklung (Ed.), Urbane Mobilität. Verkehrsforschung des Bundes für die kommunale Praxis. NW-Verlag: Bremerhaven, pp. 39–52.
Groneck, C., 2003. Neue Straßenbahnen in Frankreich. Die Wiederkehr eines urbanen Verkehrsmittels. EK-Verlag: Freiburg.
Groneck, C., 2009. Erfolgsrezepte von Frankreichs neuen Straßenbahnsystemen: Warum die Tram-Renaissance westlich des Rheins so überzeugend ist. Der Nahverkehr 26 (5), 34–37.
Haefeli, U., 2008. Verkehrspolitik und urbane Mobilität - Deutsche und Schweizer Städte im Vergleich 1950-1990. Beiträge zur Stadtgeschichte und Urbanisierungsforschung, 8. Franz Steiner: Stuttgart.
Handy, S. L., 1992. Regional Versus Local Accessibility: Neo-Traditional Development and its Implications for Non-work Travel. Built Environment 18 (4), 253-267.
Handy, S. L., Cao, X., Mokhtarian, P., 2005. Correlation or Causality Between the Built Environment and Travel behavior? Evidence from Northern California. Transportation Research Part D 10, 427–444.
Hass-Klau, C., Crampton, G., Biereth, C., Deutsch, V., 2003. Bus or light rail: Making the right choice ; a financial, operational and demand comparison of light rail, guided buses, busways and bus lanes, 2nd ed. Environmental & Transport Planning: Brighton.
Heinen, E., Van Wee, B., Maat, K., 2010. Bicycle use for commuting: a literature review. Transport Reviews 30 (1), 105–132.
Hesse, M., Nuhn, H., 2006. Verkehrsgeographie. Schöningh: Paderborn.

Hickman, R., Banister, D., 2005. Reducing travel by design: What about change over time? In: Williams, K. (Ed.), Spatial planning, urban form, and sustainable transport. Ashgate: Aldershot, pp. 102–119.
Hörning, K., 1999. Kulturelle Kollisionen. Die Soziologie vor neuen Herausforderungen. In: Hörning, K., Winter R. (Eds.), Widerspenstige Kulturen. Cultural Studies als Herausforderung. Suhrkamp: Frankfurt am Main, pp. 84–115.
infas, DIW, 2004. Mobilität in Deutschland 2002: Ergebnisbericht. infas; DIW: Bonn, Berlin. http://www.mobilitaet-in-deutschland.de/03_kontiv2002/publikationen.htm. Accessed April 26, 2013.
infas, DLR, 2010. Mobilität in Deutschland 2008: Ergebnisbericht, Struktur – Aufkommen – Emissionen – Trends. infas, DLR: Bonn, Berlin. http://www.mobilitaet-in-deutschland.de/pdf/MiD2008_Abschlussbericht_I.pdf Accessed April 26, 2013.
IW Consult, 2008. Fahrkosten-Ranking 2008: Vergleich der 100 größten deutschen Städte: Köln. http://www.insm-fahrtkostenranking.de/files/Endbericht-2008-02-06.pdf. Accessed 2 December 2012.
Janowicz, C., 2006. Vom ‚Kitt' der Gesellschaft zum ‚doing culture': Eine kleine Typologie der Kulturbegriffe. In: ISOE (Ed.), Schlussbericht zu dem Projekt „Nachhaltige Mobilitätskultur". Entwicklung eines integrierten Konzepts der Planung, Kommunikation und Implementierung einer nachhaltigen, multioptionalen Mobilitätskultur. Projekt 70.0749/04(FOPS) BMVBS Referat A 32., Anhang 1c: Frankfurt am Main, pp. 1–8.
Jenks, M., Burton, E., Williams, K. (Eds.), 2000. The compact city: A sustainable urban form? E & FN Spon: London.
Jensen, O.B., 2009. Flows of Meaning, Cultures of Movements - Urban Mobility as Meaningful Everyday Life Practice. Mobilities 4 (1), 139-158.
Kenworthy, J. R., 2008. An International Review of The Significance of Rail in Developing More Sustainable Urban Transport Systems in Higher Income Cities. World Transport Policy and Practice 14 (2), 21–37.
Khattak, A. J., Rodriguez, D., 2005. Travel behavior in neo-traditional neighborhood developments: A case study in USA. Transportation Research Part A 39 (6), 481–500.
Krizek, K. J., 2003. Residential relocation and changes in urban travel: Does neighborhood-scale urban form matter? Journal of the American Planning Association 69 (3), 265–281.
Kulash, W., Anglin, J., Marks, D., 1990. Traditional neighborhood development: Will the traffic work? Development 21 (July/August), 21–24.
Lanzendorf, M., 2002. Mobility styles and travel behavior: Application of a lifestyle approach to leisure travel. Transportation Research Record 1807, 163–173.
Lanzendorf, M., Busch-Geertsema, A., 2012. The cycling boom in some German cities – understanding and explaining behavioral change. Paper presented at the 13th International Conference on Travel Behaviour Research (IATBR), Toronto, 15-20 July 2012
Lötscher, L., Mayer, O., Monheim, R., 2001. Mobilität und Verkehrsmittelwahl. In: Deiters, J., Gräf, P., Löffler, G. (Eds.), Nationalatlas Bundesrepublik Deutschland. Bd. 9: Verkehr und Kommunikation, pp. 58–61.
Löw, M., 2008. A city's own logic: The Perspective of spatial sociology on urban theory. In: Bielańska, J., Birne, T. (Eds.), (Urban potentials). Konzepte und Handlungen = ideas and practice. Jovis: Berlin.
McKinsey, Stern, ZDF, Web.de, 2006. Perspektive Deutschland. http://www.perspektive-deutschland.de. Accessed 30 June 2010.
McNally, M. G., Ryan, S., 1993. A comparative assessment of travel characteristics for neo-traditional developments. Transportation Research Record 1400, 67–77.
Mokhtarian, P. L., Cao, X., 2008. Examining the impacts of residential self-selection on travel behavior: A focus on methodologies. Transportation Research Part B-Methodological 42 (3), 204–228.
Næss, P., 1993. Energy use for transport in 22 Nordic towns: NIBR Report. Norwegian Institute for Urban and Regional Research: Oslo.

Næss, P., 1995. Urban form and energy use for transport: A Nordic experience. Norwegian Institute of Technology: Trondheim.
Næss, P., Jensen, O., 2004. Urban Structure Matters, Even in a Small Town. Journal of Environmental Planning and Management 47 (1), 35–57.
Newman, P., Kenworthy, J., 1989a. Gasoline consumption and cities: A comparison of U.S. cities with a global survey. Journal of the American Planning Association 55 (1), 24–37.
Newman, P., Kenworthy, J., 1989b. Cities and Automobile Dependence: An International Sourcebook. Gower Publishing: Aldershot, UK.
Newman, P., Kenworthy, J., 1999. Sustainability and cities: Overcoming automobile dependence. Island Press: Washington, D.C.
Newman, P., Kenworthy, J., 2006. Urban Design to Reduce Automobile Dependence. Opolis 2 (1), 35–52.
Pucher, J., Buehler, R., 2006. Why Canadians cycle more than Americans: A Comparative analysis of bicycling trends and policies. Transport Policy 13 (3), 265–279.
Pucher, J., Buehler, R., Seinen, M., 2011. Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. Transportation Research Part A 45, 451-475.
Pucher, J., Lefèvre, C., 1996. The Urban Transport Crisis in Europe and North America. Macmillan: London.
Ryley, T., 2006. Use of non-motorised modes and life stage in Edinburgh. Journal of Transport Geography 14 (5), 367–375.
Schafer, A., Victor, D. G., 2000. The Future Mobility of the World Population. Transportation Research Part A 34, 171–205.
Scheiner, J., 2005. Auswirkungen der Stadt- und Umlandwanderung auf Motorisierung und Verkehrsmittelnutzung: ein dynamisches Modell des Verkehrsverhaltens. Verkehrsforschung Online 1 (1), 1–17.
Scheiner, J., 2009a. Is travel mode choice driven by subjective or objective factors? In: Holz-Rau, C., Scheiner, J. (Eds.), Subject-oriented approaches to transport. Institut für Raumplanung (IRPUD): Dortmund, pp. 53–69.
Scheiner, J., 2009b. Sozialer Wandel, Raum und Mobilität: Empirische Untersuchungen zur Subjektivierung der Verkehrsnachfrage. VS: Wiesbaden.
Scheiner, J., Holz-Rau, C., 2007. Travel mode choice: affected by objective or subjective determinants? Transportation 34 (4), 487–511.
Schiefelbusch, M., 2009. Miteinander reisen: Vom Transport zum Reiseerlebnis - Reiseerleben und Reisekultur im Nahverkehr. Der Nahverkehr 26 (5), 29–33.
Schiller, P. L., Bruun, E. C., Kenworthy, J. R., 2010. An introduction to sustainable transportation: Policy, planning and implementation. Earthscan: London, Washington D.C.
Schipper, L., Deakin, E., Sperling, D., 2010 [1994]. Sustainable transportation. The future of the automobile in an environmentally constrained world. UCTC 697. Berkeley.
Schuitema, G., Anable, J., Skippon, S., Kinnear, N., 2013. The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. Transportation Research Part A 48, 39-49.
Schwanen, T., Dieleman, F. M., Dijst, M., 2001. Travel behaviour in Dutch monocentric and polycentric urban systems. Journal of Transport Geography 9 (3), 173–186.
Schwanen, T., Mokhtarian, P., 2005. What Affects Commute Mode Choice: Neighborhood Physical Structure or Preferences Toward Neighborhoods? Journal of Transport Geography 13 (1), 83–99.
Sheller, M., Urry, J., 2006. The new mobilities paradigm. Environment and Planning A 38 (2), 207-226.
Sherwin, H., Chatterjee, K., Jain, J., 2012. An Exploration of the Importance of Social Influence in the Decision to Start Bicycling in England. 13th International Conference on Travel Behavior Research, July 15-20, 2012: Toronto.
Siedentop, S., Lanzendorf, M., Kausch, S., 2006. Siedlungsstruktur- und Mobilitätsprofile suburbaner Gemeindetypen. Berichte zur deutschen Landeskunde 80 (4), 415–431.

Simma, A., Axhausen, K. W., 2001. Structures of commitment in mode use: a comparison of Switzerland, Germany and Great Britain. Transport Policy 8 (4), 279–288.
Snellen, D., 2001. Urban form and activity-travel patterns: An activity-based approach to travel in a spatial context. Techn. Univ. Fac. Bouwkunde: Eindhoven, Eindhoven.
Stead, D., 2001. Relationships between land use, socioeconomic factors and travel patterns in Britain. Environment and Planning B 28 (4), 499–529.
Stone, J., 2009. Contrasts in Reform: How the Cain and Burke Years Shaped Public Transport in Melbourne and Perth. Urban Policy Research 27 (4), 419-434
Tabachnick, B. G., Fidell, L. S., 2009. Using multivariate statistics, 5th ed. Pearson, Allyn and Bacon: Boston, Mass.
Thomson, J. M., 1977. Great Cities and Their Traffic. Penguin: Harmondsworth.
Van Acker, V., Van Wee, B., Witlox, F., 2010. When Transport Geography Meets Social Psychology: Toward a Conceptual Model of Travel Behaviour. Transport Reviews 30 (2), 219–240.
Vannini, P., 2009. The Cultures of Alternative Mobilities: Routes Less Travelled. Ashgate: Farnham.
Van Wee, B., 2002. Land use and transport: research and policy challenges. Journal of Transport Geography 10 (4), 259–271.
Vigar, G., 2002. The politics of mobility. Transport, the environment and public policy. Spon Press: London.
Waddell, P., Bhat, C. R., Outwater, M. L., 2001. Land use and travel demand forecasting models: Review of the literature and operational models: final report. The Council: Seattle.
Williams, K. (Ed.), 2005. Spatial planning, urban form, and sustainable transport. Ashgate: Aldershot.