Journal of Transport Geography xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

En-route weather and place valuations for different transport mode users

Lars Böcker [a,*], Martin Dijst [a], Jan Faber [b], Marco Helbich [a]

[a] Department of Human Geography and Spatial Planning, Faculty of Geosciences, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands
[b] Innovation Studies, Copernicus Institute of Sustainable Development, Faculty of Geosciences, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands

ARTICLE INFO

Article history:
Received 26 June 2014
Revised 29 May 2015
Accepted 1 June 2015
Available online xxxx

Keywords:
Weather
Thermal perception
Transport mode choice
Place valuation
Netherlands

ABSTRACT

With the increasing societal interest in climate change, mostly separated strands of literature have investigated the travel-behavioural, thermo-sensational and environmental–psychological effects of weather on people in everyday life. This research conceptually and statistically integrates these fragmented insights. Drawing on unique Greater Rotterdam (The Netherlands) travel diary data enriched with hourly meteorological and spatial route attributes, we analyse how weather affects different transport mode users' en-route place valuations in terms of liveliness, friendliness and aesthetics. Our main findings indicate that windy, cloudy, cold (<15 °C) or too hot (⩾25 °C) weather conditions negatively affect en-route place valuations, either directly or through lower thermal comfort. Active mode users generally value their route surroundings more positively than motorised transport modes, however they also appear more strongly affected by weather in their thermal experiences and place valuations. Policy makers are advised to expand climate-sensitive urban planning along active transport mode infrastructures.

1. Introduction

With climate change high on the political agenda, weather and climate have emerged as important topics in travel behavioural research and transport planning. On the one hand, transport forms an important contributor to climate change through greenhouse gas emissions (e.g. Chapman, 2007). On the other hand, as of its direct exposure to weather, the transport sector is also highly affected by climate change (e.g. Koetse and Rietveld, 2009). In this light, various studies investigated the effects of weather on daily travel behaviours, including choices for active and motorised transport modes, destinations and travel distances (for detailed reviews see Koetse and Rietveld, 2009; Böcker et al., 2013). While most of these studies focus on objective weather and behaviour, much less is known on how weather is subjectively experienced and how it affects the experience of place during travel. Exactly this knowledge, on subjective experiences of weather and place during travel, is crucial to better understand transport mode decisions and to support *climate-sensitive urban planning* (Eliasson et al., 2007; Lenzhölzer and Wulp, 2010) – especially with regard to the facilitation of infrastructures for healthy and sustainable, but weather-exposed, active transport modes.

The relationships between weather, travel and subjective experiences of weather and place, have been addressed in three separated strands of literature. First, transport scientists have investigated the *travel-behavioural effects* of objectively measured weather conditions on transport mode choices. Studies generally conclude that cold, cloudy, wet and windy weather conditions stimulate motorised transport, while warm, sunny and dry weather conditions increase usage of active modes – with typically larger effects for leisure than for utilitarian trips (e.g. Hanson and Hanson, 1977; Sabir, 2011; Creemers et al., 2014). Regarding temperature, some studies added that not only cold, but also hot weather above optimums between 25 and 30 °C may negatively affect walking (Aultman-Hall et al., 2009) and cycling (e.g. Ahmed et al., 2012; Lewin, 2011; Miranda-Moreno and Nosal, 2011).

A second set of, mostly biometeorological, studies have investigated the *thermo-sensational effects* of objectively observed weather conditions on subjective weather experiences. It is indicated that we experience thermal (dis)comfort as a combination of different meteorological variables, including air temperature, wind speed, humidity and solar radiation. However, studies also observe considerable discrepancies between measured and subjectively experienced weather (e.g. Nikolopoulou and Steemers,

* Corresponding author at: Department of Sociology and Human Geography, Faculty of Social Sciences, University of Oslo, Moltke Moes vei 31, Harriet Holters hus, 0851 Oslo, Norway.
E-mail addresses: lars.bocker@sosgeo.uio.no (L. Böcker), m.j.dijst@uu.nl (M. Dijst), j.faber1@uu.nl (J. Faber), m.helbich@uu.nl (M. Helbich).

http://dx.doi.org/10.1016/j.jtrangeo.2015.06.003
0966-6923/

2003), which could be related to personal or cultural backgrounds (e.g. Knez and Thorsson, 2006; Thorsson et al., 2007), clothing and physical activity levels (e.g. Havenith et al., 2002) or site-specific spatial configurations. Green, shadowed and/or wind-exposed environments are generally perceived as colder than concrete, sunlit and/or wind-sheltered environments (e.g. Nikolopoulou and Lykoudis, 2007; Phung and Rose, 2008; Lenzhölzer and Wulp, 2010).

A third, but very limited, selection of studies investigates the *environmental–psychological effects* of weather on place perception and valuation. From a philosophical viewpoint Yurike Saito (2005:160) explores the multisensory effects of weather on aesthetic experiences of everyday environments: "Our experience of a fierce autumn wind is not simply the feeling of wind against our body; the way in which fallen leaves swirl around, the dynamic swaying of tree branches, the rustling sound they make, the slightly musty smell coming from half-decaying leaves accumulated on the ground, and the rapid movement of clouds all contribute toward our experience of this windy weather". Within the fields of biometeorology and climate-sensitive urban design, some quantitative studies also investigated the role of weather or seasonality on experiencing aesthetics in outdoor urban public spaces. Mambretti (2011) finds that two urban parks in Zurich, Switzerland, are experienced as more beautiful during spring and autumn, compared to summer and winter. Two studies from Gothenburg, Sweden, link aesthetics directly to weather. Eliasson et al. (2007) conclude that urban parks are experienced as more beautiful with higher air temperatures and lower wind speeds, while Knez et al. (2009) find no significant effects of weather conditions on aesthetic experiences. Apart from aesthetics, also social aspects of place valuation (Cattel et al., 2008) may be affected by weather. Pleasant mild to warm, sunny, dry and calm weather conditions may enhance social interactions, liveliness, friendliness and safety in outdoor public space, as these conditions increase the outdoor presence of people (e.g. Zacharias et al., 2001; Thorsson et al., 2007; Lin, 2009) and positively affect emotions (Kööts et al., 2011).

So far, despite recent calls for a more interdisciplinary approach (Eliasson et al., 2007; Böcker et al., 2013), insights into the interdependencies between the above-outlined three strands of literature are lacking. It is this paper's aim to integrate these separated insights both conceptually and statistically. This way we examine how weather experiences, mode choices and en-route place valuations influence and compensate each other. We analyse the direct and mediated (by thermal comfort) effects of hourly air temperature, precipitation sum, wind speed and sky clearness on different transport mode users' en-route place valuations in terms of liveliness, friendliness and aesthetics, while controlling for various personal, trip, temporal and spatial attributes (i.e. address density, building diversity, percentage green). Hereto, we analyse unique travel diary data from a panel study amongst 945 Greater Rotterdam respondents (The Netherlands), enriched with spatial and meteorological data, by means of Structural Equation Models. The paper first describes the study area and methods used. The results section describes and explains the model outcomes. A concluding section summarizes and discusses the main findings and draws implications for future research and policy regarding the role of climate-sensitive urban planning.

2. Research design

2.1. Study area and data

This study is situated in Greater Rotterdam, the Netherlands (Fig. 1). This coastal harbour region is part of the Randstad conurbation: the densely populated and economically vital metropolitan region, which in addition to Rotterdam contains the cities of Amsterdam, The Hague, and Utrecht. The region has a maritime climate, characterised by mild winters (lows: 1 °C; highs: 6 °C), warm summers (lows: 12 °C; highs: 21 °C), and relatively stable seasonal precipitation patterns (ranging from 158 mm in spring to 258 mm in autumn) (KNMI, 2013). Greater Rotterdam was selected for this study because of three reasons: First, the area consists of a large variety of spatial environments, ranging from largely post-WWII mid- and high-rise inner-city areas, to compact historic towns and newer lower-density satellite towns and villages in the outskirts. Second, the area has rich population diversity in terms of age, ethnicity and socio-economic status. Third, the region pursues active policy on sustainable transport and climate-sensitive urban planning.

We conducted a travel diary survey (used in two earlier studies: Böcker and Thorsson, 2014; Helbich et al., 2014) from August 2012 to February 2013 amongst a panel of 945 respondents, aged 18 and older, from different Greater Rotterdam residential environments (Fig. 1). The reason for using panel data is to have the same sample of respondents participating in travel surveys during different seasons throughout the year. Hereto, respondents were randomly assigned two regular[1] days in summer, two days in autumn and two days in winter, to report their travel behaviours and experiences. Following Moskowitz and Young (2006) an ecological momentary assessment (EMA)[2] methodology was used. Respondents report *on a trip basis* repeated measurements of weather perceptions and en-route place valuations in on site travel diaries, which can thus directly be linked to reported trip mobility data. In our sample we oversampled for non-native Dutch and older age groups (>65 years) in anticipation of lower response rates for these groups. Our sample represents the Greater Rotterdam population relatively well on several key socio-demographic statistics like age, gender and household size (CBS, 2013), except for an underrepresentation of lower educated and non-western[3] people (for more information on the sample composition, see Böcker and Thorsson, 2014).

Next, the travel survey data are enriched with spatial route attributes. Hereto, trip origin and destination addresses are geocoded via Dutch cadastral data (2014) on a 6-digit postal code level, containing roughly 17 addresses per spatial unit. Utilizing a geographic information system (GIS) and 2008-street data provided by ESRI, origins and destinations are linked along the street network using shortest-path analysis. Following Schlossberg et al. (2006), each trip path has been buffered with a radius of 200 m. This 200 m buffer is large enough to capture the area had people taken slightly different routes, while it is small enough to capture mostly the nearby surroundings in a direct line of sight that are most relevant to the traveller. Subsequently, route specific attributes describing the traversed environments are extracted. Hereto, each trip buffer is intersected with a grid having a spatial resolution of 100 m superimposed on the study area. This spatial scale keeps GIS computation time modest, while details about local urban form elements remain preserved (e.g., open spaces). For each cell three indicators are extracted: building usage diversity, address density, and greenness index. Building usage diversity and address density are extracted from the 2014-dataset 'Basisregistraties, Adressen en Gebouwen (BAG)'. Greenness is extracted from the 2001-dataset 'Landelijk Grondgebruiksbestand

[1] Regular days contain both weekdays and weekends, but exclude periods in which the respondent was ill or on holiday, in which case new days were assigned.

[2] Ecological momentary assessment (EMA) is the repeated sampling of respondents' behaviours and experiences in real time and on-site, in contrast to for instance the retrospective sampling (at home) in a survey.

[3] Respondents who, or whose parents, were been born in a non-western country.

Please cite this article in press as: Böcker, L., et al. En-route weather and place valuations for different transport mode users. J. Transp. Geogr. (2015), http://dx.doi.org/10.1016/j.jtrangeo.2015.06.003