



Weather, transport mode choices and emotional travel experiences



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ABSTRACT

With climate change high on the political agenda, weather has emerged as an important issue in travel behavioural research and urban planning. While various studies demonstrate profound effects of weather on travel behaviours, limited attention has been paid to subjective weather experiences and the psychological mechanisms that may (partially) underlie these effects. This paper integrates theoretical insights on outdoor thermal comfort, weather perceptions and emotional experiences in the context of travel behaviour. Drawing on unique panel travel diary data for 945 Greater Rotterdam respondents (The Netherlands), this paper aims to investigate how and to what extent weather conditions affect transport mode choices, outdoor thermal perceptions and emotional travel experiences. Our findings point out that observed dry, calm, sunny and warm but not too hot weather conditions stimulate cycling over other transport modes and – via mechanisms of thermal and mechanical comfort – lead to more pleasant emotions during travel. Overall, public transport users have less pleasant emotional experiences than users of other transport modes, while active mode users appear most weather sensitive. The theoretical contributions and empirical findings are discussed in the context of climate change and climate-sensitive urban planning.

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1. Introduction

With the increased scientific evidence for climate change (IPCC, 2013) and political interest in climate change adaptation and mitigation, weather and climate change have become important issues in transport planning and travel behavioural research. Research initially focussed predominantly on the effects of weather extremes on transport infrastructures (for an overview see e.g. Transportation Research Board, 2008). Recently, various scholars have investigated the effects of daily weather conditions on individual travel behaviours, including the use of transport modes (for reviews, see Koetse and Rietveld, 2009 and Böcker et al., 2013a). Many recent studies link objectively measured weather conditions to existing or self-gathered travel behaviour data and generally conclude that higher – but not too high – air temperatures enhance walking and cycling over the use of motorised transport modes, whereas precipitation sum and wind speed have opposite effects (e.g. Sabir, 2011; Ahmed et al., 2010; Creemers et al., 2014). In contrast, we know very little about how weather is perceived during travel, how it affects our emotions, and via which mechanisms it affects transport mode choices. Addressing these research gaps is crucial (1) to better understand the effects of weather and changing climate conditions on travel behaviour,

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(2) to assess its impact on daily emotional wellbeing during travel, and (3) to expand climate-sensitive urban planning (Eliasson et al., 2007; Lenzhölder and Wulp, 2010) to places and infrastructures of (active) mobility.

Existing knowledge on the experience of weather and its effects on emotions can be found mostly outside, and disconnected from, the field of transport studies. Exceptions are a Dutch study on transport mode choices in relation to weather, outdoor weather perceptions and place valuations (Böcker et al., 2015), and a Portuguese study investigating bus travel experiences in relation to (amongst other factors) subjective indoor thermal comfort (Carreira et al., 2014), both of which use structural equation modelling. To deeper investigate these subjectivities, this paper draws on biometeorological insights into the relationships and discrepancies between objectively measured and subjectively perceived weather conditions in terms of thermal and mechanical comfort (e.g. Thorsson et al., 2007; Eliasson et al., 2007; Oliveira and Andrade, 2007), and psychological insights into the relationship between weather, moods and emotions (for a review, see Kööts et al., 2011). We integrate these insights, both theoretically and empirically into the context of travel behaviour, hereby addressing recent calls for a more interdisciplinary approach of this subject (Eliasson et al., 2007; Böcker et al., 2013a).

It is our aim to investigate how and to what extent weather conditions affect transport mode choices, outdoor thermal perceptions and emotional travel experiences. Hereto, purposely-designed Greater Rotterdam (Netherlands) travel diary data ($n = 945$) – including ecological momentary assessments (EMA) of outdoor thermal perceptions and emotions (i.e. happiness, irritation, fear and tiredness) – are connected to local urban form and hourly meteorological data and analysed in structural equation models. This paper first summarizes the main findings from the literature on the effects of weather on transport modes, outdoor thermal comfort, and emotions and moods. Second, it introduces the study area, dataset and modelling framework. Third, it describes and explains the main findings in relation to the literature. Finally, it concludes with a discussion of the main findings and its policy and research implications.

2. Literature

Over the last few decades, transport research, originating mostly from maritime and continental climates in Europe, North America and Australia, has investigated the effects of temperature, precipitation and wind on transport mode choices (for literature reviews, see Koetse and Rietveld, 2009; Böcker et al., 2013a). Studies typically link (national) travel survey data to publicly available weather records from nearby meteorological stations. Regarding air temperature, studies generally find a positive effect on walking and cycling compared to motorised transport, particularly car usage (e.g. Hanson and Hanson, 1977; Sabir, 2011; Creemers et al., 2014; Liu et al., 2015). However, some others point out that this relationship between temperature and transport mode choice may be nonlinear. Above a certain optimum between 24 °C and 30°, high temperatures have been found to negatively affect walking in Montreal (e.g. Aultman-Hall et al., 2009), or cycling in Melbourne (e.g. Phung and Rose, 2008; Ahmed et al., 2010) and the Netherlands (Thomas et al., 2013; Böcker and Thorsson, 2014). When it comes to precipitation sum and wind speed, studies generally agree on more or less linear negative effects on walking and cycling and positive effects on particularly car usage (e.g. Phung and Rose, 2008; Sabir, 2011; Böcker and Thorsson, 2014; Creemers et al., 2014; Liu et al., 2015).

Where transport researchers have mostly analysed the effects of objectively measured weather conditions, biometeorologists and health scientists have also linked people's behavioural responses to weather conditions and their subjective assessments in terms of *outdoor thermal comfort*. Hereby, outdoor thermal comfort is commonly defined as “that condition of mind which expresses satisfaction with the outdoor thermal environment and is assessed by subjective evaluation” (ANSI/ASHRAE, 2004: 2). For instance three studies on urban park attendances in Japan and Sweden (Thorsson et al., 2007; Eliasson et al., 2007), a study on individual psychological weather adaptations in the United Kingdom (Nikolopoulou and Steemers, 2003), and a study on leisure activities in the USA (McGinn et al., 2007), point out that outdoor thermal comfort results from combinations of different meteorological variables, such as air temperature, relative air humidity, solar radiation and wind speed. The relationship between weather and comfort has not only thermal aspects. The exposure to wind or precipitation – or a combination of both as wind-driven rain – may have direct implications for comfort levels, for instance related to related to moist in the eyes, flapping clothes, hair disturbances, or even loosing balance and being blown over (e.g. Bottema, 1993; Blocken and Carmeliet, 2004). Such direct physical aspects, often referred to as *mechanical comfort*, have mostly been studied through wind tunnel experiments in the field of wind engineering (e.g. Blocken and Carmeliet, 2004), but are in reality often difficult to disentangle from thermal comfort (Oliveira and Andrade, 2007).

To acquire insights into the relationships between weather and emotions during travel, we need to draw on existing psychological knowledge of weather and longer-term moods (e.g. Kööts et al., 2011). Mood has often been linked to seasonality, for instance via the cyclical syndrome Seasonal Affective Disorder (Rosenthal et al., 1984), usually referring to winter depression. Also amongst the general population, scholars have confirmed the idea that moods are worst in winter and best in summer (e.g. Oyane et al., 2008), although also empirical evidences for mood dips outside winter exist (e.g. Ozaki et al., 1995; Huijbers et al., 2010). Other studies link moods directly to individual weather conditions. First, the number of sunshine hours and the level of solar radiation have been found to increase mood levels (e.g. Cunningham, 1979; Schwartz and Clore, 1983; Howarth and Hoffman, 1984; Barnston, 1988; Albert et al., 1991; Denissen et al., 2008; Ciucci et al., 2011). More specifically sunshine has been found to reduce sadness (Ciucci et al., 2011), cynicism, doubtfulness (Howarth and Hoffman, 1984), tiredness and sluggishness (Denissen et al., 2008), and increase optimism, concentration (Howarth and Hoffman, 1984) and mental activeness (Albert et al., 1991). The relationship between exposure to sunshine and positive mood is strongly embodied:

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