Journal of Transport Geography 31 (2013) 11–17

Contents lists available at SciVerse ScienceDirect

Journal of Transport Geography

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

The effect of environmental factors on bicycle commuters in Vermont: influences of a northern climate

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ARTICLE INFO

Keywords:
Bicycling
Commuting
Transportation
Environment
Weather
Safety

ABSTRACT

Bicycle commuters in many areas of the world face challenges inherent in combining non-motorized transportation and car-centric roadways. Commuters in northern Vermont face the added challenge of a northern climate that makes cycling a largely seasonal activity. Cyclists continue to face transport limitations, especially when overcoming climatic conditions. This study focused on major concerns for cyclists in Vermont with the goal of identifying and understanding specific barriers that can be overcome through policy, behavioral, and infrastructural changes. We examined issues surrounding bicycle commuting in Vermont through in-depth content analysis of transcripts from focus groups and individual interviews. Precipitation, cold temperatures, inclement road conditions, limited daylight hours, and wind were identified as uncontrollable deterrents to bicycling year-round, which have put the metaphorical brakes on many potential cycling trips. The treatment of these issues was found to be unique to individual cyclists based on their perceptions of the effects of subtle differences in climatic conditions on personal comfort and safety.

1. Introduction

A popular tale recounts that Inuit languages contain 100 words to describe many types of snow. While this account is apocryphal, it suggests the importance of subtle nuances in the ways people perceive, imagine, and interact with their environments. Northern climates often require lifestyle adaptations in order to live comfortably and safely and, at the same time, generate among residents subtle understandings about environmental conditions. In this study, we examined how bicycle commuters perceived and represented the primary ways their bicycling practices were impacted and shaped by geo-environmental contexts, especially climatic conditions. Content analysis of in-depth interviews and focus groups allowed a rich examination of environmental impacts on cycling and the identification of distinctions that create the "100 words for snow" lexicon specific to bicycle commuting in northern regions. To draw out the details of the environmental context, we focused on two questions:

- What role does individual preference for environmental conditions play in cycling to work?
- What environmental factors affect the experience and desire to ride for bicycle commuters in a northern community, and do these factors have the same consequences on cycling regardless of severity?

Bicycle commuters face challenges inherent in using non-motorized transportation in car-dominated transportation systems, and cold-region commuters encounter added environmental challenges that make cycling a seasonal activity for many. Despite these obstacles, bicycles have become a functional transit mode and viable alternative to automobile transportation in many northern cities, among them North American cities such as Montreal, Minneapolis, and Vancouver, as well as northern European cities including Stockholm, Amsterdam, Copenhagen, and Berlin (Iacono et al., 2010; Pucher and Buehler, 2005, 2008; Wahlgren and Schantz, 2012).

The research presented here focused on the greater Burlington region of northwestern Vermont, USA, and aimed to develop an understanding of the behavior and attitudes of bicycle commuters in response to specific weather conditions. Bicyclists in Burlington encounter a wide variety of daily and seasonal weather variations, yet bicycling is an important aspect of the city's recreational, cultural, and transportation networks, earning the city a Silver Level Bicycle Friendly Community designation (League of American Bicyclists, 2012). Results of this study could be instructive to policymakers seeking to increase bicycle commuting in similar regions experiencing a wide range of weather conditions.

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0966-6923/$ - see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.jtrangeo.2013.05.003

2. Literature review

2.1. Seasonality and weather-related concerns for cyclists

Transportation researchers increasingly work to understand obstacles to increasing bicycle mode share because of the social (Burton, 2003), environmental (Hanson and Hanson, 1977; Nelson and Allen, 1997), and health (Pucher et al., 1999) benefits of active transportation, including reductions in greenhouse gas emissions (Wright and Fulton, 2005; Schäfer et al., 2009), traffic congestion (Dixon, 1996), and obesity (Bassett et al., 2008; Bauman and Rissel, 2009; Oja et al., 2011). Over the past decade, bicycle commuting has increased in mode share in the United States (Pucher et al., 2011), yet barriers to further mode share growth continue to be found in socioeconomic issues – the built and natural environment; psychological factors; and cost, travel time, effort, and safety (Heinen et al., 2010). When observing environmental factors for bicycle commuting, the interaction of weather variables plays a role in deciding whether to commute by bicycle, and hesitant riders may not be swayed to increase cycling by the improvement of one factor alone (Dill and Voros, 2007). We focused this paper on weather-related influences on bicycling, specifically temperature, light conditions, precipitation, road conditions, and wind speed.

Temperature has been identified as a factor affecting bicycle ridership (Bergström and Magnusson, 2003; Hanson and Hanson, 1977; Parkin et al., 2008; Flynn et al., 2012; Thomas et al., 2013). Temperature can also affect cycling frequency when paired with other factors that affect comfort, such as precipitation (Brandenburg et al., 2004). High temperatures, unless uncomfortably warm (Miranda-Moreno and Nosal, 2011), are shown to have positive effects on bicycle ridership in some cases (Thomas et al., 2009), while cold temperatures are generally considered negative for bicycling (Nankervis, 1999; Winters et al., 2007). Temperature has been found to be a more important factor for female bicycle commuters than men (Bergström and Magnusson, 2003; Saneinejad et al., 2012).

Darkness is a prevalent factor contributing to a decrease in cycling during winter months (Nankervis, 1999; Cervero and Duncan, 2003). Previous studies have also identified sunshine and cloud cover as influences on bicycle ridership (Hanson and Hanson, 1977; Thomas et al., 2009, 2013). Street lighting is also considered an effective measure in lowering the severity of cyclist injuries (Klop and Khattak, 1999; Kim et al., 2007). Although lighting benefits the safety of all cyclists, female riders are more likely than men to value lighted bicycle facilities (Krizek et al., 2005) and to consider darkness as a travel factor (Bergström and Magnusson, 2003; Heinen et al., 2011).

Precipitation, in all forms, influences bicycle ridership (Nankervis, 1999; Bergström and Magnusson, 2003; Cervero and Duncan, 2003; Parkin et al., 2008). The duration and intensity of precipitation affect cycling volume (Thomas et al., 2009, 2013), although commuters are thought to be more likely to endure rain than recreational cyclists (Brandenburg et al., 2004). Snow is seen as a major deterrent for some bicycle commuters (Flynn et al., 2012), while rain is considered a potential deterrent that can be mitigated to some extent with waterproof clothing (Rietveld and Daniel, 2004). While rain may be uncomfortable, winter precipitation such as snow and ice are seen as dangerous to cyclists (Stinson and Bhat, 2004), and can result in injury rates that are higher for women than men (Nyberg et al., 1996).

Various road conditions have been found to affect bicycle ridership, including snow clearance, ice treatment, and driver interactions (Eilert-Petersson and Schelp, 1997; Bergström, 2003; Bergström and Magnusson, 2003). Previous studies on cold-climate bicycling suggest that measures such as snow removal, road salting, or sanding could mitigate cycling declines due to freezing conditions (Bergström and Magnusson, 2003; Winters et al., 2007). Driver behavior can cause concerns for bicyclists (Horton, 2007; Mullan, 2012) and inclement conditions cause declines in road safety (Bergström, 2003). Differences in treatment of cyclists by drivers based on gender appear to exist (Walker, 2007), as well as differing perceptions of male and female cyclists regarding on-road safety (Garrard et al., 2008; Emond et al., 2009).

Wind speeds have been shown to affect bicycle ridership (Thomas et al., 2009; Flynn et al., 2012; Tin Tin et al., 2012) due to the difficulty wind can add to riding (Nankervis, 1999; Rietveld and Daniel, 2004). Wind speed, or rather the binary presence or absence of wind, is especially important, because stronger winds tend to deter cyclists more than lighter winds (Thomas et al., 2009; Heinen et al., 2011; Flynn et al., 2012). Wind speed is considered to be a factor that negatively affects bicyclists more than pedestrians (Saneinejad et al., 2012).

2.2. Study context

All of the participating commuters lived and worked in the Burlington, Vermont, area. Burlington is located in Chittenden County, which had a 2011 estimated population of about 157,000, with approximately 43,000 in the city itself (U.S. Census Bureau, 2012). Chittenden County is bordered by Lake Champlain to the west and the Green Mountains to the east. The Burlington area experiences average rainfall of 36.82 in. per year, and 81.2 in. of snow each year; average temperatures and precipitation days are shown in Table 1 (National Weather Service, 2010). The city sits on Burlington Bay, and is built largely on a hill that rises from Lake Champlain.

Previous studies of environmental impacts on cycling in the Burlington area found that morning precipitation, low temperatures, increased wind speeds, and snow negatively impacted the likelihood of commuting by bicycle (Flynn et al., 2012; Sears et al., 2012). Flynn et al. (2012) surveyed 163 commuters over a 10-month period to identify the impacts of seasonality on bicycle commuting in Vermont. The four significant variables identified by these commuters highlighted the fact that bicycle commuting in a northern environment comes with specific obstacles and weather variations that may not be a concern in warmer and drier climates.

3. Materials and methods

A total of 24 adult bicycle commuters, age 22–64 years, were interviewed in four focus groups ($n = 19$) and five personal interviews during 2008 and 2009 as an initial phase of a survey study (Flynn et al., 2012; Sears et al., 2012). A combination of focus

Table 1
Burlington climate statistics.

	Average high temperature (°F)	Average low temperature (°F)	Average number of precipitation days
January	27.2	10.2	15
July	80.9	60.3	12

National Weather Service (2010).