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## Sharing urban sidewalks with bicyclists? An exploratory analysis of pedestrian perceptions and attitudes

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### ABSTRACT

Bicycling and walking are gaining popularity for both commuting and recreation. However, when faced with limited right-of-way width, many transportation agencies find it impractical to designate separate space for bicyclists in urban roadway corridors, instead devoting their limited funds to other projects. As a result, some bicyclists – feeling threatened by motor vehicles – use sidewalks for at least part of their trip. Laws governing bicyclist use of sidewalks are not consistently enforced in various cities and countries. Pedestrian–bicycle shared space has rarely been studied from a pedestrian's perspective in an urban context. Therefore, gaining a better understanding of the factors that influence pedestrian attitudes toward sharing a sidewalk with bicyclists can be useful in evaluating shared space strategies and guiding investments in bicycle facilities. Using the responses of 114 persons to 15 carefully constructed 60-s video clips of urban sidewalks in four Chinese cities, this study characterizes pedestrian attitudes regarding sharing sidewalks with bicycles under different sidewalk configurations. By estimating a random parameters ordered probability model (to account for unobserved heterogeneity across respondents), we found pedestrians who wanted a "safe distance" greater than 1.5 meters were more likely to possess a less tolerant attitude. Attitudes of pedestrians toward bicyclists on sidewalks also depend on the presence or absence of dedicated bicycle facilities. The effects of other significant factors are also quantified in this paper. Implications for policy makers in evaluating shared-space strategy can be drawn from this empirical study.

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### 1. Introduction

A growing number of travelers have switched from motor vehicles to bicycling and walking for their daily trips (Hopkinson and Wardman, 1996; Wardman et al., 1997) in the context of forming a more sustainable transportation system (Henao et al., 2015). According to the 2009 National Household Travel Survey (NHTS), the number of reported walking trips in the U. S. has more than doubled since the first survey, from 18 billion in 1990 to 42.5 billion in 2009. Reported bicycling trips have increased from 1.7 billion to 4 billion during the same time period (Pedestrian and Bicycle Information Center, 2010). By reviewing the trends in bicycling in Canada and the USA, Pucher et al. (2011) point out that bicycling is concentrated in central cities. However, for most urban areas, where road networks have been historically designed primarily for motor vehicles, limited funding and insufficient space

for bicyclists and pedestrians make it difficult to meet the increasing demand of non-motorized travel. Numerous cities have, where space was available, marked sidewalks to create side-by-side bicycle and pedestrian spaces. However, poorly designed shared space can be unwelcoming, uncomfortable, or even frightening, suppressing levels of walking and cycling (Department for Transport, 2011). Limited bicycling right-of-way and safety concerns due to sharing space with motor vehicles have driven a significant proportion of bicyclists to ride on sidewalks (Aultman-Hall and Adams, 1998; Ford et al., 2011; Kang and Fricker, 2013a, 2013b). According to a U. S. national survey of Bicyclist and Pedestrian Attitudes and Behavior (Royal and Miller-Steiger, 2008), 14% of bicycling trips were made on sidewalks in U. S. What is more, bicycle sidewalk riding is also a common phenomenon in many countries, e. g., China (Kang et al., 2013) and Denmark (Jensen, 2007). Even though it is also the case that bicyclists are prohibited from riding on the sidewalk in many cities, such laws are not usually enforced. This is especially the case on and near university campuses (Kang and Fricker, 2013). Where interaction between bicycles and pedestrians on sidewalks is frequent, consideration of strategies to manage this space or to justify the

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expense of creating new dedicated space may benefit from a systematic study of the interaction between sidewalk users (Kang et al., 2013). This paper seeks to show how such a study can be undertaken. While non-motorized traffic in the U. S. is increasing, many urban cities in China have witnessed that their non-motorized traffic has declined. For instance, the 2013 Nanjing Transport Annual Report<sup>1</sup> indicates that bicycling in that city has accounted for 36.8%, 35.7%, and 31.3% of total travel in years 2010, 2011, and 2012. Suzhou City<sup>2</sup> exhibits similar downward trends. Despite these downward trends, the amount of non-motorized travel is still significant large to make shared space policy important. It is critical to include pedestrians and bicycles when making the most efficient use of the entire right-of-way.

There is a general consensus that having pedestrians and bicyclists share the same facility is not desirable, yet it is often tolerated due to the cost of constructing separate facilities and concerns relating to bicyclist safety on roadways (Cyclists Touring Club, 2000). To develop a more scientific strategy regarding sharing sidewalks, policymakers need to take users' perceptions and attitudes into account, because corresponding policies and strategies need to address the comfort and safety levels of their served population. When it comes to implementing shared use space policy, city engineers would benefit from knowing (a) under which scenarios are pedestrians more comfortable in sharing the sidewalk with bicyclists and (b) how to quantify the impacts of various operational and physical settings.

A companion paper (Kang et al., 2013) looks at how pedestrians perceive level of service on an urban sidewalk segment under various urban-street conditions, particularly when interacting with bicyclists. Using the same survey data, this study looks at how pedestrian attitudes towards sharing a sidewalk with bicyclists are influenced. It helps identify significant factors that affect pedestrian attitudes toward sharing a sidewalk and measures the magnitude of each factor's effect. Given limited resources, bicycle and pedestrian facility improvement decisions and strategy making should be based on a comprehensive understanding of bicycle and pedestrian behaviors and attitudes, especially when sharing space is at issue.

## 2. Literature review

Vehicles and bicycles are often expected to share on-street facilities. Vehicle-pedestrian shared space can exist along urban segments without sidewalks. In many of these cases, curbs are not present to separate pedestrians and vehicular traffic. The key factors affecting pedestrian comfort in this shared right-of-way appear to be the volume, type, and speed of vehicle traffic. The more pedestrians that use the street, the more slowly vehicles tend to travel (Department for Transport, 2011). Using two web-based surveys, Kaparias et al. (2012) developed two binary logistic regression models to analyze the effects of variables that were found to significantly influence one's comfort level as a pedestrian or as a driver when sharing space. They found that pedestrians felt most comfortable in shared space under conditions that ensure that their presence was clear to other road users. These conditions include low vehicular traffic, high pedestrian traffic, good lighting and pedestrian-only facilities. Conversely, the presence of many pedestrians makes drivers feel uneasy and, therefore, enhances driver alertness. Space shared by pedestrians and motorists has been discussed and investigated in many other dimensions. A comprehensive review of current literature on vehicle-pedestrian

shared space can be found in Reid et al. (2009).

In this paper, we focus on the sharing of off-street right-of-way, in which bicyclists could be considered intruders by pedestrians on sidewalks. Non-motorized space sharing often occurs on bicycle trails or shared-use trails that have been designed primarily to serve recreational purposes, where the primary anticipated users are bicyclists. Even so, it is important that proper weight is given to the needs of pedestrians (Department for Transport, 2012). Following the background study on users' perceived level-of-service by Hummer et al., (2005), an analytical tool to determine the level-of-service of off-road facilities designed for shared-use by bicyclists, pedestrian, skaters, and runners, has been developed by Patten et al. (2006). One-way user volume in the design hour,<sup>3</sup> mode split percentages, trail width, and presence or absence of a centerline have been used as model inputs. An urban area study in Denmark by Jensen (2007) used respondent ratings of video clips to estimate a cumulative logit model. Respondents gave level of service ratings on a 1–6 scale to capture the factors affecting pedestrian and bicycle satisfaction. Bicycle volume and speed were found to significantly impact a pedestrian's satisfaction level.

The focus of this paper will be to consider pedestrian attitudes along urban sidewalk segments. As the literature and current practice suggests, shared-space can be appropriate under well-designed schemes for vehicle-pedestrian and pedestrian-bicycle cases. However, pedestrian-bicycle shared space has rarely been studied from a pedestrian's point of view in an urban context. A wide variety of factors need to be considered to adequately capture the full spectrum of pedestrian attitudes toward sharing a sidewalk with other users, especially with bicyclists. Policy makers and city engineers should take into consideration pedestrian preferences and perceptions when designing pedestrian-friendly facilities. By identifying significant factors influencing pedestrians' attitudes toward sharing space in this context, we hope to provide new insights that will guide future investment in safe, efficient, and pleasant shared spaces. In order to provoke thinking with respect to evaluating the feasibility of introducing shared-use sidewalk policy, this paper contributes to the current literature by providing an empirical case study that identifies various significant factors influencing sidewalk users' attitude.

## 3. Data collection

Urban bicycling facilities often include a mixture of on-street and shared use situations. Each segment can have its own properties. To obtain pedestrian attitudes toward sharing sidewalks with bicyclists, 60-s video clips were developed from 15 typical urban sidewalk segments in the Chinese cities of Shanghai, Beijing, Hangzhou, and Hefei. The video clips were taken of actual pedestrian conditions observed in Fall 2011. The 15 sidewalk segments chosen for the video clips provide a range of sidewalk widths and represent different sidewalk configurations and operational conditions, and various weather conditions and pedestrian flow rates. Three types of sidewalk segments were included:

- segments without bicycle lanes on street or sidewalk
- bicycle-pedestrian shared-use segments
- street adjacent to sidewalk has marked bicycle lanes

Fig. 1 shows two examples of each segment type. It is common in China to have urban sidewalks designed to be shared by

<sup>1</sup> Source: Nanjing Urban Planning Bureau, <http://www.njghj.gov.cn/ngweb/>

<sup>2</sup> Source: <http://bbs.pinggu.org/thread-3109938-1-1.html>

<sup>3</sup> Design hour volume is the 30th highest hourly traffic volume (in both directions) in the year in which data was collected.

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