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# The perceptions of bicycling intersection safety by four types of bicyclists

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## ABSTRACT

Over the last decade, American cities have shown a growing interest in designing bicycle-friendly intersections. Provisions of bicycle infrastructure at intersections, such as bicycle boxes, bicycle crossing signs and intersection crossing markings, may improve both perceived and actual bicycling safety, thereby encouraging more bicycling. Using survey data collected at the main campus of The Ohio State University, this study compares the influences of intersection design features on the safety perceptions of different bicyclist typologies. We group our respondents into four categories: (i) regular bicyclists, (ii) potential bicyclists, (iii) non-bicyclists who are pro-drive, (iv) non-bicyclists who are pro-public transit and pro-walk. We develop hierarchical ordered logit models for these four types of bicyclists. The model outcomes suggest that the effects of certain bicycle facilities vary across bicyclist typologies. For example, we find that installing two-stage turning boxes may promote the perceived safety levels of regular and potential bicyclists. However, this factor does not significantly affect non-bicyclists' perceived bicycling safety at intersections. The results can be used by transportation planners to project the changes in different bicyclists' safety perceptions with respect to changes in intersection features. The results also suggest specific infrastructure investments aimed at targeted groups for promoting bicycling for urban mobility.

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## 1. Introduction

Bicycling is an environmentally friendly, healthy, and affordable mode of transportation that is viable for short distance trips in particular. Bicycling offers a wide range of benefits to both individuals and society. Riding bicycles may reduce fuel consumption, provide physical exercise for the cyclists, and improve the overall quality of life. Still, a large number of people do not consider bicycling. The latest nationwide travel survey (NHTS 2017) suggests that nearly 90% of respondents do not make any bicycle trips. Only 1% of employees regard bicycling as a commute mode. Researchers have pointed out that safety concern is one of the most important deterrents preventing people from bicycling in U.S. (e.g., Akar & Clifton, 2009; Pucher & Buehler, 2008). Cities throughout North America are now increasing investments in bicycle facilities to enhance both perceived and actual bicyclist safety, thereby encouraging more bicycling (Dill, Monsere, & McNeil, 2012; Zangenehpour, Strauss, Miranda-Moreno, & Saunier, 2016).

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Many transport planning and safety agencies are developing plans and programs to address the intersection safety problem due to the high number of fatalities and injuries at intersections (2017 National Agenda for Intersection Safety). An intersection is a complex area where many interactions can occur between bicyclists, motor-vehicles and pedestrians (Carter, Hunter, Zegeer, Stewart, & Huang, 2007; Korve & Niemeier 2002; Strauss, Miranda-Moreno, & Morency, 2013; Wang & Nihan, 2004). Bicycling through intersections may significantly increase the risk of traffic accidents (Dozza & Werneke, 2014). Installing bicycle facilities at intersections may significantly improve bicyclists' safety perceptions (Carter et al., 2007; Dill et al., 2012; Lawson, Pakrashi, Ghosh, & Szeto, 2013). One potential issue with these investments is that the needs and concerns regarding bicycling are heterogeneous among bicyclists (Damant-Sirois, Grimsrud, & El-Geneidy, 2014; Dill & McNeil, 2013; Wang, Akar, & Chen, 2018). For instance, experienced bicyclists are less likely to use and depend on bicycling facilities as compared to others. They may feel comfortable even when riding through busy intersections (Larsen & El-Geneidy, 2011). It is important for planners and policymakers to understand the varying relationships between street intersection features and bicycling safety perceptions across different types of bicyclists.

Segmenting the bicyclist population, based on bicycling frequency, risk perceptions and bicyclist facility preferences, instead of treating them as a homogenous group has been proven to recommend better policy interventions and infrastructure investments (Damant-Sirois et al., 2014; Dill & McNeil, 2013; Geller, 2006; Kroesen and Handy, 2014; Larsen & El-Geneidy, 2011; Sanders, 2015). To date, the most famous cyclist typology is developed by Geller (2006) for Portland, OR. This typology divides the entire commuting population – both non-bicyclists and bicyclists into four types: *no way no how, interested but concerned, enthused and confident*, and *strong and fearless*. His classification is based on a person's level of comfort when bicycling on different types of bikeways. Geller's (2006) theory provides great assistance to policymakers as it points out the target population segments for investments in bicycle facilities. However, the underlying assumption of classification is that bicycle facilities would not affect non-bicyclists' comfort levels. Though these individuals do not currently bicycle (belonging to 'no way no how' group), they should not be ignored while making policy and infrastructure decisions (Félix, Moura, & Clifton, 2017). Planners and transport practitioners need to acknowledge non-bicyclists' attitudes towards these bicycle facilities in order to be able to influence their travel choices.

The proposed study contributes to the literature by analyzing and comparing the influences of intersection features on the safety perceptions of multiple types of bicyclists. Specifically, we focus on the effects of bicycle infrastructure at intersections. The data used in this study come from an online visual survey conducted at the main campus of The Ohio State University in 2017. We collected data on respondents' safety perceptions at various intersection scenarios. These respondents rate a set of intersection images on a five-point scale ("Very unsafe to cross" to "Very safe to cross"). We also collected data on other factors that are known to affect bicycling decisions, such as socio-demographic characteristics, bicycling experience levels, and main travel mode. We group our respondents into four categories:

- (i) regular bicyclists,
- (ii) potential bicyclists,
- (iii) non-bicyclists who are pro-drive,
- (iv) non-bicyclists who are pro-public transit and pro-walk.

The research results are expected to be used by transportation planners to project the changes in safety perceptions across different types of bicyclists with respect to changes in intersection features. The research results also suggest interventions for encouraging bicycling among potential bicyclists and non-bicyclists.

The remainder of the paper is organized as follows. A brief overview of earlier research is presented in Section 2. Section 3 describes the study area, explanatory analysis, and model structures. Section 4 discusses the model results with policy implications. Section 5 presents our concluding remarks.

## 2. Literature review

The determinants of perceived bicycling safety at intersections have been widely studied in literature (Carter et al., 2007; Dill et al., 2012; Harkey, Reinfurt, & Knuiman, 1998; Landis, Vattikuti, & Brannick, 1997; Landis et al., 2003; Lawson et al., 2013; Foster, Monsere, Dill, & Clifton, 2015; Majumdar & Mitra, 2017; Sanders, 2015; Sorton & Walsh, 1994; Zhu, Zhai, Jian, & D., 2017; Wang & Akar, 2018). Although the findings of these studies are mixed, their results consistently indicate bicyclists feel safer when separated from motor vehicles and pedestrians.

Factors related to road traffic, in terms of traffic volumes, posted speed limits, presence of turning lanes, and number of auto lanes are regarded as the main contributors to bicyclists' safety perceptions at intersections (Carter et al., 2007; Landis et al., 1997, 2003; Schepers, Hagenzieker, Methorst, Van Wee, & Wegman, 2014). Based on 145 bicyclists' real-time perceptions when traveling in actual urban traffic and roadway conditions, Landis et al. (1997) suggest that increases in traffic volumes and posted speed limits are associated with lower safety ratings. They also point that the number of through lanes and good pavement surface conditions may reduce bicyclists' stress levels. With a specific focus on intersection features, Landis et al. (2003) find that roadway traffic volume and intersection crossing distance are negatively associated with bicyclists' safety perceptions when riding through intersections. In another study, Carter et al. (2007) suggest that main street traffic volume and presence of turning vehicles are negatively associated with perceived bicycling intersection safety. Above

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