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Project Title

Investigating Bicyclist Safety Perceptions and Behaviors at Roundabouts

University

Utah State University

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Research Needs

The modern roundabout is an intersection design treatment that has been increasingly used in the US, from zero in the early 1990s to more than 4,200 estimated in 2016 (Rodegerdts, 2017). Agencies may install or convert an existing intersection to a roundabout for multiple reasons, primarily to improve traffic flow by eliminating stop signs or signals, and to improve safety by reducing the number of conflict points. The roundabout is a proven safety countermeasure (FHWA, 2017) that has been shown to reduce all crashes by roughly 40% and substantially reduce injury and other severe crashes (by 50% or more) in both US and international studies (Elvik, 2003; Persaud et al., 2001; Rodegerdts et al., 2007).

Despite this safety success, questions remain regarding the safety performance of roundabouts for specific road users, particularly people cycling. Research from Europe—where roundabouts are more common and have been used for longer—suggests that roundabouts have mixed results for bicycling safety (depending on design characteristics) and even may yield an overall increase in vehicle-bicycle crashes. An observational before-after analysis of 91 roundabouts in the Flanders region of Belgium (using crash data from 1991 to 2001) found a 27% increase in bicyclist injury collisions and a larger increase (>40%) in fatal and serious injury crashes involving bicyclists (Daniels et al., 2008). A similar observational before-after study of 332 roundabouts in Denmark circa 2010 found a 65% increase in total bicycle crashes and a 40% increase in bicycle injury crashes (Jensen, 2013). Research out of the UK and Australia determined that bicyclist crashes are overrepresented at roundabouts compared to other modes and different intersection types (Patterson, 2010). Regarding roundabout designs, European studies suggest that multilane, higher-speed roundabouts and those with bicycle lanes have more frequent and perhaps more severe bicycle crashes, while roundabouts with separated cycle paths and medium-sized central islands may perform better for bicyclists (Daniels et al., 2011; Hels et al., 2007; Jensen, 2017; Polders et al., 2015).

Unfortunately, corresponding evidence for the bicyclist safety performance of roundabouts in US contexts is extremely limited and remains an important research need. One challenge of safety analyses that rely upon historical crash data is that bicycle–vehicle collisions are relatively rare events, and bicycle crashes at roundabouts are even less common. The recent NCHRP Research Report 888 (Ferguson et al, 2019) proposed creating robust roundabout crash prediction models for vehicle–bicycle crashes but concluded that there was an insufficient number of bicycle crashes (only 75 at the 355 roundabouts in the study) to do so. Instead, a few US studies have relied on surrogate safety measures collected via video-based analyses of road conflicts between motor vehicles and bicycles at roundabouts (Arnold et al., 2010; Berthaume et al., 2015; Rodergerdts et al., 2007; Shen et al., 2000). Although conflict analysis can identify some of the fundamental road user behaviors and site conditions that may contribute to potential bicycle collisions, it is unable to account for potential avoidance and other behaviors by cyclists who may have negative perceptions of the safety of roundabouts.

Collecting and analyzing qualitative safety perceptions can be a useful method of safety analysis, especially when quantitative safety outcomes (crash frequencies) are sparse. Several studies have investigated cyclists' safety perceptions of various bicycle facilities (e.g.: Foster et al., 2015; Monsere et al., 2012; Sanders, 2016), but only a few have investigated roundabouts. Møller and Hels (2008) interviewed over 1,000 Danish cyclists about their perceptions of risk in different traffic scenarios at roundabouts. They found that cyclists perceived the highest risk situation being a collision with a vehicle exiting the roundabout; perceptions of safety increased with the presence of a separated bicycle facility. Focus groups of 36 cyclists held by Arnold et al. (2010) in California and Maryland reported changing their behavior at roundabouts (such as riding on the sidewalk or avoiding roundabouts altogether) and perceived roundabouts to be less safe than other intersection types.

Understanding the safety-driven motivations for certain bicyclist behaviors at or near roundabouts can offer a complementary and sometimes deeper knowledge about the safety of specific roundabout characteristics. Furthermore, bicyclists' perceptions of safety, comfort, and how to navigate roundabouts has important implications for designing roundabouts so that they are both safe and attractive for people on bicycles, thus helping to improve healthy and sustainable transportation mode usage. There is a clear and important need for additional qualitative research on bicyclist safety at US roundabouts.

Research Objectives

The primary research objectives are listed and described in more detail below:

1. Characterize bicyclists' safety perceptions of roundabouts and roundabout elements.
2. Identify bicyclists' preferences for various roundabout elements.

The overarching objective of this research project is to characterize and evaluate how bicyclists perceive the safety of roundabouts. As part of this, we aim to identify bicyclists' preferences for and perceptions of the safety and comfort of specific design and operational elements of roundabouts (e.g., number of lanes, crossing treatments, options for taking the lane vs. joining the sidewalk), as well as how bicyclists would navigate through various types of roundabouts. Such information can inform the future design and operation of safe roundabouts for bicycling.

Research Methods

To ascertain bicyclists' safety perceptions and preferences regarding roundabouts, this research project will make use of survey data collection and analysis methods. A questionnaire will ask bicyclists about their personal characteristics, user behaviors, perceptions of safety and risk, and preferences for various design and operational elements of roundabouts. Specific questions about safety perceptions and preferences will utilize multiple choices, Likert-type scales, and/or open-ended responses; various images or videos may be used to enhance realism. For example, questions may include: "How much of a risk, on a scale from "very little" to "very large", does this situation pose for being involved in a collision with a motor vehicle? Which roundabout design do you think is the safest for bicycle users? If faced with this design, what path would you take through the roundabout?" Other US research on perceptions of bicycle facilities have also used similar types of questionnaires and online surveys (Foster et al., 2015; Monsere et al., 2012; Sanders, 2016). Results will be analyzed using statistical modeling of associations between safety perceptions and user characteristics, roundabout designs, and other factors. More detailed information on the questionnaire content, recruitment approach, and data analysis methods is described in the work plan. The PI has experience designing, managing, and analyzing travel behavior survey data such as will be used in this study.

Expected Outcomes

This research is expected to generate insights into the perceptions of the safety of roundabouts for people bicycling, and therefore the safety of specific roundabout design and operational characteristics. As local and state transportation agencies consider installing roundabouts to improve overall traffic safety, the findings from this research can inform practitioners about particular design treatments that have been demonstrated to improve bicyclists' perceived safety at roundabouts, or specific designs to avoid that appear to degrade bicyclists' perceived safety. Such information can assist in the planning, design, and roadway safety management processes to help make roundabouts a safe and proven countermeasure for all road users. Installing bicycle-friendly roundabouts can also help to increase active transportation mode shares, improving public health and helping local government achieve sustainable transportation targets.

Relevance to Strategic Goals

This project directly addresses the USDOT strategic goal of Safety. Studying the impacts of roundabouts on bicyclist safety will help to inform safer intersection design treatments that can reduce transportation-related fatalities and injuries.

This project also indirectly addresses the USDOT strategic goal of Environmental Sustainability. Bicycling is a sustainable transportation mode, but research suggests that safety concerns are a primary impediment to more people bicycling. Studying the impacts of roundabouts on bicyclist safety perceptions can help to promote bicycle-friendly intersections that encourage more people to cycle, thus reducing transportation-related emissions.

Educational Benefits

One MS student will be involved in this project as a graduate research assistant. This student will gain general project management, communication, and data management skills, as well as discipline-specific skills such as survey design, transportation data analysis, and traffic safety

analysis. The MS student will take the lead on many of the research project's major tasks, including preparing and administering the questionnaire as well as writing and presenting results.

The PI teaches an undergraduate/graduate level course on transportation data and safety analysis. Data, analyses, and findings from this project will be used as examples in that course.

Technology Transfer

The findings of this research project will be disseminated to other researchers, professionals, and practitioners in several ways. We will share results with the research and professional community through presentations at local, national and/or international conferences such as meetings of the Institute of Transportation Engineers and the Transportation Research Board. In addition to the project report, we plan to prepare two manuscripts and submit them for publication in transportation and traffic safety journals. The final report will be sent to traffic safety staff colleagues at state and local transportation agencies, and the presentations and articles will also be shared on the PI's personal research website.

Work Plan

The research project will involve the following major tasks over approximately 20 months:

1. Review literature on bicyclist safety, perceptions, and behavior at roundabouts.
2. Develop a questionnaire to survey bicyclists' safety perceptions of roundabouts.
3. Administer the questionnaire on roundabout bicycling safety perceptions.
4. Conduct a statistical analysis of the survey results.
5. Prepare report, presentation(s), and paper(s).

The first task involves reviewing existing knowledge on bicyclist safety at roundabouts. We will conduct a detailed literature review of existing journal articles, conference presentations, government reports, and design guidelines. This review will likely address the following topics related to roundabout safety: statistics on vehicle–bicycle crashes, results of conflict analyses between people driving and bicycling, bicyclist perceptions of safety and comfort, and surveys of bicyclist behaviors. The purpose of the review is to identify objective and subjective bicycle safety issues with roundabouts—including specific roundabout design and operational characteristics, bicycle facility types, unsafe traffic situations, and dangerous maneuvers—that can inform the development of a survey on bicyclist safety perceptions. The MS student will complete this task with supervision from the PI. This task will be completed approximately 4 months after the project starts.

The second task involves developing a questionnaire on bicyclists' safety perceptions of roundabouts. Informed by the literature review, the questionnaire will be used to survey various topics, potentially including: personal characteristics (socio-demographics, attitudes, and personality); familiarity with roundabouts; perceptions of safety and comfort, expectations of how to use and navigate, and preferences associated with roundabouts in general and with specific roundabout design and operational elements (number of lanes, speed, traffic volumes, bicycle facilities, signage, pavement markings, etc.); perceptions of risk and expected behaviors under various traffic situations (types of maneuvers and road user conflicts); and any impacts of roundabouts on route choice or mode choice decisions. To increase the realism of situations posed to respondents, we will use sketches, renderings, photographs, and/or videos of

roundabouts and particular designs and situations. The MS student will complete this task with supervision from the PI. This task will be completed approximately 8 months after the project starts.

The third task involves administering the questionnaire on bicyclists' safety perceptions of roundabouts. The target population includes adults who bicycle in areas with roundabouts. Depending on response rates, we will invite participants from Utah, neighboring states, or even from elsewhere in the US. Participants may be recruited using a variety of methods, such as: intercepting bicyclists at/near roundabouts or high-volume locations, posting fliers in bicycle shops, and/or emailing membership lists of bicycling clubs and organizations. The survey will likely be hosted online and is expected to take roughly 10–20 minutes to complete. To incentivize participation, respondents will be offered the chance to win a modest prize (e.g., a cash gift card). The questionnaire and survey approach will be approved by Utah State University's Institutional Review Board prior to survey distribution and data collection. The MS student will complete this task with supervision from the PI. This task will be completed approximately 14 months after the project starts.

The fourth task involves analyzing the survey results. Broadly, we will associate reported safety perceptions and behaviors with various roundabout design and operational elements and with personal characteristics. Quantitative analyses of questionnaire responses will utilize various statistical methods, potentially including regression modeling and factor analysis. Qualitative investigation into open-ended survey responses may utilize content analysis. Overall, analysis will help to develop findings that increase our knowledge on bicyclists' behaviors and safety perceptions as well as suggest potential design and operational recommendations. The MS student will complete this task with supervision from the PI. This task will be completed approximately 18 months after the project starts.

The fifth task involves preparing the final report, creating presentations, and writing papers. As described in the Technology Transfer section, we anticipate presenting our results at several conferences and preparing two manuscripts for publication. The PI and the MS student will complete this task. This task will be completed approximately 20 months after the project starts.

Project Cost

Total Project Costs:	$99,997.82
MPC Funds Requested:	$49,998.91
Matching Funds:	$49,998.91
Source of Matching Funds:	Local Technical Assistance Program

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