



Pedestrian preferences with respect to roundabouts—A video-based stated preference survey

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ABSTRACT

Research on user behavior and preferences has been a helpful tool in improving road safety and accident prevention in recent years. At the same time, there remain some important areas of road safety and accident prevention for which user preferences, despite their importance, have not been explored. Most road safety research has not explicitly addressed vulnerable user (pedestrians and cyclists) preferences with respect to roundabouts, despite their increasing construction around the world. The present research stems from the fact that studies related to roundabout safety have generally focused on drivers, while overlooking the importance of safety as it relates to vulnerable users, especially pedestrians. Moreover, it handles this particular issue through an approach that has not been used so far in this context; the Stated Preference (SP) survey. As such, there are two main goals (and contributions) of this work. First, to show how SP surveys can be used to investigate the importance of different design and operational features to pedestrian perceptions of safety in roundabouts. This allows us, for example, to quantify how some features of roundabouts (e.g. high traffic volume) can be compensated for by design features such as pedestrian islands. This is useful in helping to design roundabouts that pedestrians prefer and will hopefully use, to help encourage active transport. Second, to demonstrate how traffic simulation software can be successfully used to include difficult-to-communicate attributes in SP surveys.

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1. Introduction

Developed initially in the UK in the 1960s, roundabouts have become increasingly popular in the last two decades in North America. Roundabouts are circular intersections where traffic flows counter-clockwise around a central island, preventing vehicles from crossing in a straight, and therefore faster, path. These intersections work based on the principle that vehicles entering the

roundabout must yield to those already traveling within the central circle (Rodegerdts et al. (2010), pp. 3–5).

There are several commonly identified benefits of roundabouts compared to regular intersections that have been documented in the significant body of research on the topic. These benefits can be divided into different categories including environmental (e.g. reduced emissions because of increased fluidity of traffic flow, in particular fewer stops), mobility (increased fluidity of traffic flow compared with regular intersections), and safety (fewer accidents) improvements – the former of which can be further classified between driver and vulnerable user safety benefits.

How roundabouts improve driver safety is an issue addressed in the majority of the studies on the topic, although in some cases vulnerable road users (cyclists and pedestrians) are also considered. In the literature focusing mainly on motorists it has been shown that for these users, roundabouts are safer than other types of intersections, both in terms of frequency of accidents and their severity (Bared et al., 1997; Bie et al., 2008; Chen et al., 2013; Gross et al.,

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2013). On the other hand, (Daniels et al., 2010a,b) found that vulnerable road users have a higher probability of being injured in roundabouts than expected based on their share of occupancy in traffic. (Daniels et al., 2010a,b) also found that some geometric elements such as the presence of bicycle lanes inside roundabouts are a significant risk factor. At the same time there is a bit of literature that has touched on the question of vulnerable road users in roundabouts, according to Wall et al. (2005) there are simply not enough studies related to the safety of this type of roundabout user, despite the importance of the subject.

While there has not been much research on the safety of vulnerable road users in roundabouts, pedestrian safety has attracted increased attention recently. Different approaches have been proposed to map injury risk and/or identify factors associated to injury frequency or severity of pedestrians using traditional methods based on historical crash data, but many of these have been focused on intersections or crosswalks (Harwood et al., 2008; Clifton et al., 2009; Miranda-Moreno et al., 2011). To address some of the issues of traditional crash-based methods, surrogate safety methods have also been proposed to investigate pedestrian safety using field observations such as video data (Ismail et al., 2009). While there is an important body of literature on objective safety using crash-risk or surrogate measures, the literature on safety perception is limited, in particular at roundabouts (Li, 2006; Ren et al., 2011; Brosseau et al., 2013; Lipovac et al., 2013). Papadimitriou et al. (2013) focuses on pedestrian perceptions of intersection safety with respect to traffic characteristics such as vehicle volume and vehicle speeds. De Brabander and Vereeck (2007) and Xi and Son (2012) on the other hand concentrate on statistical analyses of pedestrian accidents and injuries, but do not consider pedestrian preferences or behavior explicitly. Finally, Meneguzzer and Rossia (2011) examine the empirical relationships between pedestrian occupancy of crosswalks and impedance to vehicle flow in roundabouts. Despite there being a literature on roundabouts, and there being a literature on pedestrian safety, there is little research that focuses exclusively on pedestrian safety in roundabouts, especially when compared with how much literature there is for drivers. Perhaps the most comprehensive research focused on pedestrian safety in roundabouts is Report 674 of the National Cooperative Highway Research Program (see Schroeder et al., 2011, pp. 34–61), which gathers various studies of the National Research Council of America on roundabouts. In the report, different roundabout attributes are studied in order to provide specific recommendations for their construction. While some of the research surveyed in the report looks at pedestrian preferences with respect to roundabouts, none of that research broached the question by means of an Stated Preference (SP) survey.

SP surveys have been used in a limited number of situations to understand vulnerable road user preferences and behavior. The method has been used for example to better understand cyclist preferences, although never in the context of roundabouts (see e.g. Krizek (2006)). Furthermore, pedestrian preferences and behavioral analyses have been confined to: route choice and behavior at intersections (Papadimitriou et al., 2009); the influence of perceived level of safety at an intersection and where pedestrians cross (Li, 2006); preferences with respect to pedestrian crossing facilities (Sisiopiku and Akin, 2003) and pedestrian-motorist interactions at intersections (Kaparias et al., 2012).

Another field related to this research is that on the use of visual aids in transportation SP surveys. Studies by Taylor and Mahmassani (1996), Krizek (2006) and Arentze et al. (2003) can be observed as evidence of the good results that visual aids can produce in SP surveys. Particularly interesting is the work of Krizek (2006), where the use of visual aids (10-second video clips of bicycle paths) was reported to improve survey performance markedly.

In summary, the existing literature on roundabouts has focused on motorists and has mostly ignored vulnerable road users, despite an explosion in research and interest of this subject recently. Moreover, despite being used to successfully understand user preferences in other branches of transportation research, there has been no research to have explored the use of SP surveys to understand pedestrian preferences with respect to safety in roundabouts.

Understanding pedestrian preferences and behavior is an important goal in order to help encourage the use of active modes of transportation (see e.g. NCHRP report 674 (Schroeder et al., 2011)). Also, the use of visual aids in SP surveys to understand preferences, especially those that are difficult to communicate in words – and particularly in the context of vulnerable road users – is in its infancy.

As such, this research contributes to existing literature along these dimensions through the use of a video-based stated preference survey of pedestrian preferences in terms of safety with respect to roundabouts. There are two main goals of this work. First, to show how SP surveys can be used to quantify the importance of different design and operational features to pedestrian perceptions of safety in roundabouts. This allows us to quantify how some factors such as high traffic volume can be compensated for, by design features such as pedestrian islands. Second, to demonstrate how traffic simulation software can be successfully used to include difficult-to-communicate attributes in SP surveys.

The paper continues with a description of the development and administration of the survey. This is followed by a description of the statistical model used to analyze the data, model results and interpretation. The paper is finished with a discussion and conclusion of the results as well as a few notes on future work.

2. Methodology

An SP study typically involves a long process that includes: the design, administration and analysis of collected data (Louviere et al., 2000; Arentze et al., 2003; Chu et al., 2004; Papadimitriou et al., 2009; Kelly et al., 2011; Kaparias et al., 2012). In the present research, the purpose of the survey was to understand what factors (and to what degree those factors) influence vulnerable user preferences with respect to roundabouts in terms of safety. The first step in the development of an SP survey is an examination of the existing literature to understand what characteristics and attributes have been considered important in previous relevant studies. Table 1 provides a summary of relevant work for pedestrian safety where vulnerable road user safety has been considered, focusing on the attributes (geometrical and operational) and their levels that have been used and evaluated in them. The literature is categorized by the type of intersection considered (traditional or roundabout) and the methodological approach adopted (SP or Other). This organization of the existing research allowed us to know which attributes (and their levels) have been found to be important in previous vulnerable user safety studies.

As can be seen, most of the research has considered the following attributes: traffic volume, traffic speed, pedestrian volume, signalization, pedestrian crossing location and the presence of physical barriers (e.g. pedestrian islands).

While the first step provides an idea of the attributes that are likely to be included in the survey instrument, further complementary studies, such as focus groups and pilot tests are necessary to establish which attributes should be included in the final survey instrument. This constitutes a second step in survey development. A focus group is an exploratory research tool where a group of potential respondents are asked to identify which attributes they consider to be important in the question (choice) of interest. While being asked what attributes are important, respondents are also

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