



Cyclists' Perceived Safety and Comfort of Dutch Roundabouts

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Introduction

While roundabouts, in comparison with intersections, are associated with decreased severity of motor vehicle crashes (Distefano, 2019), recent crash data suggest that this is not the case for bicycle crashes (12% of all bicycle collisions) (Wegman, 2024). At the same time, the Netherlands is experiencing increasing congestion in bicycle facilities as new types of bicycles (e.g., fat tire bikes, e-bikes, cargo bikes, etc.) are becoming increasingly popular. Researchers and professionals are actively working on updating roundabout design guidelines. Several factors were identified from past research that have an influence on objective and subjective bicycle safety at roundabouts (Shen, 2020; Wegman, 2024; de Waard, 2020). These include among others: bicyclist crash history, yielding priority, buffer width between car lanes and bicycle facility, the number of crossing points for bicycles, and cyclists' behaviors (e.g., long term level of risk taking, errors, and positive behaviors) (Useche, 2021; CROW, 2023).

Research aim

This study aims to explore which design characteristics and socio-demographic factors influence bicyclists' perceptions of safety and comfort at Dutch roundabouts. The objective of this study is to assess how typical Dutch bicycle infrastructure design at urban roundabouts, influences bicyclists' intended behavior and subjective safety and comfort.

Research method

The research utilized a mixed-method approach comprising a literature review, field observations, expert interviews, and a stated preference survey. The literature review and expert interviews assisted in determining which independent socio-demographic and roundabout infrastructure variables are important to include in the survey. Expert interviews were conducted with designers and government officials participating in the Center for Regulation and research in civil, water and Road Construction and traffic technology (CROW) workshops (the goal of the workshops is to create an update to the 2014 roundabout design guidelines, focusing on bicycle design). During the workshops, the following topics were discussed:

- Yielding priority
- bi-directional vs uni-directional bicycle facilities
- different type of bicycles and how that affects designs
- Visibility for the bicyclist and anticipation of turning movements
- Buffer width between bikes and vehicles



Field observations at over 50 Dutch urban roundabouts during PM peak rush hour were conducted, collecting data on bicycle volumes, observing the behaviors of bicyclists, and taking survey photos. A stated choice experiment design was then used to determine the number of locations to use in the survey. Photos of eight real world roundabouts were modified and used in the survey construction. In addition to the other mentioned factors in the introduction, this research analyzes different bicycle volumes, the presence of art and/or advertisements in the center island, whether the bicycle path is uni-directional or bi-directional, and the shape of the bicycle path at the roundabout (e.g. a bent/diamond or circular shape). All the roundabout infrastructure characteristics were reduced to binary variables in order to simplify the survey and the amount of respondents needed to reach statistical significance. The survey asks respondents to rank on a 5-point Likert scale, how comfortable and how safe they would feel if they cycle through those locations. Other socio-demographic and cyclists' behavioral questions were asked as well.

The survey is currently ongoing with random sampling of the Dutch population, via online forums such as Ouders.nl and Fietsersbond, and the cities of Amsterdam, Rotterdam, and The Hague. Currently there have been over 325 complete responses and 55 in progress. Following completion of the data collection, statistical modeling approaches (multivariate random effect ordered probit model and a model from the ordinal SEM family) will be used to investigate the heterogeneous interactions amongst respondent groups regarding the relationship between bicyclists' perceptions of comfort and safety with the aforementioned roundabout features. Due to the ordinal nature of most of the independent variables, ordinal models will be used in order to prevent underestimation of the fit indices and the standard errors of the parameter estimates (Xing, 2019).

Results

Findings from the literature review, expert interviews, and field observations have yielded interesting results. The literature review concluded that the link between perceived comfort and safety and objective safety is ambiguous, with past studies finding that only vehicle speed had a strong correlation between the two (Sakshaug, 2010; Tan, 2019; Meuleners, 2019). In addition, past research and design workshops found that the heterogeneity of roundabouts can cause confusion to motorists and bicyclists as they may encounter two roundabouts in the vicinity of each other which vary in design characteristics such as speed limit, bicycle facility, or center island features (Sakshaug, 2010; ARUP, 2022; Poudel, 2021; van der Leeden, 2012).

The expert interviews confirmed that the CROW design guidelines leaves room for designer's choice, in particular with regards to which mode should have yielding priority when the distance between the bike crossing and the vehicle entrance/exit of the roundabout is between 5 and 10 meters. Deviation from the CROW design guidelines occurs due to various reasons. The CROW workshop confirmed that certain bicycle design features are more important than others in terms of providing the safest possible design. Those were added into the survey. In addition, other key takeaways were the debates on collecting better bicycle collision data due to chronic underreporting, lowering speeds (all modes) to accommodate all the complex roundabout turning movements, and city-wide consistency of roundabout designs which may increase road user compliance.



During the field observations, several notable behaviors were observed such as: preference for bicyclists to use one side of a roundabout (even though the bike facility was bi-directional on all sides), bicycles weaving into the vehicle lane as a shortcut when the buffer width was less than 1 meter, wrong-way bicycle riding in the bike facility as that provided the most direct path to residences, avoided a complex tram crossing, and other neighborhoods, and the presence of a major grocery store at one corner which lead to many bicycle turning movements to and from that corner.

The results and findings from the survey are expected to be completed by mid-July. The main contribution that this research hopes to provide is bicycle oriented design and policy recommendations for government agencies in order to maximize perceived safety and in this way compliance.

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