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# Assessing Perceived Safety of Non Motorized Travel with Virtual Reality

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## Introduction

Non-motorized traveler safety remains a pressing concern in urban transportation planning, as pedestrian and bicyclist fatalities continue to rise. Despite the well documented health and environmental benefits of active transportation, safety concerns deter many individuals from walking or cycling regularly. Creating inclusive, user-centered roadway environments is critical to promoting safer and more accessible transportation options for all non-motorized travelers.This research explores the application of Immersive Virtual Environment (IVE) technology to evaluate perceived safety and behavioral responses of non-motorized travelers—specifically cyclists—under different roadway designs. Using a bike simulator integrated with virtual reality (VR) and biometric sensors, the study offers a cost-effective, controlled, and safe method to investigate how environmental and infrastructural factors influence perceptions of safety and behavior. These insights are vital for designing inclusive infrastructure that supports active travel modes.

## Study Methods

An IVE-based simulator was employed to replicate realistic active travel experiences. The experimental setup featured a stationary unisex city bicycle equipped with motion sensors and biometric tracking. A head-mounted display (HMD) provided immersive visuals, enabling participants to experience urban environments virtually while capturing real-time physiological and behavioral data, including gaze direction, heart rate (HR), speed, and lane positioning. Participants experienced three common urban roadway scenarios: (1) as-built shared lanes (sharrows); (2) curbside bike lanes; and (3) protected bike lanes with flexible delineators. Fifty participants navigated each scenario in the virtual environment—calibrated to match a real-world street segment in Long Beach, California—and completed pre- and post-simulation surveys assessing perceived safety and travel attitudes. The virtual scenarios were modeled using two weeks of actual traffic data.

## Findings

The study generated several important findings about how roadway design impacts the safety perceptions and behaviors of non-motorized travelers:

1. Perceived Safety: Protected bike lanes with flexible delineators were rated the safest, followed closely by curbside lanes. Both offered significant improvements in comfort compared to shared lanes.
2. Behavioral Patterns: Participants rode slower and maintained greater lateral distance from vehicle lanes in protected lane scenarios—behaviors linked to safer travel environments.
3. Visual Engagement: Gaze concentration improved in protected and curbside lanes, suggesting fewer distractions and heightened environmental awareness.
4. Stress Indicators: Physiological data showed reduced heart rate variability in protected and curbside lanes, indicating lower stress levels and enhanced psychological comfort.
5. Gender Insights: Female participants reported lower perceived safety in shared lanes and a strong preference for protected infrastructure, although objective data showed minimal gender differences in physiological or behavioral metrics.
6. Simulator Validity: The IVE setup demonstrated high validity for key performance metrics, affirming its value for replicating real-world travel experiences. Minor limitations were noted in capturing complex vertical movements related to road surface variation.

Protected bike lanes significantly improve perceived safety, reduce stress, and enhance behavioral focus among non-motorized travelers—supporting safer, more equitable transportation networks.

## Policy Recommendations

The findings support prioritizing protected and curbside infrastructure to improve safety and comfort for non-motorized travelers. These designs not only enhance behavioral and physiological outcomes but also address equity concerns, particularly around gender based perceptions of safety. Furthermore, IVE technology presents a valuable tool for future infrastructure design and evaluation, offering a safe, scalable, and cost effective platform for testing new concepts and understanding user experiences. Future research should expand to include a broader range of non-motorized users, urban contexts, and sensor technologies to further inform data-driven planning and design.

## About the Authors

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Dr. Balali is a transportation researcher specializing in virtual reality applications and cyclist safety. He leads innovative studies on human factors and non-motorized traveler behavior.

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Sahand is pursuing his master's in Construction Engineering and Management at California State University, Long Beach. He is passionate about exploring innovative technologies and developing solutions for complex spatial problems to enhance the efficiency and safety of construction operations. He has contributed to several significant projects, helping streamline processes and optimizing operational costs through the application of software development and advanced technological solutions.

## To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2349

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