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LONG BEACH

Assessing the Perceived Safety of Cyclists with Virtual Reality

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Introduction

Cyclist safety remains a critical issue in urban transportation planning, as non-motorized traveler fatalities, including bicyclists, have been steadily increasing. Despite the health and environmental benefits of cycling, perceptions and concerns about safety continue to deter individuals from adopting cycling as a primary mode of transportation. Addressing these concerns is paramount to fostering safer and more inclusive urban roadways.

This research investigates the use of Immersive Virtual Environment (IVE) technology to evaluate cyclists' perceived safety and behavioral responses under various roadway designs. By leveraging a bike simulator integrated with virtual reality (VR) and biometric sensors, the study offers a cost-effective, controlled, and safe method for assessing cyclist behavior in real-world scenarios. This approach enables researchers to model environmental and design factors influencing cyclists' perceived safety, providing actionable insights for enhancing transportation infrastructure.

Study Methods

The study utilized an IVE-based bike simulator designed to replicate real-world cycling conditions. The simulator consisted of a stationary unisex city bicycle equipped with various sensors to translate cyclists' physical actions into virtual interactions. Immersive visuals were provided through a head-mounted display (HMD) with positional tracking. The simulator captured key physiological and behavioral data, including gaze direction, heart rate (HR), speed, and lane positioning.

The experiment focused on three roadway design scenarios: (1) as-built shared bike lanes (sharrows), (2) curbside bike lanes, and (3) protected bike lanes with flexible delineators. Fifty participants cycled through these environments in the IVE and completed pre- and post-simulation surveys to assess perceived safety and attitudes toward cycling. The virtual environment was calibrated to replicate a real-world road segment in Long Beach, California, at a 1:1 scale. The virtual roadway was designed based on two weeks of real-world traffic data.

Findings

The study produced several key findings that highlight the impact of roadway design on cyclists' perceived safety and behavior:

- Perceived Safety: Participants rated the protected bike lane with flexible delineators as the safest roadway design. However, the difference in perceived safety between curbside and protected bike lanes was minimal, indicating that both designs significantly improve cyclists' comfort compared to shared bike lanes.

The study revealed that protected bike lanes with flexible delineators significantly enhance cyclists' perceived safety, reduce stress levels, and improve behavioral focus compared to shared bike lanes.

- Cycling Behavior: The protected bike lane scenario was associated with the lowest cycling speeds and the greatest lateral distance from vehicle lanes. These behaviors suggest a safer cycling experience due to reduced speeds and increased separation from motorized traffic.
- Gaze Metrics: Participants demonstrated higher gaze concentration and fewer distractions in the curbside and protected bike lane scenarios.
- Physiological Responses: Lower HR changes were observed in curbside and protected bike lanes, indicating reduced stress levels compared to shared bike lanes. This finding underscores the potential of separated bike lanes to enhance cyclists' psychological well-being.
- Gender Differences: Female participants reported lower perceived safety for shared bike lanes and higher preferences for protected bike lanes, consistent with existing literature. However, no significant gender differences were observed in objective behavioral or physiological responses.
- Validity of the IVE: The IVE bike simulator demonstrated strong relative and absolute validity for most performance metrics, suggesting its effectiveness as a tool for replicating real-world cycling conditions. However, discrepancies in vertical gaze and head movement data highlighted limitations in modeling complex real-world features, such as road irregularities.

Policy Recommendations

The findings emphasize the importance of investing in protected and curbside bike lanes to enhance perceived and actual safety for cyclists. These designs not only improve behavioral and physiological responses but also address gender disparities in perceived safety, promoting more equitable cycling infrastructure. Policymakers and planners should prioritize roadway designs that provide greater separation from motorized traffic.

Additionally, the use of IVE technology offers a promising avenue for future research and infrastructure evaluation. The low cost, safety, and replicability of IVE experiments make them a valuable tool for testing new designs and understanding user behavior. Future studies should focus on larger and more diverse participant samples, incorporate additional sensor measurements, and explore various urban settings to validate and expand upon these findings.

About the Author

Vahid Balali, PhD

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.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2327

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