International Co-operation on Theories and
Concepts in Traffic Safety

Measuring Pedestrian Perception and Behavior along an Urban Street during the Daytime and Nighttime through the use of Eye-Tracking Technology

[1]*de Cárdenas, C.A., [2]Raida, A. [2]Aliabad, A., [2]O'Connor, E., [2]Mondschein, A., [2]Heydarian, A. & [2]Chen, T.D. *lead presenter
[1]cad3ev@virginia.edu, University of Virginia, United States of America
[2] University of Virginia, United States of America

Walking is one of the most sustainable and equitable modes of transportation and the creation of safe and pleasant pedestrian infrastructure is vital for promoting this form of mobility. Pedestrians are some of the most vulnerable road users and pedestrian fatalities have been increasing over the last 15 years. When people feel that conditions are not safe, they will often forgo walking, so it is critical to understand pedestrian perception when making decisions about a built environment. This is largely due to incidents that occur at night making it imperative to understand how pedestrian perception and behavior varies between the daytime and nighttime. Understanding pedestrian behaviors, preferences, and perception of the built environment is essential for creating spaces that promote more active modes of transportation. Visual behavior is closely associated with underlying cognitive processes and there is a strong connection between where we look and our actions in the world. However, the ability to measure these elements in real-world settings was limited until recently, with the introduction of mobile eye-tracking glasses. Studies on visual behavior as it relates to the built environment have previously only been possible in laboratory settings, due to technological constraints and the complexity of monitoring tasks in their natural environments. The study had two main objectives. The study both examines the impact of lighting conditions on pedestrian behavior and perception as well as establishes a comprehensive framework for applying this technology to built environment scenarios for use in future studies. The study took place along a commercial street in Charlottesville, VA, USA and employs mobile eye tracking glasses and stated preferences surveys to provide more insight on pedestrian interaction with the built environment. By integrating mobile eye-tracking glasses and pre- and post-experiment surveys, this study explores how to better understand pedestrian response to changes in urban infrastructure design and environmental conditions.

This naturalistic pedestrian study employs mobile eye tracking glasses and stated preferences surveys to provide more insight about pedestrian perception and interaction with the built environment. Using a within-subjects experimental design, variations in the experience along the same street, during the day and at night, are measured. For this study, the physical and social elements that make cities and streetscapes dynamic spaces are identified as Urban Typologies that help categorize and understand the role different types of urban stimuli play within urban streetscapes. This study presents the differences in the pedestrian' attention to urban typology, including traffic, infrastructure, and people. There were a total of 63 participants, each walking up and down the 4-block study route once during the day and once during the night while wearing the mobile sensors. Participants had the choice to cross at whichever location they would under normal conditions. Eye-tracking data, physiological

data, and environmental condition data was collected for each experiment. Eye tracking data was analyzed using Tobii software to determine which elements gained the greatest share of total fixation duration. Gaze variability and Gaze Entropy are also analyzed to provide more insight into the best metrics to measure cognition and interaction in this environment.

The initial results indicate that, on average, participants spent a larger share of fixation duration on vehicles, lighted crossing infrastructure, and lighting features during the nighttime scenario (Figure 1). Participant ages ranged from 20 to 88 years old and the fixation duration data was disaggregated by age group to explore differences across this range. Most notably, there was an increase in attention to general pedestrian infrastructure (mostly consisting of sidewalks) with age. Based on some conversations with participants, one possibility for this increase is a greater concern about sidewalk conditions and tripping as people get older. Previous studies have also found that the sidewalk conditions and the fear of falling is a concern for middle-aged and senior adults and can impact (*41–43*). There was little variation when data was separated by gender. The data also suggest that gaze variability increases when crossing at night which can be connected to increased anxiety and stress (Figure 2). Further analysis is being completed to gain more insight.

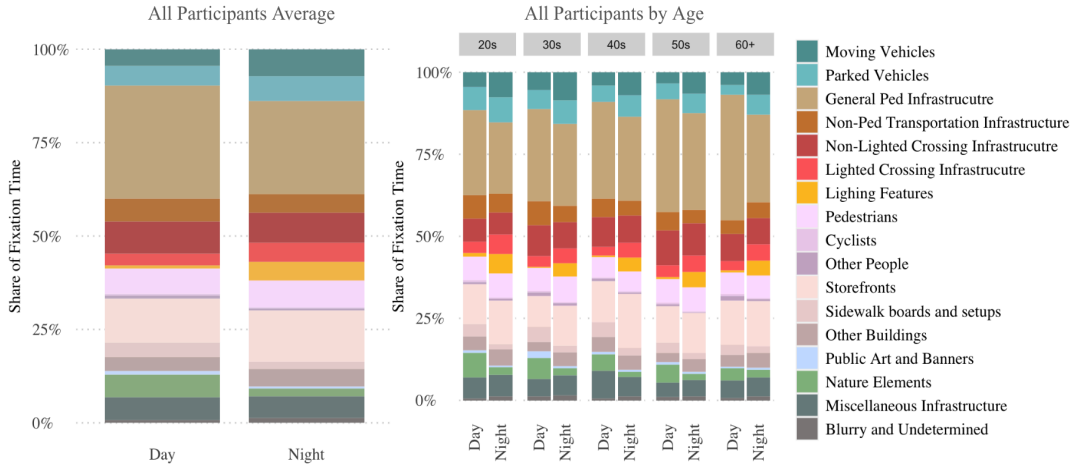

Figure 1: The mean share of fixation duration for all participants and disaggregated by Age during the Day and Night Scenarios

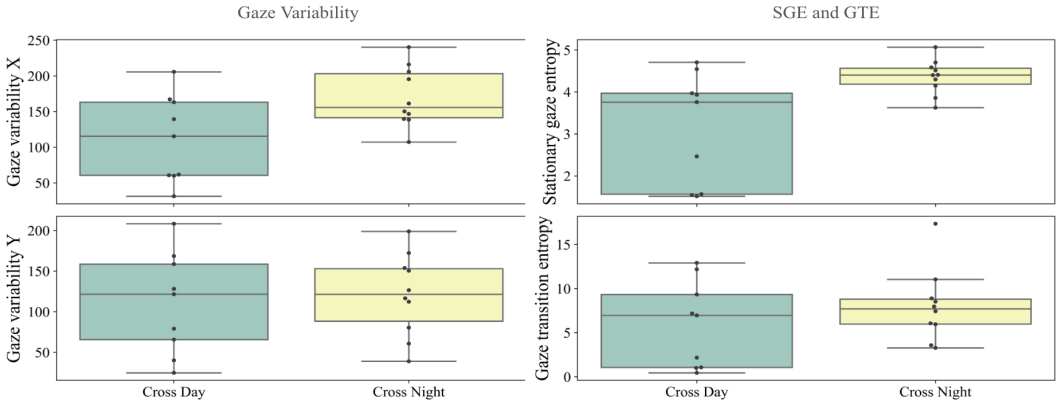

Figure 2: Gaze Variability, Stationary Gaze Entropy (SGE), and Gaze Transition Entropy (GTE)

Physiological response of participants was measured by collecting heart rate data via the smartwatch worn by participants. The initial findings suggest that Heart Rate variability increases at night, particularly for female participants. The route also had various types of intersections, including signalized intersections and intersections with only crosswalks. The analysis suggests that the signalized intersection (I3) was the most commonly chosen intersection by participants.

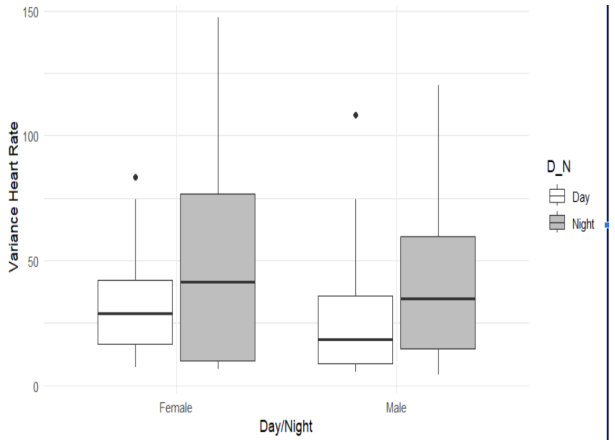

Figure 3: Heart Rate Variance

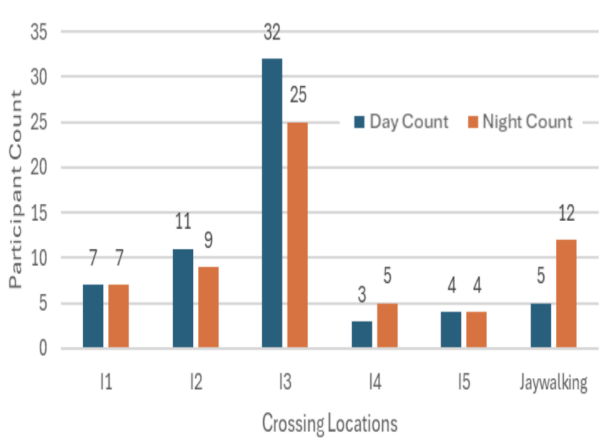

Figure 4: Crossing Behavior by Time of Day

While further analysis is being completed to gain a deeper understanding of how pedestrians perceive their surroundings and interact with the built environment, the initial analysis highlights some differences in attention, physiological response, and behavior that can inform decisions that improve conditions for pedestrians. The increased attention to lighted features when navigating at night and the variation and the variation by age group can contribute to designing infrastructure that works for users of all mobility levels. The study proposes a comprehensive model of measuring attention, perception, and cognition, and sets the groundwork for future research on linkages between the experiential dimensions of streets, human-wellbeing, and pedestrian behaviors. With the increase in nighttime pedestrian fatalities that the US is experiencing, the need for creating safer spaces and infrastructure for pedestrians and other vulnerable road users is greater than ever. The results from these studies, and future work that builds on this framework, can help inform the choices of communities and decision makers.